ESA Recovery Plan for Snake River Sockeye Salmon
(Oncorhynchus nerka)

June 8, 2015

WEST COAST REGION

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Additional copies of this plan can be obtained from:

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Cover Photo: 2008 Adult release into Redfish Lake. *Photo: Mike Peterson, IDFG*

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Acknowledgements

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NMFS Snake River Hydro Module
NMFS Snake River Harvest Module
NMFS Snake River Ocean Module

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Abbreviations and Acronyms

2008 SCA	2008 Supplemental Comprehensive Analysis
BACI	before after control influence
BiOp	biological opinion
BPA	Bonneville Power Administration
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CA	Comprehensive Analysis
CHaMP	Columbia Habitat Monitoring Program
CWT	coded wire tags
DDT	Dichlorodiphenyltrichloroethane
DPS	distinct population segment
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
GIS	geographic information system
GM	geometric mean
HGMP	Hatchery Guidance Management Plan
HSRG	Hatchery Scientific Review Group
ICTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IHOT	Integrated Hatchery Operations Team
ISDA	Idaho State Department of Agriculture
ISRP	Independent Scientific Review Panel
MCR	Middle Columbia River
MPG	major population group
NAWQA	National Water Quality Assessment
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
OSC	Office of Species Conservation
PAHs	polycyclic aromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers
PBT	parental based tagging
PCBs	polychlorinated biphenyls
PIBO	Pacfish - Infish Biological Opinion

PIT	passive integrated transponder
PNI	proportionate natural influence
RIST	Recovery Implementation Science Team
RM	river mile
Rkm	river mile in kilometers
RME	research, monitoring, and evaluation
RPA	reasonable and prudent alternative
SAR	smolt-to-adult return
SBSTOC	Stanley Basin Sockeye Technical Oversight Committee
SBT	Shoshone Bannock Tribe
SCA	Supplemental Comprehensive Analysis
Sawtooth NRA	Sawtooth National Recreation Area
SR	Snake River
TCDDs	tetra-chlorinated dibenzo-p-dioxius
TDG	total dissolved gas
TMDL	total maximum daily load
TOC	Technical Oversight Committee
TRT	Technical Recovery Team
UCR	Upper Columbia River
UI	University of Idaho
USFS	U.S. Forest Service
VIC	variable infiltration capacity

Terms and Definitions

Abundance	In the context of salmon recovery, abundance refers to the number of adult fish returning to spawn.
Acre-feet	A common measure of the volume of water in the river system. It is the amount of water it takes to cover one acre (43,560 square feet) to a depth of one foot.
Adaptive Management	The process of adjusting management actions and/or directions based on new information.
All-H Approach	The idea that actions could be taken to improve the status of a species by reducing adverse effects of the hydrosystem, predators, hatcheries, habitat, and/or harvest.
Anadromous Fish	Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.
Baseline Monitoring	In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.
Biogeographical Region	An area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.
Broad Sense Recovery Goals	Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for ESA delisting, to address, for example, other legislative mandates or social, economic, and ecological values.
Brood Cycles	Salmon and steelhead mature at different ages so their progeny return as spawning adults over several years. When all progeny at all ages have returned to spawn, the brood cycle is complete.
Comprehensive Analysis (CA)	The analysis conducted by the FCRPS Action Agencies to assess impacts of proposed operation of major projects in the Federal Columbia River Power System (FCRPS). The CA provides the basis underlying the biological assessments on the FCRPS and Upper Snake River projects.
Compliance Monitoring	Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.
Conservation Gap	The difference between a population's baseline status and its target status.
Contributing Population	A population for which some restoration will be needed to achieve the MPG-wide average viability recommended by the Interior Columbia Technical Recovery Team.

Delisting Criteria	Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4(a)(1), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species.
Distinct Population Segment (DPS)	A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NOAA Fisheries policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.
Diversion	Refers to taking water out of the river channel for municipal, industrial, or agricultural use. Water is diverted by pumping directly from the river or by filling canals.
Diversity	All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy versus lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.
Effectiveness Monitoring	Monitoring set up to test cause-and-effect hypotheses about RPA actions intended to benefit listed species and/or designated critical habitat. Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?
Endangered Species	A species in danger of extinction throughout all or a significant portion of its range.
ESA Recovery Plan	A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the maximum extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.
Evolutionarily Significant Unit (ESU)	A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment and treated as a species under the Endangered Species Act.
Extinct	No longer in existence. No individuals of this species can be found.

Extirpated	Locally extinct. Other populations of this species exist elsewhere. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.
Factors for Decline	Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or human-made factors affecting its continued existence.
FCRPS Action Agencies	The three agencies that operate the Federal Columbia River Power System: Bonneville Power Administration, U.S. Army Corps of Engineers and Bureau of Reclamation.
Fish Ladder	A series of stair-step pools that enables adult salmon and steelhead to migrate upstream past a dam. Swimming from pool to pool, adult salmon and steelhead work their way up the ladder to the top where they continue upriver.
Flow Augmentation	Water released from system storage at targeted times and places to increase streamflows to benefit migrating juvenile salmon and steelhead.
Freshet	The heavy runoff that occurs in the river when streams are at their peak flows with spring snowmelt. Before the dams were built, these freshets moved spring juvenile salmon quickly downriver.
Functionally Extirpated	Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.
Heterozygosity	The presence of different alleles at one or more loci on homologous chromosomes.
Hyporheic Zone	The hyporheic zone is a region beneath and alongside a stream bed where shallow groundwater and surface water mix.
Implementation Monitoring	Monitoring to determine whether an activity was performed and/or completed as planned.
Independent Population	A group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For NMFS' purposes in recovery planning, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame (McElhany et al. 2000).

Independent Scientific Review Panel (ISRP)	The Independent Scientific Review Panel reviews individual fish and wildlife projects funded by Bonneville Power Administration and makes recommendations to the Northwest Power and Conservation Council on matters related to those projects.
Indicator	A variable used to forecast the value or change in the value of another variable.
Intrinsic Potential	The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.
Intrinsic Productivity	Productivity at very low population size; unconstrained by density.
Introgression	The incorporation of genes from one species into the gene pool of another as a result of hybridization.
Interoparity	The ability to reproduce more than once during a lifetime.
Jack and Jill salmon	Jack and Jill salmon return to freshwater one or two years earlier than their counterparts. They are usually smaller but are sexually mature and return to spawn at an earlier age.
Juvenile salmon	Juvenile salmon is the term applied to a salmonid fish between the egg and adult stages. Juvenile salmonid stages include sac fry or alevin, fry, parr, and smolts. The juvenile stage last until the fish are grown and sexually mature.
Kokanee	A self-perpetuating, generally non-anadromous form of *Oncorhynchus nerka* that is distinct from sockeye. Kokanee occur in balanced sex-ratio populations where the parents, for several generations back, have spent their whole lives in fresh water. Kokanee are genetically distinct from sockeye and are not the focus of this recovery plan.
Large Woody Debris (LWD)	A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.
Legacy Effects	Impacts from past activities (usually a land use) that continue to affect a stream or watershed in the present day.
Limiting Factors	Impaired physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's (or major population group's or species') ability to reach its desired status.
Major Population Group	An aggregate of independent populations within an ESU that share

(MPG)	similar genetic and spatial characteristics.
Maintained Status	Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU recovery.
Management Unit	A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.
Metrics	Something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.
Morphology	The form and structure of an organism, with special emphasis on external features.
Natural-origin Fish	Fish that were spawned and reared in the wild, regardless of parental origin.
Northern Pikeminnow	A large member of the minnow family, the Northern Pikeminnow (formerly known as Squawfish) is native to the Columbia River and its tributaries. Studies show a Northern Pikeminnow can eat up to 15 young salmon a day.
Parr	The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.
Peak Flow	The maximum rate of flow occurring during a specified time period at a particular location on a stream or river.
Persistence Probability	The complement of a population's extinction risk (i.e., persistence probability = 1 – extinction risk).
Phenotype	Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.
Photic Zone	The depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur.
Piscivorous	Describes any animal that preys on fish for food.
Primary Population	A population that is targeted for restoration to high or very high persistence probability.
Productivity	The average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

Reach	A length of stream between two points.
Reasonable and Prudent Alternative	Recommended alternative actions identified during formal consultation that can be implemented in a manner consistent with the purposes of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that are economically and technologically feasible, and that the Service finds would avoid the likelihood of jeopardizing the continued existence of the listed species or the destruction or adverse modification of designated critical habitat.
Recovery Domain	An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.
Recovery Goals	Goals incorporated into a locally developed recovery plan. These goals may go beyond the requirements of ESA de-listing by including other legislative mandates or social values.
Recovery Scenarios	Scenarios that describe a target status for each population within an ESU, generally consistent with TRT recommendations for ESU viability.
Recovery Strategy	A statement that identifies the assumptions and logic—the rationale—for the species' recovery program.
Redd	A nest constructed by female salmonids in streambed gravels where eggs are deposited and fertilization occurs.
Resident Fish	Fish that are permanent inhabitants of a water body. Resident fish include trout, bass, and perch.
Residual Sockeye	Sockeye that are genetically aligned with the anadromous form of sockeye but have adopted a resident life history pattern, remaining in freshwater to mature and reproduce.
Riparian Area	Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.
River Reach	A general term used to refer to lengths along the river from one point to another, as in the reach from the John Day Dam to the McNary Dam.
Runoff	Precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water.
Salmonid	Of, belonging to, or characteristic of the family Salmonidae, which includes salmon, steelhead, trout, and whitefish. In this document, it refers to listed steelhead distinct population segments (DPS) and salmon evolutionarily significant units (ESU).

Shoal	A shallow place in a lake or other body of water. Sockeye shoal spawners return to spawn along the shoreline of the lake.
Smolt	A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt from freshwater to a saltwater environment.
Smoltification	The transformation from parr to smolt. The transformation involves a series of physiological changes where juvenile salmonid fish adapt from living in freshwater to living in saltwater.
Spatial structure	The geographic distribution of a population or the populations in an ESU.
Spill	Water released from a dam over the spillway instead of being directed through the turbines.
Stabilizing Population	A population that is targeted for maintenance at its baseline persistence probability, which is likely to be low or very low.
Streamflow	Streamflow refers to the rate and volume of water flowing in various sections of the river. Streamflow records are compiled from measurements taken at particular points on the river, such as The Dalles, Oregon.
Supplemental Comprehensive Analysis (SCA)	An analysis by NOAA Fisheries of the environmental baseline and cumulative effects on ESA-listed Columbia River salmon and steelhead species from operations of the Federal Columbia River Power System (FCRPS) and the Upper Snake River water management systems and the *U.S. v. Oregon* Harvest Management Agreement. The SCA used the most recent available scientific data and information to update a previous Comprehensive Analysis prepared by the FCRPS Action Agencies. The SCA provides the analysis underlying the evaluations in the FCRPS Biological Opinions on the effects of the three actions on the species.
Technical Recovery Team (TRT)	Teams convened by NOAA Fisheries to develop technical products related to recovery planning. Technical Recovery Teams are complemented by planning forums unique to specific states, tribes, or regions, which use TRT and other technical products to identify recovery actions. See SCA Section 7.3 for a discussion of how TRT information is considered in these Biological Opinions.
Threatened Species	A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
Threat Reduction Scenario	A specific combination of reductions in threats from various sectors that would lead to a population achieving its target status.
Threats	Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

Total Maximum Daily Loads (TMDLs)	A calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.
Viability criteria	Criteria defined by NOAA Fisheries-appointed Technical Recovery Teams based on the biological parameters of abundance, productivity, spatial structure, and diversity, which describe a viable salmonid population (VSP) (an independent population with a negligible risk of extinction over a 100-year time frame) and which describe a general framework for how many and which populations within an ESU should be at a particular status for the ESU to have an acceptably low risk of extinction. See SCA Section 7.3 for a discussion of how TRT information is considered in these Biological Opinions.
Viability Curve	A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.
Viable Salmonid Population (VSP)	An independent population of any Pacific salmon or steelhead that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity change (random or directional) over a 100-year time frame.
VSP Parameters	Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, Viable salmonid populations and the recovery of evolutionarily significant units (McElhany et al. 2000).
Yearling	A fish that is in its second year of life; sometimes used synonymously with smolt.

Snake River Sockeye Salmon Recovery Plan Executive Summary

Introduction

This recovery plan (Plan) serves as a blueprint for the protection and restoration of Snake River Sockeye Salmon (*Oncorhynchus nerka*). Snake River Sockeye Salmon were listed as an endangered species under the Endangered Species Act (ESA) in 1991. The listing was reaffirmed in 2005. The species remains at risk of extinction.

Today, the last remaining Snake River Sockeye Salmon spawn in Sawtooth Valley lakes, high in the Salmon River drainage of central Idaho in the Snake River basin. While very few Sockeye Salmon currently follow an anadromous life cycle, the small remnant run of the historical population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake and Columbia Rivers to the ocean (Figure ES-1). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major federal dams, four on the Columbia River and four on the lower Snake River. Anadromous Sockeye Salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 1,448 kilometers (900 miles), to a higher elevation (1,996 meters [6,500 feet]) than any other Sockeye Salmon population. They are the southernmost population of Sockeye Salmon in the world.

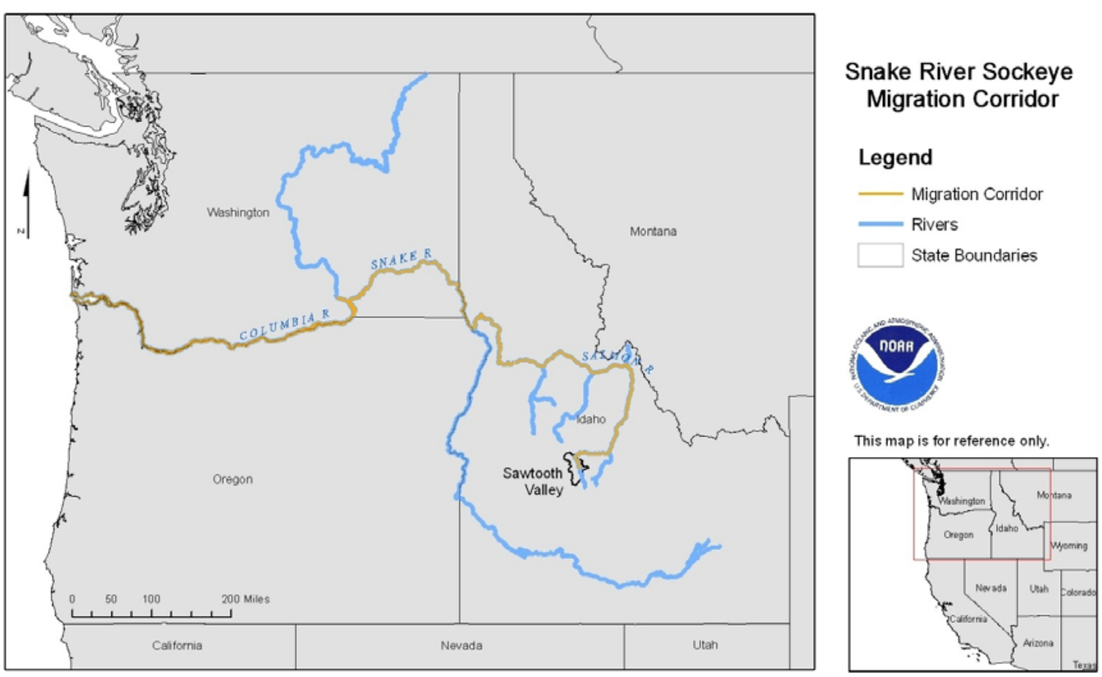


Figure ES-1. Snake River Sockeye Salmon migration corridor from Columbia River estuary to Sawtooth Valley lakes.

Before the turn of the twentieth century, large runs of Sockeye Salmon returned annually to the Snake River basin (Evermann 1896; Selbie et al. 2007). In fact, one of the major historical spawning areas, Redfish Lake, was named for the large numbers of Sockeye Salmon that returned to spawn each year turning the lake a shimmering red during the spawning season. Sockeye Salmon ascended the Snake River to the Wallowa River basin in northeastern Oregon and the Payette and Salmon River basins in Idaho to spawn in natural lakes. Within the Salmon River basin, Sockeye Salmon spawned in Warm Lake in the South Fork Salmon River basin, as well as in the Sawtooth Valley lakes: Stanley, Redfish, Yellowbelly, Pettit and Alturas Lakes (Figure ES-2). A smaller Sawtooth Valley lake, Hell Roaring Lake, may have also supported some Sockeye Salmon production. The historical relationships between the different fish populations are not known.

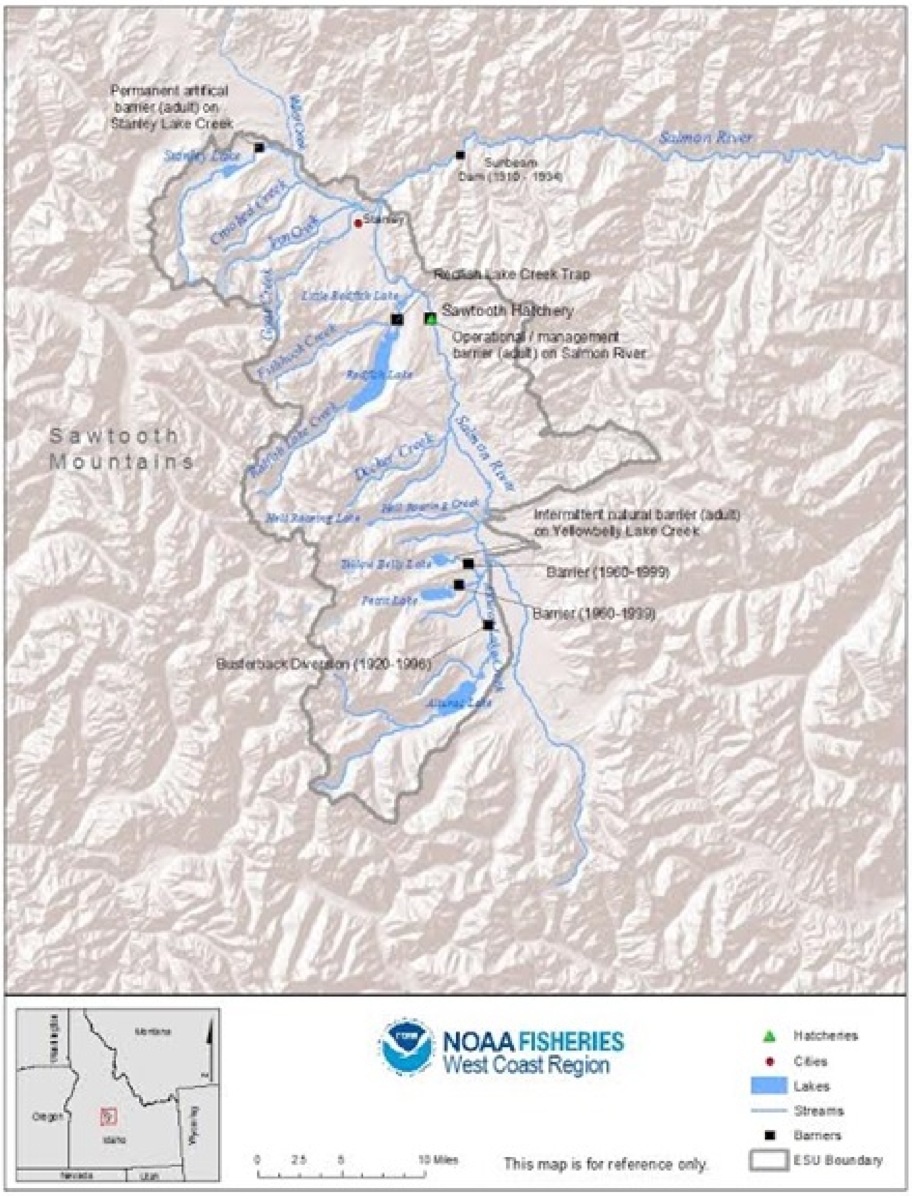


Figure ES-2. Map of the Sawtooth Valley, Idaho.

The Sockeye Salmon populations declined through the early- and mid-1900s, leading to the National Marine Fisheries Service (NMFS) proposed ESA-listing of the species as endangered in April 1991 (56 FR 14055) and final ESA-listing in November 1991 (56 FR 58619). NMFS reaffirmed the listing in 2005 (70 FR 2853). NMFS is a branch of the National Oceanic and Atmospheric Administration (NOAA) and is sometimes referred to as NOAA Fisheries. As the federal agency charged with stewardship of the nation's marine resources, NMFS has the responsibility for listing and delisting salmon and steelhead species under the ESA.

When Snake River Sockeye Salmon were ESA-listed as endangered in 1991, all of the Snake River Sockeye Salmon populations but one, the Redfish Lake population in the Sawtooth Valley, were gone, and that population had dwindled to fewer than 10 fish per year. In some years before 1998, no anadromous Sockeye Salmon returned to the Snake River basin. This major decline in the number of Sockeye Salmon returning to the Sawtooth Valley put the population at significant risk of extinction. Many human activities contributed to the near extinction of Snake River Sockeye Salmon. The NMFS status review that led to the original listing decision attributed the decline to "overfishing, irrigation diversions, obstacles to migrating fish, and eradication through poisoning." NMFS' 1991 listing decision for Snake River Sockeye Salmon noted that such factors as hydropower development, water withdrawal and irrigation diversions, water storage, commercial harvest, and inadequate regulatory mechanisms represented a continued threat to the species' existence.

In 1991, a partnership of state, tribal and federal fish managers initiated a captive broodstock hatchery program to save the Redfish Lake Sockeye Salmon population. Between 1991 and 1998, all 16 of the natural-origin adult Sockeye Salmon that returned to the weir at Redfish Lake were incorporated into the captive broodstock program, as well as out-migrating smolts captured between 1991 and 1993, and residual Sockeye Salmon captured between 1992 and 1995. The program

Why restore Snake River Sockeye Salmon?

Snake River Sockeye Salmon are listed as endangered under the Endangered Species Act because they are in danger of becoming extinct.

Their numbers have dramatically declined from historical levels. In some years before 1998, no anadromous Sockeye Salmon returned to the Snake River basin.

What is the captive broodstock program?

A captive broodstock program for Snake River Sockeye Salmon began in May 1991. The program has prevented extinction in the near term and preserved the genetic lineage of Redfish Lake Sockeye Salmon. The program was developed using captured adult Sockeye Salmon that returned to Redfish Lake (1991-98), out-migrating smolts (1991-93), and residual adult Sockeye Salmon (1992-95). Reintroduction of captive broodstock progeny has followed a "spread-the-risk" philosophy, incorporating multiple release strategies into Redfish, Pettit, and Alturas Lakes.

What does "recovery" mean?

Biological recovery for a salmon species means that it is naturally self-sustaining — enough fish spawn in the wild and return year after year so they are likely to persist in the long run, defined as the next 100 years. The species also has to be resilient enough to survive catastrophic changes in the environment, including natural events such as floods, storms, earthquakes, and decreases in ocean productivity.

What about other fish species in the lakes?

Other fish species will also benefit from habitat and passage improvements for Snake River Sockeye Salmon.

has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several million eggs and juveniles, as well as several thousand adults, for release into the wild.

The Sawtooth Valley is seeing results from the captive broodstock program. Sockeye Salmon returns to the valley have increased, especially in recent years, to 646 in 2008 (including 140 natural-origin fish), 832 in 2009 (including 86 natural-origin fish), 1,355 in 2010 (including 178 natural-origin fish), 1,117 in 2011 (including 145 natural-origin fish), 257 in 2012 (including 52 natural-origin fish), 272 in 2013 (including 79 natural-origin fish), and 1,579 in 2014 (including 453 natural-origin fish). However, while the program has successfully prevented extinction and preserved the genetic lineage of Redfish Lake Sockeye Salmon, the species remains at risk of extinction. Snake River Sockeye Salmon cannot be said to be recovered until it is made up of natural-origin fish spawning in the wild and surviving their two-way journey in far greater numbers.

About This Recovery Plan

The ESA requires NMFS to develop recovery plans for species listed under the ESA. This Plan was developed to comply with the law.

This Plan provides information required by NMFS to satisfy the requirements of section 4(f) of the ESA. It describes: (1) recovery goals and objective, measurable criteria which, when met, will result in a determination that the species be removed from the threatened and endangered species list; (2) site-specific management actions necessary to achieve the plan’s goals; and (3) estimates of the time required and cost to carry out the actions needed to achieve the plan’s goals. It also includes direction for monitoring and evaluation and adaptive management to fine-tune the course towards recovery when needed.

NMFS has directed preparation of this Plan. The Plan is the product of a collaborative process with contributions by a wide group of governments, sovereigns (tribes), and organizations with the potential to contribute to recovery. Participants included Idaho Department of Fish and Game, Shoshone-Bannock Tribes, NMFS’ Northwest Fisheries Science Center, members of NMFS’ Interior Columbia Technical Recovery Team, Bonneville Power Administration, Stanley Basin Sockeye Salmon Technical Oversight Committee, and the U. S. Forest Service. The goal is to produce a Plan that meets NMFS’ ESA requirements for recovery plans as well as State of Idaho’s needs. NMFS intends to use the Plan to organize and coordinate recovery of the species in partnership with state, tribal, and federal resource managers.

The Plan builds upon ongoing Snake River Sockeye Salmon recovery and research efforts. It describes the limiting factors and threats that impact survival and recovery. It then identifies a set of strategies and actions to address the limiting factors and threats, and restore natural Sockeye Salmon populations in Sawtooth Valley lakes to levels that will achieve Snake River Sockeye Salmon recovery. It also describes a comprehensive research, monitoring, and evaluation program so that species status is evaluated over time, and based on new information, recovery actions can be adjusted as part of an adaptive management strategy. The actions are voluntary and may be taken to restore the species to a healthy, naturally self-sustaining condition.

Contents of Recovery Plan

The document describes:

- Purpose and uses of the Plan, and context of Plan development (Section 1).
- Relationship of the Plan to other planning processes and other ESA mandates (Section 1).
- The geographic area that supports the historical population (Section 2).
- Characteristics that define the species, including critical habitat (Section 2).
- Salmonid biological structure used in recovery planning (Section 2).
- Recovery goals and ESA requirements for delisting (Section 3).
- Desired Status —biological and threats criteria for delisting; broad sense recovery goals (Section 3).
- Current status of Snake River Sockeye Salmon and populations (Section 4).
- Limiting factors and threats (habitat, hydropower, hatcheries, fisheries, predation, competition, toxics, climate change) and critical uncertainties (Section 5).
- Recovery strategies for Snake River Sockeye Salmon (Section 6).
- Site-specific actions for recovery of Snake River Sockeye Salmon (Section 7).
- Predicted effectiveness of proposed actions (Section 8).
- Time and Cost estimates for recovery (Section 9).
- Framework for implementation, defining progress, and status assessment (Section 10).
- Framework for research, monitoring, and evaluation for adaptive management (Section 11).

Several modules developed by NMFS provide key support to the Plan. NMFS produced these modules, which address regional-scale issues affecting Snake River Sockeye Salmon, as well as other ESA-listed Columbia River salmon and steelhead species, to assist in recovery planning. These modules provide a consistent set of assumptions and recovery actions that recovery planners incorporated into species-specific recovery plans. The following modules are used in the Snake River Sockeye Recovery Plan: (1) Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (*herafter* Estuary Module) (NMFS 2011a), (2) Supplemental Module for Snake River Salmon and Steelhead , Mainstem Columbia River Hydropower Projects (*hereafter* Hydro Module) (NMFS 2014a), (3) Columbia River Harvest Module (Harvest Module), and (4) Module for the Ocean Environment (Ocean Module). The modules will be updated periodically to reflect new data.

Scientific Foundation

NMFS' belief that it is critically important to base recovery plans on a solid scientific foundation that sets the stage for developing recovery plans. NMFS appointed teams of scientists with geographic and species expertise to develop recovery plans for each ESA-listed species from a common scientific foundation. The team responsible for Snake River Sockeye Salmon, the Interior Columbia Technical Recovery Team (ICTRT), includes biologists from NMFS and several states, tribal entities, and academic institutions.

This common approach recognizes that, historically, most salmon or steelhead species contained multiple populations connected by some small degree of genetic exchange with spawners straying in from other areas. Thus, the overall biological structure of a species is hierarchical. The species is essentially a metapopulation defined by the common characteristics of populations within a geographic range.

The ICTRT treats Sawtooth Valley Sockeye Salmon as the single major population group (MPG) within the Snake River Sockeye Salmon evolutionarily significant unit (ESU). The MPG contains one extant population (Redfish Lake) and two (Alturas Lake and Pettit Lake) to four (Stanley and Yellowbelly Lakes) other historical populations.

What is an evolutionarily significant unit (ESU)?

An ESU is a group of Pacific salmon that is (1) substantially reproductively isolated from other groups of the same species and (2) represents an important component of the evolutionary legacy of the species. ESUs are defined based on geographic range as well as genetic, behavioral and other traits.

All Pacific salmon belong to the family Salmonidae and the genus Oncorhynchus. Sockeye Salmon belong to the species *Oncorhynchus nerka*.

The Snake River Sockeye Salmon ESU

The Sawtooth Valley supports three forms of *O. nerka.* The Snake River Sockeye Salmon ESU includes two of the forms: anadromous and residual Sockeye Salmon.

- Anadromous Sockeye Salmon usually spend 1 to 3 years in the nursery lakes before migrating to sea as smolts. They remain at sea for 1 to 3 years before returning to natal areas to spawn.
- Residual Sockeye Salmon are genetically aligned with the anadromous form but have adopted a resident life history pattern, remaining in freshwater to mature and reproduce.
- Kokanee are a type of *O.nerka* (*O. nerka kennerlyi*) that is genetically distinct from Sockeye Salmon and is not included in the Snake River ESA listing. Kokanee are a self-perpetuating, generally non-anadromous form of *O.nerka* whose parents, for several generations, have spent their whole lives in freshwater. While Kokanee are generally a resident fish, and mostly segregated from Sockeye Salmon during spawning, the Alturas Lake early stream spawning Kokanee produce considerable numbers of smolts and some anadromous returns. Consequently, Kokanee represent an important life history type and add to the spatial diversity of anadromous *O. nerka* in the Sawtooth Valley.

Recovery Goals and Criteria

The Plan (Section 3) identifies the recovery goals and criteria that NMFS will use in future status reviews of the Snake River Sockeye Salmon ESU. The primary goal is to ensure that the species is viable and no longer needs ESA protection. Two types of criteria are used to describe viability and inform future ESA-delisting decisions: "Biological viability" criteria define population or demographic parameters. "Threats" criteria relate to the five listing factors detailed in the ESA. This Plan addresses these criteria for Snake River Sockeye Salmon populations. In addition, broad sense recovery goals identify a future species status beyond ESA delisting.

Biological Viability Criteria: The primary goal is for biological recovery to support removal of Snake River Sockeye Salmon from the threatened and endangered species list. The delisting decision must be based on the best available science. Biological recovery for a salmon species (the basis for delisting) means that it is naturally self-sustaining — enough fish spawn in the wild and return year after year so they are likely to persist in the long run, defined as the next 100 years. The species also has to be resilient enough to survive catastrophic changes in the environment, including natural events, such as floods and changes in ocean productivity. A viable ESU is naturally self-sustaining, with a high probability of persistence over a 100-year time period. The viability of an ESU reflects the viability of its populations. A Viable Salmonid Population is an independent population of Pacific salmon or steelhead that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.

What is the goal of this recovery plan?

The primary recovery goal for Snake River Sockeye Salmon is to ensure that the species is self-sustaining in the wild and no longer needs the protection of the ESA. The ESU-level objectives are the following:

- Population-level persistence in the face of year-to-year variations in environmental influences.
- Resilience to the potential impact of catastrophic events.
- Maintaining long-term evolutionary potential.

Once the fish achieve recovery under the ESA, the recovery plan will help meet other "broad sense" goals that go beyond delisting and provide social, cultural, or economic values.

What is delisting? Who makes the decision?

Under the ESA, listing and delisting of marine species, including salmon, are the responsibility of NMFS. If a fish or other species is listed as threatened or endangered, legal requirements to protect it come into play. When NMFS decides through scientific review that the species is doing well enough to survive without ESA protection, NMFS will "delist" it. The decision must reflect the best available science concerning the current status of the species and its prospects for long-term survival.

The ICTRT proposed biological criteria for the ESU define a viable salmonid population based on four viable salmonid population (VSP) parameters: population abundance, productivity, spatial structure, and diversity. The ICTRT criteria are hierarchical, with ESU- level objectives expressed in terms of the VSP status of the individual populations. The viability criteria are summarized here and discussed in more depth in Chapter 3.

Abundance/Productivity: Abundance is expressed in terms of natural-origin spawners (adults on the spawning ground) measured over a time series. The ICTRT used a recent 10-year geometric mean of natural-origin spawners as a measure of current abundance. Productivity is defined in terms of the average number of surviving offspring per parent, or a population's ability to sustain itself. The ICTRT measured productivity as returns per spawner or recruits per spawner.

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets.

The ICTRT developed viability curves that used quantitative metrics to evaluate the abundance and productivity of the populations. A viability curve describes combinations of abundance and productivity that correspond to a range of extinction risks: 1% (very low), 5% (low), and 25% (moderate) over a 100-year period. The ICTRT set the minimum spawning abundance threshold at 1,000 natural-origin spawners, measured as a ten-year geometric mean, for the Redfish and Alturas Lake populations, and 500 natural-origin spawners for the smaller Pettit, Yellowbelly, and Stanley Lake populations. The productivity needed to achieve an average natural-origin spawning abundance at the minimum threshold varies as a function of population size and target risk level. For example, an average productivity exceeding 1.2 and a minimum average natural-origin spawner abundance of 1,000 would be required to achieve Highly Viable status, with very low (<1%) risk projected over 100 years for the Redfish Lake and Alturas Lake populations (Figure ES-3).

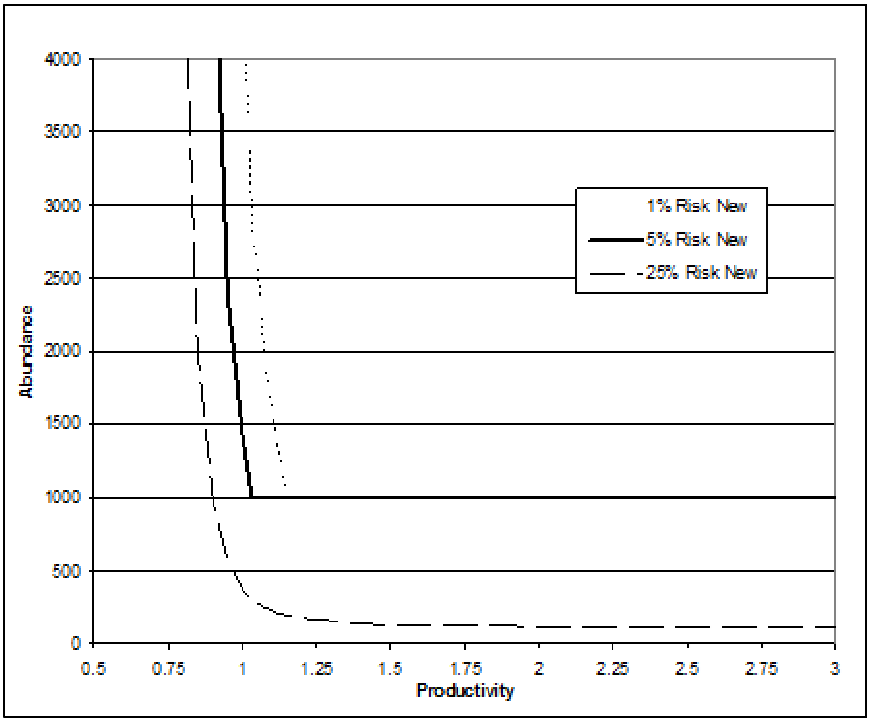


Figure ES-3. Viability curve for intermediate-size Redfish Lake and Alturas Lake Sockeye Salmon populations.

Spatial Structure/Diversity: A population's spatial structure reflects both the geographic distribution of individuals in the population and the processes that generate that distribution. Diversity refers to the distribution of traits within and among populations. The ICTRT defined two primary goals to address the spatial structure and diversity criteria: 1) maintain natural rates and levels of spatially mediated processes, and 2) maintain natural patterns of variation. It also identified mechanisms, factors and metrics for assessing a population's spatial structure and diversity. The ICTRT defined population structure/diversity risk levels by integrating across the measures of spatial structure and diversity.

Populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life history characteristics. For Snake River Sockeye Salmon, the ICTRT determined that risks to ESU life history diversity and spatial structure could be diminished by reestablishing or reintroducing independent Sockeye Salmon populations to Alturas and Pettit Lakes, and possibly eventually into Stanley or Yellowbelly Lake. Risks to ESU life history patterns could also be reduced by reestablishing historical life history patterns that may have been present in the natal lakes.

Table ES-1 shows the ICTRT's biological viability criteria for Snake River Sockeye Salmon. The ICTRT-recommended quantitative criteria (including minimum abundance thresholds) reflect the best information currently available. Information gained from ongoing studies of production potential and exchange rates among the lakes as natural reintroduction efforts progress will be periodically reviewed to determine if the basic assumptions behind the current quantitative criteria are valid, or if updates are warranted.

Table ES-1. Viable salmonid population (VSP) parameters and biological viability criteria for Snake River Sockeye Salmon.

VSP Parameter	Biological Viability Criteria
Abundance	• Minimum spawning abundance threshold measured as a ten-year geometric mean of estimated natural-origin spawners: 1,000 for Redfish Lake and Alturas Lake populations (intermediate size category); • Minimum spawning abundance threshold measured as a ten-year geometric mean of estimated natural-origin spawners: 500 for populations in the smaller historical size category (Pettit, Stanley, or Yellowbelly Lakes)
Productivity	• Population growth rate is stable or increasing
Spatial Structure and Diversity	• Very low to low risk rating for a highly viable population; and • Moderate risk rating for a viable population

Threats Criteria: At the time of a delisting decision for Snake River Sockeye Salmon, NMFS will examine whether five listing factors (or threats) detailed in section 4(a)(1) of the ESA have been addressed:

A. Present or threatened destruction, modification, or curtailment of [the species'] habitat or range;

B. Over-utilization for commercial, recreational, scientific, or educational purposes;

C. Disease or predation;

D. Inadequacy of existing regulatory mechanisms; or

E. Other natural or human-made factors affecting [the species'] continued existence.

The listing factors, or threats, need to have been addressed to the point that delisting is not likely to result in their re-emergence. NMFS also expects that the relative priority of threats will change over time and that new threats may emerge. NMFS will examine whether the listing factors have been addressed during its five-year reviews.

The Plan identifies threats criteria for each of the relevant listing/delisting factors. Addressing these criteria will help to ensure that underlying causes of decline have been addressed and mitigated before a species is considered for delisting. NMFS expects that if the proposed actions described in the Plan are implemented, they will make substantial progress toward meeting the threats criteria.

Broad Sense Recovery: The immediate goal of this Plan is ESA delisting. Once the fish achieve recovery under the ESA, the recovery plan will help meet broader goals. These "broad sense" goals may go beyond the requirements for delisting to acknowledge social, cultural, or economic values regarding the listed species.

Current Status of the ESU

The endangered Snake River Sockeye Salmon ESU has a long way to go before it will meet the biological viability criteria that signal it is self-sustaining and naturally producing at targeted levels. Still, annual returns of Snake River Sockeye Salmon through 2013 show that more fish are returning than before initiation of the captive broodstock program (Table ES-2). Between 1999 and 2007, more than 355 adults returned from the ocean from captive brood releases — almost 20 times the number of wild fish that returned in the 1990s. However, this total is primarily due to large returns in the year 2000. Returns dropped from 2003 through 2007, but began building in 2008. Adult returns the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Two-thirds of the fish were captured at the Redfish Lake Creek weir and the remaining fish were captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. Sockeye Salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014.

Table ES-2. Hatchery and natural-origin Sockeye Salmon returns to Sawtooth Valley, 1999 – 2014 (IDFG, in prep).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns*	Observed Not Trapped
1999	7	0	7	0	0
2000	257	10	233	0	14
2001	26	4	19	0	3
2002	22	6	9	1	7
2003	3	0	2	0	1
2004	27	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	646	140	456	1	50
2009	832	86	730	2	16
2010	1,355	178	1,144	14	33
2011	1,117	145	954	2	18
2012	257	52	190	0	15
2013	272	79	191	0	2
2014	1,579	453	1,062	0	63

*These fish were assigned as Sockeye Salmon returns to Alturas Lake and are included in the natural return numbers.

Survival by life stage

Building to target levels of adult hatchery returns and gaining knowledge of key survival rates are important steps towards successfully reestablishing natural production in the Sawtooth Valley. Recent increased returns of anadromous Snake River Sockeye Salmon from captive brood releases have made it possible to compare survival/mortality during different life stages, and to determine key areas, concerns and strategies for recovery. Recent survival estimates during different life stages are summarized below.

- *Spawner to smolt survival* - Currently, the hatchery program controls productivity and survival for this life stage. An increase in parent spawning levels in the lakes will provide insights into juvenile production and survival levels in the lakes.
- *Juvenile migrant survival - Sawtooth Valley to Lower Granite Dam:* Juveniles migrate quickly through the Salmon River to Lower Granite Dam. Estimated survival of hatchery juveniles in the reach has been highly variable, ranging from 11.4% in 2000 to 77.6% in 2008.
- *Juvenile migrant survival - Lower Granite Dam to Bonneville Dam:* Juvenile survival from Lower Granite to Bonneville Dam since 2008 has ranged from 40% to 57%. Within this reach, mean survival is estimated at 60% from Lower Granite to McNary Dam (1996-2010) and at 54% from McNary to Bonneville Dam (1998-2003, 2006-2010).
- *Juvenile and adult migrant survival - Estuary, Plume and Ocean:* Survival rates for Snake River Sockeye Salmon during this life stage remain unknown due to small numbers of migrants.
- *Adult migrant survival - Bonneville Dam to Lower Granite Dam:* Estimated survival rates for 2010-2013 show that survival averaged 56% to 83% from Bonneville to McNary, 92% to 99% from McNary to Ice Harbor, and 71% to 97% from Ice Harbor to Lower Granite.
- *Adult migrant survival - Lower Granite Dam to Sawtooth Valley:* Estimated survival rates for PIT-tagged Sockeye Salmon show that 73% of the adults that passed Lower Granite Dam (2008-2012) were recovered at Redfish Lake, the Sawtooth Hatchery weir or other locations.

Adult Sockeye Salmon in Redfish Lake. *Photo courtesy Mike Peterson, Idaho Fish & Game.*

Historical Snake River Sockeye Salmon Life Cycle

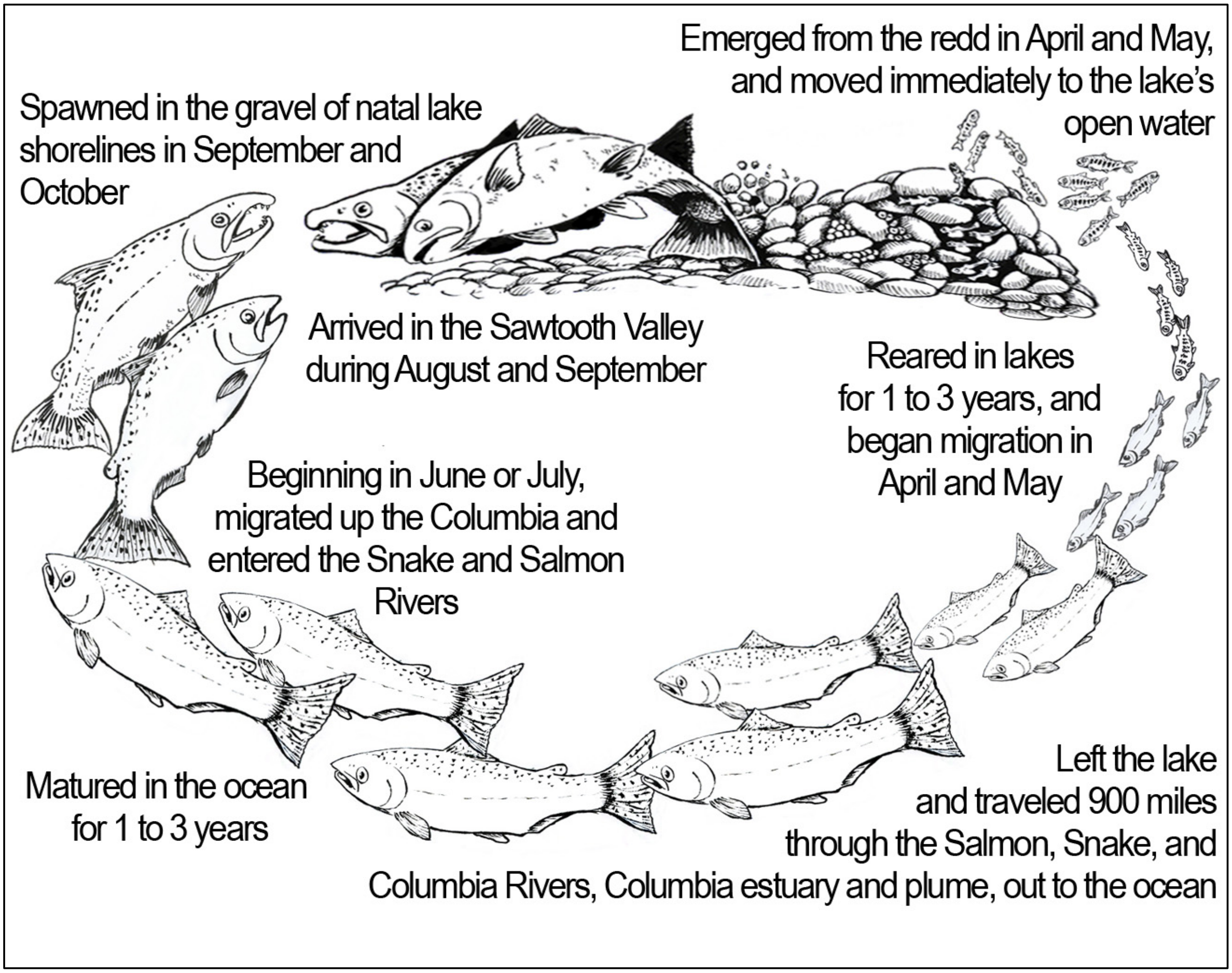


Figure ES-3. Historical Snake River Sockeye Salmon Life Cycle.

Limiting Factors and Threats Analysis

> **What are limiting factors and threats?**
>
> *Limiting factors* are the biological and physical conditions that limit a species' viability (e.g. high water temperature).
>
> *Threats* are the human activities or natural processes that cause the limiting factors.
>
> The term "threats" carries a negative connotation; however, they are often legitimate and necessary activities that at times may have unintended negative consequences on fish populations. These activities can be managed to minimize or eliminate the negative impacts.

NMFS biological review teams have concluded that the decline of the Snake River Sockeye Salmon ESU is the result of widespread habitat degradation, impaired mainstem and tributary passage, historical commercial fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, and poor ocean conditions. These combined factors reduced the number of Sockeye Salmon to the single digits. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity.

Today, some threats that contributed to the original listing of Snake River Sockeye Salmon now present little harm to the ESU, while others continue to threaten viability. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, pose limited concern since most passage barriers have been removed and much of the natal lakes area and headwaters remain protected. Efforts to eradicate the species from the natal lakes through chemical treatment ended decades ago. Hatchery-related concerns have also been reduced through improved management actions.

The mainstem hydropower system, while less of a constraint than in the past, continues to threaten Sockeye Salmon viability. Both juvenile and adult losses occur during travel through the Salmon, Snake, and Columbia River migration corridor. In addition, the combined and relative effects of different threats across the life cycle, including threats from climate change and other unknowns, remain poorly understood. Consequently, while the Plan presents the full range of threats and limiting factors throughout the life cycle, the different threats do not carry equal weight in their impact on Sockeye Salmon. Our recovery strategy focuses on gaining a better understanding of combined threats to Snake River Sockeye Salmon through the life cycle, and targeting actions effectively to achieve recovery.

The Idaho Department of Fish and Game, Shoshone-Bannock Tribes, NMFS, and many independent researchers have conducted decades of scientific research and analysis concerning Snake River Sockeye Salmon. Key findings are summarized below. Section 5 of the Plan provides a detailed discussion of these limiting factors and threats.

Sawtooth Valley Lakes

Sockeye Salmon historically spawned and reared in five nursery lakes in the Sawtooth Valley: Redfish, Pettit, Alturas, Yellowbelly, and Stanley Lakes. They usually spent one to three years in the nursery lakes before migrating to sea as smolts. Because of the captive broodstock program and reintroduction work, Sockeye Salmon currently spawn in Redfish, Alturas, and Pettit Lakes. The lakes lie within the Sawtooth National Recreation Area, managed by the U.S. Forest Service. The headwaters of each lake drain lands in the Sawtooth Wilderness Area. Overall, habitat conditions for Snake River Sockeye Salmon in these high mountain lakes remain in relatively pristine condition. The lakes are, and were historically, oligotrophic—lacking in nutrients and with relatively low natural aquatic productivity compared to lower elevation lakes in other areas. In addition, zooplankton abundance and composition vary across the lakes, which may be an important factor in successfully reintroducing anadromous Sockeye Salmon production. Lake nutrient supplementation has been implemented in Redfish, Pettit, and Alturas Lakes to increase Sockeye Salmon carrying capacity. Summer water temperatures in the lakes also temporarily spike to levels that make Sockeye Salmon more susceptible to disease and infection. Introduction and continued stocking of non-native fish species such as brook trout, lake trout, and kokanee creates competition and predation risks. Potential interbreeding between hatchery-origin fish and natural-origin spawners could further reduce genetic diversity. Providing connectivity of migratory corridors and increasing spatial distribution is critical to successful Sockeye Salmon recovery. Passage is now available to Redfish Lake, but a weir at Sawtooth Hatchery blocks passage in the Salmon River to upstream lakes. Providing passage at the weir is critical to reestablishing production in Alturas and Pettit Lakes —important early steps in the recovery strategy. An artificial barrier on Stanley Lake Creek also prevents access to Stanley Lake. Potential removal of this barrier will receive further consideration.

Salmon River Mainstem

The Salmon River runs 684 kilometers (410 miles) through central Idaho to join the Snake River in lower Hells Canyon, almost half the length of the Sockeye Salmon migration route. Juvenile Sockeye Salmon leave the natal lakes in late spring and early summer, often arriving at Lower Granite Dam about seven days later. Juvenile Sockeye Salmon survival varies between years and reaches. Tracking studies indicate that a large portion of the loss of outmigrating juvenile hatchery Sockeye Salmon in the Salmon River occurs between release sites and the North Fork Salmon confluence, with higher losses occurring within Little Redfish Lake, in the reach just above Valley Creek near Stanley, between the Pahsimeroi and Lemhi Rivers, and in the slow-river reach at Deadwater Slough. Predation appears to cause much of the juvenile mortality in the upper Salmon River; however, loss of juvenile migrants may also reflect competition with non-native species, environmental conditions, or rearing and release strategies.

Adult Sockeye Salmon return to the Salmon River in late summer and travel approximately 30 days up the free-flowing river to reach the Sawtooth Valley. A number of adult migrants are lost in the Salmon River corridor. The factors responsible for the losses of adult Sockeye Salmon migrants are not fully established, but are believed to be strongly related to stream flow and temperature. Adult Sockeye Salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak. Research continues to identify how and where these conditions in the Snake and Salmon Rivers affect Sockeye Salmon migrants. A weir at Sawtooth Hatchery on the Salmon River and a barrier below the Stanley Lake outlet restrict Sockeye Salmon passage to natal lakes.

Columbia and Snake River Mainstem

The Columbia and Snake River hydrosystem remains a threat to the viability of Snake River Sockeye Salmon. Four federal dams on the lower Snake River mainstem (Lower Granite, Little Goose, Lower Monumental and Ice Harbor) and four federal dams on the lower Columbia River mainstem (McNary, John Day, The Dalles and Bonneville) limit passage for juvenile Sockeye Salmon migrating to the ocean, and adult Sockeye Salmon returning to their natal lakes. All eight dams are part of the Federal Columbia River Power System (FCRPS). Specific limiting factors that impact viability include mortality and delayed upstream passage (adults), direct and indirect mortality on downstream migrants (juveniles), alteration of the hydrograph and riverine habitat, delayed migration and reduced survival due to high water temperatures, and predation by birds, pinnipeds, and non-native fish species. Some incidental take of Snake River Sockeye Salmon occurs in mainstem fisheries. The length and duration of the species' migration (900 miles) also increases their risk of exposure to agricultural and industrial chemicals.

Columbia River Estuary, Plume and Ocean

The cumulative impacts of past and current land use (including dredging, filling, diking, and channelization) and alterations to the Columbia River flow regimes have reduced the quality and quantity of estuarine and plume habitat. Snake River Sockeye Salmon, like other stream-type salmonids, move relatively quickly through the estuary, probably passing through the area within two to three days. Juveniles Sockeye Salmon may use the low-salinity gradients of the plume to achieve growth and gradually acclimate to saltwater. They would be affected by changes in flow and sediment in these areas. They are also vulnerable to bird predation in the estuary, as well as to pinniped predation when they return to the estuary as adults. High concentrations of urban and industrial contaminants in some areas of the lower Columbia River and estuary may affect fish health and behavior.

Ocean conditions and food availability contribute to the health and survival of Sockeye Salmon returning to the Columbia Basin, and eventually the Sawtooth Valley. Early ocean life is a critical time for the fish. Most early marine mortality likely occurs during two periods: first, predation-based mortality that occurs during the first few weeks to months; second, mortality due to food availability/ starvation during and following the first winter at sea. Poor ocean condition from 1977 through the late 1990s was one of several factors that drove the stock to a very small remnant population.

Future Implications from Climate Change

Likely changes in temperature, precipitation, wind patterns, and sea-level height due to climate change have profound implications for survival of Snake River Sockeye Salmon populations in both freshwater and marine habitats. Stream flows and temperatures—the environmental attributes that climate change will affect—already limit Sockeye Salmon productivity in areas of the Sawtooth Valley lakes, Salmon River, and mainstem Columbia and Snake Rivers. In the ocean, climate-related changes are expected to alter primary and secondary productivity, the structure of marine communities, and in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids is currently poorly understood. All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat due to climate change can be expected to reduce viability or survival of naturally produced adult Sockeye Salmon returning to the Sawtooth Valley lakes.

Recovery Strategies and Actions

Strategies and actions for the Snake River Sockeye Salmon ESU aim to recover self-sustaining, naturally spawning populations that are likely to persist for at least 100 years. Consistent with the long-term recovery scenario for Snake River Sockeye Salmon (discussed in Section 3), the strategies (Section 6) and actions (Section 7) intend to restore at least two of the three historical lake populations in the ESU to highly viable status, and one to viable status. The recovery strategies focus on Redfish, Alturas, and Pettit Lakes. As recovery efforts progress over time, expansion of reintroductions into Stanley Lake and Yellowbelly Lake will be considered.

> **Principles for sound salmon recovery**
>
> - Assess, protect and maintain biological and habitat processes.
> - Reconnect isolated habitat to increase spatial structure.
> - Restore ecological processes.
> - Restore degraded habitat.
> - Conserve or restore evolutionary processes.
> - Develop goals and objectives based on a deep understanding of ecological properties of the system.
> - Manage actions to be adaptive and minimally intrusive.

Overall Recovery Strategy

Overall, the strategy aims to reintroduce and support adaptation of naturally self-sustaining Sockeye Salmon populations in the Sawtooth Valley lakes. An important first step toward that objective has been the successful establishment of anadromous returns from natural-origin Redfish Lake resident stock gained through a captive broodstock program. That program is transitioning as higher levels of anadromous Sockeye Salmon return to spawn in Redfish Lake. The long-term strategy is for the naturally produced population to achieve escapement goals in a manner that is self-sustaining and without the reproductive contribution of hatchery spawners.

Our recovery strategy recognizes that efforts to address habitat, fisheries, hatchery, and hydrosystem issues affecting Snake River Sockeye Salmon need to be planned and implemented with a clear understanding of ecological processes — both biological and habitat processes — and how past and current activities affect these processes. Since the ESU is at risk for extinction, the first phase in recovery, the captive broodstock program, helped maintain the population and prevent species extinction. The second phase, recolonization, which we are now entering, will incorporate more natural-origin Sockeye Salmon returns in the hatchery-spawning program to maintain the genetic fitness of the natural population and to provide anadromous adults to recolonize available habitat in Redfish, Pettit, and Alturas Lakes. Ultimately, the program will move to a third phase emphasizing natural adaptation and viability. At the same time, recovery efforts will address habitat, fisheries, and hydro-related issues affecting Snake River Sockeye Salmon. Together, these efforts aim to provide sufficient fish to restore populations adapted to the specific conditions of lakes in the Sawtooth Valley, while also protecting and improving habitat conditions, and addressing passage, competition and predation concerns, to support a self-sustaining population.

The approach is adaptive in nature. The strategy for Redfish Lake is based on the working assumption that fostering relatively high numbers of returns from hatchery releases will lead to increasing numbers of naturally produced adult returns in the future, ultimately leading to natural production at self-sustaining levels. This strategy is based on a careful assessment of the best available scientific information and has associated monitoring and evaluation studies targeting key assumptions and uncertainties to support future adaptations to achieve the recovery objectives. In addition, the strategies for Pettit and Alturas Lakes are tailored to specific circumstances associated with each lake and are designed to evaluate variations on the basic restoration strategy. Taken as a whole, the information from each of the approaches in combination will guide future adaptation of the overall program to meet natural production recovery objectives.

The proposed recovery strategy contains elements to address limiting factors and threats at the local level (Sawtooth Valley and upper Salmon River) and regional level (Salmon, Snake and Columbia Rivers, Columbia River estuary and plume, and ocean). The recovery strategy for Snake River Sockeye Salmon is summarized in the box: Recovery Strategy for Snake River Sockeye Salmon ESU.

Site-Specific Actions

Section 7 of the Plan describes specific actions proposed under each of the local and regional recovery strategies discussed in Section 6 to address problems for Sockeye Salmon. The actions build on recovery actions that have been implemented over the last 20 years. Table 7-1 defines over 90 specific actions that correspond to the different local-level recovery strategies and address problems for Sockeye Salmon in the natal lakes and upper Salmon River. The table identifies the actions as well as the sites, VSP parameters, limiting factors, and threats that each action targets. The table also provide estimated costs and potential implementing entities for each action, and priority for implementation. The Plan also identifies actions needed at the regional level (mainstem Salmon, Snake and Columbia Rivers and the estuary, plume and ocean) to support recovery of Snake River Sockeye Salmon. Many of these proposed actions are designed to be integrated with current, ongoing programs and regulations.

RECOVERY STRATEGY FOR SNAKE RIVER SOCKEYE SALMON ESU

At the local level (Sawtooth Valley and upper Salmon River):

- Conserve population genetic and life history diversity, and spatial structure.
- Increase naturally spawning Snake River Sockeye Salmon abundance.
- Improve Sockeye Salmon passage to natal lakes.
- Reestablish a self-sustaining anadromous Sockeye Salmon population in Redfish Lake.
- Investigate/develop strategies for future actions to support Sawtooth Valley Sockeye Salmon reintroduction and adaptation phases for Pettit Lake.
- Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning early stream-spawning outmigrants produced by Alturas Lake kokanee.
- As sufficient numbers of natural-origin adults return, develop an integrated approach to manage natural- and hatchery-origin adults in the hatchery program and in the wild.
- As sufficient numbers of hatchery-origin anadromous adults return to the basin, identify options for future harvest.
- Continue research and actions to reestablish natural populations in other natal lakes.
- Continue research on natal lakes' carrying capacity, nutrients, and ecology.
- Protect and conserve natural ecological processes at the watershed scale that support population viability.
- Protect, restore and manage spawning and rearing habitat.
- Maintain unimpaired water quality and improve water quality as needed.
- Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Snake River Sockeye Salmon.
- Monitor for predation, disease, aquatic invasive species, and competition and develop actions as needed.
- Create an adaptive management feedback loop to track progress toward recovery, monitor and evaluate key information needs, assess results, and refine strategies and actions accordingly.

At the regional level (mainstem Salmon, Snake and Columbia Rivers; estuary; plume; and ocean):

- Implement 2008/2010 FCRPS BiOp's reasonable and prudent alternative to reduce mortalities associated with migration through the mainstem Salmon, Snake and Columbia Rivers, estuary and plume.
- Continue research and monitoring on Snake River Sockeye Salmon survival/mortality in mainstem Salmon, Snake and Columbia River migration corridor; estuary; plume; and ocean.
- Update Snake River Sockeye Salmon life cycle models using latest information on survival through mainstem Salmon, Snake, and lower Columbia River migration corridor; estuary; and plume.
- Manage to maintain current low impact fisheries and reduce fishery impacts in those fisheries that affect Snake River Sockeye Salmon.
- Protect and conserve natural ecological processes that support population viability.
- Improve degraded water quality and maintain unimpaired water quality.
- Address ecosystem imbalances in predation, competition, and disease through the strategies and actions in this Plan, the Estuary Module and FCRPS BiOp.
- Respond to climate change threats by implementing research, monitoring and evaluation to track indicators related to climate change and by preserving biodiversity.
- Implement this recovery plan through effective communication, coordination and governance.
- Continue research, monitoring and evaluation for adaptive management.
- Prioritize and address key information needs and create an adaptive management feedback loop to revise recovery actions as needed.

Considerations for Setting Priorities

Based on the current endangered status of the Snake River Sockeye Salmon ESU, our goal is to have viable independent populations in at least three or more natal lakes to expand spatial distribution and diversity, and protect the relatively healthy habitat conditions in the Sawtooth Valley. The following are recommendations for prioritizing the sequence of implementing recovery actions. These recommendations reflect the principles for sound salmon recovery:

1. *Implement the current captive broodstock program.* Actions support conservation of life histories and genetic attributes.
2. *Reestablish self-sustaining anadromous Sockeye Salmon populations in Redfish, Pettit, and Alturas Lakes***.** Actions enhance viability and protection of multiple Sockeye Salmon populations through continued implementation of the Redfish Lake program, implementation of introduction strategies for Pettit and Alturas Lakes, and reconnection of isolated habitat to improve spatial structure and diversity.
3. *Protect and enhance existing habitat conditions and conserve natural ecological processes.* Actions support the viability of the populations and their primary life history strategies throughout their entire life cycle. Continued implementation of the Management Plan for the Sawtooth National Recreation Area, together with continued wilderness protections in the Sawtooth Valley will protect habitat processes for the natal lakes watersheds. Additional habitat protection and restoration actions for the migration corridor are identified in Sections 6 and 7.
4. *Improve survival for all life stages in the migration corridor*. Strategies and actions to improve survival in the migration corridor are described in Section 6.3.2.
5. *Carry out research, monitoring, and evaluation actions.* Actions provide critical information needed to assess fish viability responses and adapt management decisions as needed based on this information. Section 11 identifies the adaptive management approach, together with research, monitoring, and evaluation actions to continually adapt recovery actions over time.

We believe the recovery strategies and management actions identified in the Plan will be effective in improving survival of Snake River Sockeye Salmon; however, we have uncertainties about whether they will be sufficient to achieve viability. Thus, the Plan depends on an adaptive management framework that implements the actions based on best available science, monitors to improve the science, and updates actions based on new knowledge.

Summaries describing strategies and actions for Sockeye Salmon recovery in Redfish Lake, Pettit Lake and Alturas Lake, and potentially in Stanley and Yellowbelly Lakes, follow.

Redfish Lake Sockeye Salmon Population

Redfish Lake Sockeye Salmon Population

Current Status

- Extant population; at high risk of extinction in its current state.

Proposed Recovery Scenario

- Achieve highly viable (<1% extinction risk) or viable (<5% extinction risk) status for population.
- Achieve a minimum spawning abundance threshold measured as a ten-year geometric mean of 1,000 natural-origin spawners, with a stable or increasing population growth rate.
- Achieve a spatial structure/diversity rating of low risk for highly viable status or maintained for viable status.

Recovery Strategy

As the only extant population of Snake River Sockeye Salmon, the Redfish Lake population plays a key role in ESU recovery. A captive broodstock program has successfully prevented the population's extinction in the near term and preserved its genetic lineage. That program will now transition to increase hatchery releases to support sufficient natural-origin anadromous Sockeye Salmon returns. Next, it will shore up adaptation to reestablish a natural self-sustaining anadromous Sockeye Salmon population.

Redfish Lake. *Photo courtesy of Andy Kohler,Shoshone-Bannock Tribes.*

Key Strategies and Actions

- Conserve population genetics and life history diversity by establishing a composite hatchery and natural Sockeye Salmon population in Redfish Lake.
- As natural-origin adult returns increase, reestablish a self-sustaining anadromous Sockeye Salmon population in the lake.
- Maintain current wilderness protection and protect pristine habitat and natural ecological processes.
- Continue research on lake carrying capacity, nutrients, and ecology.
- Investigate whether water quality, including temperatures, affects Sockeye Salmon carrying capacity in the lake and improve water quality as needed.
- Protect and enhance spawning and rearing habitat in Redfish Lake and Fishhook Creek.
- Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating juvenile and adult Sockeye Salmon.
- Implement FCRPS BiOp actions to reduce mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects.
- Continue research on Sockeye Salmon survival/mortality in Snake and Columbia Rivers, estuary, plume, and ocean.
- Manage risks from mainstem Columbia River and lower Snake River fisheries through *U.S. v. Oregon*.
- Identify options for future fisheries as sufficient numbers of hatchery-origin Sockeye Salmon adults return to basin.
- Monitor and control predation, disease, aquatic invasive species, and competition.
- Respond to climate change threats by implementing research, monitoring, and evaluation (RM&E) to track indicators and by preserving biodiversity.

Pettit Lake Sockeye Salmon Population

Pettit Lake Sockeye Salmon Population

Current Status

- Potential historical population; now functionally extirpated.

Proposed Recovery Scenario

- Achieve highly viable (<1% extinction risk) or viable (<5% extinction risk) status for population.
- Achieve a minimum spawning abundance threshold measured as a ten-year geometric mean of 500 natural-origin spawners, with a stable or increasing population growth rate.
- Achieve a spatial structure/diversity rating of low risk for highly viable status or maintained for viable status.

Recovery Strategies

Reintroduction strategies for the extirpated Pettit Lake Sockeye Salmon population will be further developed and refined during implementation of the Redfish Lake strategy. An interim strategy may include initial reintroductions to Pettit Lake from volitional spawning of Pettit Lake-origin anadromous adults and release of captive broodstock. The reintroduction plan will be refined over time through an adaptive management process to achieve a naturally adapted anadromous population.

Pettit Lake. *Photo courtesy Andy Kohler, Shoshone-Bannock Tribes.*

Key Strategies and Actions

- Improve Sockeye Salmon passage at the Sawtooth Hatchery weir on the Salmon River.
- Improve/replace juvenile trapping structure on Pettit Lake Creek.
- Allow anadromous adult Sockeye Salmon to return to Pettit Lake for volitional spawning.
- Release captive broodstock adults into Pettit Lake representing the entire genetic diversity of the broodstock for several years.
- After several years of direct outplanting of adults sourced from the Redfish Lake population, stop stocking and evaluate the natural production response; continue to allow anadromous Pettit Lake-origin adults to return for volitional spawning.
- Evaluate and refine the reintroduction program as needed to reestablish a locally adapted population in Pettit Lake.
- Maintain current wilderness protection and protect pristine habitat and natural ecological processes.
- Continue research on lake carrying capacity, nutrients, and ecology.
- Investigate whether water quality affects Sockeye Salmon carrying capacity in the lake and improve water quality as needed.
- Protect and enhance spawning and rearing habitat in Pettit Lake.
- Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Sockeye Salmon.
- Implement FCRPS BiOp actions to reduce mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects.
- Continue research on Sockeye Salmon survival/mortality in Snake and Columbia Rivers, estuary, plume, and ocean.
- Manage risks from mainstem Columbia River and lower Snake River fisheries through *U.S. v. Oregon*.
- Identify options for future fisheries as sufficient numbers of hatchery-origin Sockeye Salmon adults return to basin.
- Monitor and control predation, disease, aquatic invasive species, and competition.
- Respond to climate change threats by implementing RM&E to track indicators and by preserving biodiversity.

Alturas Lake Sockeye Salmon Population

Alturas Lake Sockeye Salmon Population

Current Status

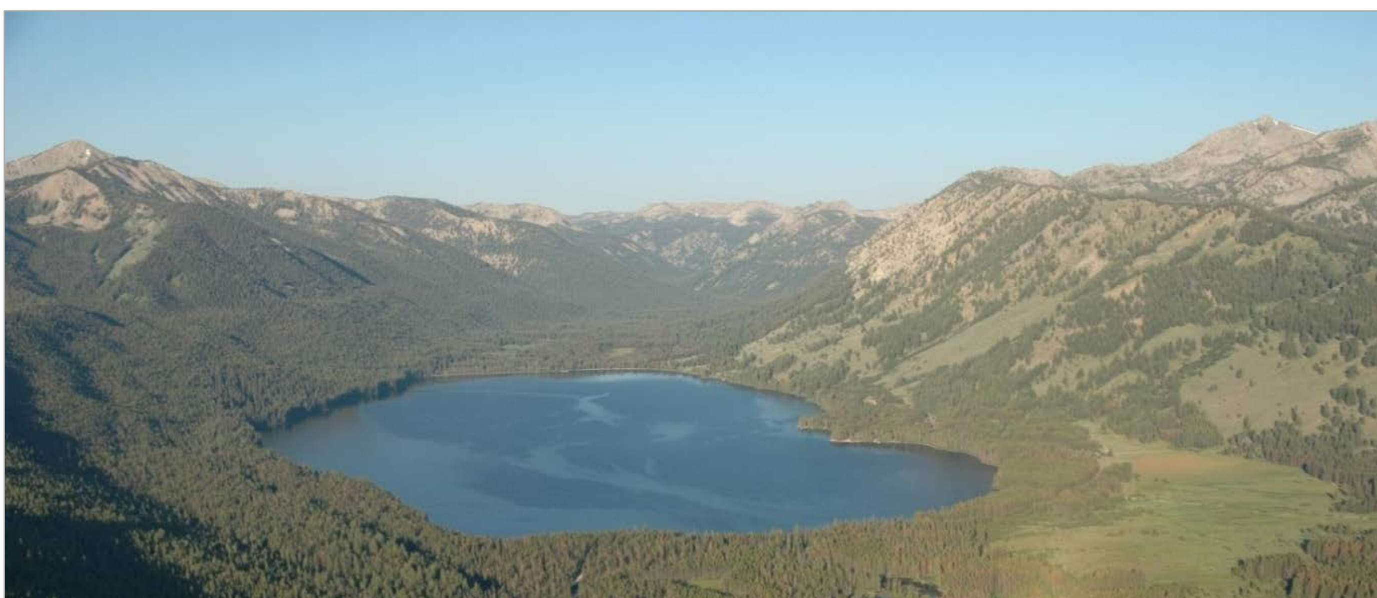
- Historical population; now functionally extirpated.

Proposed Recovery Scenario

- Achieve highly viable (<1% extinction risk) or viable (<5% extinction risk) status for population.
- Achieve a minimum spawning abundance threshold measured as a ten-year geometric mean of 1,000 natural-origin spawners, with a stable or increasing population growth rate.
- Achieve a spatial structure/diversity rating of low risk for highly viable status or maintained for viable status.

Recovery Strategies

The recovery strategy for Alturas Lake Sockeye Salmon focuses on rebuilding the population using the lake's existing native kokanee population. The Alturas Lake kokanee population exhibits an earlier return time than the Redfish Lake population and maintaining this diversity is important. Reintroduction strategies for Alturas Lake will be developed based on investigations and evaluations regarding the potential to restore natural production of anadromous Sockeye Salmon from early returning, early stream spawning outmigrants produced by kokanee in the lake. Careful steps will be taken to maintain the population's unique genetic diversity and spatial structure, and capture the benefits of local adaptation. Reintroduction options will be refined over time through adaptive management.



Alturas Lake. *Photo courtesy Andy Kohler, Shoshone-Bannock Tribes.*

Key Strategies and Actions

- Improve Sockeye Salmon passage at the Sawtooth Hatchery weir on the Salmon River.
- Trap and transport or allow volitional migration of anadromous adults identified as Alturas Lake origin to Alturas Lake for volitional spawning.
- Establish a new hatchery program for Alturas Lake anadromous Sockeye Salmon using returning anadromous Alturas Lake-origin adults.
- Identify appropriate donor stocks and investigate strategies to establish a new hatchery captive broodstock program for anadromous Alturas Lake Sockeye Salmon. Investigate alternative strategies for the early stream spawning Alturas Lake population that will support and enhance anadromy.
- Construct and operate trapping structure in Alturas Lake Creek.
- Maintain current wilderness protection and protect pristine habitat and natural ecological processes.
- Continue research on lake carrying capacity, nutrients, and ecology.
- Investigate whether water quality affects Sockeye Salmon carrying capacity in the lake and improve quality as needed.
- Protect and enhance spawning and rearing habitat in Alturas Lake.
- Investigate and improve conditions in Salmon River and tributaries to increase survival of migrating Sockeye Salmon.
- Implement FCRPS BiOp actions to reduce mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects.
- Continue research on Sockeye Salmon survival/mortality in Snake and Columbia Rivers, estuary, plume, and ocean.
- Manage risks from mainstem Columbia River and lower Snake River fisheries through *U.S. v. Oregon*.
- Identify options for future fisheries as sufficient numbers of hatchery-origin Sockeye Salmon adults return to basin.
- Monitor and control predation, disease, aquatic invasive species, and competition.
- Respond to climate change threats by implementing RM&E to track indicators and by preserving biodiversity.

Stanley Lake and Yellowbelly Lake Sockeye Salmon Populations

Stanley Lake and Yellowbelly Lake Sockeye Salmon Populations

Current Status

- Historical populations; now functionally extirpated.

Proposed Recovery Scenario

- As recovery efforts progress over time, expansion of Snake River Sockeye Salmon reintroductions into Stanley Lake and Yellowbelly Lake will be considered.

Recovery Strategies

The long-term recovery scenario for the Snake River Sockeye Salmon ESU focuses initial efforts on restoring self-sustaining, naturally producing populations in Redfish, Pettit, and Alturas Lakes. Currently, stocking Sockeye Salmon in Stanley and Yellowbelly Lakes is not a priority. This may change as adult returns increase and passage to the upper basin is restored. It is likely that Sockeye Salmon may return to Yellowbelly Lake through straying and natural recolonization. Reintroduction efforts for Stanley Lake would include developing a lake trout management strategy and reestablishing adult passage at the outlet of Stanley Lake that currently prevents adult Sockeye Salmon immigration.

Key Potential Strategies and Actions

- Continue research on lake carrying capacity, nutrients, and ecology.
- Investigate whether water quality affects Sockeye Salmon carrying capacity in the lakes; improve conditions as needed.
- Take actions to prevent the spread of non-native lake trout to other Sawtooth Valley nursery lakes.
- Remove an upstream fish passage barrier in Stanley Lake Creek. Develop program to support Sockeye Salmon recovery.
- Investigate and manage risks to native kokanee in Stanley Lake.
- Develop and implement a study in Yellowbelly Lake to evaluate lake-carrying capacity of Sockeye Salmon in the absence of resident kokanee.
- Determine under what migratory conditions (timing, water flows, temperatures) and how often returning adult Sockeye Salmon can currently migrate through a boulderfield (lag deposit) in the outlet stream of Yellowbelly Lake.
- Investigate whether varying flow regimes affect Sockeye Salmon migration and passage below/ above Yellowbelly Lake.
- Evaluate the potential effects of cutthroat trout on Sockeye Salmon in Yellowbelly Lake.
- Maintain current wilderness protection and protect pristine habitat and natural ecological processes.
- Protect and enhance spawning and rearing habitat in Stanley and Yellowbelly Lakes.
- Investigate and improve conditions in Salmon River and tributaries to increase survival of migrating Sockeye Salmon.
- Implement FCRPS BiOp actions to reduce mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects.
- Continue research on Sockeye Salmon survival/mortality in Snake and Columbia Rivers, estuary, plume, and ocean.
- Manage risks from mainstem Columbia River and lower Snake River fisheries through *U.S. v. Oregon*.
- Identify options for future fisheries as sufficient numbers of hatchery-origin Sockeye Salmon adults return to basin.
- Monitor and control predation, disease, aquatic invasive species, and competition.
- Respond to climate change threats by implementing RM&E to track indicators and by preserving biodiversity.

Adaptive Management, Research, Monitoring, and Evaluation

Adaptive management plays a critical role in recovery planning. The long-term success of recovery efforts will depend on the effectiveness of incremental steps taken to move the one remaining extant Snake River Sockeye Salmon population from its current status to a viable level, and to restore naturally self-sustaining Sockeye Salmon populations in other Sawtooth Valley lakes. Adjustments will be needed if actions do not achieve desired goals, and to take advantage of new information and changing opportunities. Adaptive management provides the mechanism to facilitate these adjustments.

Adaptive management works by binding decision making with data collection and evaluation. Most importantly, it offers an explicit process through which alternative approaches and actions can be proposed, prioritized, implemented, and evaluated. Successful adaptive management requires that monitoring and evaluation plans be incorporated into overall implementation plans for recovery actions. These plans should link monitoring and evaluation results explicitly to feedback on the design and implementation of actions.

Figure ES-4. The adaptive management process.

The research, monitoring, and evaluation plan described in Section 11 identifies the level of monitoring and evaluation needed to determine the effectiveness of recommended actions, and whether they are leading to improvements in population viability. The RM&E plan also identifies critical data gaps in species and habitat knowledge. The data obtained through RM&E plan implementation will be used to assess and, if necessary, correct current restoration strategies. The Snake River Recovery Implementation and Science Team will oversee implementation of the adaptive management process in coordination with participating agencies, tribes, and entities (Section 10).

A major challenge facing the development and implementation of an effective adaptive management strategy for Snake River Sockeye Salmon is the large number of organizations that implement management actions, as well as the complexity in jurisdictional and management decision authority. These organizations include, but are not limited to: Idaho Department of Fish and Game, Idaho Governor's Office of Species Conservation, Shoshone-Bannock Tribes, state agencies, counties, irrigation districts, agriculture and private forest land managers, NMFS, U.S. Forest Service, BLM, other federal agencies, utilities, citizen groups, and others. The intent of the adaptive management plan is to develop a collaboration and coordination process that uses the current implementation structures and allows for sharing of information and decisions that influence recovery of Snake River Sockeye Salmon.

Implementation

Implementation of recovery actions has been occurring for all threats since ESA listing in 1991. Successful implementation of recovery actions, research and monitoring projects will build upon the over 20 years of leadership and Sockeye Salmon recovery work carried out by the Stanley Basin Sockeye Salmon Technical Oversight Committee, with the Idaho Department of Fish and Game, Shoshone-Bannock Tribes, U.S. Forest Service, NMFS and other partners to prevent ESU extinction. Plan implementation will also involve counties, other state and federal agencies, private landowners and individuals.

Section 10 proposes an overall framework for coordinated implementation of this Plan. The implementation framework includes several integrated components with different responsibilities, including the Snake River Sockeye Salmon Implementation and Science Team, Stanley Basin Sockeye Salmon Technical Oversight Committee, and the NMFS' Snake River Coordination Group. The figure below illustrates how these different groups will work together. The different groups will work closely with existing groups and seek collaborative initiatives to recover Snake River Sockeye Salmon populations.

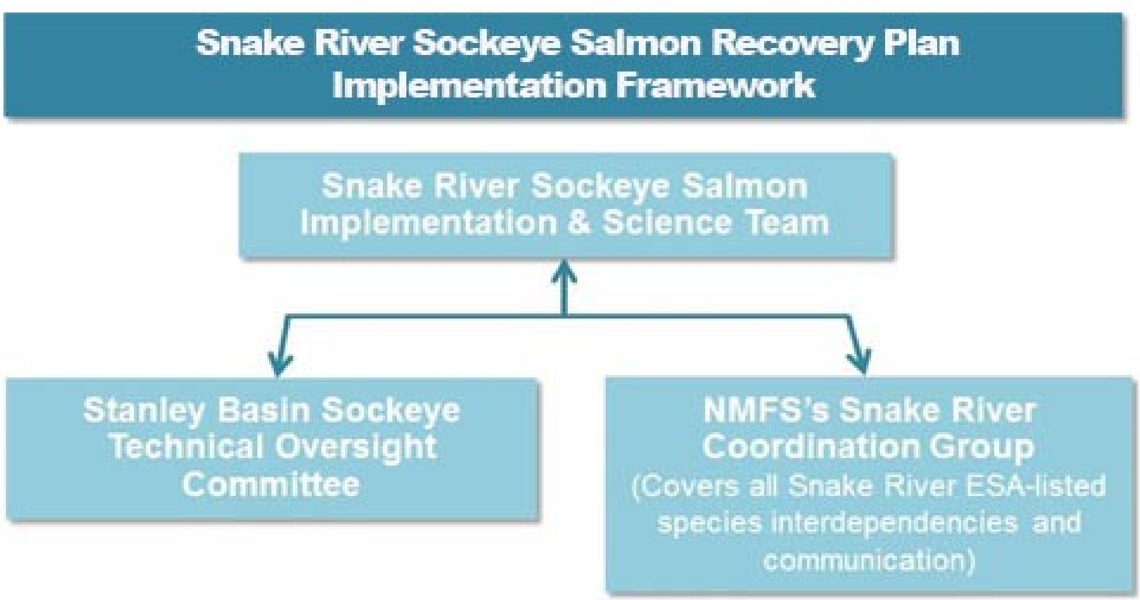


Figure ES-5. Snake River Sockeye Salmon Recovery Plan implementation framework.

Time and Cost Estimates

It is important to consider the unique challenges of estimating time and cost for salmon and steelhead recovery, given the complex relationship of these fish to the environment and to human activities on land and water. NMFS estimates that recovery of Snake River Sockeye Salmon could take 50 to 100 years. The recovery plan (Section 7) contains an extensive list of actions to recover the populations; however, it recognizes that there are many uncertainties involved in predicting the course of recovery and in estimating total costs over such a long recovery period. Such uncertainties include biological and ecosystem responses to recovery actions.

NMFS believes it is feasible to focus on the first five years of implementation and in five-year intervals thereafter, with the understanding that before the end of each five-year implementation period, specific actions and costs will be estimated for subsequent years. The Plan (Section 9) discusses cost estimates for all projects judged to be feasible and projected to occur over the initial five-year period of Plan implementation, fiscal years (FY) 2014 through 2018. It also estimates the total cost of recovery over the next 25 years. The estimated total cost for implementation of all actions during the initial five-year period, FY 2014 to FY 2018, where costs are available, is approximately $20,293,955. The total estimated cost of recovery actions for the ESA-listed Snake River Sockeye Salmon ESU over the next 25 years is projected to be about $101,469,775. The Recovery Cost Summary Table in Appendix A provides the estimated costs for specific recovery actions identified in the Plan for the first five-year period.

There are several cautions that must be highlighted regarding these costs. Many of these costs may be incomplete in scope, scale, or magnitude until actions are better defined. Specifically, costs for potentially expensive projects such as land and water acquisition, water leasing, and research, monitoring, and evaluation have not yet been estimated for this ESU. Costs estimates may be adjusted up or down, as unit cost estimates, scale of projects, total number of actions, and currently unforeseen costs for actions are determined.

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Section 1: Introduction

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1. Introduction

NOAA's National Marine Fisheries Service (NMFS) is required, pursuant to section 4(f) of the Endangered Species Act (ESA), to develop and implement recovery plans for species listed under the ESA. This is a recovery plan (Plan) for the protection and restoration of Snake River Sockeye Salmon (*Oncorhynchus nerka*), proposed for listing on April 5, 1991 (56 FR 14055) and listed under the ESA as endangered on November 11, 1991 (56 FR 58619) (NMFS 1991); the listing was reaffirmed on June 28, 2005 (NMFS 2005a). The anadromous and residual forms of Snake River Sockeye Salmon are listed under the ESA and are the focus of this Plan.

Historically, a number of lakes throughout the Columbia River basin supported Sockeye Salmon production (Gustafson et al. 1997; Waples et al. 1991). Sockeye Salmon are native to the Snake River basin and historically were abundant in several lake systems in Idaho and Oregon. Today, the last remaining Snake River Sockeye Salmon spawn in Sawtooth Valley lakes high in the Salmon River drainage of the Snake River basin in Idaho. While very few Sockeye Salmon currently follow an anadromous life cycle, the small remnant run of the historical population migrates downstream from the lakes through the Salmon River, Snake River, and Columbia River to the ocean (Figure 1-1). After one to three years in the ocean, they return as adults, passing once again through these mainstem rivers and through eight major Federal dams, four on the Columbia River and four on the lower Snake River. Anadromous Sockeye Salmon returning to Redfish Lake in Idaho's Sawtooth Valley[1] travel a greater distance from the sea (1,448 km [900 miles]) to a higher elevation (1,996 m [6,500 feet]) than any other Sockeye Salmon population in the world (Waples et al. 1991). They are the southernmost population of Sockeye Salmon (Bjornn et al. 1968; Foerster 1968).

Adult release into Redfish Lake. *Photo: C. Kozfkey, IDFG.*

[1] Previous studies frequently did not differentiate the Stanley Basin from the Sawtooth Valley, or they called the whole area the Stanley Basin. In this Plan, the term "Sawtooth Valley" will be used to encompass both the Sawtooth Valley and the associated lakes, except where the Stanley Basin specifically is referred to.

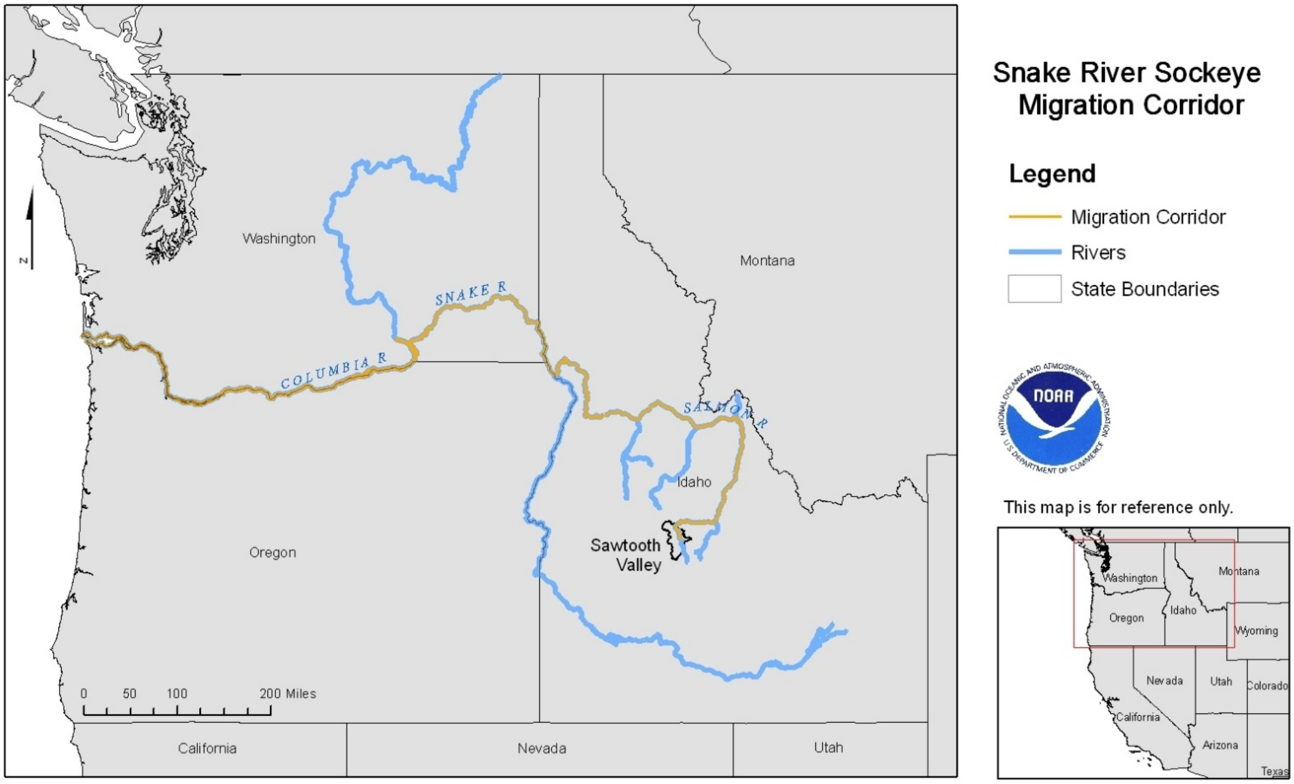

Figure 1-1. Snake River Sockeye Salmon migration corridor, from estuary to Sawtooth Valley Lakes in Idaho.

Reports by Barton W. Evermann, an ichthyologist commissioned by the U.S. Bureau of Fisheries to investigate the status of salmon in the Snake and Columbia Basins, provide an indication of Sockeye Salmon abundance before the turn of the twentieth century. During his investigations, early settlers reported that many Sockeye Salmon returned to the Snake River basin (Evermann 1896; Selbie et al. 2007). In fact, one of the major historical spawning areas, Redfish Lake, was named for the large numbers of Sockeye Salmon that returned to spawn each year turning the lake a shimmering red during the spawning season. Sockeye Salmon ascended the Snake River to the Wallowa, Payette, and Salmon River basins to spawn in natural lakes (Figure 1-2). Within the Salmon River basin, Sockeye Salmon spawned in Warm Lake in the South Fork Salmon River basin, as well as in the Sawtooth Valley lakes: Stanley, Redfish, Yellowbelly, Pettit, and Alturas Lakes. A smaller Sawtooth Valley lake, Hell Roaring Lake, probably also supported some Sockeye Salmon production historically, but it may not have been large enough to support an independent population. Therefore, the lake is not included in the recovery strategy (ICTRT 2005a). The historical relationships between the different Snake River Sockeye Salmon populations are not known. Because of the large geographic separation between the Wallowa, Payette, and Salmon River lakes, it is possible that each drainage supported a separate evolutionarily significant unit (ESU) (ICTRT 2005a).

The Sockeye Salmon populations declined through the early- and mid-1900s. When ESA listing of Snake River Sockeye Salmon was completed in 1991, all of the Snake River Sockeye Salmon populations but one, the Redfish Lake population in the Sawtooth Valley, were gone and that population had dwindled to fewer than 10 fish per year and was at a high risk of extinction. In 2003, the Interior Columbia Basin Technical Recovery Team (ICTRT) recognized the Redfish Lake population as the single extant Sockeye Salmon population in the Snake River Sockeye Salmon ESU. In 2005, The ICTRT designated three historical Sockeye Salmon populations within the Sawtooth Valley; Redfish Lake, Alturas Lake, and Stanley Lake. They also determined that Pettit Lake and Yellowbelly Lake may have supported independent Sockeye Salmon populations but, because of the uncertainty, characterized these as potential populations. Accordingly, only the five Sockeye Salmon populations in the Sawtooth Valley are included in the listed Snake River Sockeye Salmon ESU.

Building on Early Recovery Efforts

In 1991, a group of agencies began collaborating to recover the species. The group’s near-term goal was to avoid extinction and to maintain remaining genetic diversity and population heterozygosity. In the long term they hoped to rebuild the population to facilitate delisting and to increase abundance to levels sufficient to support sport and tribal harvest needs. Central to this effort has been a captive broodstock program for the Redfish Lake population that has prevented extinction in the near term and preserved the genetic lineage of Redfish Lake Sockeye Salmon. The program began with 16 remaining adult Sockeye Salmon ─ 11 males and 5 females ─ taken into captivity from 1991 to 1998.

Today, the program continues to gain ground in reaching its goals. Using advanced aquaculture techniques, the 20-year program has retained about 95 percent of the species' remaining genetic variability, while releasing more than 3.8 million Sockeye Salmon eggs and fish into Sawtooth Valley lakes and streams. Further, the program has produced more than 10,000 adult descendants from the program’s initial 16 wild anadromous adult Sockeye Salmon (Kline and Flagg 2014). The program is coordinated by the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC). SBSTOC members include representatives of the Idaho Department of Fish and Game (IDFG), Bonneville Power Administration (BPA), NMFS, Oregon Department of Fish and Wildlife (ODFW), the University of Idaho (UI), U.S. Forest Service (USFS or U.S. Forest Service), and the Shoshone-Bannock Tribes (SBT). The program includes hatchery facilities in Idaho, Washington, and Oregon.

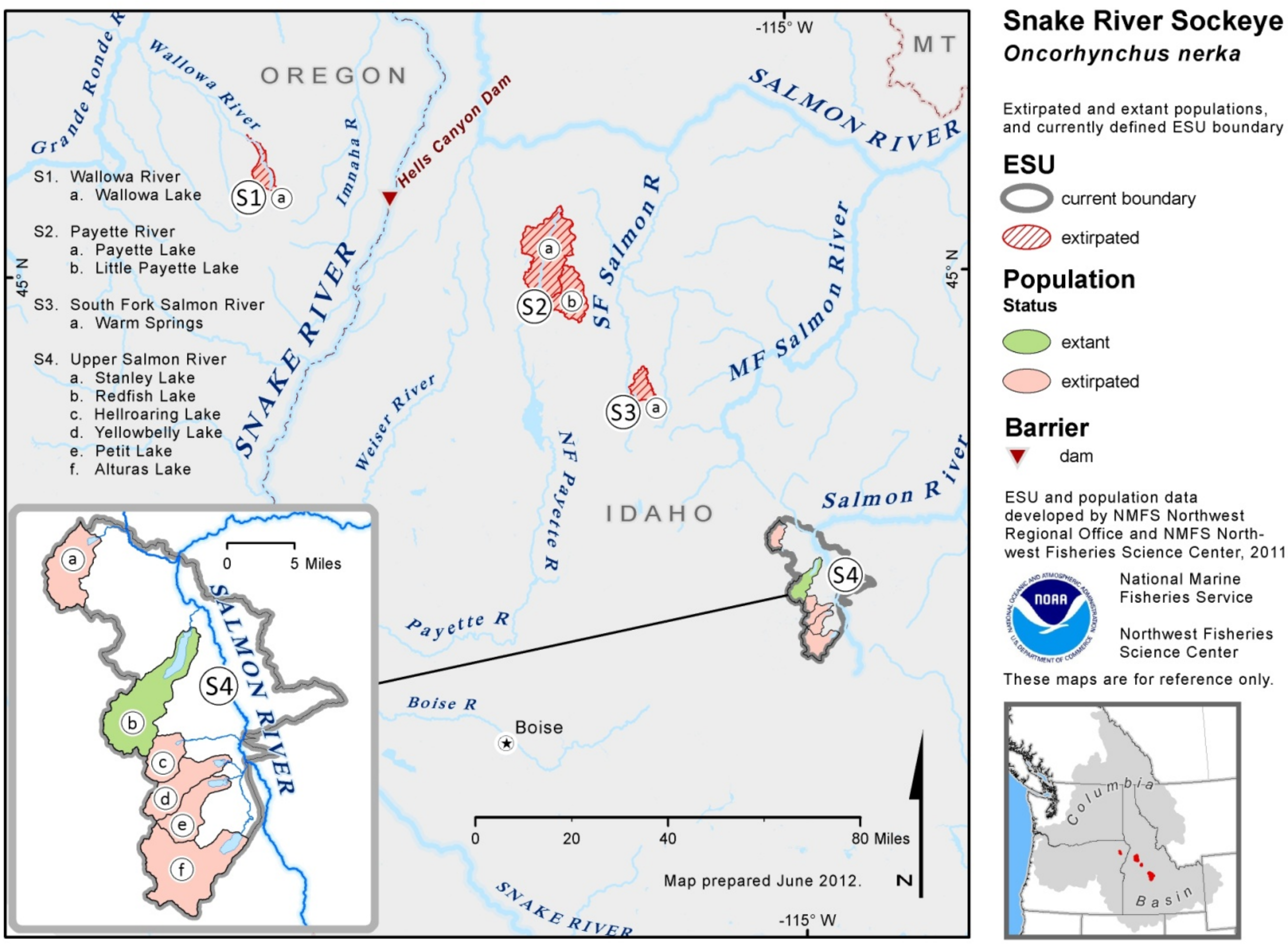

Figure 1-2. Historical populations of Sockeye Salmon in the Snake River basin (NWFSC 2011).

Between 1999 and 2007, more than 355 adult Snake River Sockeye Salmon from captive broodstock releases returned to Redfish Lake from the ocean—almost 20 times the number of wild fish that returned in the 1990s (Flagg et al. 2004; Peterson et al. 2011). These returns have increased within the last seven years, to 646 in 2008 (including 140 natural-origin fish), 832 in 2009 (including 86 natural-origin fish), 1,355 in 2010 (including 178 natural-origin fish), 1,117 in 2011 (including 145 natural-origin fish), 257 in 2012 (including 52 natural-origin fish), 272 in 2013 (including 79 natural-origin fish), and 1,579 in 2014 (including 453 natural-origin fish) (IDFG, in prep.).

Nevertheless, the ESU cannot be said to be recovered until it is made up of natural-origin fish spawning in the wild and surviving their two-way journey in far greater numbers. This Plan identifies the minimum required number of annual natural adult Sockeye Salmon returns and the spatial distribution to the natal Sawtooth Valley lakes to support recovery. It also describes a set of strategies and actions to restore natural Sockeye Salmon populations in Sawtooth Valley lakes to levels that will achieve ESU recovery.

This Plan identifies the conditions that led to the listing of Snake River Sockeye Salmon as an endangered species and the designation of critical habitat under the ESA, and builds upon the work of the Stanley Basin Sockeye Technical Oversight Committee and other ongoing Sockeye Salmon research and recovery efforts. The Plan presents the biological viability and threats criteria for assessing biological recovery and describes recovery strategies and actions to improve the Snake River Sockeye Salmon's environment and long-term chances for survival. The Plan also presents other delisting considerations that will be used in future ESU delisting evaluations.

1.1 Purpose of the Plan

The purpose of a recovery plan is to identify actions needed to restore threatened and endangered species to the point that the ecosystems upon which the species depend are conserved such that the ESU is self-sustaining in the wild and no longer need the protections of the ESA. A recovery plan serves as a roadmap for species recovery—it sets out where we need to go and how best to get there. Without a plan to organize, coordinate, and prioritize the many possible recovery actions on the part of Federal, state, and tribal agencies, local watershed councils and districts, and private citizens, our efforts may be inefficient or even ineffective. Prompt development and implementation of a recovery plan will help target limited resources effectively.

1.2 Endangered Species Act Requirements

Although recovery plans are guidance, not regulatory documents, the ESA clearly envisions recovery plans as the central organizing tool for guiding species' recovery. Section 4(f) of the ESA requires that a recovery plan be developed and implemented for species listed as endangered or threatened under the statute.

ESA section 4(a)(1) lists factors for delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of [the species'] habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting its continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the maximum extent practicable, incorporate:

- a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;

- objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and
- estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and strategies needed to recover a listed species and the science underlying those conclusions (NMFS 2006).

Once a species is deemed recovered and therefore removed from a listed status, section 4(g) of the ESA requires monitoring of the species for a period of not less than five years to ensure that it retains its recovered status.

1.3 Context of Plan Development

This Plan is the product of a collaborative process initiated by NMFS with contributions by a wide group of governments, sovereigns (tribes), and organizations with the potential to contribute to recovery. The goal was to produce a plan that meets NMFS' ESA requirements for recovery plans as well as the State of Idaho's needs. Participants included Idaho Department of Fish and Game, Shoshone-Bannock Tribes, NMFS' Northwest Fisheries Science Center, members of NMFS' Interior Columbia Technical Recovery Team (ICTRT), Bonneville Power Administration, Stanley Basin Sockeye Technical Oversight Committee, and the U.S. Forest Service. This Plan builds upon the ongoing efforts of the Technical Oversight Committee, including hatchery programs, research, restoration, and habitat assessment activities.

This collaborative effort reflects NMFS' belief that it is critically important to base ESA recovery plans on state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support for recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery measures, is essential. NMFS, therefore, supports and participates in locally led collaborative efforts to develop recovery plans, involving local communities, state, tribal, and Federal entities, and other stakeholders.

1.3.1 Recovery Domains and Technical Teams

Currently, 19 evolutionarily significant units (ESUs) and distinct population segments (DPSs)[2] of Pacific salmon and steelhead in the Pacific Northwest are listed under the ESA as endangered or threatened. For the purpose of recovery planning for these species, the NMFS West Coast Region designated five geographically based "recovery domains": Interior Columbia; Willamette-Lower Columbia; Puget Sound and Washington Coast; the Oregon Coast; and the Southern Oregon/Northern California Coast (Figure 1-3). The range of the Snake River Sockeye Salmon is in the Snake River sub-domain of the Interior Columbia domain.

For each domain, NMFS appointed a Technical Recovery Team (TRT) of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each TRT was to define the populations and major population groups (MPGs) within each ESU/DPS, develop recommendations on biological viability criteria for each ESU/DPS and its component populations, provide scientific support to local and regional recovery efforts, and provide scientific evaluations of proposed recovery plans. The TRT responsible for Snake River Sockeye Salmon, the Interior Columbia Technical Recovery Team, includes biologists from NMFS and several states, tribal entities, and academic institutions.

All the TRTs used the same biological principles in developing their recommendations for species and population viability criteria—criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be down-listed or delisted. The principles are described in NMFS' technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). Viable salmonid populations (VSPs) are defined in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. A viable ESU or DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework. Their recommendations were also based on data availability, the unique biological characteristics of the species and habitats in the domain, and the members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches to evaluating viability and identifying factors limiting recovery, all the TRTs worked from a common scientific foundation.

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[2] An ESU of Pacific salmon (Waples et al. 1991; NMFS 1991) and a DPS of steelhead (NMFS 2006) are considered to be "species" as the word is defined in section 3 of the ESA. In addition, it should be noted that the terms "artificially propagated" and "hatchery" are used interchangeably in this Plan, as are the terms "naturally propagated" and "natural."

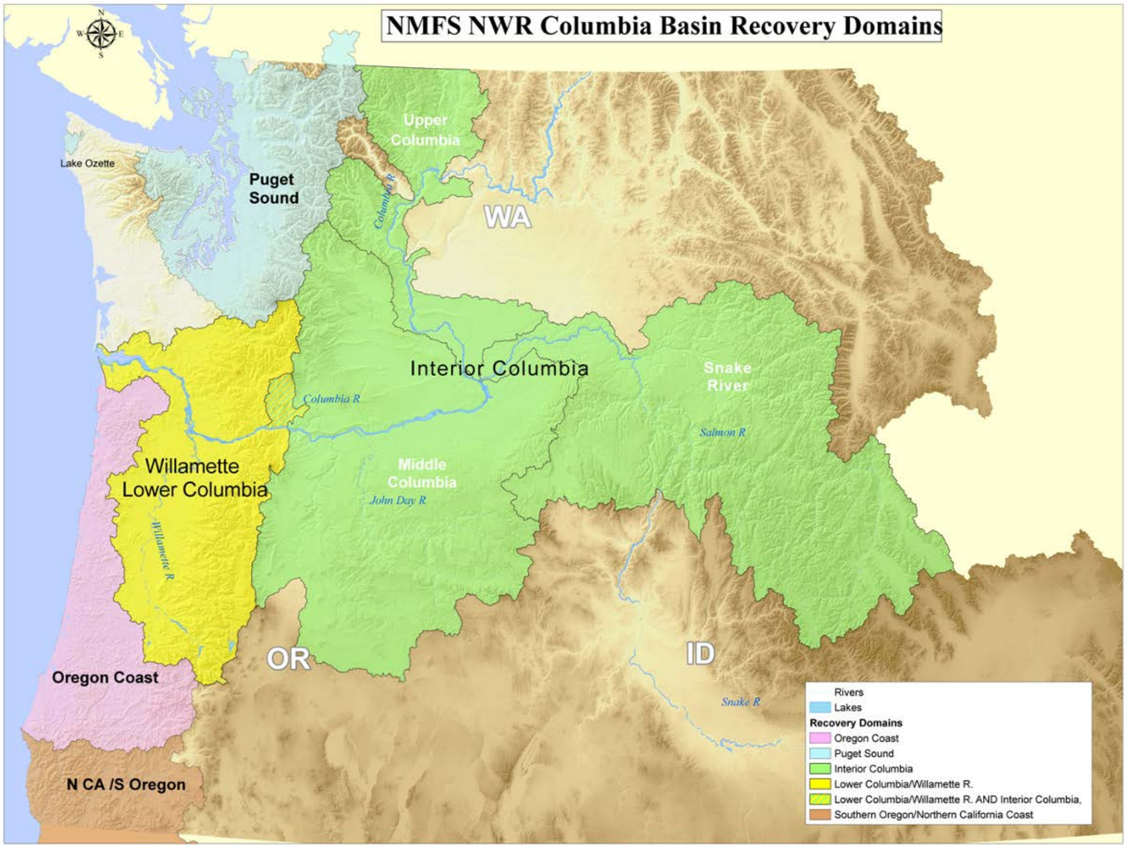

Figure 1-3. Columbia Basin recovery domains for NMFS West Coast Region.

1.3.2 Snake River Sockeye Salmon Stakeholder Groups

In each recovery domain, NMFS has worked with state, tribal, local, and other Federal stakeholders to develop planning forums that build, to the extent possible, on ongoing locally led recovery efforts. While these forums are working from a consistent set of assumptions regarding needed recovery plan elements, the process by which they develop those elements, and the form they take, may differ among domains.

NMFS formed two stakeholder groups to assist in development of the Snake River Sockeye Salmon recovery plan. First, in 2010 it created the Snake River Coordination Group with representatives from state, tribal and Federal governments and agencies to review and provide guidance to NMFS on development of the three recovery plans for the four Snake River species listed under the ESA. The Coordination Group has met periodically to review draft information as the recovery plan was developed and NMFS will edit the draft Plan based on comments received.

Second, in May 2012, NMFS formed the Snake River Sockeye Salmon Technical Team (Technical Team) made up of technical staff from state, tribal, and Federal entities. The Technical Team reviews and provides input on technical content during writing, revision, and completion of the draft Plan.

1.4 Tribal Trust and Treaty Responsibilities

The salmon and steelhead that were once abundant in the watersheds throughout the Snake River basin were crucial to Native Americans throughout the region. Pacific Northwest Indian tribes today retain strong spiritual and cultural ties to salmon and steelhead, based on thousands of years of use for tribal religious/cultural ceremonies, subsistence, and commerce. Many Northwest Indian tribes have treaties reserving their right to fish in usual and accustomed fishing places, including areas covered by this recovery plan. Additionally, four Washington coastal tribes have treaty rights to ocean salmon harvest that may include some fish that are destined for the Snake River basin. These Columbia Basin and Washington coast treaty tribes are co-managers of salmon stocks, and participate in management decisions including those related to hatchery production and harvest. Some other tribes in the Columbia River basin, whose reservations were created by Executive Order, do not have reserved treaty rights but do have a trust relationship with the Federal government and an interest in salmon and steelhead management, including harvest and hatchery production.

The NMFS Regional Administrator, in testimony before the U.S. Senate Indian Affairs Committee (June 2003), emphasized the importance of this co-manager relationship: “We have repeatedly stressed to the region’s leaders, tribal and non-tribal, the importance of our co-management and trust relationship to the tribes. NMFS enjoys a positive working relationship with our Pacific Northwest tribal partners. We view the relationship as crucial to the region’s future success in recovery of listed salmon.”

Native American treaty-reserved fishing rights in the Columbia Basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case *United States v. Oregon*, No. 68-513 (filed in 1968). In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes up to 50% of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas. The *U.S. v. Oregon* process has the potential to affect Snake River populations as some co-managing tribes assert their reserved fishing rights.

Restoring and sustaining a sufficient abundance of salmon and steelhead for harvest is important in fulfilling tribal fishing aspirations. It is NMFS’s policy to promote restoration of salmon and steelhead runs sufficient for tribal harvest. This policy is described in a July 21, 1998, letter from Terry D. Garcia, Assistant Secretary for Oceans and Atmosphere, U.S. Department of Commerce, to Mr. Ted Strong, Executive Director of the Columbia River Inter-Tribal Fish Commission (CRITFC). This letter states that recovery “must achieve two goals: 1) the recovery and delisting of salmonids listed under the provisions of the ESA; and 2) the restoration of salmonid populations over time, to a level to provide a sustainable harvest sufficient to allow for the meaningful exercise of tribal fishing rights.”

Thus, it is appropriate for recovery plans to acknowledge tribal harvest goals. Where tribal harvest goals can only be met through hatchery production, recovery plans will identify strategies and actions to ensure the hatchery production is consistent with recovery of naturally spawning populations.

1.5 Recovery Planning Modules

NMFS has produced modules to assist in recovery planning for ESA-listed Columbia Basin salmon and steelhead species. These modules provide consistent information that can be referenced in species-specific recovery plans. Modules will be updated periodically to reflect new data. The following modules are incorporated into the Plan by reference: (1) Module for the Ocean Environment (*hereafter* Ocean Module) (Fresh et al. 2014), (2) Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (*herafter* Estuary Module) (NMFS 2011a), (2) Supplemental Module for Snake River Salmon and Steelhead , Mainstem Columbia River Hydropower Projects (*hereafter* Hydro Module) (NMFS 2014a), and (4) Columbia River Harvest Module (*hereafter* Harvest Module) (NMFS 2014b). These modules contain information specific to the four ESA-listed Snake River Salmon ESUs and Steelhead DPS, including Snake River Sockeye Salmon.

The Ocean Module (Fresh et al. 2014) uses the latest science to a) synthesize what is known about how each of the four listed Snake River species uses ocean ecosystems, b) identify major uncertainties regarding their use of the ocean environment, and c) define the role of the ocean in recovery planning and implementation of each species. The module is available on the NMFS web site: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/drft-sr-ocean-mod.pdf.

The Estuary Module (NMFS 2011a) discusses limiting factors and threats that affect all the salmonid populations in the mainstem Columbia River estuary and plume, and presents actions to address these factors. The 2011 Estuary Module was prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). It provides the basis of estuary recovery actions for ESA-listed salmon and steelhead in the Columbia River basin. This module is available on the NMFS web site: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/estuary-mod.pdf. This Plan summarizes actions identified in the Estuary Module to address threats to Snake River Sockeye Salmon. The Estuary Module discusses these actions in more detail.

NMFS completed the Hydro Module in June 2014 (NMFS 2014a). The document supplements the 2008 Hydro Module for Snake River anadromous fish species listed under the ESA: Snake River steelhead, Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, and Snake River Sockeye Salmon (NMFS 2008a). The 2008 Hydro Module overviews limiting factors, summarizes current recovery strategies, and provides survival rates associated with the Federal Columbia River Power System (FCRPS). The FCRPS consists of 14 Columbia and Snake River hydropower and water storage projects that are operated as a coordinated system for power production and flood control. The 2014 Snake River Hydro Module provides new information relevant to the Snake River species, including the most recent survival estimates and discussion of latent and delayed mortality. The Snake River Hydro Module is available on the NMFS web site: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/drft-sr-hydro-mod.pdf.

The 2014 Harvest Module describes fishery policies, programs, and actions affecting the fish species covered by the Snake River Recovery Plan (NMFS 2014b). The Harvest Module is available on the NMFS web site: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/drft-sr-hrvst-mod.pdf.

A captive broodstock program for the Redfish Lake population has been successful in preventing extinction in the near term and preserving the genetic lineage of Redfish Lake Sockeye Salmon. The program is coordinated by the Stanley Basin Sockeye Technical Oversight Committee, which was formed in 1991 to guide new research, coordinate ongoing research, and actively participate in all elements of the Snake River Sockeye Salmon recovery effort (Baker et al. 2011; Lewis et al. 1998). Stanley Basin Sockeye Technical Oversight Committee members include representatives of the Bonneville Power Administration, NMFS, Idaho Department of Fish and Game, the University of Idaho, U.S. Forest Service, and the Shoshone-Bannock Tribes, with hatchery facilities in Idaho, Washington, and Oregon.

Hatchery effects on Sockeye Salmon and potential actions contributing to recovery are also discussed in NMFS' Appendices C and D of the Supplemental Comprehensive Analysis (SCA) of the FCRPS Biological Opinion (NMFS 2008b). Additional actions will likely be identified through the Hatchery Scientific Review Group's work and in hatchery management plans (Paquet et al. 2011). These hatchery reform proposals will be addressed and implemented through the development of Hatchery and Genetic Management Plans (HGMPs), ESA section 7 consultations, and the *U.S. v. Oregon* process.

1.6 How NMFS Intends to Use the Plan

Although recovery plans are not regulatory and their implementation is largely voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions.
- Guide decision making by Federal, state, tribal, and local jurisdictions.
- Provide criteria for status reporting and delisting decisions.
- Organize, prioritize, and sequence recovery actions.
- Organize research, monitoring, and evaluation efforts.

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions by federal agencies carried out to meet their ESA section 7(a)(1) obligations to use their programs in furtherance of the purposes of the ESA and to carry out programs for the conservation of threatened and endangered species.

- Actions that are subject to ESA sections 4(d), 7(a)(2), or 10.
- Hatchery and Genetic Management Plans and permit requests.
- Harvest plans and permits.
- Selection and prioritization of subbasin planning actions.
- Development of research, monitoring, and evaluation programs.
- Revision of land use and resource management plans.
- Other natural resource decisions at the state, tribal, and local levels.

NMFS will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of the ESA section 4(d) Rule by considering:

- The importance of affected populations to listed species viability.
- The importance of the action area to affected populations and species viability.
- The relation of the action to recovery strategies and management actions.
- The relation of the action to the research, monitoring, and evaluation plan for the affected species.

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal Action Agencies to describe in their biological assessments how their proposed actions will affect specific populations and limiting factors identified in the recovery plans, and to describe any conservation measures and voluntary recovery activities in the action area.

Section 2: Biological Background

2.1 Geographic Setting

2.2 Sockeye Salmon Overview

2.3 Snake River Sockeye Salmon

2.4 Critical Habitat

2.5 Salmonid Biological Structure

2.6 Viable Salmonid Populations

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2. Biological Background

This section provides a summary of the Snake River Sockeye Salmon ESU: its geographic setting, overview of the ESU, life history, distribution, and designated critical habitat. The section also reviews key concepts in salmonid biology, i.e. the hierarchical structure of salmonid species, from independent population to major population group to evolutionarily significant unit; and the parameters that measure viability for salmonid populations: abundance, productivity, spatial structure, and diversity.

2.1 Geographic Setting

The geographic setting for the Snake River Sockeye Salmon life cycle includes the Pacific Ocean, the Columbia River estuary, the mainstem Columbia River, the Snake River, the Salmon River, and the Sawtooth Valley lakes. Snake River Sockeye Salmon also migrate through eight major dams and their reservoirs (four on the Columbia River and four on the lower Snake River) more than any other Columbia Basin salmonids except Snake River fall Chinook salmon, Snake River Steelhead, Snake River Spring/Summer Chinook salmon and salmonids migrating above Wells Dam on the upper Columbia River (Figure 2-1).

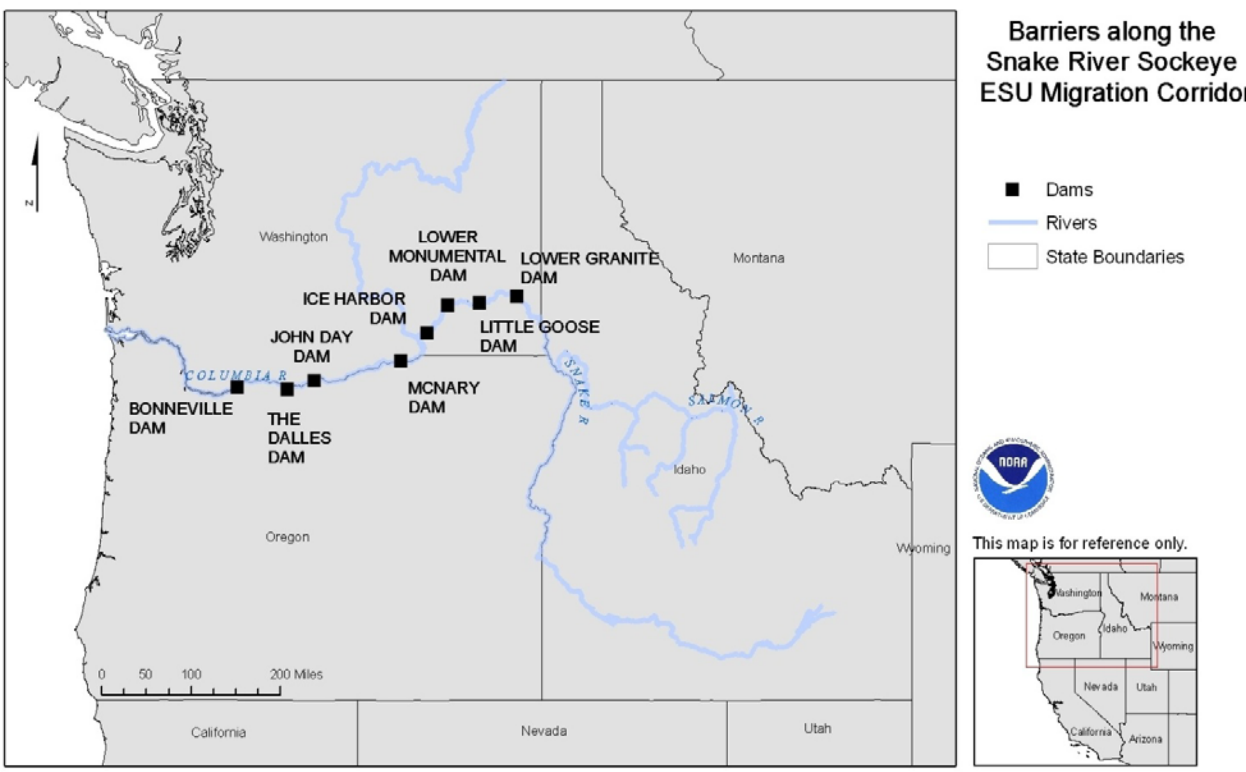

Figure 2-1. Hydropower facilities on Snake River Sockeye Salmon migration route.

The Snake River basin is characterized by dramatic changes in elevation, from 3,859 meters (12,662 feet) at Mount Borah in the headwaters of the Pahsimeroi basin to 104 meters (340 feet) at the Snake River confluence with the Columbia River. Terrestrial habitats in the basin include high elevation deserts, alpine peaks, temperate rain forests, and the deepest river canyon in North America (Hells Canyon – 2,346 m. [7,993 ft.] from the rim at its deepest point). Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas and warmer and drier climates in the lower elevations.

Within the Snake River basin, land use varies from wilderness to agriculture and rangeland to developed cities. The Snake River basin contains the largest contiguous wilderness in the lower 48 states. Of the 83 square kilometers (31,862 square miles) of land in the Snake River recovery domain, 69.4% is federally owned, 24.3% is privately held, and 6.5% is state or tribal. Although population growth in the basin is not keeping pace with other areas in the Pacific Northwest, development is occurring and tends to be concentrated in the valley bottoms. The twin port cities of Lewiston, Idaho and Clarkston, Washington at the confluence of the Snake and Clearwater Rivers send inland commodities such as wheat and forest products downriver and receive industrial products such as gasoline and other fuel oils from downstream sources (Makaryan et al. 2005). Figure 2-2 shows land use and cover in the Snake River basin.

The Sawtooth Valley, where the only extant Snake River Sockeye Salmon spawn, is a scenic, glaciated intermontane basin bordered on the west by the Sawtooth Mountains and on the east by the White Cloud Mountains. The Sawtooth Mountains are part of the Idaho batholith, made up of granite-like rock, consisting of granodiorite, quartz diorite, and quartz monzonite (Emmett 1975). The Stanley Basin lies in the northern portion of the Sawtooth Valley and is the location of the small town of Stanley, Idaho. The Sawtooth Valley lakes, carved by glaciers, receive runoff from the Sawtooth Mountains and drain to the upper Salmon River. The upper Salmon River runs south to north through the Sawtooth Valley, from its headwaters high in the Sawtooth range. Elevation in the valley and basin varies between 1,890 and 2,134 meters (6,200 and 7,000 feet), while many of the surrounding peaks rise above 3,048 meters (10,000 feet). The climate is characterized by severe winter weather and dry, hot summers. Vegetation varies with altitude, soils, and exposure; lodgepole pine and aspen groves predominate in the higher altitudes, while sagebrush and grass cover the hills formed by moraines and the alluvial flats.

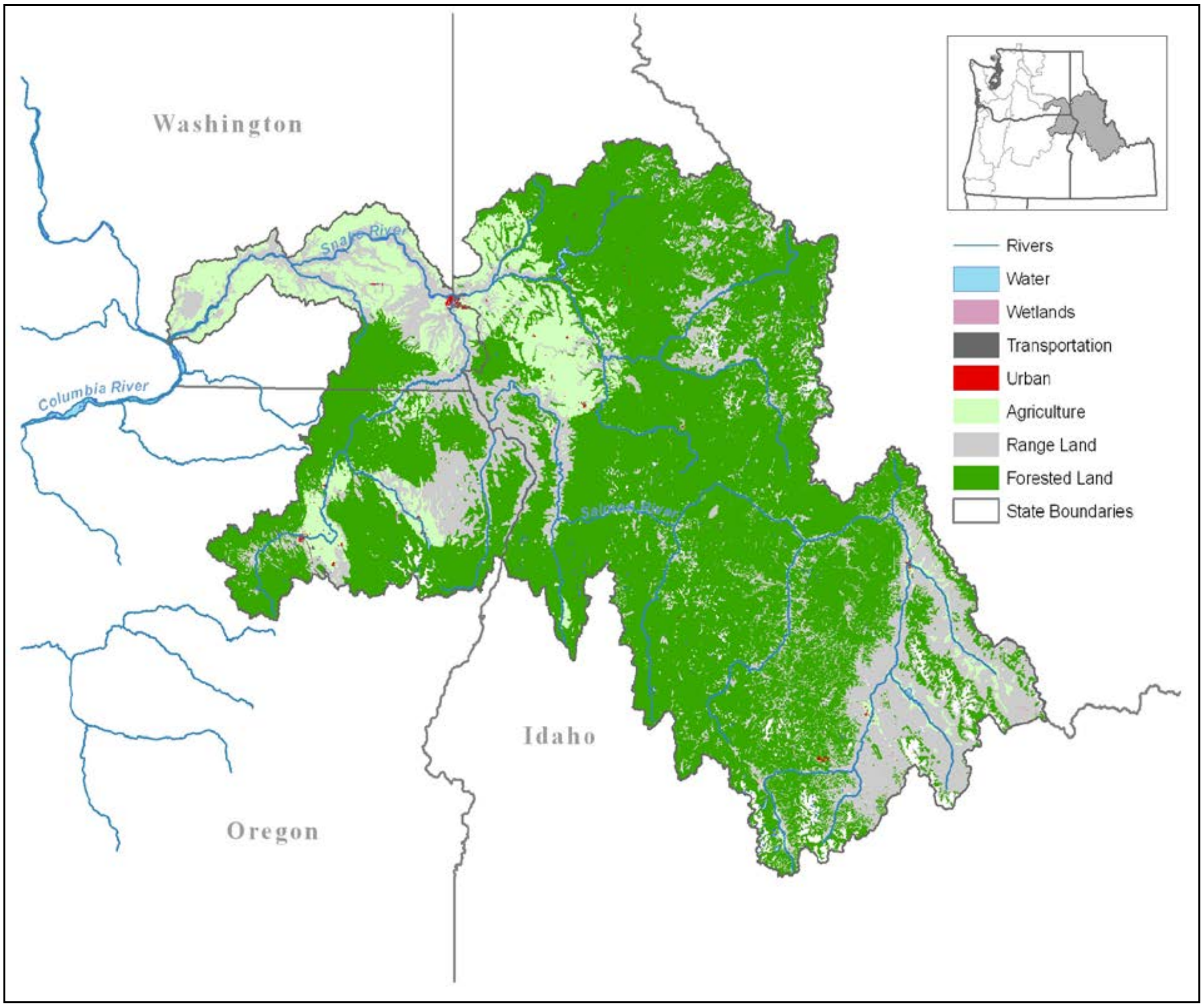

Figure 2-2. Land use and cover in the Snake River basin.

The five Sawtooth Valley lakes that historically supported Sockeye Salmon ─ Stanley Lake, Redfish Lake, Yellowbelly Lake, Pettit Lake, and Alturas Lake ─ range in elevation from 1,985 m to 2,157 m (6,512 ft to 7,077 ft), and are located in central Idaho (Figure 2-3). A neighboring smaller Sawtooth Valley lake, Hell Roaring Lake, also probably supported some Sockeye Salmon production at one time. NMFS did not include this lake in the recovery strategy because it may not have been large enough to support an independent population.

The lakes lie at the western edge of the Sawtooth Valley and south of the town of Stanley, except Stanley Lake, which is slightly to the north and west of the Sawtooth Valley. They all drain into the upper Salmon River mainstem. The lakes are oligotrophic (low in nutrients) but high in oxygen, especially in the depths. They are underlain by granitic bedrock. Redfish Lake is the largest, at 615 hectares (1,520 acres), and Alturas is next largest, with about half the area. Table 2-1 shows the surface area, depth, and other characteristics of the lakes. Redfish Lake is approximately 1,450 km (900 miles) from the mouth of the Columbia River. There are 616 km

(380 miles) of free-flowing river from Redfish Lake to the mouth of the Salmon River and an additional 835 km (520 miles) impacted by eight dams on the Snake and Columbia Rivers.

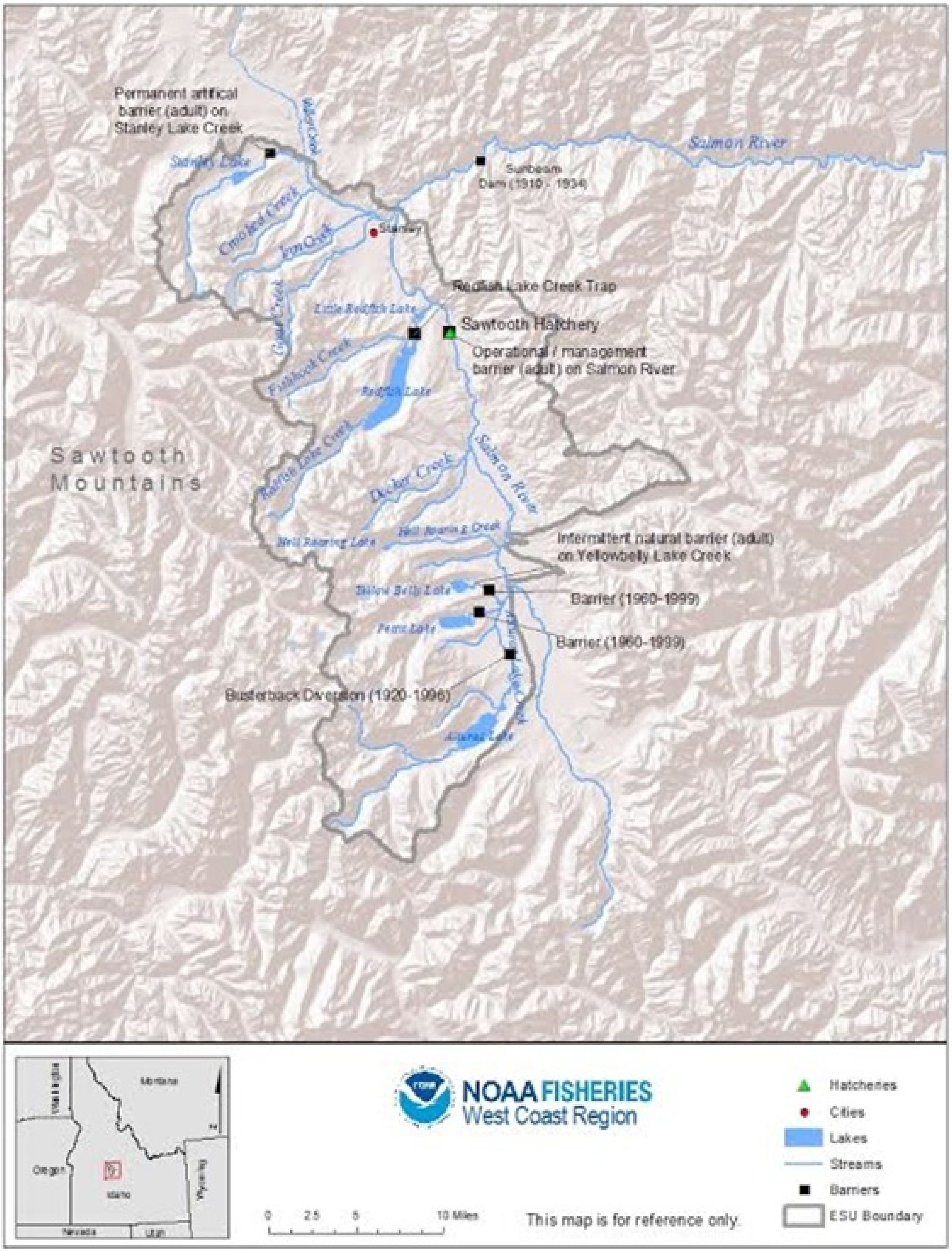

Figure 2-3. Map of the Sawtooth Valley, Idaho.

Table 2-1. Physical and morphometric characteristics of the Sawtooth Valley lakes (BPA 1995).

Lake	Surface Area (ha)	Elevation (m)	Volume (m^3 x 10^6)	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km^2)
Redfish Lake	615	1,996	269.9	44	91	108.1
Alturas Lake	338	2,138	108.2	32	53	75.7
Pettit Lake	160	2,132	45.0	28	52	27.4
Stanley Lake	81	1,985	10.4	13	26	39.4
Yellowbelly Lake	73	2,157	10.3	14	26	30.4

Land use in the Sawtooth Valley is primarily recreation, with some ranching. Land ownership is 90% Federal and 6% private, with a very small amount owned by the state of Idaho (Figure 2-4). The Sawtooth National Recreation Area (Sawtooth NRA), administered by the U.S. Forest Service, encompasses the Salmon River corridor from its headwaters to Stanley; the Sawtooth Valley and surrounding lakes; and the eastern foothills of the Sawtooth Mountains and western portion of the White Cloud Mountains. The Sawtooth NRA lies in Custer, Blaine, and Boise Counties. It encompasses roughly 3,150 km^2 (778,000 acres), of which the U.S. Forest Service administers 89%. Another 10% is private land and 1% is state land (USFS 2003). Virtually all of the private and state inholdings lie along the Salmon River or Valley Creek corridors. The Sawtooth Valley lakes and Redfish Lake in particular, are recreational destinations and are highly valued for their scenic qualities and clear water. In the summer, the area is used for fishing, boating, hiking, picnicking, and camping, and in the winter, for cross-country skiing, snowmobiling, and other outdoor activities.

The vision for the Sawtooth NRA is embodied in its enabling legislation, the Sawtooth National Recreation Area Act (PL 92-400). PL 92-400 identifies the specific values and purposes that the Sawtooth NRA is to emphasize. On August 22, 1972 Congress passed PL 92-400 to establish the Sawtooth NRA "…in order to assure the preservation and protection of the natural, scenic, historic, pastoral, and fish and wildlife values and to provide for the enhancement of the recreation values associated therewith…" These features are often referred to as the Sawtooth NRA's "core values." The vision of PL 92-400 tips the balance toward protection and preservation. Some development and use is welcome, but it must not "substantially impair" the primary values. The restoration of the salmon and other fisheries was one of the key purposes for establishing the Sawtooth NRA.

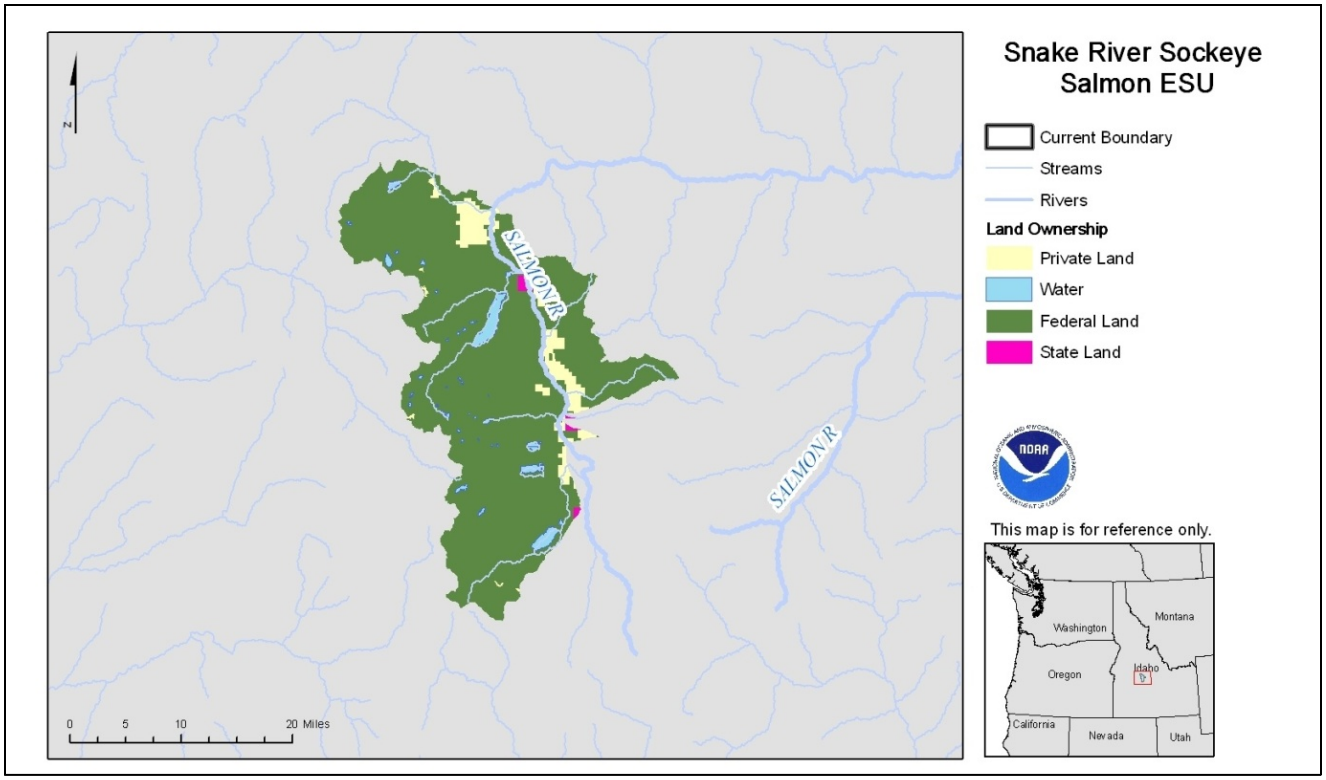

Figure 2-4. Land ownership in the spawning range of the Snake River Sockeye Salmon ESU.

Until recently, hatchery rainbow trout were stocked in Redfish, Alturas, Pettit, and Stanley Lakes. Currently, only Alturas and Stanley Lakes are stocked. Sport fishing for salmonid fishes is open during specified fishing seasons on all lakes as well as on inlet and outlet streams.

As described in Selbie et al. 2007, "Redfish Lake has a large, relatively pristine watershed that drains from the granitic Sawtooth Mountains. Lower elevation portions of the drainage area are vegetated and support a mixed aspen and coniferous forest (Wurtsbaugh et al. 1997). Redfish Lake is a steep-sided system of Pleistocene glacial origin (deglaciation occurred by about 14,000 years before the present), impounded behind a large glacial moraine (Killsgaard et al. 1970; Alt and Hyndman 1989; Thackray et al. 2004). Redfish Lake is classified as an ultraoligotrophic lake system. The paleolimnological data are in agreement with this and indicate that the lake was consistently oligotrophic throughout the past 500 years." The other Sawtooth Valley lakes are physically, geologically, and visually quite similar to Redfish Lake.

2.2 Sockeye Salmon Overview

All Pacific salmon belong to the family *Salmonidae* and the genus *Oncorhynchus.* Sockeye Salmon are the species *Oncorhynchus nerka*. Snake River Sockeye Salmon are an ESU of *O. nerka*. ESUs are defined based on geographic range as well as genetic, behavioral, and other traits. Sockeye Salmon are the second most abundant of the seven Pacific salmon species (Quinn 2005).

The vast majority of Sockeye Salmon populations spawn in or near lakes. Spawning can take place in lake tributaries, lake outlets, rivers between lakes, and on lake shorelines or beaches where suitable upwelling or intra-gravel flow is present. Spawn timing is often determined by water temperature. In spawning habitats with cooler water temperatures, Sockeye Salmon typically spawn earlier (August) than in warmer habitats (November) (Burgner 1991). Sockeye Salmon fry spawned in lake tributaries typically exhibit a behavior of rapid downstream or upstream migration to the nursery lake after emergence, whereas lake/beach spawned Sockeye Salmon rapidly migrate to open limnetic waters after emergence. Lake-rearing juveniles typically spend 1 to 2 years in their nursery lake before emigrating to the marine environment (Gustafson et al. 1997).

Upon smoltification, Sockeye Salmon emigrate to the ocean. Peak emigration to the ocean occurs in mid-April to early May in southern Sockeye Salmon populations (<52ºN latitude) and as late as early July in northern populations (62ºN latitude) (Burgner 1991). Upon entering marine waters, Sockeye Salmon may reside in the nearshore or coastal environment for several months but are typically distributed offshore by fall (Burgner 1991). Section 2.3.2 provides a detailed description of the life history characteristics specific to Snake River Sockeye Salmon.

In North America, Sockeye Salmon spawn from the Columbia River north to the Noatak River in Alaska, but historically ranged as far south as the Sacramento River (California) and as far north as Kotzebue Sound (Alaska) (Atkinson et al. 1967; Burgner 1991). Sockeye Salmon in commercially important numbers occur only from the Columbia River to the Kuskokwim River in the Bering Sea (Foerster 1968; Burgner 1991; Quinn 2005). In the Western Pacific, Sockeye Salmon can be found from the Kuril Islands (Japan) to Cape Chaplina (Russia) (Burgner 1991; Gustafson et al. 1997).

2.3 Snake River Sockeye Salmon

Five lakes in the Sawtooth Valley historically contained anadromous Sockeye Salmon: Alturas, Pettit, Redfish, Stanley, and Yellowbelly Lakes (Bjornn et al. 1968). Currently, only the Redfish Lake population, supported by a captive broodstock program, is considered extant (Figure 2-5). However, reintroduction efforts have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997 with Redfish Lake stock (Hebdon et al. 2004).

The Sawtooth Valley lakes support three forms of *O. nerka:*

- Anadromous Sockeye Salmon — Sockeye Salmon in the Sawtooth Valley generally display an anadromous life history strategy. They spend 1 to 2 years in nursery lakes before migrating to sea as smolts during the spring of the year. They remain at sea for an additional one to three years before returning to natal areas to spawn (Bjornn et al. 1968; Foerster 1968; Groot and Margolis 1991).

- Residual Sockeye Salmon — These Sockeye Salmon are genetically aligned with the anadromous form but have adopted a resident life history pattern, remaining in freshwater to mature and reproduce. They mature earlier (males earlier than females) and at a smaller size than anadromous Sockeye Salmon and have a sex ratio biased toward males. They spawn in the vicinity of anadromous individuals. Due to the low carotenoid resources available in freshwater lakes, residuals are normally a dusky color at spawning rather than the more vibrant red/green of ocean return fish (Waples 1992, as referenced in Flagg et al. 1995). They can produce either resident or anadromous offspring (Rieman et al. 1994), but generally produce anadromous offspring (Ricker 1938; Foerster 1968; Groot and Margolis 1991). Residuals may act as a safety net against failure of year-classes at sea. They are ESA-listed along with the anadromous portion.
- Kokanee — Kokanee are a type of *O. nerka (O. nerka kennerlyi)* that is genetically distinct from Sockeye Salmon and is not included in the Snake River ESA listing. Therefore, they are not the main focus of this recovery plan; however, they represent important life history and spatial diversity and may contribute to recovery. Kokanee are a self-perpetuating, generally non-anadromous form of *O. nerka* that occurs in balanced sex-ratio populations and whose parents, for several generations back, have spent their whole lives in fresh water. Kokanee have adapted to the carotenoid-poor forage environment of lakes, appear more efficient than Sockeye Salmon at storing carotenoid, and have a vibrant red/green color at spawning (Waples 1992, as referenced in Flagg et al. 1995). Kokanee are generally a resident fish and mostly segregated from Sockeye Salmon during spawning, both temporally and spatially. However, in Alturas Lake the early stream spawning kokanee produce considerable numbers of smolts and some anadromous adult returns.

The five Sawtooth Valley lakes support different forms of *O. nerka*:

Redfish Lake

Redfish Lake remains the only lake with returning anadromous Sockeye Salmon adults. The lake supports both anadromous and residual Sockeye Salmon, as well as a genetically distinct and non-ESA-listed form of native kokanee. Kokanee in Redfish Lake are segregated from anadromous and residual Sockeye Salmon during spawning, both temporally and spatially. The anadromous and residual forms are shoal spawners that reproduce in the lake in late September and October, whereas kokanee spawn in a tributary to the lake in August and early September (Peterson et al. 2011). Kokanee are native to Redfish Lake; the previous stocking from a range of hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990) has appeared to have no lasting impacts (Waples et al. 2011).

Stanley Lake

While anadromous Sockeye Salmon were historically indigenous to Stanley Lake, an artificial fish passage barrier below the lake's outlet has prevented recolonization of the lake by anadromous Sockeye Salmon since its installation in 1956. The lake continues to support two kokanee populations, one native and one non-native. Recent data analysis suggests that the current population constitutes a native population of kokanee with low levels of non-native introgression and a non-native stock descended from the introduction(s) of Wizard Falls stock kokanee (Kozfkay 2013a).

Yellowbelly Lake

Yellowbelly Lake historically contained Sockeye Salmon but currently *O. nerka,* Sockeye Salmon or kokanee, are not present in the lake. The lake's historical Sockeye Salmon population likely displayed anadromous and residual life history strategies. Prior passage issues existed at the outlet stream due to an outlet barrier constructed by IDFG in 1962. The U.S. Forest Service removed the barrier in 2000 to reestablish connectivity with the mainstem Salmon River. Biologists reported in 1968 that fish found in the lake following chemical treatment appeared to be residual Sockeye Salmon (Bjornn et al. 1968). There is no record of Sockeye Salmon or kokanee salmon stocking in the lake.

Pettit Lake

Pettit Lake historically supported an anadromous Sockeye Salmon population but an outlet barrier prevented all upstream fish migration from 1960 until 1996 when the barrier was removed by the Shoshone-Bannock Tribes. The downstream Salmon River mainstem weir at Sawtooth Hatchery continues to prevent anadromous returns to Alturas, Pettit, and Yellowbelly Lakes. Since 2000, a residualized/anadromous Sockeye Salmon population appears to be developing in Pettit Lake from reintroductions of Redfish Lake stock (egg boxes, pre-smolts). In addition, the Shoshone-Bannock Tribes have captured unmarked outmigrants at a fish trap below the lake. These fish were most likely produced from the descendants of fish introduced in egg-boxes or as pre-smolts that residualized in the lake. Kokanee are also native to Pettit Lake; however, genetic analyses indicate that the native population of kokanee may have been completely replaced by non-native introductions of kokanee from northern Idaho (Winans et al. 1996; Waples et al. 2011).

Alturas Lake

Alturas Lake supports a native predominately resident population of kokanee (not ESA listed) that also produces anadromous *O. nerka*. The lake has also received reintroductions of Redfish Lake Sockeye Salmon, primarily through pre-smolt and egg-box releases. It is not uncommon for these anadromous *O. nerka* to outmigrate as one- or two-year old smolts during the typical spring smolt outmigration window. Adults produced from these experimental releases were not provided direct access back to Alturas Lake from 1991 to 2014; however, one fish was released into Alturas Lake in 2011 following genetic confirmation. In addition to these adults, approximately 20 Sockeye Salmon of Alturas Lake-origin (anadromous offspring of early stream spawning kokanee) have been identified at the Sawtooth Fish Hatchery weir as early-returning anadromous adults since the inception of the program in 1991 (IDFG, in prep.). The anadromous Alturas Lake *O. nerka* population exhibits an earlier spawn time than the Redfish Lake Sockeye Salmon population. Studies indicate that kokanee from Redfish and Alturas Lakes are genetically similar (Monan 1991).

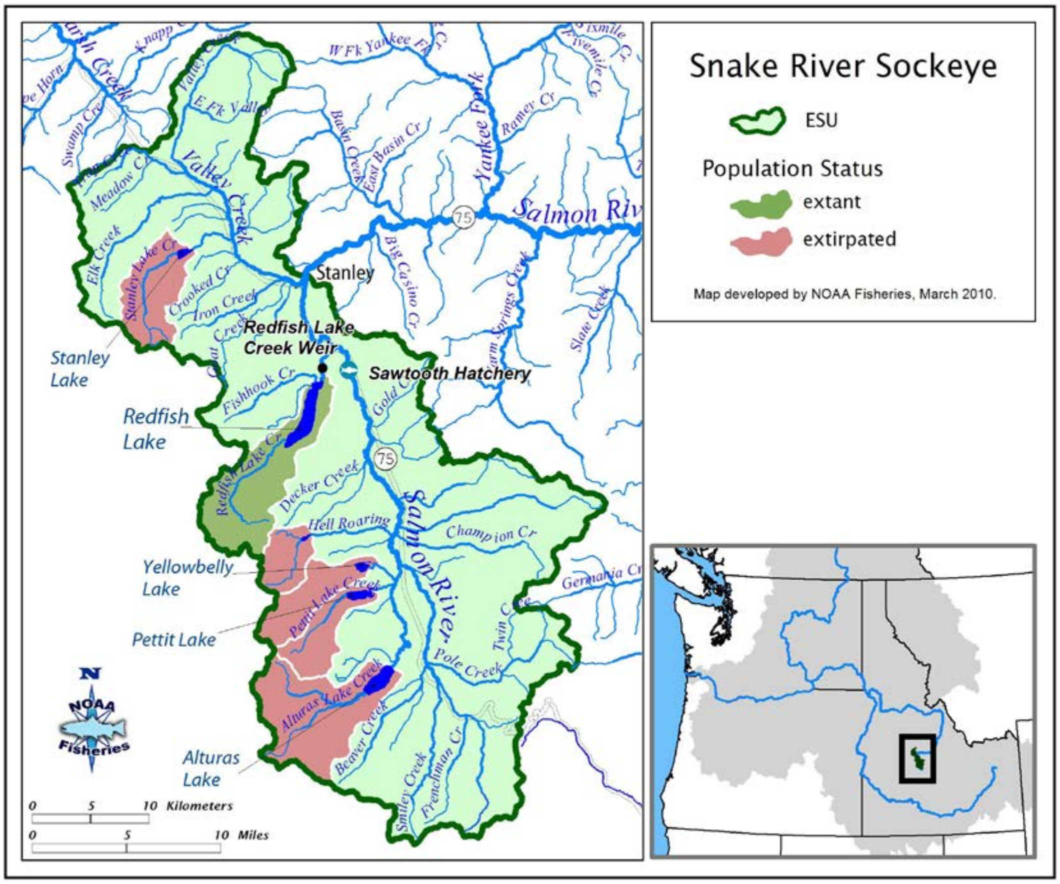

Figure 2-5. The Snake River Sockeye Salmon ESU with current status designations (Ford 2011).

2.3.1 Recent History

It is not known what proportion of all Snake River Sockeye Salmon, including those from the Payette and Grande Ronde River systems, originated in the Sawtooth Valley. Historically, Sawtooth Valley lakes and streams were described as “teeming with redfish” (Evermann 1895), but numerical estimates are not available (Spaulding 1993). Evermann reported that in 1881, nearly 1,360 kgs (3,000 lbs) of Sockeye Salmon were harvested from Alturas Lake for mining camps, and there were plans to build a cannery at Redfish Lake (Evermann 1895, cited by Bowles and Cochnauer 1984). Historical evidence from upstream anglers suggests that noticeable reductions in upriver spawner returns to Idaho coincided in the 1890s with the peak of the downriver commercial harvest of Sockeye Salmon from the entire Columbia and Snake River basins. More than 1.1 to 1.3 million Sockeye Salmon were harvested annually during that period (Evermann 1895; Beiningen 1976).

Selbie et al. (2007) noted that "The intensification of the commercial fishery occurred concurrently with other documented negative human influences on salmon in the Columbia River basin, including mining, logging, and agriculture (Beiningen 1976). As such, it is difficult to attribute the trends . . . solely to the effects of the commercial harvest." However, Selbie et al. (2007) conducted paleolimnological studies in the Sawtooth Valley lakes, finding corroborating evidence "that the onset of a decline in Snake River Sockeye Salmon was concurrent with the inception and intensification of the commercial fishery, and it probably had a substantial early and persistent negative influence on these fish" (Selbie et al. 2007).

In 1910, Sunbeam Dam was constructed on the Salmon River approximately 32.1 kilometers (20 miles) downstream of Redfish Lake. Although it is generally believed that Sunbeam Dam largely prevented adult Sockeye Salmon from returning to the Sawtooth Valley from 1910 to 1934 (Chapman et al. 1990), it has also been hypothesized that some passage occurred while the dam was in place, allowing the Sawtooth Valley population or populations to persist (see Bjornn et al. 1968; Waples et al. 1991). Sockeye Salmon runs to Redfish Lake may have been sustained by an inadequate fish ladder and a diversion tunnel through the dam (Waples et al. 1991), downstream lakes (e.g., Sullivan Lake) functioning as refugia (Foerster 1968), and/or residual outmigrants from Redfish Lake. In 1934, the 9.1 meter-high (30-foot) Sunbeam Dam was partially removed. Sunbeam Dam currently poses no migration problem.

An irrigation diversion on Alturas Creek is thought to have blocked the entire adult Sockeye Salmon migration to Alturas Lake and also entrained juvenile outmigrants from 1914 until the Sawtooth National Forest purchased the water right in 1992. The U.S. Forest Service removed and rehabilitated the headgate, screen and ditch in 1997 (Chapman et al. 1990). The early stream spawning kokanee population in Alturas Lake continues to produce smolts and some anadromous adult returns in spite of the fact that anadromous adults have had little to no access to the lake for approximately 100 years. Adult Sockeye Salmon returns to Alturas Lake that were produced by the early stream spawning kokanee include one fish in 2002, one fish in 2008, two fish in 2009, fourteen fish in 2010 and two fish in 2011. No adult Sockeye Salmon returned to Alturas Lake in 2012, 2013, or 2014 (IDFG, in prep: see Table 4-1).

From 1954 to 1990, the IDFG chemically treated Pettit, Stanley, Yellowbelly, and Hell Roaring Lakes to eradicate Sockeye Salmon and other unwanted species, preparatory to planting the lakes with trout. (Stanley Lake was treated with Rotenone. Yellowbelly and Pettit Lakes received Toxaphene treatments in the 1950s and 1960s. Yellowbelly Lake was treated a second time with Rotenone in 1990. Stanley Lake was treated with Fish-Tox (a compound that is a mix of Toxaphene and Rotenone)). Hell Roaring Lake was chemically treated in 1970. The IDFG then built permanent structures on each of these three lake outlets to prevent re-entry of anadromous Sockeye Salmon (Chapman and Witty 1993). A fish barrier may have been constructed in the outlet stream to Hell Roaring Lake using natural materials (M. Moulton, personal communication). Redfish and Alturas Lakes were not chemically treated.

In the 1990s, non-game fish barriers were removed from the outlet of Yellowbelly Lake by the Sawtooth National Forest (USFS 2011) and from the outlet of Pettit Lake by the Shoshone-Bannock Tribes. The fish barrier on Alturas Lake Creek (an irrigation intake) was also removed (Teuscher and Taki 1996, cited in Flagg et al. 2004). The only remaining non-game fish barrier is on Stanley Lake Creek. However, the Sawtooth Fish Hatchery weir prevents Sockeye Salmon from accessing Alturas, Pettit, Yellowbelly, and Hell Roaring Lakes.

From 1960 to 1973, commercial and tribal Sockeye Salmon fisheries in the Columbia River harvested an average of 35,956 fish per year. In that period, returns to Redfish Lake declined by about 85%, from an average of about 1,250 fish to about 170 (Bjornn et al. 1968). Commercial fisheries were closed from 1974 to 1983 (NMFS 1991). During the commercial closure, tribal harvest averaged approximately 1,000 fish annually. Snake River Sockeye Salmon may have been susceptible to proportionately higher harvest rates than other stocks because of their low abundance relative to other Sockeye Salmon populations and also because Redfish Lake Sockeye Salmon are relatively large compared to other Columbia River stocks and harvest practices selected for larger fish (Bjornn et al. 1968). Although little data are available on exploitation rates specific to Snake River Sockeye Salmon, the NMFS listing decision noted commercial fisheries on Sockeye Salmon in the lower Columbia River and historical harvest on the spawning grounds as primary factors for decline of the ESU (NMFS 1999a). Recreational fishing impacts were considered negligible.

The construction of Federal dams on the Columbia and Snake Rivers from 1938 to 1975 presented further challenges to the Sockeye Salmon returning to Redfish Lake (Figure 2-1). A description of limiting factors and threats related to hydropower and water storage projects is described in Section 5.2 and in NMFS' Hydro Module (NMFS 2014a).

2.3.2 Life History

Historically, adult Snake River Sockeye Salmon entered the Columbia River in June and July, migrated upstream through the Snake and Salmon Rivers, and arrived at the Sawtooth Valley lakes in August and September (Bjornn et al. 1968). Spawning in lakeshore gravels peaked in October. Fry emerged in late April and May and moved immediately to the open waters of the lake where they feed on plankton for one to three years before migrating to the ocean. Juvenile Sockeye Salmon generally left the Sawtooth Valley lakes from late April through May and migrated nearly 900 miles to the Pacific Ocean. While pre-dam reports indicate that Sockeye Salmon smolts passed through the lower Snake River in May and June, passive integrated transponder (PIT)-tagged smolts from Redfish Lake recently passed Lower Granite Dam from mid-May to mid-July (SCA, NMFS, 2008b). Collaborative PIT tag and radiotelementry studies conducted by NMFS and IDFG during the 2012 and 2013 outmigration determined that median travel time for Sawtooth and Oxbow Hatchery releases was approximately 7 days to Lower Granite Dam (Axel et al. 2013, 2014).

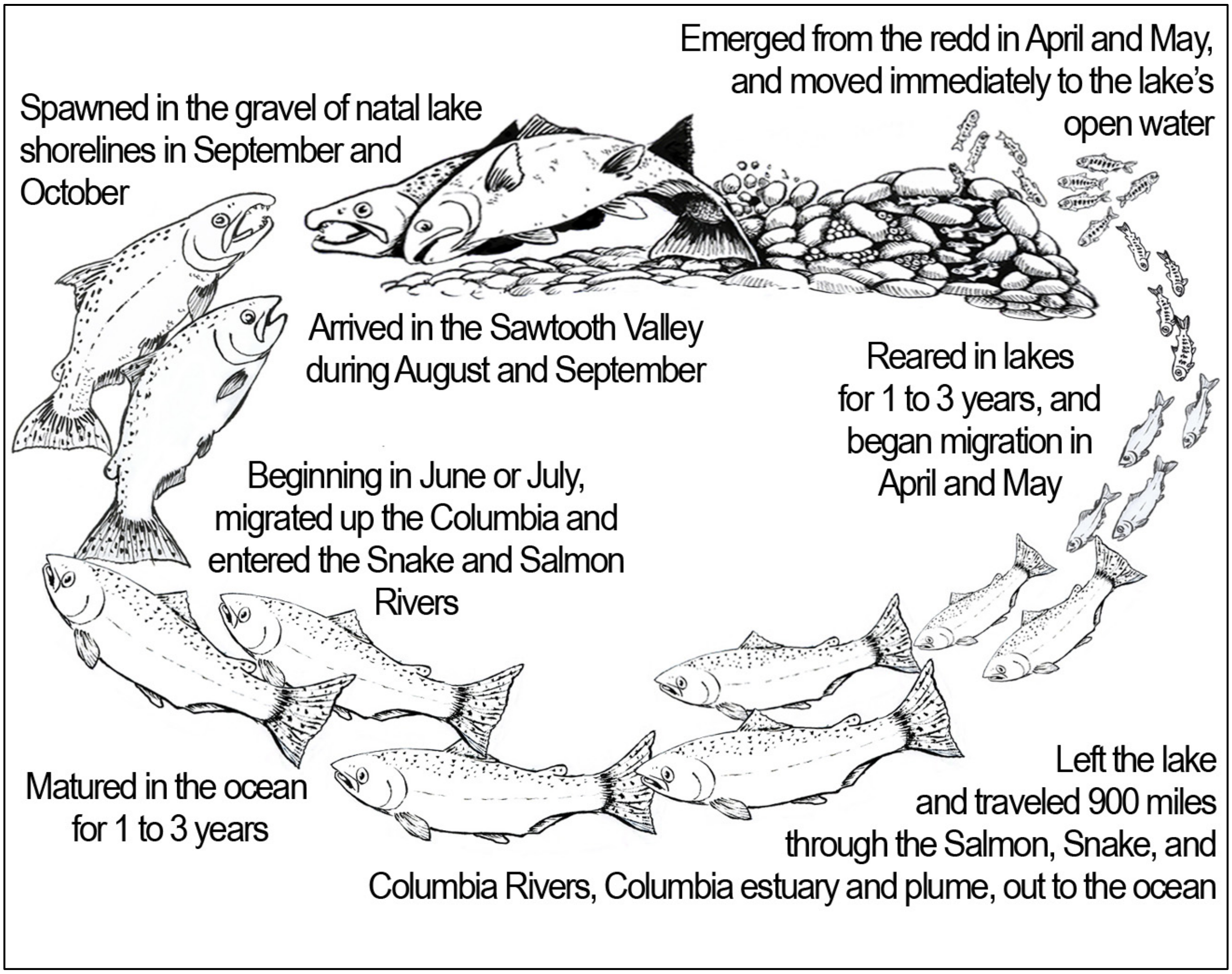

Figure 2-6. Historical Snake River Sockeye Salmon Life Cycle.

For hatchery juvenile Sockeye Salmon, estimated survival between the Sawtooth Valley and Lower Granite Dam has been highly variable between release locations, rearing strategies, origin, and years. Measuring the magnitude of mortality, as well as determining where, when and why mortality is occurring, is critical to successful restoration and recovery of endangered Snake River Sockeye Salmon. Based on detections of Sockeye Salmon hatchery juveniles tagged with a PIT-tag and released in spring, estimates of survival to Lower Granite Dam have ranged from 0.114 in 2000 (Zabel et al. 2001) to 0.776 in 2008 (Faulkner et al. 2008). The tagging studies indicate that timing of juvenile migration may influence survival. For example, for groups of PIT-tagged fish released to Redfish Lake Creek in 2013, estimated survival to Lower Granite Dam ranged 51.0% to 59.2%, with earliest released fish groups often experiencing the highest mortality (Axel et al. 2014). Study findings also indicate that a large portion of the observed mortality is occurring in reaches of the upper Salmon River, with physical observations of removal by bull trout *Salvelinus confluentus,* osprey *Pandion haliaetus*, common mergansers *Mergus merganser*, and western grebes *Aechmophorus occidentalis*.

Snake River Sockeye Salmon enter the estuary at a large size as a result of the long time they spend in the natal lakes before emigrating as juveniles to the ocean. Although they experience significant mortality in the Columbia River estuary, juvenile Snake River Sockeye Salmon are presumably affected to a lesser degree by limiting factors and threats in the estuary because of their shorter residency times in the reach (NMFS 2011a). Snake River Sockeye Salmon spend the majority of their life in the Pacific Ocean, generally returning as four-year old or older fish to their natal Sawtooth Valley lake to spawn. Similar to many species of salmon, some anadromous *O. nerka* return as three-year-olds, which are referred to as jacks or jills, depending on their sex.

Brannon et al. (1994) reported that the anadromous Sockeye Salmon spawned only along a 400-meter section of shallow beach on the northeast shoreline of Redfish Lake during the months of October and November. Current spawning locations for anadromous and residual Sockeye Salmon include: (1) the transfer dock area near the inlet of Redfish Lake Creek at the southwest corner of the lake, (2) a small section of substrate at the southeast corner of Redfish Lake Creek, (3) the southern snorkel transect, also at the southern end of Redfish Lake; (4) Sockeye Beach at the northeastern end of the lake, and recently (5) Fishhook Creek (Figure 2-7) (IDFG 2013a).

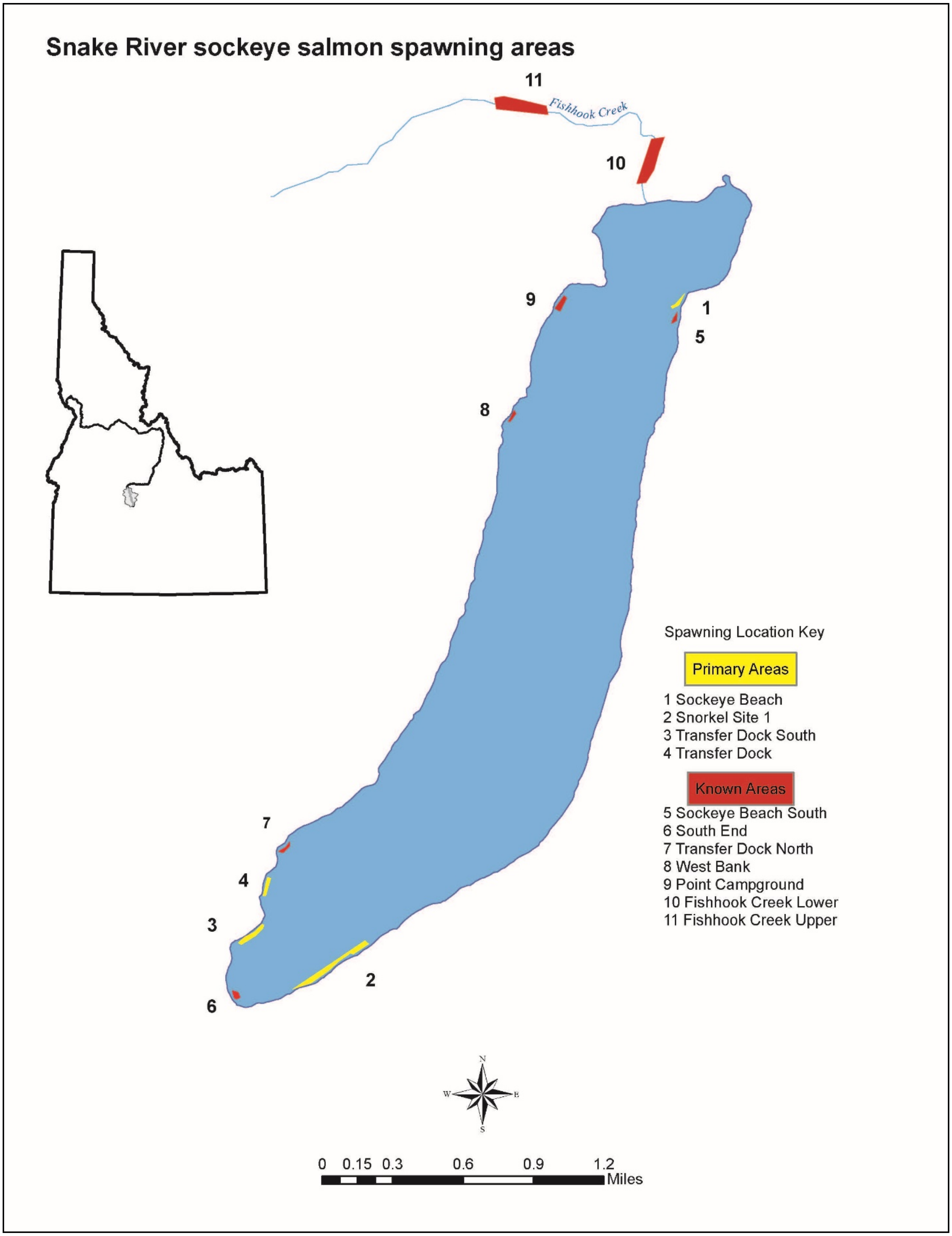

Figure 2-7. Spawning locations for Sockeye Salmon in Redfish Lake.

2.3.3 Genetic Analyses

At the time of the first status review for Snake River Sockeye Salmon (Waples et al. 1991), the relationship between kokanee and Sockeye Salmon in Redfish Lake was uncertain. Monan (1991) concluded that kokanee from Redfish and Alturas Lakes were genetically similar but distinct from samples collected in other lakes in Idaho, Washington, and British Columbia. Waples et al. (1991) suggested that Redfish Lake Sockeye Salmon were genetically distinct from other Sockeye Salmon populations.

After the first status review, genetic analyses were conducted that included adult anadromous Sockeye Salmon that returned to Redfish Lake and residual Sockeye Salmon. Adult Redfish Lake Sockeye Salmon samples collected from 1991, 1992, and 1993 were genetically distinct from Fishhook Creek kokanee, and similar to residual Sockeye Salmon samples (Waples et al. 1997). Alturas Lake kokanee were most similar to Redfish Lake kokanee (Winans et al. 1996). Two important findings presented by Winans et al. (1996) were that 1) stock transfers of *O. nerka* in the Sawtooth Valley did not result in any substantial genetic effects and 2) Sawtooth Valley kokanee are genetically distinct from all other kokanee and Sockeye Salmon sampled in Idaho, Washington, and British Columbia. The dissimilarity between Fishhook Creek kokanee and anadromous and resident Sockeye Salmon was confirmed through analysis of mitochondrial DNA (Faler and Powell 2003). Waples et al. (2011) used variation at 64 allozyme loci to examine genetic relationships among 32 samples of Sockeye Salmon and kokanee from the Snake River basin and other North American locations. Results confirm findings from the previous studies, Griswold et al. (2012) provides an additional review.

Two gene pools of kokanee were identified in Stanley Lake (WCSBRT 2003; Waples et al. 2011). One appears to have originated from introductions of Wizard Falls Hatchery (Oregon) kokanee and the other is a possible remnant of a native *O. nerka* population that survived Rotenone treatments in the 1950s and 1960s. Recent genetic analyses by the IDFG indicate that the native *O. nerka* population is still present within Stanley Lake, and that it has low levels of introgression from non-native introductions of kokanee (Kozfkay 2013a). In contrast, genetic analyses of Pettit Lake kokanee samples did not reveal any trace of the original *O. nerka* gene pool, and the current kokanee population spawning in the lake was traced to kokanee introductions from north Idaho lakes, whose origin was traced to Lake Whatcom (Washington) kokanee (WCSBRT 2003; Waples et al. 2011).

The ICTRT (2003) initially recognized a single extant Sockeye Salmon population in the Snake River ESU (Redfish Lake) but later (ICTRT 2005a) designated three historical Sockeye Salmon populations within the Sawtooth Valley; Redfish Lake (including Little Redfish Lake), Alturas Lake, and Stanley Lake. They also determined that Pettit Lake and Yellowbelly Lake may have supported independent Sockeye Salmon populations, but because of the uncertainty, characterized these as potential populations. All five populations fall within the geographic area of the Snake River Sockeye Salmon ESU.

2.3.4 Lake Hydrology, Limnology, and Carrying Capacity

The Sawtooth Valley lakes are located on the east side of the relatively pristine, granitic Sawtooth Mountains with the majority of their watersheds designated as wilderness. The lakes were formed behind glacial moraines, are relatively deep and are classified as oligotrophic (Table 2-2). They are dimictic, mixing completely in the spring and fall, except for Pettit Lake, which is meromictic, meaning that it does not mix completely during spring and fall turnover. The lakes are thermally stratified during the summer and ice covered from December to early May. The lakes have no man-made hydraulic controls, thus water level elevation is relatively stable, with minor seasonal variation (Graves 2012.) There is no data available for water level elevations (Griswold 2013). Water and nutrient budgets were developed for Redfish Lake in 1992 and 1993 (Gross 1995; Gross et al. 1998).

Table 2-2. Characteristics of Sawtooth Valley lakes with comparison to Lake Wenatchee and Lake Osoyoos (Columbia River basin lakes currently supporting natural Sockeye Salmon production) (BPA 1995).

Lake	Elevation M (ft.)	Secchi Reading m (ft.)	Surface Area hectares (acres)	Maximum Depth m (ft.)
Stanley	1,985 (6,513)	7 (23)	81 (200)	26 (85)
Redfish	1,996 (6,548)	12 (39)	615 (1,519)	91 (299)
Alturas	2,138 (7,014)	10 (33)	338 (835)	53 (174)
Yellowbelly	2,157 (7,076)	9 (30)	73 (200)	26 (85)
Pettit	2,132 (6,996)	13 (43)	162 (400)	52 (171)
Lake Wenatchee	572 (1,877)	6.3 (21)	990 (2,446)	73 (240)
Lake Osoyoos	278 (912)	3.3 (11)	2,300 (5,683)	63 (207)

Researchers have conducted limnology studies in Redfish, Stanley, Yellowbelly, Pettit, and Alturas lakes since 1991. The studies help determine production potential and carrying capacity in the lakes for juvenile Sockeye Salmon. The Shoshone-Bannock Tribes monitor the limnological characteristics of the three largest lakes (Redfish, Pettit and Alturas) and have conducted similar research on Stanley Lake from 1993 to 2005 and Yellowbelly Lake during 1992 and 1993. The monitoring program examines water temperature and dissolved oxygen profiles, water transparency, light penetration, nutrient concentrations, chlorophyll *a* concentrations, phytoplankton and zooplankton abundance, biomass, and species composition.

Monitoring shows that maximum surface water temperatures usually occur during July or August and range from approximately 17-20 ^{o}C (62-68 °F). Mean seasonal (June-October) water temperatures between 0 and 10 m depth range from 10.7-15.8 ^{o}C (51-60 °F) for the four lakes (Redfish, Pettit, Alturas, and Stanley) (Table 2-3). Mean surface water temperatures are inversely correlated with Salmon River discharge. Mean summer water transparencies (Secchi) range between 9.6 m and 15.2 m (31-50 ft) in Redfish, Pettit, and Alturas Lakes and 5.0-8.2 m (16-27 ft) in Stanley Lake. Mean summer total phosphorous concentrations in the epilimnion range from 4.9 to 11.8 *u*g/l. Seasonal mean epilimnetic chlorophyll *a* concentrations range from 0.3 to 2.3 *u*g/l. For all lakes and years, epilimnetic chlorophyll *a* averages 0.8 *u*g/L without nutrient supplementation and 1.6 *u*g/L during years with nutrient supplementation. Algal productivity is generally considered low and limited by both nitrogen and phosphorus (Wurtsbaugh et al. 1997). Gross et al. (1992) conducted nutrient supplementation studies and conclude that it was unlikely that silicate or other micronutrients were controlling algal growth but could possibly become limiting with nutrient supplementation (N and P).

Table 2-3. Seasonal mean (June-October) water temperatures (^{o}C) for 0-10 m depth (measured in 1 m intervals) for Redfish, Petti, Alturas, and Stanley Lakes, Idaho.

	Surface temperature (^{o}C) 0-10m			
Year	Redfish	Pettit	Alturas	Stanley
1992	14.9	15.1	14.7	14.7
1993	13.4	13.6	13.1	11.9
1994	14.7	15.6	14.3	14.6
1995	13.4	13.2	12.2	12.0
1996	12.0	12.2	11.5	10.7
1997	12.2	12.4	11.4	11.5
1998	13.3	13.6	12.6	11.8
1999	12.7	12.7	11.8	11.1
2000	14.2	14.4	13.8	12.4
2000	14.2	14.4	13.8	-
2001	14.3	14.8	14	-
2002	13.6	13.8	12.3	-
2003	13.9	13.7	12.9	-
2004	13.5	14	13.3	-
2005	14.1	13.7	13.1	-
2006	13.3	12.1	12.7	-
2007	13.9	13.6	13.6	-
2008	14.9	15.8	15.3	-
2009	13.9	13.2	13.1	-
2010	12.3	12.6	12.1	-
2011	12.1	12.3	11.9	-

Lake productivity is characterized by the existence of a seasonal, deep chlorophyll *a* maximum, probably due to a plunging inflow of colder, comparatively nutrient-enriched river water during the ice-free period. Planktonic algae are dominated by Chryso- and Cryptophycean nano-flagellates, autotrophic picoplankton, diatoms, and green algae (Budy et al. 1995; Griswold et al. 2002). Primary productivity measurements were obtained in Redfish, Pettit, Alturas, and Stanley

Lakes during 1993, 1995-1997, and 2002 to evaluate the effects of whole-lake nutrient supplementation (Griswold et al. 2002) and for use in the Photosynthetic Rate model (Shortreed et al. 2000). The Photosynthetic Rate model will be used to estimate the rearing capacity for juvenile Sockeye Salmon in Sawtooth Valley lakes. The model is based on a correlation between photosynthetic rate expressed as metric tons of carbon per year and Sockeye Salmon smolt biomass. From this, one can estimate the optimum spawning escapement and spring fry recruitment required to produce maximum smolt numbers and biomass.

Zooplankton biomass and species composition varies among lakes and over time (Figures 2-8 and 2-9). The presence of kokanee with highly variable annual escapement, particularly in Alturas Lake, creates "boom and bust" cycles that result in shifts in species abundance and composition. Zooplankton biomass, which is often the driver for Sockeye Salmon growth, is typically dominated by *Daphnia rosea*, calanoid copepods, and *Bosmina longirostris* with contributions from *Holopedium gibberum*, *Polyphemus pediculus*, and the calanoid copepod *Epischura nevadensis* (Budy et al. 1995; Griswold et al. 2002).

Zooplankton data for Yellowbelly Lake is limited but Steinhart et al. (1993) reported that in 1992 and 1993 the "highest zooplankton biomasses were observed in Yellowbelly and Pettit followed by Stanley Lake. The lowest total zooplankton biomass was observed in Redfish and Alturas Lakes in both years." In 2007, zooplankton was sampled during September in Yellowbelly Lake and compared to several other Sawtooth Valley lakes. Results showed that zooplankton biomass was slightly lower in Yellowbelly than in Redfish and Pettit but the presence of large bodied *Daphnia* and calanoid copepods indicated low levels of planktivory (Figure 2-10).

These data combined with *O. nerka* population data, such as rearing densities and size and growth of outmigrants, are beginning to provide insights into the relative carrying capacities for Sockeye Salmon production (e.g., Flagg et. al. 2004; Selbie et al. 2007). Detailed limnology methods and results can be found in the SBT annual reports to BPA (e.g. Kohler et al. 2000).

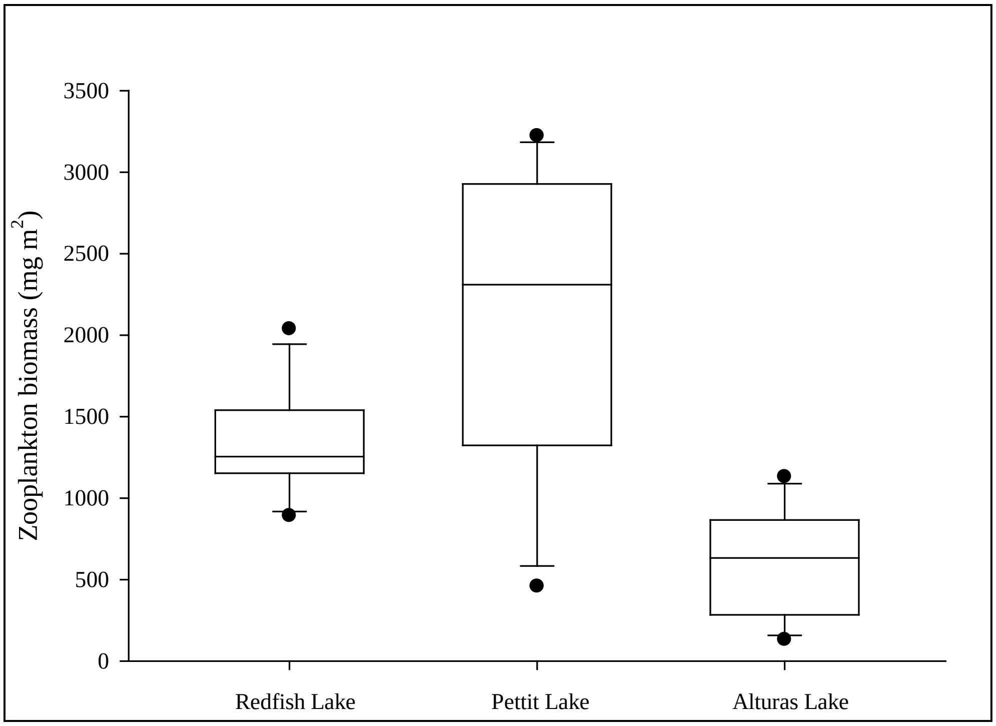

Figure 2-8. Box and whisker charts depicting mean upper and lower quartile and range of zooplankton biomass over time (2000-2011) in Redfish, Pettit, and Alturas Lakes in the Sawtooth Valley, Idaho. (Shoshone-Bannock Tribes unpublished data).

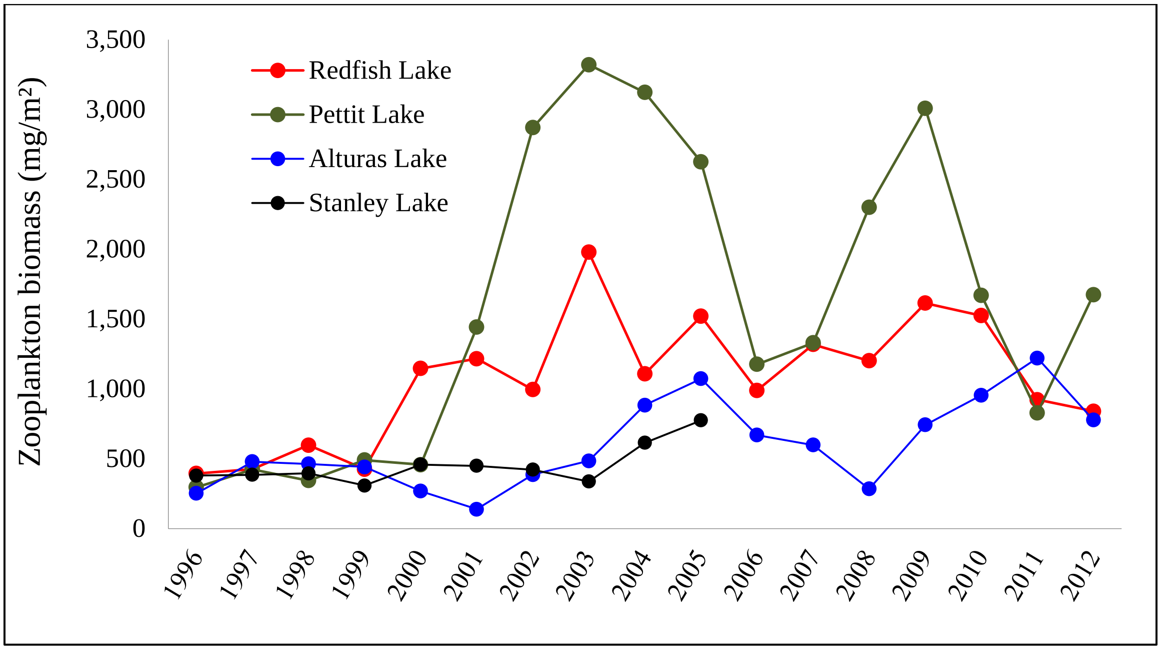

Figure 2-9. Seasonal mean zooplankton biomass for the Sawtooth Valley lakes (June-October), 1996-2012.

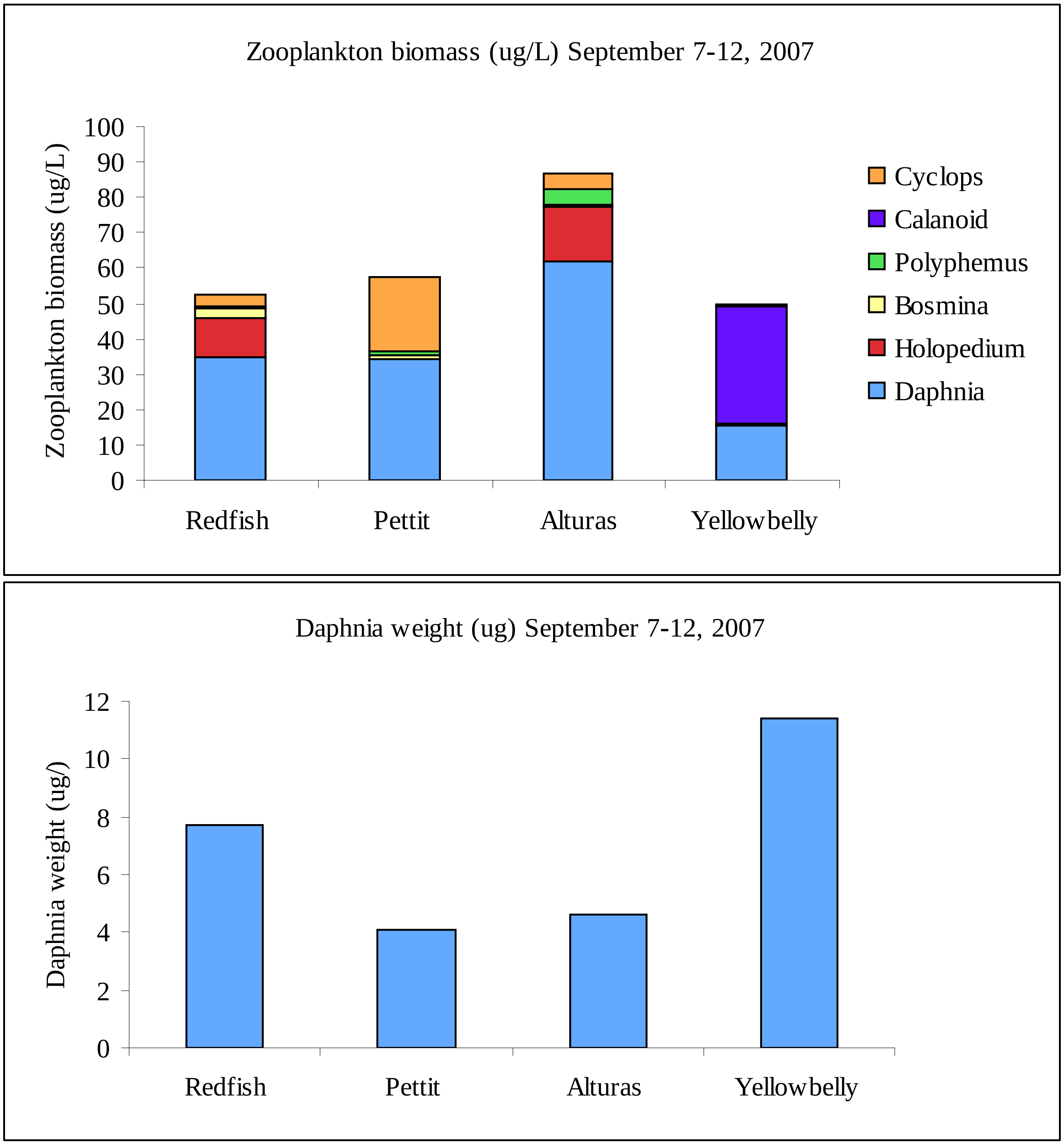

Figure 2-10. Comparison of zooplankton biomass and weight of individual *Daphnia* sampled during September 2007 in Redfish, Pettit, Alturas, and Yellowbelly Lakes, Idaho.

2.3.5 Other Fish Species

Native fish present in Sawtooth Valley waters include the following: Sockeye Salmon and kokanee *O. nerka*, Chinook salmon *O. tshawytscha*, rainbow trout/steelhead *O. mykiss*, westslope cutthroat trout *O. clarkii lewisi*, bull trout *Salvelinus confluentus*, sucker *Catostomus* spp., northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, redside shiner *Richardsonius balteatus*, dace *Rhinichthys* spp., and sculpin *Cottus* spp. (Peterson et al. 2010). Kokanee live in Redfish, Alturas, Pettit, and Stanley Lakes. Bull trout, pikeminnow and suckers are found in Redfish and Alturas Lakes. Alturas Lake includes whitefish at lower frequencies.

Non-native species present in Sawtooth Valley waters include lake trout *S. namaycush* (Stanley Lake only), rainbow trout *O. mykiss*, and brook trout *S. fontinalis*. Yellowbelly Lake was chemically treated in 1990 to reduce brook trout populations and it was then stocked with westslope cutthroat trout. Non-native kokanee salmon were introduced into Pettit, Redfish, Alturas, and Stanley Lakes to establish non-native recreational sport fisheries. Kokanee are native to Pettit Lake, however, genetic analyses indicate that the native population of kokanee may have been completely replaced by non-native introductions of kokanee from northern Idaho (Winans et al. 1996). Stanley Lake continues to support two kokanee populations, one native and one non-native. Recent data analysis suggests that the current population constitutes a native population of kokanee with low levels of non-native introgression and a non-native stock descended from the introduction(s) of Wizard Falls stock kokanee (Kozfkay 2013a).

According to Peterson et al. (2011), rainbow trout are released into Alturas and Stanley Lakes in the summer to increase sport fishing opportunities. Sport fishing on Alturas and Stanley Lakes is covered by Idaho's statewide general fishing regulations, which allow harvest of 6 trout per day (excluding bull trout, which must be released if caught) and 25 kokanee per day with no seasonal closures. Beginning in 2011, trout stocking was discontinued in Pettit Lake (Peterson 2013a). Sport fishing regulations on Redfish Lake restrict kokanee fishing/harvest to January 1 through August 7 to protect residual Sockeye Salmon. No trout have been stocked in Redfish Lake since 1992 (Peterson et al. 2010).

Table 2-3. Fish species present in the Sawtooth Valley Lakes.

Fish Species	Redfish Lake	Alturas Lake	Pettit Lake	Stanley Lake	Yellowbelly Lake
Sockeye salmon	√	√	√		
Kokanee	√	√	√	√	
Rainbow/steelhead		√		√	
W. cutthroat trout					√
Bull trout	√	√	√	√	√
Lake trout				√	
Brook trout	√	√	√	√	√
Sucker	√	√			
N. Pikeminnow	√	√			
Mountain whitefish		√			
Reside shiner		√			
Dace		√			

Predation on Sockeye Salmon

Several fish species that occupy the lakes potentially prey on Sockeye Salmon, including bull trout, northern pikeminnow, and brook trout. Research shows that Sockeye Salmon and kokanee are part of the diet of bull trout and northern pikeminnow. See Section 5.5, Predation for more information.

2.3.6 Captive Broodstock Program

At the time that NMFS listed Snake River Sockeye Salmon as endangered, a group of Federal, state, and tribal partners initiated a captive broodstock program in hopes of preventing the ESU's extinction. Sixteen adult Sockeye Salmon that returned to Redfish Lake from 1991 to 1998, as well as 886 out-migrating smolts captured between 1991 and 1993 and 26 residual Sockeye Salmon captured between 1992 and 1995, were used to develop the program (Hebdon et al. 2004; Flagg et al. 2004). The captive broodstock program has focused on maintaining remaining genetic diversity and population heterozygosity, while striving to rebuild the populations to support delisting and harvest needs. Recent restoration releases aim to restore anadromous *O. nerka* to Redfish, Pettit, and Alturas Lakes (Kline and Flagg 2014).

The captive broodstock program is coordinated by the multi-agency Stanley Basin Sockeye Technical Oversight Committee, whose members include representatives of BPA, NMFS, Idaho Department of Fish and Game, U.S. Forest Service, Oregon Department of Fish and Wildlife, and the Shoshone-Bannock Tribe. The BPA provides funding for the captive broodstock program through the Northwest Power and Conservation Council's Fish and Wildlife Program. NMFS manages the permitting of activities and the captive-rearing program hatchery operations in Manchester and Burley Creek, Washington. The IDFG monitors a variety of fisheries parameters in the field and is responsible for the hatchery operations in Eagle, Stanley, and Springfield, Idaho. The ODFW rears Sockeye Salmon smolts at Oxbow Hatchery near Cascade Locks, Oregon. The U.S. Forest Service participates in permitting activities and habitat improvements. The SBT monitors a variety of fisheries biology parameters and evaluates spawning and rearing habitat characteristics in the Sawtooth Valley nursery lakes (Taki et al. 2006).

Adult Sockeye Salmon at direct release event at Redfish Lake. *Photo: N. Nokkentved, IDFG*

Reintroduction plans for the captive broodstock progeny have followed a “spread-the-risk” philosophy, incorporating multiple release strategies into Redfish, Pettit, and Alturas Lakes (Hebdon et al. 2004). Monitoring and evaluation efforts have focused on maximizing the use of limited hatchery rearing space and on identifying and prioritizing the most successful reintroduction strategies. Further, the genetic focus of the program and adherence to principles of conservation aquaculture has retained approximately 95% of the original variability that remained in the population (Kalinowski et al.2012; Kline and Flagg 2014).

Today, the captive broodstock program continues to play a key role in the recovery of the Snake River Sockeye Salmon ESU, and is considered as a key component of this recovery plan for the species, as discussed in recovery strategy, Section 6.3.11. The program applies a tiered or phased approach that includes increasing the number of adult Redfish Lake Sockeye Salmon returns, incorporating more natural-origin returns in hatchery spawning designs and on spawning grounds, and moving toward the development of an integrated conservation program that takes advantage of local adaptation (IDFG 2010; Kline and Flagg 2014).

The SBSTOC continues to provide technical recommendations and coordination for the Sockeye Salmon captive broodstock program implemented by IDFG and other agencies. The captive broodstock program continues to evolve as the total number of hatchery and natural-origin Sockeye Salmon returning to Redfish Lake increases. As this Snake River Sockeye Salmon recovery plan is implemented and Sockeye Salmon recovery efforts move beyond the captive broodstock phase, IDFG plans to meet future demand for increased juvenile Sockeye Salmon production at the recently constructed Springfield Hatchery near the town of Springfield in Bingham County, Idaho, which was completed in 2013. IDFG's 2010 Springfield Hatchery Master Plan estimates production of up to one million Sockeye Salmon smolts annually to support continued re-colonization of Sockeye Salmon into Redfish, as well as potential reintroduction programs developed for Pettit, Alturas, and other Sawtooth Valley lakes (IDFG 2010). The program includes specific biological triggers to guide the transition to the final phase (local adaptation), including the ramp-down and ultimate discontinuation of captive broodstock efforts at the facilities.

2.3.7 Watershed Land Use and Demographics

Sawtooth Valley lakes and streams form the headwaters of the Salmon River, a major tributary to the Snake River. Located entirely within the Sawtooth National Recreation Area, most of the land in the valley is higher than 1,970 m (6,463 ft.) above sea level. The watersheds of these major lakes lie mostly within the Sawtooth Wilderness Area, and drain the east side of the granite Sawtooth Mountains. The U-shaped lake basins were once heavily glaciated, leaving large moraines behind which the lakes are impounded (Killsgaard et al. 1970; Alt and Hyndman 1989).

Land use in the Sawtooth Valley is predominantly cattle ranching and recreation. The private lands, with ranches and scattered residences, are primarily used as pasture. Alturas Lake Creek is the only outlet stream from the lakes that crosses these private agricultural lands before entering the Salmon River. The town of Stanley had a population of 63 in the 2010 census. More than 1 million people per year visit the Sawtooth National Recreation Area, mostly in the summer (Griswold et al. 2002).

The Sawtooth National Recreation Area encompasses roughly 3,150 km^2 (778,000 acres) and is heavily used in the summer for fishing, boating, hiking, picnicking, camping, and livestock grazing. In the winter, the area is used for cross-country skiing, snowmobiling, and other outdoor activities. The Sawtooth National Recreation Area contains five major road-accessible lakes (Alturas, Pettit, Yellowbelly, Redfish, and Stanley) and numerous other lakes and streams. The Sawtooth National Recreation Area is managed by the U.S. Forest Service.

The lakes of the Sawtooth National Recreation Area have numerous recreational facilities such as campgrounds and picnic areas. Camping, fishing, scuba diving, hiking, sightseeing, swimming, boating, jet skiing, and other day-use activities are common on each of the five major Sawtooth Valley lakes. Table 2-4 lists the recreational facilities and activities at each lake.

Table 2-4. Recreation facilities and activities on Sawtooth Valley lakes (BPA 1995).

Lake	Facilities	Activities
Stanley	campgrounds (39 sites) 1 boat ramp 1 picnic and overlook area	Fishing, motor boating, sail boating, canoeing, and snowmobiling
Redfish	Visitor Center Lodge (holds 125 persons) 5 campgrounds (105 sites) 1 boat ramp 2 swimming beaches 3 picnic areas	Fishing, swimming, all types of boating, waterskiing on 615-acre lake, 5 miles in length cross-country skiing, horseback riding and boat tours
Yellowbelly	No improved facilities	Fishing, dispersed camping, and boating with horsepower restrictions
Pettit	Campgrounds (5 sites) Boat ramp Day use area	All types of boating, waterskiing, fishing, snowmobiling, and cross-country skiing
Alturas	campgrounds (55 sites) Picnic area for up to 125 persons	All types of boating, waterskiing, fishing, snowmobiling, cross-country skiing and amphitheater events

The Shoshone-Bannock and Nez Perce Tribes have hunting and fishing rights in the Sawtooth National Forest that have been reserved by treaty.

Stanley Lake

Stanley Lake supports rainbow trout, kokanee, and lake trout. The self-sustaining population of lake trout is present in Stanley Lake as a result of a one-time introduction by IDFG in 1975 (USFS 2011). It is regularly stocked with rainbow trout by IDFG. Brook trout, Chinook salmon, westslope cutthroat trout, steelhead, and various species of sculpin and sucker are found in Stanley Lake Creek, the outlet of the lake. In 1956, a barrier was installed at the outlet of Stanley Lake by IDFG to prevent fish from migrating into the lake; it remains today.
Stanley Lake was stocked with non-native kokanee from 1988 to 1991, an early spawning stock. The 1990s data from Waples (1991) suggests that kokanee are a mix of native and non-native fish within this lake. IDFG has re-sampled the kokanee population to identify the current genetic composition of kokanee. Results of this recent analysis suggest that the current Stanley Lake population constitutes a native population of kokanee with low levels of non-native introgression (Kozfkay 2013a).

Recreation facilities at Stanley Lake include three campgrounds, a day use area, a boat launch, and hiking trails. The lake is a common fishing destination for both shore and boat anglers.

Redfish Lake

Redfish Lake remains the only lake with returning Sockeye Salmon adults. The recovery program continues to introduce Sockeye Salmon adults and juveniles into Redfish Lake and IDFG operates a weir within Redfish Lake Creek. Successful adult returns have occurred since 2000, with a high of 1,117 Sockeye Salmon returning in 2011 (including 142 natural-origin fish); 1,355 returning in 2010 (including 179 natural-origin fish); 833 fish returning in 2009 (including 85 natural-origin fish); and 650 fish in 2008 (including 142 natural-origin fish).

Kokanee are a target game fish species in Redfish Lake. Fishhook Creek, a tributary to Redfish Lake, was stocked with non-native kokanee from 1930 to 1987, with an early spawning stock from the Anderson Ranch Reservoir. Similar to the kokanee in Alturas Lake, genetic analyses suggest no remaining impacts from these earlier stocking events (Waples et al. 2011).

Salmonid species present in the lake include Chinook salmon and steelhead. Sockeye Salmon are released into the lake to spawn naturally as part of the Sockeye Salmon recovery program. Between Redfish Lake and the Salmon River, Little Redfish Lake and Redfish Lake Creek also contain bull trout and cutthroat trout.

Yellowbelly Lake

Target game fish species in Yellowbelly Lake include brook trout and cutthroat trout; the latter are stocked in most years. An outlet barrier was constructed by IDFG in 1961 to prevent access by anadromous fish and it was removed by the U.S. Forest Service in 2000. A lag deposit formation located 402 meters (a quarter-mile) below the outlet of the lake, where Yellowbelly Lake Creek flows through pore spaces of a boulder field, that did not historically restrict Sockeye Salmon passage. Yellowbelly Lake hosts no developed campgrounds and development around the lake is minimal.

Pettit Lake

Pettit Lake contains kokanee, rainbow trout, and Sockeye Salmon. Sockeye Salmon are planted in the lake annually. The lake was stocked with non-native kokanee from 1932-1968. In the early 1960s, it was chemically treated. The kokanee that exist today are a non-native north Idaho late spawning stock. Development on Pettit Lake is limited to one campground and day use area, mountain cabins, and a boat launch. Pettit Lake Sockeye Salmon/kokanee are shoal spawners.

Alturas Lake

Alturas Lake is a highly oligotrophic lake located at an elevation of 2,138 m (7,014 ft). The lake has a surface area of 338.2 ha (835 ac) and 7.9 km (4.9 miles) of shoreline. Its source (inlet) and drainage (outlet) is Alturas Lake Creek. The lake supports a population of bull trout, along with kokanee, mountain whitefish, suckers, northern pikeminnow, and hatchery rainbow trout. "Historically, spring Chinook salmon spawned and reared in Alturas Lake Creek above and below the lakes and in Alpine Creek, a tributary of Alturas Lake Creek, for approximately (2.4 km (1.5 miles). Some summer steelheads also use Alturas Lake Creek. Sockeye Salmon spawned in the upper drainage and reared in Alturas Lake" (Andrews et al. 1987). Spring Chinook salmon still spawn in Alturas Lake Creek, though at reduced levels from historical abundance.

Fisheries for kokanee and rainbow trout occur in Alturas Lake. Brook trout, bull trout, and the occasional Chinook salmon or steelhead can also be found. Rainbow trout and Sockeye Salmon are stocked in Alturas Lake annually. Alturas Lake is one of the more developed lakes in the Sawtooth Valley, with three campgrounds, day use areas and a boat launch (IDFG 2010).

2.4 Critical Habitat

The ESA requires the Federal government to designate "critical habitat" for any species it lists under the ESA. The Act defines critical habitat as areas that contain physical or biological features that are essential for the conservation of the species, and that may require special management or protection. Critical habitat designations must be based on the best scientific information available, in an open public process, within specific timeframes. The designations are one factor to consider during the identification and prioritization of recovery actions in recovery plans.

A critical habitat designation applies only when Federal funding, permits, or projects are involved. Under section 7 of the ESA, all Federal agencies must ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species, or destroy or adversely modify its designated critical habitat. Before critical habitat is designated, careful consideration must be given to its economic impacts, impacts on national security, and other relevant impacts. The Secretary of Commerce may exclude an area from critical habitat if the benefits of exclusion outweigh the benefits of designation, unless excluding the area will result in the extinction of the species concerned. A critical habitat designation does not set up a preserve or refuge. Critical habitat requirements do not apply to citizens engaged in activities on private land that do not involve a Federal agency; however, activities that impair habitat used by listed species may constitute a violation of the ESA in some circumstances.

The physical and biological elements, also called "primary constituent elements," or PCEs, that support one or more life stages and are considered essential to the conservation of the species are described in detail in the final rule designating critical habitat for 12 West Coast salmon and steelhead ESUs/DPSs (NMFS 2005b). Essential salmon habitat consists of four components: (1) spawning and juvenile rearing areas: (2) juvenile migration corridors; (3) areas for growth and development to adulthood; and (4) adult migration corridors. Essential features of spawning and rearing areas include adequate (1) spawning gravel; (2) water quality; (3) water quantity; (4) water temperature; (5) food; (6) riparian vegetation; and (7) access (NMFS 1993). Essential features of juvenile migration corridors include adequate: (1) substrate; (2) water quality; (3) water quantity; (4) water temperature; (5) water velocity; (6) cover/shelter; (7) food; (8) riparian vegetation; (9) space; and (10) safe passage conditions (NMFS 1993). The adult migration corridors are the same areas, and the essential features are the same with the exception of adequate food (adults do not eat on their return migration to natal streams).

The Pacific Ocean areas used by listed salmon for growth and development to adulthood are not well understood and essential areas and features in the ocean have not been identified (NMFS 1993).

Table 2-5 is a summary of the physical and biological features considered essential for anadromous salmon and steelhead.

Table 2-5. Types of sites and essential physical and biological features designated as PCEs for anadromous salmonids, and the life stage each PCE supports (NMFS 2005b).

Site	Essential Physical and Biological Features	ESU/DPS Life Stage
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity	Juvenile growth and mobility
	Water quality and forage	Juvenile development
	Natural cover[a]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[b]	Juvenile and adult mobility and survival
Estuarine areas	Free of obstruction, water quality and quantity, and salinity	Juvenile and adult physiological transitions between salt and freshwater
	Natural cover[a,] forage[b] and water quantity	Growth and maturation
Nearshore marine areas	Free of obstruction, water quality and quantity, natural cover[a] and forage[b]	Growth and maturation, survival
Offshore marine areas	Water quality and forage[b]	Growth and maturation

[a] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.

Critical habitat for Snake River Sockeye Salmon was designated on December 28, 1993 (NMFS 1993). It includes the juvenile and adult migration corridor to the Pacific Ocean: the Columbia River and its estuary, the Snake River, and the main fork of the Salmon River up to the Sawtooth Valley and the site of current spawning, Redfish Lake. Other historical nursery areas that are essential to the conservation of the species and identified as critical habitat include Alturas, Pettit, Stanley, and Yellowbelly Lakes and their inlet and outlet creeks, Alturas Lake Creek, and that portion of Valley Creek between Stanley Lake Creek and the Salmon River (NMFS 1993). NMFS is currently working to produce a map showing critical habitat for this ESU and will add the map to the recovery plan when it becomes available.

The lower Columbia River corridor is among the areas of high conservation value to all Columbia and Snake River basin species because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats.

For Snake River Sockeye Salmon designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high water line on each side of the river channel) (NMFS 1999). Specific watersheds constituting critical habitat for each species were identified in the respective final rules (NMFS 1993, NMFS 1999b, and NMFS 2005b).

NMFS recognizes that salmon habitat is dynamic and that present understanding of areas important for conservation will likely change as recovery planning sheds light on areas that can and should be protected and restored, such as areas upstream of barriers where fish could be reestablished in historical habitat.

NMFS will update its critical habitat designations as needed as new information becomes available, including information developed during recovery plan implementation. Critical habitat designations are one element to consider in identifying and prioritizing recovery actions.

2.5 Salmonid Biological Structure

Most of the time salmon return to spawn in the streams or lakes where they were born. However, they occasionally “stray” and choose to spawn where conditions are right, perhaps in an adjacent stream or lake. The result is that salmon populations that are geographically widespread may have some amount of genetic similarity. They are linked because of straying, and differentiated because of long-term adaptation to different environments. Diverse genetic, life history, and morphological characteristics that have evolved over generations give the species as a whole the resilience to persist over time.

Historically, most salmon or steelhead species typically contained multiple populations connected by some small degree of genetic exchange with spawners straying in from other areas, (exceptions to this general pattern, however, are the examples of single lake ESUs for Sockeye Salmon, e.g., Lake Ozette Sockeye Salmon.) Thus, the overall biological structure of the species is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles will have less genetic similarity. The species is essentially a metapopulation defined by the common characteristics of populations within a geographic range (Figure 2-10).

McElhany et al. (2000) formally identified two levels in this hierarchy for recovery planning purposes: the evolutionarily significant unit (ESU), which is a special type of distinct population segment (DPS) applicable to Pacific salmon, and the independent population. (An independent populaions is a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For NMFS' purposes in recovery planning, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame (McElhany et al. 2000)). The ICTRT identified an additional level between the population and ESU/DPS levels, which they call a major population group (MPG) (McClure et al. 2003).

Unlike most Chinook salmon ESUs and steelhead DPSs, the lake-spawning Sockeye Salmon ESUs may comprise only a single population, such as, for example, the Lake Ozette Sockeye Salmon ESU, which is made up of Sockeye Salmon that spawn exclusively in Lake Ozette, on the Olympic Peninsula in Washington State. Different spawning aggregates may represent spatial diversity for these Sockeye Salmon: beach locations vs. lake tributaries, lake outlets, rivers between lakes. In the case of Snake River Sockeye Salmon, spawners returning to the various lakes within the Sawtooth Valley may historically have constituted separate ESUs.

2.5.1 Evolutionarily Significant Units (ESUs) and Distinct Population Segments (DPSs)

A salmon ESU or steelhead DPS is a distinctive group of Pacific salmon or steelhead that is uniquely adapted to a particular area or environment. Because of the hierarchical structure of salmonid populations, the concept of "distinctive group" has received considerable attention and refinement. An ESU is defined as "a group of Pacific salmon that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment and treated as a species under the Endangered Species Act." (Waples et al. 1991). A "population segment" is considered "distinct" (a DPS and hence, like ESUs, considered a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, or if it occupies an unusual or unique ecological setting, or if its loss would represent a significant gap in the species' range. ESUs/DPSs may contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds and river basins.

2.5.2 Major Population Groups

Within an ESU/DPS, independent populations can be grouped into larger populations that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). These "major population groups" (MPGs) are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between ESUs/DPSs. The relationship between ESU/DPS, MPG, and independent populations is depicted in Figure 2-11.

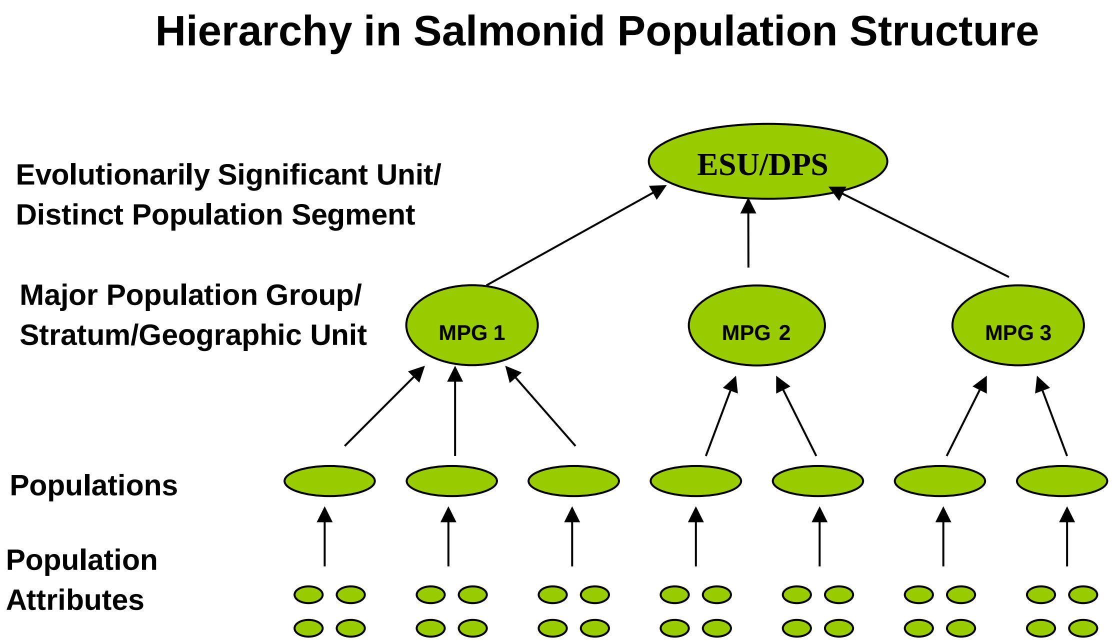

Figure 2-11. Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning.

2.5.3 Independent Populations

McElhany et al. (2000) defined an independent population as follows:

> *…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame.*

2.5.4 Snake River Sockeye Salmon ESU Structure

The ICTRT defined Snake River Sockeye Salmon as a single ESU with a single major population group, the Sawtooth Valley Lakes MPG. The group determined that the one MPG historically supported at least three independent sockeye salmon populations (Redfish, Alturas, and Stanley Lakes) (ICTRT 2007). The MPG is currently made up of one extant population (Redfish Lake) and two (Alturas Lake and Stanley Lake) to four (possibly also Pettit and Yellowbelly Lakes) other historical populations (Figure 2-12).

Hierarchy in Snake River Sockeye Salmon ESU Structure

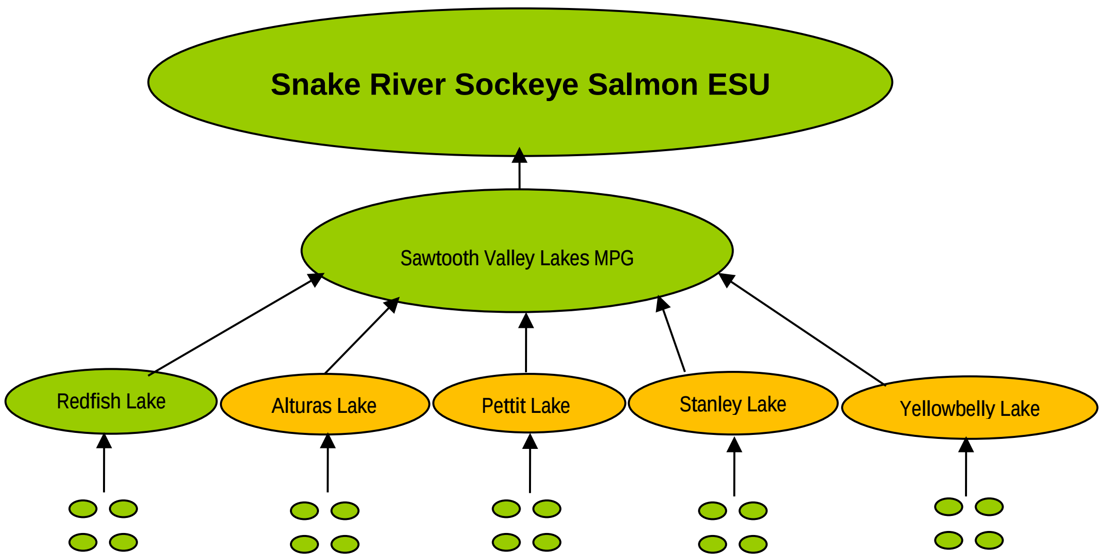

Figure 2-12. Hierarchial levels in Snake River Sockeye Salmon ESU. Redfish Lake (shown in green) is the ESU's only extant population. The Alturas, Pettit, Stanley and Yellowbelly Lake populations are currently extirpated.

Historically, the Snake River basin likely supported additional Sockeye Salmon populations and MPGs, and possibly other separate ESUs. As discussed earlier in the Plan, Sockeye Salmon once ascended the Snake River to the Wallowa, Payette, and Salmon River basins to spawn in natural lakes. Within the Salmon River basin, Sockeye Salmon spawned in Warm Lake in the South Fork Salmon River basin, as well as in the Sawtooth Valley lakes. The historical relationships between the different Snake River Sockeye Salmon populations are not known.

2.6 Viable Salmonid Populations

A Viable Salmonid Population is an independent population of any Pacific salmon or steelhead that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame (McElhany et al. 2000). NMFS scientists measure salmon recovery in terms of four parameters, called the viable salmonid population (VSP) parameters: abundance, productivity, spatial structure, and diversity. Biological viability criteria, described in more detail in Section 3, establish threshold values for the VSP parameters appropriate to population size.

2.6.1 Abundance and Productivity

Abundance is expressed in terms of spawners (adults on the spawning ground), measured over a time series, i.e. some number of years. The ICTRT often uses a recent 10- or 12-year geometric mean of natural spawners as a measure of current abundance.

The productivity of a population (the average number of surviving offspring per parent) is a measure of the population's ability to sustain itself. Productivity can be measured as spawner: spawner ratios (returns per spawner or recruits per spawner) (or adult progeny to parent), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, typically subject to a high degree of annual variability and sampling-induced uncertainties. The ICTRT recommends estimating current intrinsic productivity using spawner-to-spawner return pairs from low to moderate escapements over a recent 20-year period.

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations.

The VSP guidelines for abundance recommend that a viable population should be large enough to have a high probability of surviving environmental variation observed in the past and expected in the future; be resilient to environmental and anthropogenic disturbances; maintain genetic diversity; and support/provide ecosystem functions (McElhany et al. 2000).

Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on the average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels (ICTRT 2005b).

Abundance should be high enough that 1) declines to critically low levels would be unlikely, assuming recent historical patterns of environmental variability and intrinsic productivity; 2) compensatory processes provide resilience to the effects of short-term perturbations; and 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns) (ICTRT 2005b).

2.6.2 Spatial Structure and Diversity

A population's spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000, p. 18). Diversity refers to the distribution of traits within and among populations. Some traits are completely genetically based, while others, including nearly all morphological, behavioral, and life history traits, vary as a result of a combination of genetic and environmental factors (McElhaney et al. 2000). Spatial structure and diversity considerations are combined in the evaluation of a salmonid population's status because they are so interrelated.

Populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events, such as a landslide, than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life history characteristics.

Population-level diversity is similarly important for long-term persistence. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes. Phenotypic diversity, which includes variation in morphology and life history traits, allows more diverse populations to use a wider array of environments, and protects populations against short-term temporal and spatial environmental changes. Underlying genetic diversity provides the ability to survive long-term environmental changes.

Because neither the precise role that diversity plays in salmonid population viability nor the relationship of spatial processes to viability is completely understood, the ICTRT adopted the principle from McElhany et al. that historical spatial structure and diversity should be taken as a "default benchmark," on the assumption that historical, natural populations did survive many environmental changes and therefore must have had adequate spatial structure and diversity.

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Section 3: Recovery Goals and Delisting Criteria

3.1 Background on Developing Biological Viability Criteria

3.2 Recovery Goals and Biological Viability Criteria for Snake River Sockeye Salmon

3.3 Listing Factors / Threats Criteria

3.4 Delisting Decision

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3. Recovery Goals and Delisting Criteria

This section describes the biological recovery goals and delisting criteria that NMFS will use in future ESA status reviews of the Snake River Sockeye Salmon ESU. These reviews will contribute to NMFS' larger objective of delisting the Snake River Sockeye Salmon ESU.

The recovery goals that are incorporated into a recovery plan may include delisting, reclassification (e.g., from endangered to threatened), and/or other "broad sense" goals that may go beyond the requirements for delisting to acknowledge social, cultural, or economic values regarding the listed species. Delisting criteria must meet ESA requirements, while recovery may be defined more broadly. The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species should be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12; 50 CFR 223.102 and 224.101). These criteria are of two kinds: the biological viability criteria, which deal with population or demographic parameters, and the "threats" criteria, which relate to the five listing factors detailed in the ESA (see Section 3.2 and 3.4 of this Plan). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B) for the delisting decision.

The delisting criteria are based on the best available scientific information and incorporate the most current understanding of the ESU and the threats it faces. As this recovery plan is implemented, additional information will become available that can increase certainty about whether the threats have been abated, whether improvements in population and ESU status have occurred, and whether linkages between threats and changes in salmon status are understood. These delisting criteria will be assessed through an adaptive management program and NMFS may review whether the criteria may warrant revision during its five-year reviews of the ESU. As the biological status of natural-origin spawners improves over time, the ESA five-year status review process can be used to articulate the changes in viability parameters and ESA listing factors that might warrant a review of whether the ESU's listing status should be changed from endangered to threatened, as well as to delist. Given the current abundance of natural-origin spawners, however, NMFS is not proposing downlisting criteria in this recovery plan. The five-year status review process will be used to evaluate this ESU's progress toward recovery and determine if any future change in ESA listing status is warranted.

As described in Section 4, NMFS convened the ICTRT and requested that they develop biological viability criteria specifically adapted for listed Interior Columbia salmon and steelhead. The ICTRT developed its viability criteria based on a set of general guidelines set out in McElhany et al. (2000), expressed in terms of population level abundance, productivity, spatial structure, and diversity (the VSP parameters). The ICTRT criteria represent a consistent framework with examples of metrics that are intended to be evaluated and adapted to fit the specific characteristics and conditions of a particular ESU or DPS. The criteria are hierarchical, with ESU/DPS level objectives being expressed in terms of the viability status of individual populations considered in aggregate major population groupings (MPGs).

NMFS has adopted recovery plans covering listed species in two of the three major sub-regions of the Columbia River domain: Middle Columbia River steelhead and Upper Columbia River steelhead in the Middle Columbia subregion, and spring Chinook salmon in the Upper Columbia subregion. Both of these plans incorporated biological recovery criteria that build on the viability criteria developed by the ICTRT (ICTRT 2007).

The following sections describe background information for developing biological viability criteria, proposed recovery goals, and biological viability criteria for Snake River Sockeye Salmon, listing factors/threats criteria, and delisting decision evaluation considerations that describe conditions on the basis of which, if met, NMFS would decide to remove the species from the Federal list of endangered and threatened species.

3.1 Background on Developing Biological Viability Criteria

In 2007, the ICTRT completed its Technical Review Draft of Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs (ICTRT 2007). Biological viability criteria are quantitative metrics that describe ESU/DPS characteristics associated with a low risk of extinction for the foreseeable future. These criteria are based on the VSP parameters of abundance, productivity, spatial distribution, and diversity, according to guidelines developed by NOAA's Northwest Fisheries Science Center and published as a NOAA Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000, ICTRT 2007).

Sections 2.5 and 2.6 of this Plan describe salmonid biological structure and the viable salmonid population parameters of abundance, productivity, spatial structure, and diversity to characterize the viability status of salmon and steelhead (McElhany et al. 2000). The ICTRT used these parameters to describe biological viability criteria applicable to each of the ESA-listed Interior Columbia Basin salmonid ESUs (ICTRT 2007). Following the guidance in McElhany et al. (2000), the ICTRT developed ESU-level criteria expressed in terms of the status of component populations organized into major population groups (MPGs). These criteria can then be used to understand the status of Interior Columbia Basin ESA-listed salmon and steelhead ESUs and DPSs with the goal of having ESUs be at low risk and provide for the greatest probability for persistence of the ESU (ICTRT 2007).

3.1.1 Viability Criteria for ESUs with One MPG

In 1991, NMFS determined that the Snake River Sockeye Salmon is a “species,” an ESU, under the ESA and concluded that it should be listed as endangered (NMFS 1991). The ESU includes “all naturally spawned anadromous and residual Sockeye Salmon originating from the Snake River basin. Also, sockeye salmon from one artificial propagation program: the Redfish Lake Captive Broodstock Program” (70 FR 37160, Jun 28, 2005, (NMFS 2005b); reaffirmed 79 FR 20802, April 14, 2014).

Further investigations have clarified our understanding of the different Sockeye Salmon life history forms in the Sawtooth Valley natal lakes. For example, following the 1991 listing decision, a “residual” form of Snake River Sockeye Salmon was identified in Redfish Lake. In 1993 NMFS determined that the residual population of Snake River Sockeye Salmon that exists in Redfish Lake is substantially reproductively isolated from kokanee and represents an important component in the evolutionary legacy of the species and should be included in the listed ESU (NMFS 1993).

Kokanee are defined as the self-perpetuating, generally non-anadromous form of *O. nerka* that occurs in balanced sex-ratio populations and whose parents, for several generations back, have spent their whole lives in fresh water. The NMFS Biological Review Team determined in its status review that Redfish Lake Sockeye Salmon are genetically distinct from kokanee and did not include the fish in the ESA listing (Waples et al. 1991). NMFS continues to reevaluate the situation. Genetic analysis in 1997 showed that Redfish Lake sockeye and kokanee are genetically distinct, and that Alturas Lake kokanee are most similar to Redfish Lake kokanee (Waples et al. 1997). NMFS recognizes, however, that in some situations where there is presumably some regular, or at least episodic, genetic exchange between resident and anadromous forms, they should be considered part of the same ESU. The key issue is evaluating the strength and duration of reproductive isolation between the resident and anadromous forms. If in the future it is determined that kokanee are part of the ESU’s genetic and evolutionary legacy, or that extant kokanee populations are contributing to the anadromy, their relationship will be re-evaluated. As recovery progresses over time, and as anadromous or residual fish in the natal lakes re-emerge or are reestablished, any new information about kokanee will be considered regarding whether it should be part of the listed ESU.

NMFS’ subsequent 1997 Technical Memo discusses *O. nerka* life history and non-anadromous life history forms. NMFS cites Ricker’s 1938 definition of the terms "residual Sockeye Salmon" and "residuals" to identify resident, non-migratory progeny of anadromous Sockeye Salmon parents. For the purposes of NMFS’ 1997 review, “resident Sockeye Salmon” referred to those fish that are the progeny of anadromous parents, yet spend their adult life in freshwater and are observed together with their anadromous siblings on the spawning grounds.

A number of lakes ranging widely in size within the Columbia River basin historically supported Sockeye Salmon production. In the Snake River drainage, Wallowa Lake, the Payette Lake basin, and Warm Lake formerly supported Sockeye Salmon. However, these lake groups are separated by distances that are consistent with those between other Sockeye Salmon ESUs. The ICTRT concluded that it is unclear, and currently unresolvable, whether these lake groups were MPGs of the same ESU or separate ESUs (ICTRT 2007). Given this uncertainty, the ICTRT treats the Snake River Sawtooth Valley Sockeye Salmon as a single ESU with a single MPG made up of one extant population (Redfish Lake) and two (Alturas Lake and Stanley Lake) to four (possibly also Pettit and Yellowbelly Lakes) other historical populations (ICTRT 2010). The ICTRT has used the best available scientific information to make these ESU/MPG determinations; however, these delineations will be re-evaluated as new information becomes available.

ESUs that contain only one MPG are inherently at greater extinction risk than salmon species with several MPGs (ICTRT 2007). Such species will, by definition, have a more limited spatial structure, less diversity, and potentially less abundance and productivity than those with multiple MPGs. In addition, such ESUs typically have fewer component populations, which increases their risk level (Boyce 1992; Tear et al. 2005; ICTRT 2007). The ICTRT developed more stringent applications of their biological criteria for ESUs with a single MPG to mitigate this inherently higher risk. The persistence of multiple single population Sockeye Salmon ESUs across the range of the species supports the assumption that long-term sustainability in the face of year-to-year variations in environmental effects and localized catastrophic events is possible with sufficiently high levels of abundance, productivity, diversity and spatial structure.

ESUs that contained only one MPG historically, or that include only one MPG critical for proper function, should meet the ICTRT's MPG criteria, as well as the following additional criteria (ICTRT 2007):

1. Two-thirds or more of the historical populations within the MPG should meet viability standards; and
2. At least two populations should meet the criteria to be "Highly Viable."

3.1.2 Recovery Scenarios

For most ESUs, the ICTRT viability criteria could be met with alternative combinations of populations meeting their individual objectives. The possible combinations of risk status for populations in each MPG that would allow the ESU/DPS to meet the viability criteria are called "recovery scenarios."

The ICTRT included examples of possible recovery scenarios that would allow each Snake River ESU/DPS to meet the viability criteria (ICTRT 2007). The ICTRT selected these combinations of risk status based on the populations' unique characteristics, such as run timing, population size, or genetics; major production areas in the MPG; and spatial distribution of the populations. The ICTRT cautioned against prematurely restricting the options for any population. In most cases, the ICTRT recovery scenarios reflected information on current and historical production from the target ESU. In other cases, including Snake River Sockeye Salmon, longer-term viability analyses and estimates of current natural production characteristics must depend largely on inferences from monitoring populations in other areas (e.g. Upper Columbia River, Fraser River system). The current ICTRT recovery scenarios and the ESU specific applications reflect the best available information. The following section includes a summary of the example developed by the ICTRT for the Snake River Sockeye Salmon ESU.

3.2 Recovery Goals and Biological Viability Criteria for Snake River Sockeye Salmon

Snake River Sockeye Salmon are still close to extinction, supported primarily by a captive broodstock program. This program has substantially improved the numbers of hatchery-produced *O. nerka* for use in supplementation, and in recent years the levels of naturally produced Sockeye Salmon returns have increased. Nevertheless, substantial increases in survival rates across life history stages must occur in order to reestablish sustainable natural production (Ford 2011).

3.2.1 Recovery Goals

This Plan aims to meet two types of recovery goals. The primary goal is for biological recovery to support removal of the Snake River Sockeye Salmon ESU from the threatened and endangered species list. Once the fish achieve recovery under the ESA, this Plan also aims to meet broader goals. These “broad sense” goals strive to rebuild the populations to provide for sustainable fisheries and other benefits.

Biological Recovery Goals

The recovery goal for the Snake River Sockeye Salmon, as for all ESUs/DPSs, is to ensure that the ESU is self-sustaining and no longer needs the protection of the ESA. The ESU-level objectives are the following:

- Population-level persistence in the face of year-to-year variations in environmental influences.
- Combination of abundance and productivity sufficient to sustain a population (in the absence of hatchery supplementation) at levels that will maintain genetic and spatial diversity.
- Resilience to the potential impact of catastrophic events.
- Populations distributed in a manner that insulates against loss from a local catastrophic event and provides for recolonization of a population that is affected by such an event.

- Maintaining long-term evolutionary potential.
- Sustaining natural production across a range of conditions, allowing for adaptation to changing environmental conditions.

Broad-Sense Recovery Goals

The immediate goal of this Plan is ESA delisting of Snake River Sockeye Salmon. This Plan also recognizes that while the goal of recovering Sockeye Salmon to the point that it no longer requires protective measures of the ESA is an immediate priority, building on this success with continued recovery efforts will be important to achieve broader goals. The broad sense goal is that naturally spawning Snake River Sockeye Salmon populations are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) to provide significant ecological, cultural, social, and economic benefits. Recovery of Snake River Sockeye Salmon populations throughout the full life cycle will require actions that preserve, enhance and restore healthy watershed conditions where ecosystem functions, processes and dynamics are intact ─ including instream conditions, riparian habitat diversity and complexity, and upland watershed health in concert with complementary management of harvest, hatcheries, and hydropower. Recovery is a process that leads to Sockeye Salmon populations that are not only viable, but that also provide a harvestable surplus for the treaty tribes, citizens of Idaho, and for others in the region.

3.2.2 Biological Viability Criteria

The ICTRT adapted its approach to accommodate the biological characteristics and available data for the Snake River Sockeye Salmon, but generated a viability curve for this ESU following the same analytical steps as applied to the stream-type Chinook salmon and steelhead ESUs (ICTRT 2010). Table 3-1 shows the biological viability criteria for Snake River Sockeye Salmon.

Table 3-1. VSP parameters and biological viability criteria for Snake River Sockeye Salmon.

VSP Parameter	Biological Viability Criteria
Abundance	• Minimum spawning abundance threshold measured as a ten-year geometric mean of estimated natural-origin spawners: 1,000 for Redfish Lake and Alturas Lake populations (intermediate size category); • Minimum spawning abundance threshold measured as a ten-year geometric mean of estimated natural-origin spawners: 500 for populations in the smaller historical size category (Pettit, Stanley, or Yellowbelly Lakes)

Productivity	• Population growth rate is stable or increasing
Spatial Structure and Diversity	• Very low to low risk rating for a highly viable population; and • Moderate risk rating for a viable population

3.2.2.1 Abundance and Productivity

Redfish Lake is approximately 62% of the size of Lake Wenatchee in the upper Columbia Basin, yet the other Sawtooth Valley lakes are relatively small compared to other lake systems in the Columbia Basin that historically supported Sockeye Salmon production. The ICTRT developed a general approach for assigning individual populations to one of four size categories based on historical habitat intrinsic potential (ICTRT 2007). For each ESU, populations in the smallest size category based on habitat intrinsic potential were assigned a minimum abundance level of 500 spawners (measured as a ten-year geometric mean of estimated natural-origin spawners). The minimum abundance levels for larger historical size categories were assigned systematically to ensure that average spawning densities were sufficient to provide for within population diversity and spatial structure (ICTRT 2007). These viability criteria may be revised as new information becomes available, and as the production potential of other natal lakes becomes more certain. This is a critical uncertainty and key information need that is further discussed in Section 6.4.

For Sockeye Salmon, intrinsic potential was estimated in terms of lake surface area (hectares) based on relationships reported for Sockeye Salmon lakes in Alaska and Canada (e.g., Burgner 1991). Stanley, Pettit, and Yellowbelly Lakes are assigned to the smallest size category. Redfish and Alturas Lakes are classified as intermediate in size. For Snake River Sockeye Salmon, the ICTRT minimum abundance thresholds for Redfish Lake (intermediate) and Pettit Lake (small) were the same as recommended by the Snake River Recovery Team (Bevan et al. 1994). Alturas Lake was assigned to the intermediate-size category in the historical size analysis conducted by the ICTRT, which resulted in a higher recommended target minimum abundance threshold of 1,000 (measured as a ten-year geometric mean of estimated natural-origin spawners). It is important to note that the Sawtooth Valley lakes are generally smaller than the lakes used to generate the general relationship between lake area and average Sockeye Salmon production, and that the Sawtooth Valley is at a significantly higher elevation. The ICTRT recommended criteria (including the minimum abundance thresholds) reflect the best information currently available. Still, information gained from ongoing studies of the production potential in each of the Sawtooth Valley lakes, and the rates of exchange among them, should be periodically reviewed to determine if the basic assumptions behind the current criteria remain valid, or if updates would be warranted.

The ICTRT recommended considering average natural-origin abundance and productivity in combination when assessing viability and expressed criteria for these parameters in terms of viability curves corresponding to particular risk thresholds (ICTRT 2007). ESU-specific curves corresponding to thresholds of 1%, 5%, and 25% risk over 100 years were generated and used to define very low, low, and moderate extinction risk categories. These criteria were specifically designed to inform longer-term status and recovery evaluations of listed ESUs. Variations on these basic criteria for use in assessing short-term performance and risk are possible, and could be developed and incorporated into recovery implementation strategies as an aid to assessing progress. The ICTRT did not have a sufficient trend data set for Redfish Lake Sockeye Salmon to use in directly generating a viability curve. They set the minimum spawning abundance threshold at 1,000 natural-origin spawners measured as a ten-year geometric mean for the Redfish and Alturas Lake populations, and 500 natural-origin spawners measured as a ten-year geometric mean for populations in the smallest historical size category (e.g., Pettit, Yellowbelly or Stanley Lake). They used a run reconstruction of Lake Wenatchee Sockeye Salmon as the basis for a representative set of variance and autocorrelation input values along with average age structure from historical Redfish Lake data (ICTRT 2007, Appendix A). The viability curves that correspond to the two size categories of Sawtooth Valley lakes (e.g., intermediate and small) are depicted in Figures 3-1 a & b. The productivity associated with achieving an average natural-origin spawning abundance at the minimum threshold varies as a function of population size category and target risk level. For example, an average productivity exceeding 1.2 and a minimum average natural-origin spawner abundance of 1,000 would be required to achieve a very low risk rating (<1% risk projected over 100 years) for abundance and productivity for intermediate category populations (Redfish Lake and Alturas Lake).

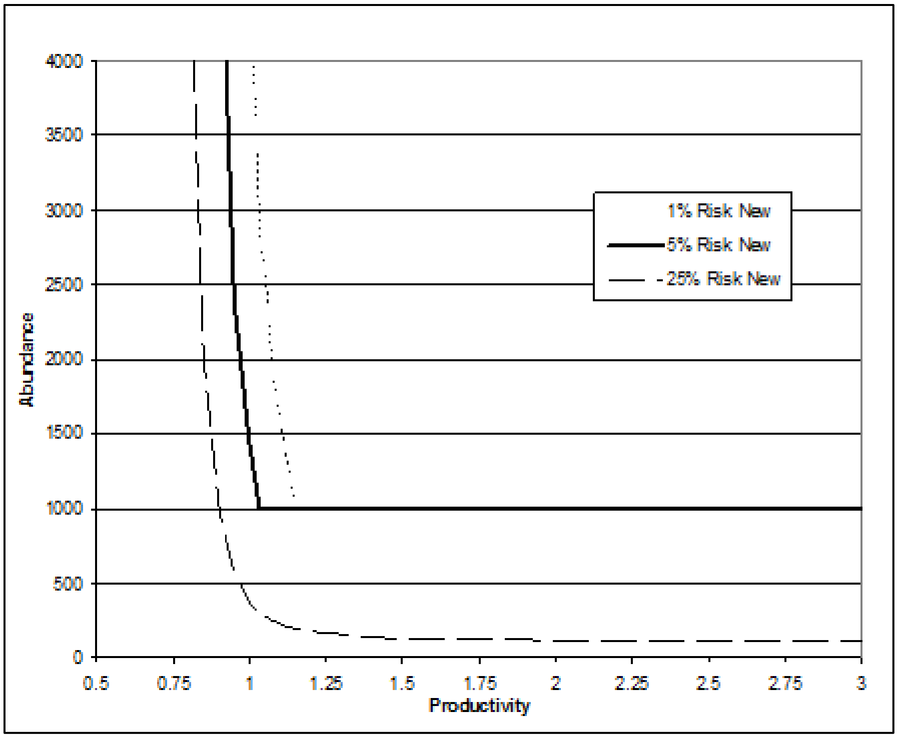

Figure 3-1. a.

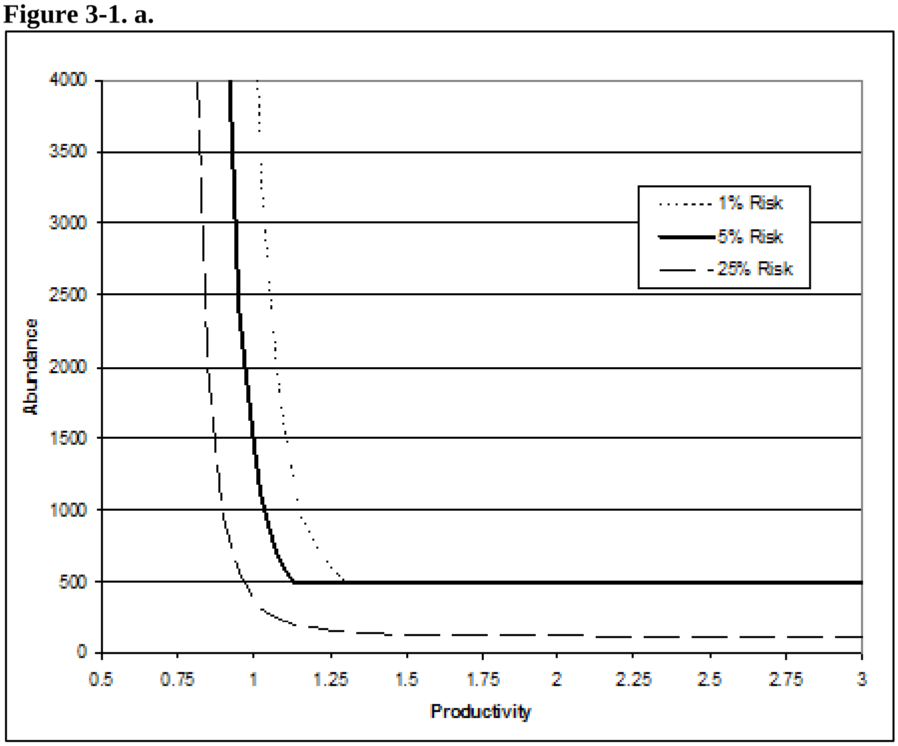

Figure 3-1. b.

Figures 3-1a & b. Viability curves for application to Snake River Sockeye Salmon lake populations. a) Redfish Lake and Alturas Lake (Intermediate). b) small lake populations (Stanley Lake). Age structure used was 60% age-4 and 40% age-5 adult returns. Adjusted variance (variance unexplained by autocorrelation) and autocorrelation parameters (derived from Lake Wenatchee data) were 0.42 and 0.41, respectively.

3.2.2.2 Spatial Structure and Diversity

Reintroduction or reestablishment of independent Sockeye Salmon populations in Alturas and Pettit Lakes will increase the spatial structure and diversity of the MPG/ESU. An important recent development is that Alturas Lake native kokanee have produced early-returning and earlier spawning anadromous *O. nerka* (than adults returning to Redfish Lake). Recent trucking of these early-returning fish above the Sawtooth Hatchery weir to Alturas Lake presents promise of improving ESU spatial structure and diversity. After successful reintroductions in Alturas and Pettit Lakes, the feasibility of reestablishing a population in Stanley Lake will be explored.

It is possible that distinct naturally spawning aggregations in Redfish Lake could develop. Recently, some Redfish Lake Sockeye Salmon have been spawning in Fishhook Creek. More detailed information on the spatial structure within and among the Sawtooth Valley lakes populations will be generated as recovery efforts progress. As with abundance and productivity, results from these specific investigations may provide for more specific expressions of viability criteria for application to Snake River Sockeye Salmon to ensure the underlying objectives are met. The risks to ESU life-history diversity will be diminished by reestablishing life-history patterns that may have been present in the natal lakes. It appears that we may have such an opportunity to restore both shoal beach and stream spawning life-history types in the ESU.

3.2.2.3 Recovery Scenario

The ICTRT recommended that the long-term recovery scenario should include restoring at least two of the three historical lake populations in the ESU to highly viable, and one to viable status, using Redfish Lake, Alturas Lake, and Pettit Lake. As recovery efforts progress over time, the ICTRT recommended considering expansion of reintroductions into Yellowbelly Lake and Stanley Lake.

3.3 Listing Factors/Threats Criteria

Threats, in the context of salmon recovery, are understood as the activities or processes that cause the biological and physical conditions that limit salmon survival (the limiting factors). Threats also refer directly to the listing factors detailed in section 4(a)(1) of the ESA. Listing factors are those features that are evaluated under section 4(a)(1) when initial determinations are made whether to list species for protection under the ESA.

ESA section 4(a)(1) listing factors are the following:

A. Present or threatened destruction, modification, or curtailment of [the species'] habitat or range;
B. Over-utilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms; or

E. Other natural or human-made factors affecting [the species'] continued existence.

At the time of a delisting decision for the Snake River Sockeye Salmon ESU, NMFS will examine whether the section 4(a)(1) listing factors have been addressed. To assist in this examination, NMFS will use the listing factors (or threats) criteria described below, in addition to evaluation of biological recovery criteria and other relevant data and policy considerations. The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence.

NMFS recognizes that perceived threats, and their significance, can change over time due to changes in the natural environment or changes in the way threats affect the entire life cycle of salmon. Indeed, this has already happened. As discussed earlier, some threats perceived as significant effects on Snake River Sockeye Salmon at the time of listing, such as harvest mortality, have since been addressed through management adjustments and now pose little danger to species viability. Other threats, such as the mainstem hydropower system, continue to limit recovery efforts. At the same time, new threats, such as those posed by climate change, may be emerging. Consequently, NMFS expects that the relative priority of threats will continue to change over time and that new threats may be identified. During its five-year reviews, NMFS will review the listing factor criteria as they apply at that time.

The specific criteria listed below for each of the relevant listing/delisting factors help to ensure that underlying causes of decline have been addressed and mitigated before a species is considered for delisting. NMFS expects that if the proposed actions described in the Plan are implemented, they will make substantial progress toward meeting the following listing factor (threats) criteria for Snake River Sockeye Salmon. Section 5 discusses the threats and limiting factors that currently affect Snake River Sockeye Salmon viability.

Factor A: The present or threatened destruction, modification, or curtailment of [the species'] habitat or range.

To determine that the ESU is recovered, threats to habitat should be addressed as outlined below:

1. Passage obstructions (e.g., dams, artificial fish barriers, weirs, and culverts) are removed or modified to improve survival and restore access to historically accessible habitat where necessary to support recovery goals. Reestablish the conditions necessary for residual Sockeye Salmon to express anadromy.
2. Flow conditions that support adequate rearing, spawning, and migration are achieved through management of mainstem and tributary irrigation and hydropower operations, and through increased efficiency and conservation in other consumptive water uses such as municipal supply.
3. Forest management practices that protect watershed and stream functions are implemented on Federal, state, tribal, and private lands.

4. Agricultural practices, including grazing, are managed in a manner that protects and restores riparian areas, floodplains, and stream channels, and protects water quality from sediment, pesticide, herbicide, and fertilizer runoff.
5. Urban, rural, and recreational development does not reduce water quality or quantity, or impair natural stream or lake conditions so as to impede achieving recovery goals.
6. Limnetic processes are protected and restored so that ecological inputs (of sediment, instream and groundwater flows, insects, leaves and wood) and ecological habitat processes support properly functioning lake and shoreline habitat conditions, which in turn support adequate adult migration, rearing, and spawning habitat for Sockeye Salmon and the species they prey upon.
7. The effects of toxic contaminants on salmonid fitness and survival are understood and are sufficiently limited so as not to affect recovery.
8. Channel function, including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity are restored to provide adequate rearing and spawning habitat.
9. Floodplain function and the availability of floodplain habitats for salmon are restored to a degree sufficient to support a viable ESU/DPS. This restoration should include connectedness between river and floodplain and the restoration of impaired sediment delivery processes.

Factor B: Over-utilization for commercial, recreational, scientific, or educational purposes.

To determine that the ESU is recovered, any utilization for commercial, recreational, scientific, or educational purposes should be managed as outlined below:

1. Fishery management plans are in place that (a) accurately account for total fishery mortality (i.e., both landed catch and non-landed mortalities) and constrain mortality rates to levels that are consistent with recovery; and (b) are implemented in such a way as to avoid deleterious genetic effects on populations or negative effects on the distribution of populations.
2. Federal, tribal, and state rules and regulations are effectively enforced.
3. Technical tools accurately assess the effects of the harvest regimes so that harvest objectives are met but not exceeded.
4. Handling of fish is minimized to reduce indirect mortalities associated with educational or scientific programs, while recognizing that monitoring, research, and education are key actions for conservation of the species.
5. Routine construction and maintenance practices are managed to reduce or eliminate mortality of listed species.

Factor C: Disease or predation.

To determine that the ESU is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below:

1. Hatchery operations do not subject targeted populations to deleterious diseases and parasites and do not result in increased predation rates of wild fish.
2. Predation by avian predators is managed in a way that allows for recovery of Sockeye Salmon populations.
3. Populations of introduced exotic predators such as smallmouth bass, walleye, and catfish are managed such that competition or predation does not impede recovery.
4. Physiological stress and physical injury that may cause disease or increase susceptibility to pathogens during rearing or migration is reduced during critical low flow periods (e.g. low water years) or poor passage conditions (e.g. at diversion dams or bypasses).

Factor D: The inadequacy of existing regulatory mechanisms.

To determine that the ESU is recovered, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be addressed as outlined below:

1. Adequate resources, priorities, regulatory frameworks, and coordination mechanisms are established and/or maintained for effective enforcement of land and water use regulations that protect and restore habitats, including water quality and water quantity, and for the effective management of fisheries.
2. Habitat conditions and watershed functions are protected through land-use planning that guides human population growth and development.
3. Habitat conditions and watershed function are protected through regulations that govern resource extraction such as timber harvest and gravel mining.
4. Habitat conditions and watershed functions are protected through land protection agreements as appropriate, where existing policy or regulations do not provide adequate protection.
5. Regulatory, control, and education measures to prevent additional exotic plant and animal species invasions are in place.
6. Sufficient priority instream water rights for fish habitat are in place.

Factor E: Other natural or human-made factors affecting [the species'] continued existence.

To determine that the ESU is recovered, other natural and man-made threats to its continued existence should be addressed as outlined below:

1. Hatchery programs are being operated in a manner that is consistent with individual watershed and region-wide recovery approaches; appropriate criteria are being used for integration of hatchery Sockeye Salmon populations and extant natural populations inhabiting watersheds where the hatchery fish return.
2. Hatcheries operate using appropriate ecological, genetic, and demographic risk containment measures for (1) hatchery-origin adults returning to natural spawning areas, (2) release of hatchery juveniles, (3) handling of natural-origin adults at hatchery facilities, (4) withdrawal of water for hatchery use, (5) discharge of hatchery effluent, and (6) maintenance of fish health during their propagation in the hatchery.
3. Monitoring and Evaluation plans are implemented to measure population status, hatchery effectiveness, and ecological, genetic, and demographic risk containment measures.
4. Nutrient enrichment programs are implemented where it is determined that nutrient limitations are a significant limiting factor for Sockeye Salmon production and that nutrient enrichment will not impair water quality.
5. Recovery actions, together with monitoring and evaluation programs, seek to understand the impacts of climate change on the marine environment and marine survival of Pacific-origin Sockeye Salmon, and adapt recovery actions to address information on the impacts of climate change.

3.4 Delisting Decision

In accordance with its responsibilities under section 4(c)(2) of the ESA, NMFS will conduct reviews of Snake River Sockeye Salmon every five years to evaluate the status of the species and gauge progress toward delisting. Such evaluations will take into account the following:

- The biological recovery criteria (ICTRT 2007) and listing factor (threats) criteria described above.
- The management programs in place to address the threats.
- Principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000).
- Best available information on population and ESU status and new advances in risk evaluation methodologies.
- Other considerations, including: the number and status of extant spawning groups; the status of the major spawning groups; linkages and connectivity among groups; the diversity of life history and phenotypes expressed; and considerations regarding catastrophic risk.

Section 4: Current Status Assessment of Snake River Sockeye Salmon ESU

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4. Current Status Assessment of Snake River Sockeye Salmon ESU

In 2011, NMFS determined in its five-year review of the Snake River Sockeye Salmon that the ESU should retain its "endangered" classification (NMFS 2011b, http://www.nmfs.noaa.gov/pr/pdfs/species/snakeriver_salmonids_5yearreview.pdf). The five-year review depended in part on Ford (2011), which provided an updated scientific summary of the risk status of the subject species.

Before the initiation of the captive brood-based hatchery program, Snake River Sockeye Salmon had declined to remnant population components apparently maintained by residual spawning in one or two lakes — in some years no anadromous Sockeye Salmon returned to the basin. In terms of natural production, this ESU remains at a very high risk of extinction. As a result, the most recent five-year review discussed long-term natural production objectives and indicators measuring progress on key initial phase restoration steps. These included building a sufficient level of anadromous returns from captive brood releases for outplanting assessments and measures of key life stage survivals (e.g., egg or adult outplant to outmigrant smolt and lake migrant to Lower Granite Dam). Building to target levels of adult hatchery returns and gaining knowledge of key survival rates are important steps towards successfully reestablishing natural production in the Sawtooth Valley.

NMFS' biological viability criteria for salmonid populations and the methods for assessing risk of extinction are based on the VSP parameters of abundance, productivity, spatial structure, and diversity, described in detail in Section 3. In this section we review the most recent data on Snake River Sockeye Salmon status for these parameters, based on NMFS 2008 Supplemental Comprehensive Analysis (NMFS 2008b), as updated with IDFG's more recent adult return data; the ICTRT's 2010 status assessment (ICTRT 2010); and the most recent five-year review of West Coast ESA-listed salmonids (Ford 2011).

4.1 Abundance and Productivity

Adult Sockeye Salmon returns to Redfish Lake during the period 1954 through 1966 were of natural-origin and ranged from 11 to 4,361 fish (Bjornn et al. 1968). In 1985, 1986, and 1987, 11, 29, and 16 Sockeye Salmon, respectively, were counted at the Redfish Lake weir (WCSBRT 2003; Good et al. 2005). In 1991, at the time of the listing, only one, one, and zero Sockeye Salmon had returned to Redfish Lake in the three preceding years, respectively.

Biologists have also counted Sockeye Salmon at the Sawtooth Fish Hatchery weir since its installation on the Salmon River above Redfish Lake Creek in 1985. The weir captured three anadromous Sockeye Salmon in 1985 and two in 1987, but no Sockeye Salmon in 1986. Since then, captures of additional unmarked adult Sockeye Salmon of unknown origin at the Sawtooth

Fish Hatchery weir included one in 1988, one in 1996, three in 2002, three in 2004, one in 2006 and three in 2007. Known adult returns from Alturas Lake (confirmed by genetic analysis) have been trapped at the Sawtooth Fish Hatchery weir in recent years: one, one, fourteen, and two Sockeye Salmon in 2008, 2009, 2010, and 2011, respectively (Kozfkey 2013b).

Between 1991 and 1998, all 16 of the natural-origin adult Sockeye Salmon that returned to the weir at Redfish Lake were incorporated into the captive broodstock program, as well as out-migrating smolts captured between 1991 and 1993, and residual Sockeye Salmon captured between 1992 and 1995 (Hebdon et al. 2004). The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several million eggs and juveniles, as well as several thousand adults, for release into the wild.

4.1.1 Current Abundance Data

Estimates of annual returns are now available through 2014 (Table 4-1) (IDFG, in prep.). Between 1999 and 2007, more than 355 adults returned from the ocean from captive broodstock releases – almost 20 times the number of wild fish that returned in the 1990s (Flagg et al. 2004). However, this total is primarily due to large returns in the year 2000 (number: 257). Returns for 2003-2007 were relatively low, similar to the range observed between 1987 and 1999. Sockeye Salmon returns have increased since 2008. Adult returns the last seven years include 646 fish in 2008 (including 140 natural-origin fish), 832 in 2009 (including 86 natural-origin fish), 1,355 in 2010 (including 178 natural-origin fish), 1,117 in 2011 (including 145 natural-origin fish), 257 adults in 2012 (including 52 natural-origin fish, 272 adults in 2013 (including 79 natural-origin fish), and 1,579 adults in 2014 (including 453 natural-origin fish) (IDFG, in prep.). Approximately two-thirds of the adults captured in each year were taken at the Redfish Lake Creek weir; the remaining adults were captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence (Ford 2011). In addition, Sockeye Salmon (adults derived from early stream spawning kokanee) attempting to return to Alturas Lake, but stopped by the Sawtooth Fish Hatchery weir, have ranged from 1 adult in 2002 to 14 adults in 2010. No Sockeye Salmon attempted to return to Alturas Lake in 2012, 2013, or 2014 (IDFG, in prep.).

Table 4-1. Hatchery and natural-origin Sockeye Salmon returns to Sawtooth Valley, 1999 - 2014 (IDFG, in prep.).

Return Year	Total Return	Natural Return	Hatchery Return	Observed (Not trapped)	Assigned Alturas Returns*
1999	7	0	7	0	0
2000	257	10	233	14	0
2001	26	4	19	3	0
2002	22	6	9	7	1
2003	3	0	2	1	0
2004	27	4	20	3	0
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	646	140	456	50	1
2009	832	86	730	16	2
2010	1,355	178	1,144	33	14
2011	1,117	145	954	18	2
2012	257	52	190	15	0
2013	272	79	191	2	0
2014	1,579[3]	453	1,062	63	0

*These fish are included in the natural return numbers.

4.1.2 Productivity

The ICTRT defines productivity as the expected return per spawner (or other measure of population growth rate) from low to moderate escapements averaged over the most recent 20-year period. During the reintroduction phase, assessing productivity of naturally spawning Sockeye Salmon in each of the lakes as adults returning from the hatchery supplementation program will be an important indicator of progress towards recovery goals. Until spawning is reestablished in at least one lake (a major intermediate term objective of the recovery strategy for this ESU), direct estimates of population productivity will not be possible. However, measures of key components of overall life cycle productivity will be very informative for assessing progress towards recovery during the initial reintroduction phases. For example, with recent increased returns from the hatchery program and from outplants of anadromous spawners to Redfish Lake, it has been possible to estimate adult returns with greater accuracy, to compare juvenile survival/mortality by inriver migration vs. transport, and to compare adult survival between various reaches during upstream passage. The reintroduction of spawners into each lake, initially comprised of returns or outplants from the hatchery program, will provide for an

[3] Note: Including one unknown origin Sockeye Salmon in 2014.

opportunity to directly evaluate juvenile production rates and, ultimately, gain insights into carrying capacity relationships. As the program progresses, direct information on another key question, a potential increase in parr production rates from naturally produced adult returns, should also become available. In the short term, periodic status reviews are summarizing information on survival estimates for key sub-elements of overall productivity as it becomes available (i.e., from life stage survival studies focusing on hatchery releases and initial outplanting evaluations). Recent data on the survival of juvenile and adult migrants, which determine productivity in the smolt-to-adult portion of the life cycle, are described in the following sections.

Juvenile production from natural spawning

As adults from the reintroduction program begin to spawn in Redfish Lake, an important element of the adaptive management program will involve sampling designed to produce direct estimates of the levels of parr and outmigrant smolt abundance as a function of annual estimates of adult spawning. Evaluating juvenile production levels as parent spawning levels increase will provide important early indications of a key life stage component of overall productivity, spawner to juvenile survivals. As juvenile production levels increase, monitoring efforts should also provide direct information on density dependent limitations on production.

Juvenile migrant survival — Sawtooth Lakes to Lower Granite Dam

Hatchery releases from the captive broodstock program have allowed fish managers to track the migration of hatchery juvenile Sockeye Salmon after release in the Sawtooth Valley. These monitoring and evaluation studies show that the fish move quickly through the reach, often arriving at Lower Granite Dam in approximately seven days. Estimated survival for the hatchery juveniles in the reach has been highly variable among different release locations, rearing strategies, origin, and years (Axel et al. 2014). Based on detections of Sockeye Salmon hatchery juveniles that were tagged with a PIT-tag and released in spring, survival estimates have ranged from 11.4% in 2000 (Zabel et al. 2001) to 77.6% in 2008 (Faulkner et al. 2008).

IDFG and NMFS continue to conduct studies to characterize migration and survival for juvenile Snake River Sockeye Salmon between the upper Snake River basin and Lower Granite Dam. This project applies a multifaceted tracking approach, utilizing PIT-tag and radio-telemetry methodologies to demonstrate where and when mortality is occurring. Data collected from the studies indicates that release timing of hatchery smolts may have a direct impact on survival estimates. High flows in the upper Salmon River also likely contribute to shorter travel times between release sites and Lower Granite Dam (Axel et al. 2014).

In addition, data indicate that the majority of juvenile mortality occurs between the release location and the North Fork Salmon River, after which mortality appears to level off to Lower Granite Dam (Axel et al. 2014). Higher losses appear to occur within Little Redfish Lake, in the reach just above Valley Creek near Stanley, between the Pahsimeroi and Lemhi Rivers, and in the slow-river reach at Deadwater Slough (Axel et al. 2014). Research continues to examine the causes of mortality in each reach and determine how release strategies might be changed to improve juvenile migrant survival. Currently, losses in several of these sections seem to be related to predation; however, other possible culprits include competition with non-native species, environmental conditions, or the results of rearing and release strategies. Upon completion, the research should provide a better understanding of where mortality occurs during downstream migration to Lower Granite.

Juvenile migrant survival — Lower Granite Dam to Bonneville Dam

Survival rates for juvenile Sockeye Salmon migrants in the reach from Lower Granite Dam to Bonneville Dam reflect aggregate rates for two major downstream migration routes: inriver passage and downstream transport to below Bonneville Dam. Based on data for yearling Snake River Chinook salmon, NMFS estimates that the proportion of Snake River Sockeye Salmon migrants transported each year has ranged from approximately 98% in 2001 to 23% in 2012 (Table 23 in Faulkner et al. 2013). About 36% of yearling Chinook salmon (and potentially Sockeye Salmon) migrants were transported in 2013 (Zabel 2013). The mean estimated survival of juvenile inriver Snake River Sockeye Salmon migrants from Lower Granite to McNary Dam was 60% for the period 1996-2010; individual year estimates ranged from 28% (1996) to 76% (2008) (Ferguson 2010). Mean survival from McNary Dam to Bonneville Dam (1998-2003, 2006-2010) was 54%, which should be interpreted with caution due to small sample sizes and associated low detection probabilities for many of the individual year estimates (Ferguson 2010). Juvenile survival from Lower Granite to Bonneville Dam since 2008 has ranged from 40% to 57% (NMFS 2014c).

Juvenile and adult migrant survival — Estuary, Plume, and Ocean

The following discussion of factors that affect the survival of Columbia Basin Sockeye Salmon in the estuary, plume, and ocean is excerpted from Fresh et al. (2014).

The effects of variability in ocean productivity can mask, enhance, or even override underlying trends in freshwater habitat productivity and lead to a misinterpretation of the causes of variability in adult returns. However, the estuarine and ocean ecology of this ESU is largely unknown. After its near extirpation by the mid-1990s, the ESU remains at very low abundance levels and only a handful of the Sockeye Salmon caught in surveys off the west coast of Vancouver Island since 1998 were confirmed as originating from the Snake River (M. Trudel, Department of Fisheries and Oceans Canada, personal communication). We must use information on Sockeye Salmon originating from other spawning areas, including the unlisted Okanogan and Lake Wenatchee ESUs and the populations in British Columbia and Alaska, to draw inferences about the estuarine and marine life history of Snake River Sockeye Salmon.

Based on PIT-tag detections, peak passage of juvenile Snake River Sockeye Salmon at Bonneville Dam is generally in late May, about two weeks later than that of all Columbia Basin Sockeye Salmon juveniles combined. Catches of all juvenile Sockeye Salmon in the estuary peak in early June, with most fish caught between May 15 and June 15 (Weitkamp et al. 2012). There is relatively little annual variation in migration timing through the estuary: peak catches occurred on June 1, 2007, June 5, 2008, and June 10, 2010 (no peak observed in 2009) (Weitkamp et al. 2012). Two PIT-tagged Sockeye Salmon migrated from Redfish Lake to RM 9 in 15 and 21 days, respectively; one of the fish detected at RM 9 had been detected at Bonneville Dam three days earlier.

Sockeye Salmon immediately begin migrating north when they leave the Columbia; none have been caught south of the river's mouth in 15 years of sampling. They are most abundant off Washington in May and June, but some have migrated as far as the northern coast of British Columbia (Tucker et al. 2009) by June. Sockeye Salmon are absent from the ocean off Washington by September. They move north, with some evidence of migration along the Alaskan coast, entering the offshore waters of the Gulf of Alaska by winter (Tucker et al. 2009), although these observations were overwhelmingly dominated by fish from British Columbia populations.[4]

Evidence from a variety of salmon ESUs and steelhead DPSs, including some from the Columbia Basin, supports the hypothesis that early marine life is a critical period that largely determines the strength of adult returns years in the future (Ricker 1976; Beamish et al. 2004; Mueter et al. 2005; Farley et al. 2007; Wells et al. 2008; MacFarlane 2010; Moore et al. 2010; Duffy at al. 2011; Thomson et al. 2012; Tomaro et al. 2012; Miller et al. 2013; Burke et al. 2013). Most early marine mortality is thought to occur during two critical periods within the first year of ocean life. The first period is thought to be predation-based mortality that occurs during the first few weeks to months (e.g., Brosnan et al. 2014; Freidland et al. 2014). The second occurs during and following the first winter at sea and is thought to be driven by food availability/starvation (Beamish and Mahnken 2001; Moss et al. 2005). That is, juvenile fish have to consume enough food during their first spring and summer at sea to achieve a critical size with enough accumulated energy reserves that they can survive the following winter. Studies with a variety of salmonid stocks (including Columbia River spring Chinook salmon) have found that body size and survival are often positively related (Bilton et al. 1982; Holtby et al. 1990; Henderson and Cass 1991; Mortensen et al. 2000; Duffy et al. 2011; Tomaro et al. 2012; Woodson et al. 2013). In general, larger bodied fish are less likely to die than smaller bodied fish although this relationship may not be true under all ocean environmental conditions (Irvine et al. 2013; Woodson et al. 2013) or for all species (Welch et al. 2011). Fish size can affect vulnerability to predation as well as starvation (Willette et al. 2001). The marine diet of Sockeye Salmon is dominated by invertebrates, especially euphausiids (krill) in the Gulf of Alaska and Bering Sea (Peterson et al. 1982; Brodeur 1990; Myers et al. 1999).

[4] Of the 4,156 juvenile Sockeye Salmon analyzed by Turner et al. (2012), 4,062 were allocated to regional populations and Columbia Basin fish accounted for about 4% of these.

Adult migrant survival — Bonneville Dam to Lower Granite Dam
Adult PIT-tag detectors, in place since 2002 at Bonneville, McNary, and Lower Granite dams, allow NMFS to monitor the survival of specific stocks (e.g., those from the Oxbow versus Sawtooth hatcheries) through the Bonneville to Lower Granite Dam migration corridor.

Before the number of returning adult Snake River Sockeye Salmon increased due to releases through the captive broodstock program, PIT-tag detections from upper Columbia River Sockeye Salmon stocks were used to extrapolate the survival rates for Snake River Sockeye Salmon in the Bonneville to Lower Granite Dam migration corridor. This changed after enough known-origin adult Snake River Sockeye Salmon returned to the Columbia Basin in 2010–2012 to make PIT-tag-based direct (rather than extrapolated) conversion rate estimates for the reach.

The Corps of Engineers recently installed PIT-tag detectors in both ladders at The Dalles Dam. These detectors are allowing estimates of survival rates between Bonneville and The Dalles dams and between The Dalles and McNary dams, helping regional managers assess where losses are occurring. NMFS and the Action Agencies are assessing the need for additional detectors at John Day Dam, as discussed in the 2010 and 2014 Supplemental FCRPS BiOp. The Corps is also planning to install temporary (2 to 4 years) adult PIT-tag detectors at Lower Monumental and Little Goose dams within the lower Snake reach, which should similarly help isolate the subreaches where losses are occurring.

Recent Cormak Jolly Seber-based survival estimates for PIT-tagged Snake River Sockeye Salmon indicate that for 2010-2013, survival rates averaged from 56% to 83% for the Bonneville to McNary reach; 92% to 99% for the McNary to Ice Harbor reach; and 71% to 97% for the Ice Harbor to Lower Granite reach (Table 4-2).). Crozier et al. (2014) present similar adult survival estimates through the FCRPS dams, and from Bonneville to the Sawtooth Valley for 2008 to 2013. Survival through the entire hydrosystem (Bonneville Dam to Lower Granite Dam) exceeded 70% from 2008 to 2010, but then declined to a low of 44% in 2013. The bulk of the loss occurred in the reach between Bonneville Dam and McNary Dam, with a survival estimate of only 58% in 2012. Crozier et al. describe survival from Lower Granite to the Sawtooth Valley, which peaked in 2010 and 2011, declined in 2012, and then dropped by half in 2013. These results are similar to the estimates in Table 4-2.

Table 4-2. Cormak Jolly Seber-based survival estimates for PIT-Tagged Snake River Sockeye Salmon with 95% confidence intervals (Bellerud 2014). These estimates include the effects of the existence and operation of the FCRPS, straying of adults in the migration corridor, delayed effects of attacks by marine mammals below Bonneville Dam, harvest, and any other sources “natural” morality (i.e., that would have occurred without the influence of human activity).

<table>
<tr><th>Year</th><th>Number of Fish Detected at BON</th><th colspan="2">Bonneville to McNary</th><th>McNary to Ice Harbor</th><th>Ice Harbor to Lower Granite</th><th>Bonneville To Lower Granite</th><th colspan="3">Lower Granite to Sawtooth Valley[a]</th><th>Bonneville to Sawtooth Valley[a]</th></tr>
<tr><td>2010</td><td>41</td><td colspan="2">83%
(72.2% -95.2%)</td><td>98%
(92.3% - 100%)</td><td>93%
(83.2%-100%)</td><td>76%
(63.6%-89.9%)</td><td colspan="3">77%
(64.0%-93.6%)</td><td>58%
(42.1%-73.7%)</td></tr>
<tr><td colspan="2">Median travel time</td><td colspan="2">5.1 days</td><td colspan="2">6.5 days</td><td>–</td><td colspan="3">35.5 days</td><td>–</td></tr>
<tr><td>2011</td><td>516</td><td colspan="2">68%
(63.5%-71.6%)</td><td>99%
(97.7%-100%)</td><td>97%
(94.9%-99.2%)</td><td>65%
(61.2%-69.5%)</td><td colspan="3">74%
(69.5%-79.0%)</td><td>48%
(44.0%-52.9%)</td></tr>
<tr><td colspan="2">Median travel time</td><td colspan="2">5.9 days</td><td colspan="2">6.5 days</td><td>–</td><td colspan="3">39.3 days</td><td>–</td></tr>
<tr><td>2012</td><td>127</td><td colspan="2">56%
(47.3%-64.4%)</td><td>97%
(91.6%-100%)</td><td>93%
(85.1%-99.1%)</td><td>51%
(42.5%-58.8%)</td><td colspan="3">62%
(51.0%-75.1%)</td><td>32%
(23.5%-40.3%)</td></tr>
<tr><td colspan="2">Median travel time</td><td colspan="2">5.5 days</td><td colspan="2">6.2 days</td><td>–</td><td colspan="3">36 days</td><td>–</td></tr>
<tr><td rowspan="4">2013</td><td rowspan="4">207</td><td colspan="2">67%[b]</td><td rowspan="4">92%
(85.2%-98.2%)</td><td rowspan="4">71%
(63.3%-80.3%)</td><td rowspan="4">44%
(37.1%-51.0%)</td><td colspan="3">33%[b]</td><td rowspan="4">15%
10.0%-20.0%</td></tr>
<tr><td>Bonneville to The Dalles[c]</td><td>The Dalles to McNary</td><td>LGR to Salmon RM 262[c]</td><td>Salmon RM 262 to RM 276[c]</td><td>Salmon RM 276[c] to Sawtooth Valley[a]</td></tr>
<tr><td>83%</td><td>81%</td><td>50.2%</td><td>87.6%</td><td>75.0%</td></tr>
<tr><td>(77.8%-88.2%)</td><td>(75.5%-87.3%)</td><td>(39.7%-63.4%)</td><td>(69.0%-100%)</td><td>(58.3%-96.5%)</td></tr>
<tr><td colspan="2">Median travel time</td><td colspan="2">5.2 days</td><td colspan="2">7.1 days</td><td>–</td><td colspan="3">39.7 days</td><td>–</td></tr>
<tr><td colspan="2">Average</td><td colspan="2">69%</td><td>98%</td><td>89%</td><td>59%</td><td colspan="3">62%</td><td>38%</td></tr>
</table>

[a]These are minimum survival estimates because the detection efficiency of the Sawtooth Valley PIT-tag detection arrays is unknown. That is, some adults that are detected at Salmon RM 276 may have returned to the Sawtooth Valley, but have been outside the area interrogated by the detectors.

[b]The 67% survival estimate for the Bonneville to McNary reach for 2013 is the product of the estimates for the Bonneville-The Dalles and The Dalles-McNary subreaches in the rows underneath. In the same manner, the 33% estimate for the Lower Granite to Sawtooth Valley reach is the product of the LGR-Salmon RM 262 through Salmon RM 276-Sawtooth Valley reaches in the rows underneath.

[c]PIT-tag detectors came on line in 2013 at The Dalles Dam and at Salmon RMs 262 and 276.

Productivity of the Snake River Sockeye Salmon ESU is tied to adult run timing because survival through the 743 km (462-mile) reach from Lower Granite Dam to the Sawtooth Valley decreases as the season progresses (Crozier et al. 2011). Adult migration timing for Snake River Sockeye Salmon has been progressing earlier in the year over the 20th century and this trait may have evolved due to mortality of late migrants exposed to higher Columbia River temperatures (Crozier et al. 2011). The fish also show a strong annual response to river flow, such that they migrate earlier in low-flow years.

Adult migrant survival — Lower Granite Dam to Sawtooth Valley

Beginning in 2008, PIT-tagged adults from the captive broodstock program began to return to the Sawtooth Valley in sufficient numbers to begin investigating adult return rates from Lower Granite Dam upstream to return locations. PIT-tagged adults returning each year have enabled us to calculate survival rates from Lower Granite Dam to the Sawtooth Valley (Table 4-3). Of the 5,574 adults that passed Lower Granite from 2008 to 2012, a total of 4,207 (75%) were recovered at Redfish Lake, the Sawtooth Hatchery weir or other basin trapping locations (IDFG 2012). It is important to point out, however, that the average survival rate of 73% is only for the years 2008-2012, and does not reflect the lower rate for 2013 (Table 4-2).

Table 4-3. Adult Sockeye Salmon passage at Lower Granite Dam, adjusted for fallback and reascension using PIT-tagged adult return data and survival rates to the Sawtooth Valley (Peterson et al. 2012).

Year	Total Passage	% Fallback	95% CI	# of PIT-Tags	Adjusted Passage	# of Trapped Adults	Conversion to Sawtooth Valley
2008	909	9.10%	+/- 17.0%	10	826	599	72.52%
2009	1,219	5.60%	+/- 10.6%	17	1.151	817	70.98%
2010	2,201	11.80%	+/- 10.8%	30	1,941	1,306	67.28%
2011	1,502	13.40%	+/- 3.4%	323	1,301	1,098	84.40%
2012	470	24.40%	+/- 9.3%	62	355	243	68.45%
						Average	72.73%

Estimates of survival from Lower Granite to the Sawtooth Valley presented in Table 4-3 vary slightly from those shown in Table 4-2. The estimates in Table 4-2 are based on detections of PIT-tagged Snake River Sockeye Salmon at Lower Granite and various sites in the Sawtooth Valley, corrected for detection efficiency. In comparison, Table 4-3 uses a ratio between the number of fish counted at Lower Granite (corrected for fallback and reascension using PIT-tag information) and the total number of fish trapped in the Sawtooth Valley. Nevertheless, the findings presented in the two tables are similar. For the years 2010 through 2012, the average survival estimates are 71% for the data presented in Table 4-2 and 73% for the data presented in Table 4-3. A lower survival estimate for 2013, shown in Table 4-2, reflects losses due to high water temperatures at Lower Granite Dam in late July 2013, which blocked adult Snake River Sockeye Salmon passage for more than a week and resulted in high mortality rates for migrating adult Sockeye Salmon (see Section 3.3.3.1 in NMFS 2014c).

Information gained from the PIT-tag detectors installed in 2013 also provides a snapshot of adult Sockeye Salmon survival through different Salmon River reaches. Minimum survival estimates[5] for adult PIT-tagged Sockeye Salmon were 50% from Lower Granite Dam to Salmon RM 262, 88% from Salmon RM 262 to RM 276, and 75% from Salmon RM 276 to the Sawtooth Valley (Table 4-2). Section 5.1.2, Salmon River, describes the limiting factors and threats affecting Snake River Sockeye Salmon in the mainstem from the Sawtooth Valley to the confluence with the Snake River. Limiting factors include elevated water temperatures, altered hydrologic regimes, reduced floodplain connectivity, and blocked passage to historical habitat. Determining the magnitude of this loss, as well as where and why mortality is occurring, is critical to the successful restoration and recovery of Sockeye Salmon populations.

Sawtooth Valley-to-Sawtooth Valley Smolt-to-Adult Returns

Increased annual adult Sockeye Salmon returns since 2008 have allowed IDFG to develop Sawtooth Valley-to-Sawtooth Valley Smolt-to-Adult returns (SAR), a measure of productivity, for the different release strategies, which helps identify and prioritize the most successful reintroduction strategies. For the 2004 through 2006 brood years, the natural-origin and full-term hatchery-raised smolts produced the highest SARs. These ranged from a low of 0.06% for brood year 2004 hatchery-raised pre-smolts to a high of 3.1% for brood year 2006 smolts that hatched in and emigrated from Redfish Lake (NMFS 2013; NMFS 2014c). The latter were derived from fish that spawned naturally in the lakes or hatched from eyed-eggs that had been fertilized in the hatchery, but then outplanted in the lake.

Information gained through monitoring allows researchers to evaluate the effectiveness of different supplementation strategies — information that is critical to defining the most effective strategies for increasing the abundance of natural spawners. The data indicates that adults from natural production and hatchery full-term smolts produce higher SARs than other release strategies. The data is being used to evaluate survival processes impacting each life-history phase. For example, PIT-tag data is providing valuable information on juvenile downstream passage survival and adult upstream survival, and the factors that influence survival at different stages and locations. These include the warm water temperatures that blocked adult Sockeye Salmon passage at Lower Granite Dam during late July in 2013; a factor that NMFS is working with the Corps, tribes and other co-managers to address. Juvenile and adult losses in the migration corridor between Lower Granite Dam and the natal lakes are not fully understood, but appear to be influenced by stream flow and temperature.

[5] The survival estimates in Table 4-2 are corrected for detection efficiencies, except for the detector arrays in the Sawtooth Valley. Assuming that detection efficiency is less than 100%, the true conversion rates to the Sawtooth Valley are likely to be higher than those shown in Table 4.2.

4.2 Spatial Structure and Diversity

The same basic elements of the ICTRT spatial structure and diversity criteria that apply to stream type Chinook salmon and steelhead can be easily adapted to evaluate Sockeye Salmon populations (ICTRT 2007). Within-population spatial structure can be expressed in terms of the number and distribution of spawning beaches and/or tributary reaches. Beach vs. river spawning sub- populations, where they were likely historically present, along with anadromous and residual components represent major life history patterns. The same basic criteria apply with respect to assessing within- and among-population indicators of genetic diversity and the long-term risks from continued high levels of hatchery spawners.

Sockeye Salmon in the Snake River ESU display several different life history patterns, indicating population diversity within the ESU. Historically there may have been some Redfish Lake anadromous Sockeye Salmon that were tributary spawners, returning to habitat in Fishhook Creek, while others were shoal spawners, returning to spawning areas along the lake. Some anadromous Sockeye Salmon continue to spawn in Fishhook Creek. Information suggests that the historical Alturas Lake Sockeye Salmon population was also an early stream spawning type, similar to the Fishhook Creek kokanee population and the extant Alturas Lake kokanee. Native early stream spawning kokanee in Alturas Lake continue to produce smolts and adult returns and although they are not currently listed, they may be an important source of life history and spatial diversity. The historical Stanley Lake native kokanee population may have also expressed this early run timing. This suggests that the Alturas Lake population, and possibly the Stanley Lake population, remains genetically unique from the anadromous Sockeye Salmon population in Redfish Lake (see Griswold et al. 2012 for review). In addition, observations by Evermann (1894) indicate that the inlet to Pettit Lake supported Sockeye Salmon. Evermann reported seeing one Sockeye Salmon carcass along the inlet stream of Pettit Lake during 1894. In 1895 they caught two Sockeye Salmon in a net set in the Pettit Lake inlet on August 14 and 22. Evermann also reported seeing two Sockeye Salmon in excellent condition on a shoal in Alturas Lake in 1895 as he was preparing to leave the area, and at a time when adults likely would have just begun returning to the shoal to spawn (Evermann 1896).

At the current time, based on the low levels of naturally produced anadromous returns, the Redfish Lake population must be rated at high risk for diversity, since it is currently being maintained by captive propagation. It is at high risk of not being able to maintain: 1) natural patterns of phenotypic and genotypic expression, 2) natural patterns of gene flow, and 3) the integrity of natural systems (ICTRT 2010).

4.3 ESU Status

The captive propagation program has likely forestalled extinction of the Redfish Lake population and the ESU. This program has increased the total number of anadromous adults and has preserved what genetic diversity remained after the decline. However, the longer this program relies on captive broodstock to maintain the population, the greater the risks of domestication become. Although the program has increased the number of anadromous adults in some years, it has only begun to yield large numbers of returning adults (in part due to larger smolt releases and in part because of out-of-basin effects such as ocean conditions), and the long-term effects of captive propagation are unknown.

In recent years, sufficient numbers of returning hatchery adults and their eggs and smolts have been available to make it feasible to use supplementation strategies to increase the abundance of natural spawners. Limnological studies and direct experimental releases are being conducted to learn more about production potential in the three Sawtooth Valley lakes that are candidates for Sockeye Salmon restoration. Lake habitat rearing potential, juvenile downstream passage survivals, and adult upstream survivals are also being studied. However, substantial increases in survival rates across all life history stages must occur in order to reestablish sustainable natural production (e.g. Hebdon et al. 2004; Keefer et al. 2008).

The increased abundance of hatchery-reared Snake River Sockeye Salmon reduces the risk of immediate loss, but levels of Sockeye Salmon returns remain low. As a result, overall, although the risk status of the Snake River Sockeye Salmon ESU appears to be on an improving trend, the risk of extinction is still high and the ESU continues to be listed as endangered (Ford 2011).

Section 5: Threats and Limiting Factors

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5. Threats and Limiting Factors

The reasons for a species' decline are generally described in terms of limiting factors and threats. NMFS defines limiting factors as the biological and physical conditions that limit a species' viability – e.g., high water temperature – and defines threats as those human activities or natural processes that cause the limiting factors. For example, removing the vegetation along the banks of a stream (threat) can cause higher water temperatures (limiting factor), because the stream is no longer shaded.

Designing effective recovery strategies and actions requires understanding limiting factors and threats across the species' entire life cycle. The term threats is often used as synonymous with the listing factors detailed in the ESA section 4(a)(1): destruction of habitat, over-utilization, disease or predation, inadequacy of existing regulatory mechanisms, or other natural or human-made factors affecting [the species'] continued existence. NMFS typically organizes discussions of threats according to the four Hs (habitat, hydro, hatcheries, and harvest), which represent the types of threats most relevant to salmonids.

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are often legitimate human activities that may at times have unintended negative consequences on fish populations—and that can usually be managed in a manner that minimizes or eliminates the negative impacts.

For Sockeye Salmon and other salmonids, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration vs. egg incubation vs. juvenile rearing. In addition, the particular factors limiting production may vary across different sections of the tributary drainage used by a particular population. Data on a full range of potential limiting factors is rarely available at the reach level. As a result, the identification of limiting factors for salmonids often includes elements based on inference and expert opinion.

Identification of limiting factors for Snake River Sockeye Salmon is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements. They are made with the expectation that action will be taken in the face of some degree of scientific uncertainty. Through careful monitoring of the results, continuing research to resolve the uncertainties, and adapting management actions in response, the state of our knowledge will improve and so will the survival of these fish.

Many human activities have contributed to the near extinction of Snake River Sockeye Salmon in the Snake River basin. The NMFS status review (Waples et al. 1991) that led to the original listing decision attributed the decline of this ESU to "overfishing, irrigation diversions, obstacles to migrating fish, and eradication through poisoning." The NMFS 1991 listing decision noted that such factors as hydropower development, water withdrawal and irrigation diversions, water storage, commercial harvest, and inadequate regulatory mechanisms represented a continued threat to the ESU's existence (NMFS 1991). NMFS' 1991 listing decision also stated that predation impacts from piscivorous fish and marine mammals was increasing in Northwest salmonid fisheries; however, the extent of these impacts on Snake River Sockeye Salmon was unknown at that time. NMFS' recent review of historical threats identified intense commercial harvest of Sockeye Salmon along with other salmon species beginning in the mid-1880s; the existence of Sunbeam Dam as a migration barrier between 1910 and early 1930s; the eradication of Sockeye Salmon from Sawtooth Valley lakes in the 1950s and 1960s; development of mainstem hydropower projects on the lower Snake and Columbia Rivers in the 1970s and 1980s; and poor ocean conditions in 1977 through the late 1990s as factors that contributed to the species' decline (NMFS 2008c).

Today, some threats that contributed to the original listing of Snake River Sockeye Salmon now present little harm to the ESU while others continue to threaten viability. Impacts from ocean and inriver fisheries are now better regulated through ESA-listed constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, now pose limited concern. Several barriers that once blocked Sockeye Salmon passage to the natal lake have been removed or no longer obstruct fish migration. In addition, much of the natal lakes area and headwaters remain in excellent condition due to wilderness and other land use designations; almost 90% of the habitat in the Sawtooth Valley is within the U.S. Forest Service's Sawtooth National Recreation Area. Efforts to eradicate the species from the natal lakes through chemical poisoning ended decades ago. Hatchery-related concerns have also been reduced through management actions, particularly through the captive broodstock program that uses an integrated broodstock program to maintain and rebuild the species' genetic resources; however, continued caution needs to be applied to ensure that hatchery releases do not influence the species natural genetic diversity and fitness.

Recovery efforts focus on addressing other remaining threats. Juvenile and adult losses during travel through the Salmon, Snake, and Columbia River migration corridor continue to present a significant threat to species recovery. In addition, the combined and relative effects of different threats across the life cycle, including threats from climate change and other unknowns, remain poorly understood. Consequently, while this section presents the full range of threats and limiting factors throughout the life cycle, the different threats do not carry equal weight in their impact on Sockeye Salmon. Our recovery strategy recognizes the need to better understand the effects of combined threats to Snake River Sockeye Salmon, and to focus recovery actions on the limiting factors and threats that are most important for recovery. The Plan directs actions to gain critical information regarding how different factors affect the fish. It also identifies considerations for prioritizing actions, and charges implementation groups with developing criteria to prioritize actions and scheduling implementation according.

This section discusses the threats and limiting factors for Snake River Sockeye Salmon throughout their life cycle. Section 5.1 describes the threats and limiting factors for Snake River Sockeye Salmon related to habitat conditions in the natal lakes, Salmon River, Snake and Columbia River mainstems, Columbia River estuary and plume, and the ocean. Section 5.2 describes the impacts of hydro operations on the migration corridor through the mainstem Snake and Columbia Rivers. This section is followed by discussions of potential limiting factors associated with hatcheries (5.3), fisheries (5.4), predation and disease (5.5), competition (5.6), toxics (5.7), and climate change (5.8). Much of the following sections rely on NMFS (1991, 2008b, 2008c, 2014c) and NMFS Northwest Fisheriers Science Center five-year status assessment in Ford 2011.

The discussion of out-of-subbasin limiting factors and threats that affect all the salmonid populations in the mainstem Columbia River corridor is excerpted from the Estuary Module and from the 2008 and 2014 FCRPS Biological Opinions (NMFS 2008c, 2014c). The discussions also reflect information presented in the Hydro Module, which summarizes FCRPS actions contained in the Biological Opinion (Hydro Module, NMFS 2014a) and the Ocean Module, which discusses ocean conditions and effects (Ocean Module, Fresh et al. 2014). (The Estuary Module underwent public review; the Hydro Module is a summary of the publicly reviewed BiOp.)

5.1 Habitat

As described in Section 2.3.2, Life History, the Snake River Sockeye Salmon life cycle begins with emergence from the gravel in their natal lakes in the Sawtooth Valley and continues through rearing in the lakes; migration as smolts through the Salmon River to mainstem Snake River, Columbia River, estuary, and plume; maturation in the ocean; and the return migration to spawn. Threats and potential limiting factors in Snake River Sockeye Salmon habitat throughout the life cycle are described in this section, starting with the natal lakes and continuing to the ocean.

5.1.1 Sawtooth Valley Lakes

Sockeye Salmon are historically native to five nursery lakes in the Sawtooth Valley: Redfish, Pettit, Alturas, Yellowbelly, and Stanley lakes. The lakes lie within the Sawtooth National Recreation Area and much of the headwaters of each drainage is designated as wilderness. The glacial-carved lakes range in elevation from 1,985 m to 2,157 m (6,512 to 7,077 feet) and collect flow from the Sawtooth and Smoky Mountains. Overall, habitat conditions for Snake River Sockeye Salmon in these high mountain lakes remain in excellent shape. Factors limiting Sockeye Salmon production in the lakes are discussed below.

5.1.1.1 Lake water quality

Researchers have conducted limnology studies in Stanley, Redfish, Yellowbelly, Pettit, and Alturas Lakes since 1991. The studies examine water temperature, oxygen, light, chlorophyll, phytoplankton, and zooplankton in each lake several times from May through October. Generally, the results from limnological sampling indicate that water quality in all five lakes provides suitable rearing habitat for juvenile Sockeye Salmon, although the lakes vary considerably in the species composition and abundance of zooplankton.

Limnology monitoring between 2000 and 2010 shows that seasonal (June through October) mean surface water temperatures in the lakes generally range from 12-14 °C (53-57 °F) (Griswold et al.

2011a). These water temperatures support Sockeye Salmon life stages for spawning, incubation, and rearing. The physiological optimum water temperature defined for Sockeye Salmon is in the range of 12 to 15 °C (53-59 °F) (Brett 1971). Studies reported by Brett (1971) indicate that Sockeye Salmon performance and distribution may be limited at temperatures above 18 °C (64 °F), despite their being able to tolerate temperatures of 24 °C (75 °F). Bell (1991) reported similar findings, stating a preferred water temperature range for Sockeye Salmon of between 11.6 and 14.4 °C (52.8 and 58 °F).

The studies show that thermoclines are typically present in the Sawtooth Valley lakes from July through October, with maximum surface temperatures reaching approximately 18 °C (64 °F) in all lakes (Griswold et al. 2011a). The effects of temporary surface water temperature spikes above 15 °C (59 °F) on Sockeye Salmon may be minimal, particularly if the Sockeye Salmon can escape to deeper waters or to areas where groundwater inflow or shade reduce temperatures. However, in some cases, high water temperatures may make Sockeye Salmon more susceptible to disease and infection or promote fungal, bacterial infection or secondary wound infections that leave the Sockeye Salmon more susceptible to pre-spawning mortality (BOR 2007).

Stanley Lake

U.S. Forest Service assessments have concluded that watershed conditions in Stanley Lake Creek are “functioning at risk” primarily because of loss of connectivity resulting from the fish passage barrier below the lake. Cattle grazing has been removed, but impacts to stream channels may still linger in some areas. Headwater streams and riparian areas remain in relatively good condition. However, the 2006 Trailhead fire burned high elevation cirque basins, ridges, and steep-side slopes adjacent to Stanley Lake Creek. The main headwater channel of Stanley Lake Creek had a high severity burn for approximately one mile. In 2007, summer thunderstorms caused small debris flows and increased sediment downstream of the fire. While much of the sediment deposited upstream, some finer sediment and nutrients may have entered the lake.

A bloom of *Didymosphenia geminate* recently extended from the head of Stanley Lake Creek to Valley Creek. The bloom was first noted in 2008, and may have diminished the quantity and quality of the aquatic habitats for salmonids (USFS 2011). The U.S. Forest Service water temperature testing results in Stanley Lake Creek downstream of the lake to Valley Creek during several summer seasons from 1994 to 2009 display daily maximum surface water temperatures typically between 23 and 25 °C (73-77 °F) during the warmest summer periods. Natural heating of the lake’s surface is believed to be the primary cause of this condition and it is considered a natural phenomenon (USFS 2011).

IDEQ assessed water quality at four locations within the Stanley Lake drainage between 1995 and 2008 and concluded that beneficial uses were fully supported. As such, no waters within the Stanley Lake Creek drainage or downstream in Valley Creek were included in IDEQ’s 2008 integrated report of impaired waterbodies (IDEQ 2009). Currently, IDEQ considers Stanley Lake a Category 3 water body for which insufficient data and information, including on water temperatures, are available to determine if beneficial uses are being attained (IDEQ 2011).

In 1997, the U.S. Forest Service realigned Stanley Lake Road and closed and rehabilitated the associated former campsites to address a potential source of fine sediment in the watershed (USFS 2011). The popular recreation use of the lake and shoreline areas by motorized equipment continues to pose a potential risk of spilling chemical pollutants.

Redfish Lake

U.S. Forest Service assessments have concluded that watershed condition is "functioning appropriately" in the Redfish Lake Creek drainage. The large majority of the watershed remains in near natural condition with the exception of fire suppression that has resulted in most forests being in late seral (or "old growth") condition. However, development on the north end of Redfish Lake has been extensive. Developed recreation sites and/or commercial activities occupy approximately two miles of shoreline. Less intensive development has occurred in one-half mile of shoreline on Little Redfish Lake.

Given the high alpine headwaters and the generally unaltered riparian vegetation, maximum summer surface water temperatures naturally range from 12 to 15 °C (53-59 °F) in Fishhook Creek and 14 to 16°C (57-61 °F) in Redfish Lake Creek (above the lake). Limnology monitoring by the Shoshone-Bannock Tribes between 2000 and 2010 shows a seasonal (June through October) mean surface water temperature of 13.8 °C (56.7 °F) in Redfish Lake, ranging from 12.3°C (54 °F) (2010) to 14.9 °C (58.8 °F) (2008). The maximum recorded surface water temperature is 18 °C (64 °F) (Griswold et al. 2011a). This mean seasonal surface temperature is considered within the biological range for Sockeye Salmon; however, the maximum recorded temperatures fall above the preferred range.

IDEQ's 2010 303(d) list classifies Redfish Lake Creek from the source to Redfish Lake as a Category 1 stream: waters within wilderness or roadless areas where water quality standards are presumed to be attained (IDEQ 2011). The 303(d) list identifies stream and river reaches listed as impaired by the Idaho Department of Environmental Quality under the guidelines of the Clean Water Act. The Clean Water Action requires all states to submit a list for U.S. Environmental Protection Agency (EPA) approval every two years that identifies all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards.

Heating at the surface of the lakes is evident based on the temperatures observed near the outlet of the lake. Summer season daily maximum surface water temperatures routinely approach or exceed 20°C in Redfish Lake Creek below the lake (USFS 2011). IDEQ's 2010 303(d) list classifies Redfish Lake and Redfish Lake Creek as Category 3 water bodies, for which insufficient data and information are available to determine if beneficial uses are being attained (IDEQ 2011).

The calm waters of the lake allow incoming sediments to sink. Much of the lake shore is undeveloped and unaffected by upstream watershed activities in the Sawtooth National Recreation Area. However, shoreline development or lake recreation may result in elevated sediments in the lake bottom or water column in lake shoal habitats, as well as in the upper end of the outlet. These areas may need further monitoring to determine potential effects on fish habitat. Recreational development on the north end of the lake and seasonal motorized boating use in Redfish Lake has likely released some chemical pollutants (USFS 2011). Some conditions have been addressed (e.g. gas storage at the marina); however, with existing development, the potential for pollutant threats remains (USFS 2011).

In the past, nearshore camping and a hotel facility created the potential for nutrient stresses on the lake; however, inputs from such activities are believed to be limited, as sewage, the main potential nutrient source, is removed from the area by contained sanitation systems (Gross et al. 1998).

Yellowbelly Lake

U.S. Forest Service assessments have concluded that watershed condition is "functioning appropriately" in the Yellowbelly Lake Creek drainage. Few management activities occur within the drainage and habitat conditions are near pristine. Sediment is naturally high from granitic parent materials.

Yellowbelly Lake historically provided habitat for resident kokanee and residual Sockeye Salmon (Bjornn et al. 1968; Waples et al. 1991), suggesting the lake supported anadromous production. The U.S. Forest Service monitored water temperatures above and below the lake in 2002 and 2005. IDEQ's 2010 303(d) list classifies Yellowbelly Lake as a Category 3 water body, for which insufficient data and information are available to determine if beneficial uses are being attained (IDEQ 2011). Yellowbelly Lake was treated with Rotenone in 1990 by IDFG.

Pettit Lake

U.S. Forest Service assessments have concluded that watershed condition is "functioning appropriately" in the Pettit Lake drainage. Little management disturbance has occurred in the drainage, other than lake shore development. Habitat conditions are near pristine, although, sediment is naturally high from granitic parent materials. The U.S. Forest Service also monitors stream temperatures in reaches above and below Pettit Lake. The agency has determined that stream temperatures below the lake are likely natural and a result of heating of the lake surface.

Extensive water quality monitoring has occurred as part of the Sockeye Salmon recovery actions. In limnology monitoring studies conducted by the Shoshone-Bannock Tribes, seasonal mean surface water temperatures (June-October) in Pettit Lake measured approximately 13.8 °C (56.8 °F) between 2000 and 2010, and ranged from 12.1 °C (54 °F)(2006) to 15.8 °C (60.4 °F)(2008) (Griswold et al. 2011a). Generally, these mean temperatures remain within the physiological optimum water temperature range of 12-15 °C (53-59 °F) defined by Brett (1971) for Sockeye Salmon.

Data from 2000-2010 show that 2008 was the only year when seasonal mean surface water temperatures in Pettit Lake rose above 15 °C; however, maximum recorded surface water temperatures reached 18 °C (Griswold et al. 2011a). The effects of temperatures above 15 °C on Sockeye Salmon generally depend on exposure time. The effects of 2- to 4-day exposure to temperatures between 18-24 °C (64-75 °F) are not well documented in scientific literature. However, the high temperatures may make Sockeye Salmon more susceptible to disease and infection, or promote fungal and bacterial infections, as well as secondary wound infection, leaving the Sockeye Salmon more susceptible to pre-spawning mortality.

IDEQ's 2010 303(d) list classifies Pettit Lake as a Category 3 water body, for which insufficient data and information are available to determine if beneficial uses are being attained (IDEQ 2011).

Alturas Lake

Stream habitat is in good condition in the drainage, although fine sediment is likely elevated from headwater grazing and patented mining and granitic parent material. Historic intensive sheep grazing substantially altered stream banks in some localized areas, particularly near the corrals. However, the corrals were closed and removed in the mid-1990s, and the area is no longer authorized for grazing. As a result, streambank recovery is ongoing. In 2003, Alturas Lake Creek and lower Jakes Gulch were reviewed for impacts from domestic sheep grazing based on tracking collar data. No effects from sheep use were observed above the lake.

The Alturas Creek subwatershed has been a focus for restoration since 1999. In 2000, Alturas Lake Creek was returned to ¼ mile of natural channel above the confluence with Alpine Creek where it had been previously captured by Road 205 a decade earlier. This capture had liberated thousands of yards of sediment into Alturas Lake Creek. In 2005 and 2006, 4.5 miles of headwater road were closed and rehabilitated, including the deteriorating ford through Alpine Creek. As restoration now occurs, these changes have essentially removed all chronic sources of management related sediment within the upper watershed.

A PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) integrator reach is located on Alpine Creek 1.59 miles above the confluence with Alturas Lake Creek. The habitat index score ranged from 62.0 in a 2005 survey to 65.7 in 2010, indicating moderate to good habitat conditions when compared to reference streams. PIBO found habitat indices averaged 63.4 in unmanaged reference habitat.

Sockeye Salmon have been reintroduced into Alturas Lake since 1997: hatchery adults were released into the lake for volitional spawning in 1997 and 2000. U.S. Forest Service temperature thermograph monitoring from 2002 to 2005 recorded maximum 7-day average daily maximum summer surface water temperatures at or below 15 °C in the lake. Limnology monitoring by the Shoshone-Bannock Tribes between 2000 and 2010 shows a seasonal mean water temperature of 13.3 °C in Alturas Lake, ranging from 12.1 °C (2010) to 15.3 °C (2008) Maximum surface temperatures in the lake can reach 18 °C (Griswold et al. 2011a). These water temperatures are generally within the biological range for Sockeye Salmon spawning, incubation, and rearing. Monitoring by the Shoshone-Bannock Tribes shows that mean surface temperatures in the lake rose above 15 °C in 1 of 10 years from 2000 to 2010 (Griswold et al. 2011a). As discussed earlier, effects to Sockeye Salmon from temporary water temperature spikes depend on when and how long the temperatures remain outside the preferred range.

Sediment loading from granitic parent material results in a high natural sediment load that accumulates in the lake (USFS 2011). Historical effects of grazing and mining in the headwaters has likely exacerbated this condition. Extensive U.S. Forest Service restoration activities in the upper watershed in

2005 and 2006, including road closures and habitat rehabilitation, are intended to address the sources of land use-related impairments to sediment processes within the upper watershed (USFS 2011).

IDEQ's 2010 303(d) list identifies both Alturas Lake to its mouth and Alturas Lake Creek as not meeting the conditions needed to support aquatic plants and animals, although the cause of impairment has not been identified (IDEQ 2011). Lake nutrient supplementation permitted by IDEQ has been occurring in Alturas Lake since 1995 implemented by BPA, via the Shoshone-Bannock Tribes.

5.1.1.2 Lake food resources

Growth of Sockeye Salmon in the Sawtooth Valley lakes is often density dependent and related to zooplankton density (Hyatt and Stockner 1985; Rieman and Meyers 1992). Juvenile Sockeye Salmon rear one to three years in the lakes before emigrating to the ocean, and during their stay in the lakes Sockeye Salmon juveniles feed almost entirely on zooplankton.

Changes in zooplankton levels in the lakes contributed to the decline of Sockeye Salmon production in the lakes (Selbie et al. 2007). Low zooplankton densities can restrict growth rates and ultimately the ability of Sockeye Salmon to achieve a level of fitness needed to survive the long seaward migration from their nursery lakes. Reductions in the lakes' zooplankton communities developed after the Sockeye Salmon population drastically declined and other fish (trout, non-native kokanee) were introduced in mid-century. Ongoing studies of lake water quality seek to determine the current characteristics and carrying capacity of the lakes.

Overwintering conditions can be especially important for Sockeye Salmon in these high mountain lakes. Since Sockeye Salmon remain active at temperatures below 4 °C (39 °F), winter is not a period of dormancy (Burgner 1992). In fact, at 4 °C, Sockeye Salmon must consume about 0.1% of their wet weight per day to meet basic metabolic requirements (Brett et al. 1969). Winter productivity in the Sawtooth Valley lakes is limited because ice covers the lakes for long periods. This reduces light penetration and photosynthesis, which then limit winter productivity and Sockeye Salmon foraging ability (Steinhart and Wurtshaugh 2003).

Because of this limited winter productivity, Sockeye Salmon in the lakes may experience more competition from kokanee, as well as other Sockeye Salmon, when densities increase due to stocking. Increased competition for limited zooplankton supplies can exacerbate energetic losses during winter months, causing Sockeye Salmon to grow more slowly and to have fewer lipids, reducing outmigrant survival (Steinhart and Wurtshaugh 2003).

Powell et al. (2010) concluded that diet and fatty acid composition differed between Redfish Lake smolts of hatchery origin (planted as pre-smolts) and those produced naturally in the lake. Wild outmigrants had fatty acid profiles indicative of the zooplankton diet typical of resident Sockeye Salmon in the lake. In contrast, hatchery-produced juveniles introduced as pre-smolts had fatty acid profiles resembling those associated with hatchery diets. At outmigration, total lipids of hatchery-origin smolts were approximately half of that of wild fish despite having been nearly three times higher at planting.

Studies by Griswold et al. (2011) also suggest that growth rates may affect emigrating smolt survival. The researchers found that successful smolt migrants from the Sawtooth Valley lakes to Lower Granite Dam often maintained their weight during the winter preceding migration. They also found that smaller parr and smolts survived better. The researchers suggest that the stocking of smaller parr with lower metabolic demand may be preferable to stocking larger parr when forage is limited (Griswold et al. 2011a).

Stanley Lake

Studies consistently show lower seasonal mean zooplankton biomass (June through October) in Stanley Lake than in Pettit, Redfish and Alturas Lakes (Taki et al. 2006).

Redfish Lake

Nutrient supplementation has been implemented since 1995 by BPA through the Shoshone-Bannock Tribes to promote Sockeye Salmon growth in Redfish Lake's highly oligotrophic water and to increase lake carrying capacity. Results from 1995 to 1998 show the effectiveness of nutrient supplementation in Redfish Lake. Following nutrient supplementation, tribal personnel measured large increases in surface chlorophyll *a*, primary productivity, and zooplankton biomass in comparison to smaller changes in Stanley Lake where no nutrient supplementation occurred (Griswold et al. 2002).

Kokanee control measures are also implemented in Redfish Lake to reduce intraspecific competition. Section 5.6 provides more discussion on this competition factor. In addition, a variety of fishery and limnological parameters are monitored annually in association with these strategies.

Yellowbelly Lake

Zooplankton data for Yellowbelly Lake is limited, but Steinhart et al. (1993) reported that in 1992 and 1993 the "highest zooplankton biomasses were observed in Yellowbelly and Pettit followed by Stanley Lake. The lowest total zooplankton biomass was observed in Redfish and Alturas Lakes in both years." In 2007, zooplankton was sampled during September in Yellowbelly Lake and compared to several other Sawtooth Valley Lakes. Zooplankton biomass was slightly lower in Yellowbelly than in Redfish and Pettit Lakes.

Pettit Lake

Lake nutrient supplementation permitted by IDEQ has been occurring in Pettit Lake since 1995 and implemented by BPA, via the Shoshone-Bannock Tribes to increase Pettit Lake's carrying capacity. Nutrient supplementation of Pettit Lake may be creating short-term growth benefiting lake dwelling fish. Sockeye Salmon in Pettit Lake typically exhibit the highest growth rates compared to fish in Redfish and Alturas Lakes. Sockeye Salmon presmolts released into Pettit Lake during the fall of 2004 experienced relatively high total zooplankton biomass, composed primarily of Cyclopoids and *Daphnia*, for the first month after release. During the winter, moderate zooplankton biomass was present in the form of Cyclopoids and *Bosmina*. The fish had a higher growth rate than fish in Redfish and Alturas Lakes in terms of weight (Taki et al. 2006).

Alturas Lake

The Shoshone-Bannock Tribes continue to provide nutrient supplementation to increase Alturas Lake's carrying capacity. Nutrient supplementation of Alturas Lake may be creating short-term growth benefits to lake-dwelling fish (USFS 2011). Research by Taki et al. (2006), however, found that fall-release Sockeye Salmon presmolts experienced low zooplankton biomass and also low growth rates; growth rates were considerably lower than in Redfish and Pettit Lakes.

5.1.1.3 Blocked access

At the time of the initial listing (NMFS 1991), the greatest habitat problem faced by the Snake River Sockeye Salmon ESU was the lack of physical access to any of the lakes but Redfish Lake. As described in Sections 2.6.2 and 3.2.2.2, improving Sockeye Salmon spatial structure with broader landscape distribution and access to multiple spawning areas will reduce the risk of extinction due to catastrophic environmental events. Therefore, providing connectivity of migratory corridors and increasing spatial distribution is still important to successful Sockeye Salmon recovery. Maintaining habitat connectivity within the population will promote gene flow and aid in establishing a locally adapted, naturally spawning population, and improve overall species viability.

Local recovery actions to remove barriers to Sockeye Salmon migration and, therefore, improve spatial distribution are being implemented. For example, Sunbeam Dam, which blocked salmon passage on the Salmon River approximately 20 miles downstream from the mouth of Redfish Lake Creek, was removed in 1934. The fish barriers on Alturas and Pettit Lake creeks (an irrigation intake and a concrete non-game fish barrier, respectively) were modified to facilitate passage of anadromous Sockeye Salmon into these historical habitats in the early to late 1990s (Teuscher and Taki 1996, cited in Flagg et al. 2004). The fish barrier at Yellowbelly Lake was removed by the U.S. Forest Service in 2000. The only remaining fish barriers are the fish migration barrier at the outlet of Stanley Lake and the weir at Sawtooth Fish Hatchery. In order to improve spatial distribution, presmolt outplants into Redfish, Alturas and Pettit Lakes were initiated in the mid-1990s, with releases averaging approximately 80,000 fish per year since 1995 (Ford 2011). Currently, however, anadromous returns are entirely precluded from Alturas, Pettit and Yellowbelly Lakes by the Sawtooth weir and from Stanley Lake by the fish barrier at the lake outlet. Plans are underway to begin allowing anadromous Sockeye Salmon adults to return to their lake of origin. This would entail trapping adults at the Sawtooth weir and transporting them to Alturas or Pettit Lakes, or alternatively to pass the adults to allow for volitional migration. Presently the trap does not effectively capture adult Sockeye Salmon.

Stanley Lake

The artificial barrier on the outlet of Stanley Lake, constructed in 1956 by IDFG as an upstream barrier to non-game fish, does not prevent downstream passage. The stocking of Stanley Lake with lake trout in 1975 further changed the system (IDFG 2013). These lake trout are reproducing and pose a risk to native kokanee in Stanley Lake, as well as the other Sockeye Salmon nursery lakes in the Sawtooth Valley. Movement of lake trout from Stanley Lake has not been documented; however, the risk of lake trout moving to other tributaries and lakes in the basin, and thus impeding Sockeye Salmon recovery, remains high. Alternative lake trout management strategies must be carefully considered, including removal of the artificial barrier. The barrier prevents recolonization of the lake by Sockeye Salmon and other species, such as ESA-listed bull trout, steelhead, and Chinook salmon.

One water diversion exists on Stanley Lake Creek. The diversion does not pose a barrier to fish migration because it is screened and sits on a side channel to the creek. However, the diversion serves eight water rights totaling about 2 cfs (IDWR 2013) that reduce critically low summer flows by 20% to 60%. This level of flow depletion in the wide and shallow channel of Stanley Lake Creek reduces water depth and increases stream temperature enough to substantially impair upstream migration of adult Sockeye Salmon. There are no culvert barriers that impact historical Sockeye Salmon habitat within this subwatershed.

Redfish Lake

IDFG operates an adult and juvenile weir on Redfish Lake Creek below the lake, which detains all migrants during the period of operation. The number of captive-reared or returning anadromous adults allowed to pass over the Redfish Lake weir or outplanted into the lake has increased substantially in recent years (Ford 2011). There are no culvert barriers on Redfish Lake or Fishhook Creek.

Yellowbelly Lake

Prior passage issues existed at the outlet stream due to an outlet barrier that was constructed in 1962 by IDFG (Chapman et al. 1990). The USFS removed the barrier in 2000 to reestablish connectivity with the mainstem Salmon River. There is no record of Sockeye Salmon or kokanee salmon stocking in Yellowbelly Lake and currently *O. nerka* are not present. A natural seasonal impediment exists approximately one-half mile above the mouth where Yellowbelly Lake Creek passes through one-quarter mile of coarse glacial boulder deposits. Typically, at baseflow this results in subsurface streamflow as the creek continues within the interior of this boulder matrix (USFS 2011). Habitat access is also believed limited above the lake due to barrier cascade 3.5 km (2.2 miles) above the lake’s inlet. Future monitoring is needed to better understand Sockeye Salmon passage issues associated with these natural conditions. There are no water diversions or culvert barriers within this subwatershed.

Pettit Lake

An outlet barrier was constructed in 1960 to keep native fish from recolonizing the lake after IDFG chemically treated the lake. For three decades, prior to 1996, a barrier at the lake outlet prevented all upstream fish migration. The Pettit Lake barrier was removed in 1996 to allow for passage for anadromous Snake River Sockeye Salmon into the lake. Today, the Shoshone-Bannock Tribes operate an adult/juvenile fish trap below the lake targeting Sockeye Salmon.

Alturas Lake

No manmade barriers exist within the watershed. In some years, a reach of Alturas Lake Creek from just above the confluence with Alpine Creek and extending as much as 805 m (one-half mile) becomes dry during late summer. This condition was first documented in 1895 by Evermann and is believed to be natural (USFS 2011).

5.1.1.4 Land use and other human activities

The Sawtooth Valley's beauty and natural resources attracted 19th century European-American ranchers, miners, and loggers. Roads, scattered settlements, and recreational development followed. Current and legacy effects of land use and other human activities such as mining, lake poisoning, and introduction of non-native species have altered Sockeye Salmon habitat and may still constitute limiting factors for Sockeye Salmon survival. Land use practices may also be affecting Sockeye Salmon by reducing stream flows to critical levels; however, more information is needed to better understand this potential concern. Future land and water use, such as development of new ponds for aesthetics and irrigation purposes, could potentially affect Sockeye Salmon populations by reducing water quality. More information is needed to understand the potential impacts of this and other possible emerging threats.

Land use

Intensive sheep and cattle grazing occurred within the watershed for a century until the 1993 Record of Decision for Grazing in the Stanley Basin mandated changes in grazing management. These changes included reduction in numbers, exclusion of grazing in some areas to protect salmon habitat, fencing, limitation on duration of grazing, and monitoring of riparian conditions. Since that time, many of the stream channels have shown significant recovery.

Stanley Lake

Overall, the U.S. Forest Service characterizes the Stanley Lake watershed as having high quality habitat conditions and integrity, with some areas of low integrity along the lakeshore. Past intensive uses such as mining have occurred in places within the watershed, and some within sensitive streamside and lakeside areas. Some mining activities occurred within the headwaters in the mid-1900s, including the construction of a small access road. The main access road was upgraded in the 1930s with lengthy segments located adjacent to Stanley Lake Creek. Intensive sheep and cattle grazing occurred within the watershed for a century until these activities were removed in 1993. Timber harvest, including road building, occurred in the reasonably accessible portion of the watershed on Elk Mountain in the 1960s (USFS 2011).

Stanley Lake's small size predominantly attracts fishing boat, kayak, and canoe use, although waterski boats and other personal watercraft are also allowed. The Stanley Lake Recreation Complex includes developed campgrounds, multiple areas of unconfined or dispersed camping, a trailhead, scenic overlook, and boat launch. Although equally accessible to passenger cars, Stanley Lake offers a vastly different experience than the larger and busier lakes.

Recreational developments are located adjacent to, or in close proximity to 43% of the Stanley Lake shoreline. Visitor numbers and impacts are increasing at a time when the local natural environment is particularly vulnerable. The recent mortality of the majority of mature lodgepole pine has left much of the area with a loss of shading, screening, and natural restrictions to foot traffic. Regeneration of groundcover, shrubs and trees will be delayed until foot traffic is directed and managed. Condition assessments by the U.S. Forest Service in 2001 showed most of these shorelines had been altered, with no improving trend apparent. For example, when lakeshore developments were present, 100% of the survey area had severe or moderate bank alterations. In contrast, when development was absent, only 21% of the survey area had severe or moderate bank alterations. The U.S. Forest Service is taking action to address fuel hazards in the developed recreation sites and along roads. The popular recreation use of the lake and shoreline areas by motorized equipment presents potential risks of contaminant spills.

While the overall watershed habitat conditions are good and improving, campground and boat launch developments impact some habitat areas (USFS 2011). There are also concerns about shoreline impacts from uncontrolled access points due to mooring. The Forest Service plans to work in cooperation with the county to identify impacts and develop a mitigation plan.

In addition, the U.S. Forest Service has removed lakeshore trails and installed fences to encourage recovery of shoreline vegetation. In 2011, the U.S. Forest Service closed the Stanley Lake Inlet Campground and began rehabilitating several roads and trails located in streamside and lakeside riparian areas. If sufficient funding can be secured, the U.S. Forest Service plans to construct 14 new campsites and associated facilities on the northeast corner of Stanley Lake near the Stanley Lake Campground but outside of lakeside riparian areas. A new boat launch will also be developed near the existing Stanley Lake Inlet Campground site.

Redfish Lake

The large majority of the Redfish Lake watershed remains in near natural condition, with the exception of the results of fire suppression, which has allowed most of the surrounding forest to reach late seral condition. Currently, however, the majority of the mature lodgepole pines are now standing dead because of a recent natural infestation of mountain pine beetle (USFS 2011). Fuel reduction treatments are being carried out by the U.S. Forest Service. These treatments typically reduce risks of high intensity forest fires by thinning trees, conducting prescribed burns, and removing surface fuels (fallen branches, low flammable brush and other flammable understory vegetation.)

Some recreational facilities sit at the north end of Redfish Lake. Facilities include the Redfish Lake Lodge (restaurant, cabin, and boat rentals), U.S. Forest Service campgrounds, boat launch, day-use areas, and a visitor center. Tours on the lake are common, as are motorized and non-motorized pleasure and fishing boats (IDFG 2010). At times during the summer months, the population of the Redfish Lake Complex is likely the largest “community” in Custer County. Developed recreation sites and/or commercial activities occupy approximately two miles of shoreline (USFS 2011). Sockeye Salmon campground and Sandy Beach boat ramp occur adjacent to Sockeye Salmon Beach spawning grounds. The only other facilities near Sockeye Salmon spawning areas (e.g., the transfer dock area and southeast of the inlet of Redfish Lake Creek) are Redfish Inlet Campground and transfer dock. Redfish Lake lakeshore was surveyed in early August of 2007. Nearly 75% of Redfish Lake shoreline has no development and remains in near pristine condition. However, 25% of the shoreline was developed causing increased bank alteration and removal of riparian vegetation.

The U.S. Forest Service has implemented several projects to remove lakeshore trails and install fences to encourage recovery of shoreline vegetation. In 2011, the U.S. Forest Service decided to replace two bridges on Road No. 214, realign Road No. 214 to access the new bridge, and construct a new road to bypass the second bridge, thus eliminating the need for one bridge. The U.S. Forest Service also will relocate the Visitor Center parking lot out of its current wet location, relocating the North Shore parking lot to provide for more day-use parking, and constructing a new pedestrian/bicycle trail near the Visitor Center. Abandoned roadways in the North Shore area would be removed to reestablish natural topography.

Yellowbelly Lake

Yellowbelly Lake habitat conditions are considered near pristine (USFS 2001). Recreation use on public land and minor development on private land near the mouth of Yellowbelly Lake have had a small influence in the watershed. Few U.S. Forest Service management activities occur within the watershed. Roads are believed to have little influence within the watershed (USFS 2001). IDFG management of the lake through a former fish barrier and chemical treatments has had the greatest influence on fish.

Pettit Lake

There is little land use disturbance in the Pettit Lake watershed, other than lakeshore developments. Developed recreation sites and/or cabin lots occupy approximately two miles of the south end of Pettit Lake – nearly 50% of the shoreline. Currently these developments receive considerably less intensive use than similar lakeside areas at Redfish Lake, but use is increasing. Possible historical Sockeye Salmon shoal spawning habitats are adjacent to these lakeside developments (USFS 2011). There are also several recreation developments (Pettit Lake Campground, Day Use area, and boat launch near the lake's outlet. Condition assessments by the U.S. Forest Service in 2006 showed that shoreline near developments had more trampled banks and less vegetation and downed woody debris.

Alturas Lake

Past irrigation diversions on Alturas Lake significantly affected the Sockeye Salmon population. The historic Breckenridge/Busterback Ranch in the Sawtooth Valley had three main diversions, including one on Alturas Lake Creek. The diversion had significant effects on stream flow and fish passage. The ranch had water rights for approximately 44 cfs from the Alturas Lake Creek which was used to flood irrigate summer cattle pasture. However, during the core of the irrigation season, natural flows were less than the appropriated flows such that, prior to 1992, Alturas Lake Creek was routinely dewatered during the summer irrigation season. Munther (1974) concluded that "no other diversion in Sawtooth Valley affects as many species as the Alturas Lake Creek diversion." Even when not fully dewatered the diversion structure itself severely reduced available fish habitat by precluding or impairing upstream migration. In 1992 the U.S. Forest Service purchased much of the former Busterback Ranch and the associated water rights from both Alturas Lake Creek and the Salmon River for 3.2 million dollars. The rights from Alturas Lake Creek (35.6 cfs) were immediately returned to the creek to improve habitat and passage conditions. In 1997, immediately after the last private irrigator discontinued use, the U.S. Forest Service removed the former diversion structure and restored natural channel conditions.

Historical legacy effects of grazing and mining in the headwaters have exacerbated sediment loading impacts in Alturas Lake (USFS 2011). More recently, recreational development has occurred on the north side of Alturas Lake and developed recreation sites now occupy approximately 1.6 km (1 mile) of shoreline. Perhaps 60% or more of the potential historical Sockeye Salmon shoal-spawning habitat are now adjacent to lakeside developments (USFS 2011). Since 1999, the U.S. Forest Service has closed and rehabilitated more than eight kilometers (5 miles) of roads, and the remaining roads are paved within the Alturas Lake recreation complex. The visitor facilities have been altered to reduce streamside pressure (USFS 2011). By 2006, the objectives were believed to be essentially complete. As natural recovery of these areas now proceeds, habitat conditions are expected to improve.

Mining

In 1862, gold was discovered in the Boise basin and miners rapidly pushed into the Payette River drainage on the west slope of the Sawtooth Mountains. In July 1864, a group of miners led by Captain John Stanley arrived in the Valley Creek area near present-day Stanley, Idaho and discovered gold. They named the valley "Stanley Basin." In 1878, silver ore was discovered in the lower Sawtooth Valley, which proved to be an extraordinarily rich find. Mining towns were quickly established, yet the ore was soon depleted and the mine closed in 1887. Gold was discovered north and east of Stanley Basin in Loon Creek in 1869 and in the Yankee Fork region in 1870, where miners rushed in by 1879.

In some areas, the scars of past mining activities remain today. Mining activities, particularly dredging, have affected aquatic habitat conditions by changing channel structure, removing riparian vegetation, reducing floodplain connectivity, and/or increasing fine sediment levels. Although little mining activity currently occurs in the area, the possibility of future mining remains a potential threat, particularly if the minerals increase in value. However, under Public Law 92-400, subject to valid existing rights, all Federal lands in the Sawtooth National Recreation Area are withdrawn from all forms of mineral location, entry, and patent (Sawtooth National Forest 2006).

Stanley Lake

Placer mining occurred in some tributaries, such as Stanley Creek, and along the Salmon River within the canyon, and had severe local effects on stream habitat conditions. Some fine sediment accumulation above Stanley Lake may be due to historical effects of grazing and some mining in the headwaters. However, no mining activity has occurred for many decades (USFS 2011).

Alturas Lake

Hard rock or quartz mining boomed in 1879 at Sawtooth City. The discovery of ores that started this town did not sustain it and the supply of ore had declined rapidly by the late 1880s, although occasional spurts of activity occurred during the 1900s. Historical legacy effects, particularly grazing and patented mining in the headwaters, have exacerbated sediment loading into the lake (USFS 2001).

Lake poisoning

In the mid-1950s, based on very low levels of adult Sockeye Salmon returns to Stanley, Pettit, and Yellowbelly Lakes, the IDFG made the decision to develop these lakes for resident species sport fisheries (IDFG 1959). Yellowbelly (1961), Pettit (1961), and Stanley (1954) Lakes were chemically treated with Toxaphene, Rotenone, and Fish-Tox, but the larger Alturas and Redfish Lakes were not. Stanley Idaho resident John Rember reports that the 1961 fish kill extended down the upper Salmon River as far as the town of Stanley (Rember 2003), which suggests that a cohort of smolts from all the lakes may have been depleted by the poisoning.

Stanley Lake
Treated with Fish-Tox in 1954 and an upstream fish barrier was constructed.

Yellowbelly Lake
Native fish were chemically removed from Yellowbelly Lake with Toxaphene in the 1950s and in 1961 by IDFG and an outlet barrier was constructed at that time (Chapman et al. 1990). Bjornn et al. 1968 observed dead residual Sockeye Salmon after treatment. Bjornn stated, "Fish found in Pettit and Yellowbelly Lakes, after chemical treatment in 1961 and 1962, appeared to be residual Sockeye Salmon. The fish were darker in coloration than the bright red kokanee and would have spawned later than the kokanee populations in Redfish and Alturas Lakes. We found no record of kokanee being planted in Yellowbelly Lake." The lake was chemically treated again with Rotenone in 1990.

Pettit Lake
In the 1950s and 1960s, IDFG treated the lake with Toxaphene to remove native fish (Chapman et al. 1990).

Hell Roaring Lake
In the 1970s, Hell Roaring Lake was chemically treated. Stacey Gebbards reported seeing numerous 4 to 5 inch kokanee during treatment, an indication that the lake may have supported anadromous Sockeye Salmon at some point in time (Bowler 1990).

Introduction of Non-native Fish Species

Non-native species present in Sawtooth Valley waters include lake trout *S. namaycush* (Stanley Lake only), various hatchery strains of rainbow trout, brook trout *S. fontinalis,* and non-native kokanee.

Stanley Lake
Disturbance to the lake's biological processes began early in the 1900s with the introduction of exotic brook trout and again in 1975 with the introduction of lake trout (Curet et al. 2009; IDFG 2013). In 1993, Teuscher (1999) reported a wide range of lake trout lengths, from approximately 200 to 680 mm total length. The shorter lengths of lake trout identified by Teuscher served as the first indicator of natural reproduction within the lake trout population. Stanley Lake was stocked with non-native

kokanee from 1988 to 1991, an early spawning stock. The 1990s data from Waples (1991) suggests that kokanee in this lake are a mix of native and non-native fish. IDFG has recently re-sampled the kokanee population to identify the current genetic composition of kokanee. The recent study found that the native population of kokanee still exists within Stanley Lake but that it has been slightly introgressed with non-native kokanee. U.S. Forest Service electrofishing surveys in 2008 found brook trout in Stanley Lake Creek above the lake. Brook trout are also present in Stanley Lake Creek below the lake.

Redfish Lake

Kokanee are native to Redfish Lake. Previous kokanee stocking from a range of hatchery sources beginning in 1930 and continuing through 1972 (Waples et al. 2011; Bowler 1990) has appeared to have no lasting impacts. IDFG recently re-sampled the kokanee population to identify the current genetic composition of these fish and found the same results (Kozfkay 2013c).

Electrofishing surveys conducted by the Sawtooth National Forest in 2008 observed numerous brook trout in Redfish Creek above the lake. Brook trout have also been observed in Fishhook Creek in 2006 and 2012 Sawtooth National Forest surveys. Brook trout may indirectly impact Sockeye Salmon and kokanee that use lower Fishhook Creek by aggressively defending feeding territories and outcompeting anadromous salmon (Hutchison and Iwata 1997). Brook trout are also voracious predators, and they frequently consume juvenile salmonids (Sigler and Sigler 1987; Karas 1997). Additionally, brook trout appear to consume salmon eggs (Karas 1997). Johnson (Johnson and Ringler 1979; Johnson 1981), for example, reported that salmon eggs comprised between 38 and 95% of the diet of brook trout in a tributary of Lake Ontario.

Yellowbelly Lake

Yellowbelly Lake was chemically treated in 1990 to reduce brook trout populations and was then stocked with westslope cutthroat trout. Brook trout are numerous and widely distributed in Yellowbelly Lake Creek above and below the lake due to historic stocking.

Pettit Lake

Non-native kokanee salmon from north Idaho stock were stocked repeatedly from 1930 to 1968. Genetic analyses have confirmed that the native population of kokanee has been completely replaced by non-native introductions of kokanee from northern Idaho. The kokanee compete with listed Sockeye Salmon for the zooplankton forage base. Electrofishing surveys conducted by the Sawtooth National Forest above Pettit Lake in 2007 observed numerous brook trout. Brook trout are likely the result of emigration from Alice and Pettit Lake stocking in the 1950s and 1960s.

Alturas Lake

Alturas Lake was stocked with non-native kokanee from 1921 to 1968 with an early spawning stock of kokanee from the Anderson Ranch Reservoir. The current data from Waples et al. (2011) indicates that the fish within Alturas Lake are native and that there is no lasting impact from these past stocking activities based on the results of the genetic analyses that were conducted. Brook trout were found in eight electrofishing sites in 2012 within Alturas Lake Creek and lower Alpine Creek. Brook trout densities ranged from 1.18-2.36 fish/100m^2 with the highest densities occurring in the headwaters of Alturas Lake Creek.

Introduction of Aquatic Invasive Species

Currently very few waters on the Sawtooth National Recreation Area have been infested with aquatic invasive species. New Zealand mud snails (*Potamopyrgus antipodarum*) have only been found in a small pond on private property near Squaw Creek. Mudsnails can grow in such great densities that they endanger the food chain by outcompeting native snails and water insects for food, leading to sharp declines in the native populations. Fish populations then suffer because the native snails and insects are their main food source. Mud snails can also damage infrastructure used to manage hatcheries, weirs and other structures used to manage water resources. Mud snails were first detected in the United States in the Snake River in 1987 and have since spread to most western states. Fortunately, Eurasian water milfoil, Quagga and Zebra Mussels, and Chytrid fungus have not yet been detected in any waters on the Sawtooth National Recreational Area.

The parasite (*Myxobolus cerebralis*), which affects salmonids and causes whirling disease, is also an invasive species of concern. *Myxobolus cerebralis* spores can cause whirling disease and have been detected in rainbow trout left in live traps in the Salmon River, Pole Creek and Alturas Lake. The disease affects juvenile fish and causes skeletal deformation and neurological damage. The parasite has caused rates of high mortality of fish species important in several recreational sport fishing rivers in the West, including Idaho where it can further impact species that are already threatened or endangered. *Didymosphenia geminate* (Didymo) has been confirmed in localized areas within the Salmon River below Slate Creek and in Stanley Lake Creek below the lake. The extreme risk posed by the potential for aquatic invasive species could be mitigated by setting up check points at the three portals entering the Sawtooth Valley (Hwy 75 from Ketchum, Hwy 75 from Challis and Hwy 21 from Boise).

Redfish Lake

The greatest risk of aquatic species infestations to the upper Salmon River region comes from boats launching in large glacial lakes (e.g., Redfish, Alturas, Stanley and Pettit), commercial floatboat outfitters and private floatboaters on the Salmon River, and public fishing. The Sawtooth National Forest has worked with the Idaho State Department of Agriculture (ISDA) since 2009 to maintain a boat inspection station at the Redfish Lake Sandy Beach boat ramp (Chatel 2013). Boat inspections conducted at Redfish Lake from 2009-2011 have found a number of boaters coming from infected waters both within Idaho and outside the state. Some boats have come from as far a Maine and Florida. In 2011, eight boats were washed at the Redfish check station. Two boats had been in Utah waters (an impacted state), one boat was found with Eurasian water milfoil (from the Snake River), two boats were generally dirty, and three watercrafts were found with snails. All watercraft with snails found on them had previously launched in Magic Reservoir and the snails were determined to be a native pond snail species. In 2012, the inspectors examined 1,518 watercrafts (ISDA 2013). Four boats were washed in 2012. Two boats were washed by the ISDA crew, including a jet ski with dead quagga mussels on it and

Nevada registration. Two boats were washed by the Student Conservation Association crew. Three of the boats were just dirty, with no plants or animals visible.

Wildfire Risks

Mountain pine beetle populations are a natural part of the ecosystem. Several mountain pine beetle infestations have occurred and been recorded in the Sawtooth Valley area throughout the past century. The most recent mountain pine beetle epidemic started in 1996 (Figure 5-1). Even though mountain pine beetle epidemics are a natural part of the ecosystem, concerns have been raised about how the epidemics may influence wildfire risk. In general, the potential for high-intensity crown fires is great during two periods in the life of a lodgepole stand. The first period is in young stands, when the crowns of the growing lodgepole are in proximity to dead woody fuels. The second period is when over mature stands break up and are being replaced by shade-tolerant associates. During this period, dead fuels accumulate as lodgepole snags fall, and young shade-tolerant conifers provide a fuel ladder to the crowns of overstory trees.

In 2005, the 16,524 hectare (40,831 acre) Valley Road Fire, located 22.5 km (14 miles) southeast of Stanley, Idaho, started on private property from human causes. Weather and fuel conditions created extreme fire behavior. In 2012, the 72,461 hectare (179,055 acre) Halstead Fire started by a lightning strike on the Salmon Challis National Forest north of Stanley. In 2013, the 210 Fire was aggressively fought and contained at 93 hectares (230 acres) along Highway 75 near the Redfish Lake Road, approximately 5 miles south of Stanley, Idaho.

Although no large fires have occurred on the westside of the Sawtooth Valley, several smaller fires have occurred, including the Road 210, Gold, and Hell Roaring Fires in 2013 and 2014. The accumulation of fuel within lodgepole pine and adjacent stands place several subwatersheds that support Sockeye Salmon at risk from changed watershed conditions. How change may occur is dependent on the burn severity, fire intensity, burn area, topography, soil properties, climate, and channel proximity (Baker 1988; Beschta 1990; DeBano et al., 1998; Robichaud 2000). If kept small, wildfire and post-fire effects may have only localized impacts to watersheds and aquatic systems. However, larger fires have the potential to accelerated soil erosion and sediment delivery to streams until enough vegetative recovery occurs. Some streams with adequate wood and other obstructions may be able to temporarily store the finer sediments; however, most streams will transport material to lower gradient reaches because they are very steep and have confined channels. Spawning gravel quality may decrease in localized areas depending on how large a sediment pulse enters the channel and how much of it is stored in lower gradient areas. Pool volume may also decrease until higher flows transport the fine sediment downstream. Wildfires may also change lake water chemistry by adding nutrient-laden sediment, or through atmospheric deposition of smoke and ash.

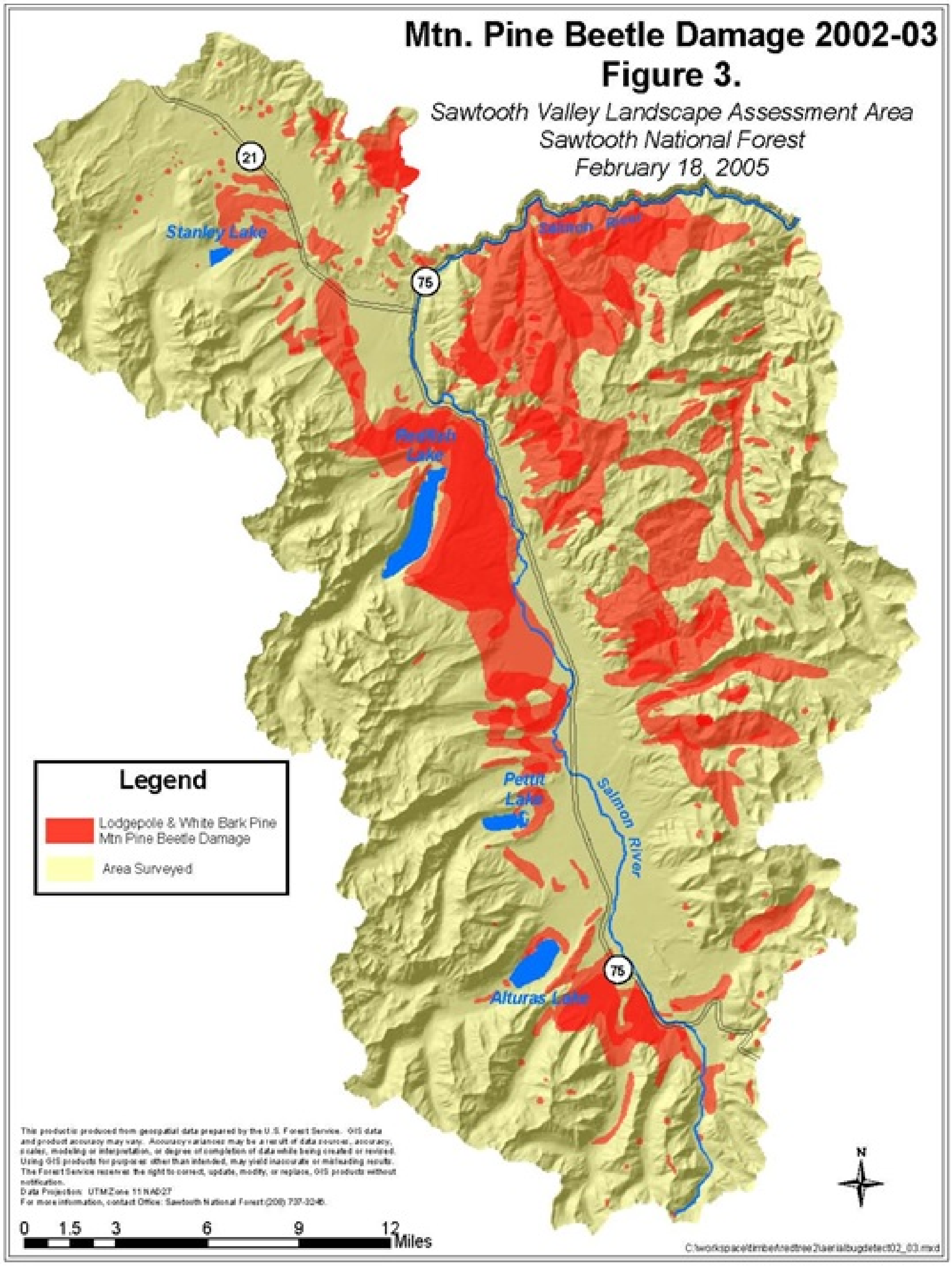

Figure 5-1. Extent of recent Mountain pine beetle epidemic beginning in 1996.

5.1.1.5 Summary of natal lakes threats and limiting factors

Threat: Introduction and continued stocking of non-native fish species such as brook trout, rainbow trout, lake trout, and kokanee.

Potential limiting factors: Unfavorable changes in lake ecology; genetic introgression and intraspecific competition between Sockeye Salmon and kokanee for food resources; predation and competition by hatchery steelhead (Cannamela 1993), rainbow trout, brook trout, and potentially lake trout if Sockeye

Salmon are allowed to enter currently inaccessible Stanley Lake or if lake trout spread to other lakes and streams.

Threat: Recreational use and development.
Potential limiting factors: Potential unfavorable changes to water quality; localized impacts to lakeshore and wetland habitats, access roads impact sediment processes and habitat if located adjacent to lakeshore or outlet streams, potential interference in historical Sockeye Salmon spawning areas; potential for chemical spill from recreational boat use in lakes; projected future increase in recreational use and development pressures on natal lakes may increase the impact of this threat in future years.

Threat: Legacy impacts from historical land use, irrigation diversions, and mining practices.
Potential limiting factors: Increased sediment inputs and lingering historical habitat impacts due to sheep and cattle grazing, timber harvest, road building, and mining; reduced flow and blocked migration due to water withdrawals and irrigation diversion structures; lake poisoning and stocking of non-native fish.

Threat: Blocked access to lakes.
Potential limiting factor: Inability to spawn in historical habitat, restricted Sockeye Salmon spatial diversity, and impacts to natal lake biological processes due to loss of connectivity of fish into lakes.

Potential Future Threat: Aquatic invasive species.
Potential limiting factors: Impacts to natal lake biological processes due to impacts in food chain species important to lake ecosystem and salmonid food sources; increased mortality at different life stages due to parasites.

Potential Future Threat: Wildfire risks.
Potential limiting factors: Impacts to watersheds may include accelerated soil erosion and sediment delivery to streams, decreased spawning gravel quality, decreased pool volume and changes to lake water chemistry due to nutrient laden sediment or through atmospheric deposition of smoke and ash.

Potential Future Threat: New pond development.
Potential limiting factors: Impacts to natal lake biological processes due to impacts from sediment delivery to streams; potential unfavorable changes to water quality, including temperature; potential introduction of aquatic invasive species.

5.1.2 Salmon River

This section discusses the threats and potential limiting factors for Snake River Sockeye Salmon in the Salmon River migration corridor. It discusses land use practices and the resulting habitat conditions that Sockeye Salmon migrants face as they make their way to and from the Sawtooth Valley lakes. The possible effects from contaminants are discussed in Section 5.7, Toxics.

The Salmon River, flowing 660 km (410 miles) through central Idaho to join the Snake River in lower Hells Canyon, represents almost half the length of the Sockeye Salmon migration route. Juvenile Sockeye Salmon migrants move quickly through the Salmon River after leaving the natal lakes in late spring and early summer, often arriving at Lower Granite Dam in about seven days. Adult Sockeye Salmon migrate upstream through the river in late summer, returning to the Sawtooth Valley lakes in August and September. Adult Sockeye Salmon migrants generally spend more than 30 days traveling up the Salmon River before reaching the Sawtooth Valley.

Much of the upper Salmon basin is managed for public use, with some of the Salmon subbasin protected in wilderness or roadless areas. High watershed and aquatic integrity is found in the Upper Middle Fork, Lower Middle Fork, and Middle Salmon–Chamberlain watersheds (NPCC 2004a). Habitats tend to be more modified or degraded in the major watersheds that have broad valleys and easier access for humans and development, such as the Little Salmon, lower Salmon, Pahsimeroi, and Lemhi watersheds. Much of the subbasin is managed by the USFS or BLM for multiple uses.

Private lands tend to be concentrated along the valley bottoms, i.e. near the river. The small towns in the subbasin are located along the river (Stanley, Challis, Salmon, Riggins, New Meadows, and White Bird), with rural populations scattered in the surrounding areas. Most of these towns have populations under 500. Salmon is the largest, with slightly more than 3,000 people (NPCC 2004a). Cattle ranching and agriculture are the main economic activities, and irrigation diversions are common; logging and mining were important historically but have declined since the 1990s (NPCC 2004a). Water quality in many areas of the subbasin is affected to varying degrees by land uses that include livestock grazing, road construction, irrigation withdrawals, logging, and mining (NPCC 2004a). A potential emerging threat is the development of new ponds for aesthetics and irrigation purposes, even when there are other means to meet existing water rights. The development of new ponds could increase losses through evaporation, reduce water quality, raise water temperature and sediment delivery, and create additional stressors to the aquatic environment. More information is needed about this potential land use issue to better understand its impacts.

5.1.2.1 Sockeye Salmon migration and survival in the Salmon River

Despite the relatively sparse human population and expanse of public lands, both juvenile and adult Sockeye Salmon experience unexplained mortality in the 743 km (462-mile) migration corridor between Redfish Lake and Lower Granite Dam. Determining the magnitude of this loss, as well as where and why mortality is occurring, is critical to the successful restoration and recovery of the Sockeye Salmon populations.

Annual tracking of hatchery Sockeye Salmon juveniles between release sites in the Sawtooth Valley and Lower Granite Dam shows that juvenile survival through this Salmon River reach varies between years. Based on detections of juvenile hatchery Sockeye Salmon that were PIT-tagged and released in the spring of each year, survival estimates have ranged from 11.4% in 2000 (Zabel et al. 2001) to 77.6% in 2008 (Faulkner et al. 2008).

The studies show that survival of juvenile hatchery Sockeye Salmon in the Salmon River varies between release strategies and different reaches (Axel et al. 2014). Researchers track and compare survival and travel times for PIT-tagged and radio-tagged hatchery Sockeye Salmon juveniles from Sawtooth and Oxbow hatcheries. The fish have been released in separate groups to compare day and night survival rates. The tracking studies also indicate that a large portion of the loss of outmigrating juvenile hatchery Sockeye Salmon in the Salmon River occurs between release sites and the North Fork Salmon confluence, with higher losses occurring within Little Redfish Lake, in the reach just above Valley Creek near Stanley, between the Pahsimeroi and Lemhi Rivers, and in the slow-river reach at Deadwater Slough (Axel et al. 2014).

Predation appears to be responsible for much of the juvenile mortality in the upper Salmon River. During fish releases, researchers have observed multiple predation events on recently released juvenile Sockeye Salmon. In 2013, common merganser *Mergus merganser*, osprey *Pandion haliaetus*, double-crested cormorant *Phalacrocorax auritus*, and western grebe *Aechmophorus occidentalis* were actively feeding in Little Redfish Lake, located below the release site, as fish were moving through the area. Bull trout *Salvelinus confluentus* were also chasing juvenile Sockeye Salmon schools as they migrated through Little Redfish Lake (Axel et al. 2014). Loss of migrating juvenile Sockeye Salmon may also be related to competition with non-native species, environmental conditions, natural mortality, or rearing and release strategies.

Adult migrants are also lost in the Salmon River corridor (Keefer et al. 2008). Of the 5,574 adult Sockeye Salmon that passed Lower Granite between 2008 and 2012, a total of 4,207 (75%) were recovered at Redfish Lake, the Sawtooth Hatchery weir, or other basin trapping locations (IDFG 2012). The factors responsible for the losses of adult Sockeye Salmon migrants are not fully established, but are believed to be strongly related to stream flow and temperature (Arthaud 2012). Adult Sockeye Salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak. Research continues to identify how and where these conditions in the Snake and Salmon Rivers affect Sockeye Salmon migrants. It is not clear where adult Sockeye Salmon mortality is occurring upstream of Lower Granite Dam.

5.1.2.2 Salmon River mainstem habitat in Sawtooth Valley

Sockeye Salmon utilize the upper mainstem Salmon River in the Sawtooth Valley as a migratory corridor to and from the natal lakes. Legacy effects from historical mining, private land grazing, and irrigated pasture use may still influence local habitat and sediment processes and conditions. However, ongoing restoration work to eliminate impacts from irrigation diversions and fence stream corridors to exclude livestock are improving habitat conditions over time.

Water Temperature and Sediment

The Salmon River from Redfish Creek to Valley Creek is currently listed on IDEQ's 2010 303(d) list (under the Clean Water Act) as "not supporting" the beneficial use "cold water aquatic life"[6] due to "water temperature and sediment/siltation" (Table TT in IDEQ 2011). Grazing and localized development pressures, numerous diversions on tributaries, irrigation return flows, and some large diversions on the mainstem Salmon River (e.g., Decker Flats), are major factors. In tributaries throughout the Sawtooth basin, Rothwell and Moulton (2001) found reductions in streamflow caused by diversions correlated with increases in stream temperature. Reductions in water quality, especially from water temperature and sediment, are widespread where tributaries cross the flat, grazed, and exposed valley floor. Water temperatures in the Salmon River rise as the river collects the warmer streamflow from these tributaries. The higher water temperatures impact Sockeye Salmon migration survival through the Salmon River. The quality of source water from the Salmon River for the Sawtooth Hatchery is also limited when temperatures warm during late summer.

Physical Barriers

Multiple diversions occur on the mainstem Salmon River upstream of Stanley, Idaho. Most of these have fish screens and head gates, but some still may entrain fish into irrigation ditches or cause significant bypass mortality. Diversions also reduce stream flows, but most mainstem diversions below the Redfish Lake Creek confluence do not currently reduce flow enough to create passage barriers. Diversions upstream of Redfish Lake Creek confluence have historically limited fish passage, especially during drought years.

A weir at Sawtooth Hatchery on the Salmon River also restricts Sockeye Salmon passage. Plans are underway to begin allowing anadromous Sockeye Salmon adults to return to their lake of origin. This would entail trapping adults at the Sawtooth weir and transporting them to Alturas or Pettit Lakes, or alternatively to pass the adults to allow for volitional migration. Presently the trap does not effectively capture adult Sockeye Salmon. The Sawtooth Hatchery on the Salmon River upstream of the mouth of Redfish Lake Creek has been in operation since 1985 as a mitigation hatchery for Chinook salmon and summer steelhead. The hatchery includes a weir on the Salmon River, a fish ladder and adult holding ponds. Adult Sockeye Salmon trapped at the Sawtooth weir are transported to the Eagle Fish Hatchery where they are identified (genetically) and either held for incorporation in subsequent spawning designs or returned to Sawtooth Valley lakes for natural spawning.

Floodplain Modification and Connectivity

Some localized floodplain modification has occurred, including road fill (particularly from Highway 75), bridges, channel modifications on private lands, residential and commercial development in Stanley and lower Stanley, and construction of the Sawtooth Hatchery (USFS 2011). River bank modifications

[6] Supporting the beneficial use "Cold Water Aquatic Life" means that water quality is appropriate for the protection and maintenance of a viable aquatic life community for coldwater species (e.g., salmon, steelhead, and bull trout).

and bank stabilization treatments have been applied to control or prevent natural movement of the river channel.

Mining

Mining activities have occurred throughout the Salmon River headwaters of the population since the latter part of the nineteenth century. However, the legislation that established the Sawtooth National Recreation Area withdrew the area from additional mineral entry under the 1872 Mining Law, and directed validation of existing mining claims. The vast majority of claims present in 1972 have since been invalidated. Valid claims remain, but active mining is not currently occurring (Sawtooth National Forest 2006).

5.1.2.3 Salmon River mainstem habitat from Sawtooth Valley to Snake River

Snake River Sockeye Salmon are affected by conditions in the Salmon River as they migrate between the Sawtooth Valley and lower Snake River. Several factors potentially influence Sockeye Salmon survival in this reach including floodplain modification, mining, irrigation withdrawals, water quality, and introduction of non-native species.

Floodplain Modification and Connectivity

The Salmon River floodplain downstream from the Sawtooth Valley has been modified considerably by conversion to cropland, such as irrigated cut hay, alfalfa, and wheat, and by residential development. Riverbanks have been altered by the construction of numerous dikes and diversions associated with agriculture, residential development, and State Highways 75 and 93. Much of the natural sinuosity of the river has been reduced and side channels filled in an effort to protect residential and agricultural lands on either side of the river channel (IDEQ 2003).

Historical and Current Mining

Many upper Salmon River watersheds have experienced mining activities in the past, with some activity remaining today. Mining and associated activities severely reduced habitat and water quality of the Salmon River. Hydraulic mining and placer mining were widely used historically, followed by shaft mines and adit mines (where the entrance to an underground mine is horizontal or nearly horizontal). Mine-related ground disturbance removed hill-slope and riparian vegetation, exposed and compacted soils, and altered drainage patterns.

Mining activities in the basin began more than 100 years ago. In 1910, Sunbeam Dam was constructed on the upper Salmon River to generate power for a mine on the Yankee Fork. The dam was used only one year, yet blocked fish passage to the entire upper Salmon River for 23 years until breached in 1934 by IDFG. In the early 1940s and 1950s, the substrate of the lower Jordan Creek and Yankee Fork was mined for gold using a floating dredge, severely affecting the Yankee Fork and mainstem Salmon River. Much of the natural meander pattern of the Yankee Fork was lost, along with associated instream habitat and riparian vegetation. Extensive unconsolidated and unvegetated dredge tailings continue to increase sedimentation and reduce water quality of the Salmon River.

Mining activities in recent decades include Grouse Creek Mine, a large surface silver mine operated in the 1990s in the Yankee Fork, which is now closed as a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) site, commonly known as a superfund site. The largest active mine in the region is the Thompson Creek Molybdenum Mine located within the Thompson Creek and Squaw Creek watersheds. Potential exists for future mining opportunities in many tributary watersheds to the Salmon River (IDEQ 2003).

Irrigation withdrawals

One of the largest impacts to salmonid habitat in the upper Salmon River comes from the effects of irrigation diversions and evapotranspiration of crops (USBWP 2005). Consumptive water use in the upper Salmon River basin reduces streamflow in individual tributaries and cumulatively in the Salmon River. Reductions during juvenile spring migration and during summer and fall adult migrations reduce the amount and function of available habitat, leading to reduced survival (Arthaud and Morrow 2007, 2013).

Diversions on the mainstem Salmon River near Challis and downstream from Salmon withdraw large proportions of water available in the mainstem. Entrainment and bypass of Sockeye Salmon is common and reduced survival may occur. Through their Anadromous Fish Screen Program, IDFG has installed fish screens on most of the diversions on the mainstem Salmon River, but tributary diversions are largely unscreened and number in the hundreds throughout the Salmon River basin (IDFG 2003). These flow reductions in tributaries contribute to flow depletions and higher water temperatures in some reaches of the Salmon River mainstem and reduce salmon rearing and migration survival. One of the most critical reaches of the Salmon River for juvenile migration is likely from Challis to Shoup, which includes the most and larger diversions, least tributary contributions, and most associated habitat and water quality degradation. The development of new ponds for aesthetics and irrigation is a potential emerging threat to water quality and stressor to the aquatic environment. More information is needed about this potential land use issue to better understand its impacts.

Water quality

The land and water uses described above have led to some stream and river reaches in upper Salmon River being listed as impaired on the Clean Water Act 303(d) list. In 2008, Idaho Department of Environmental Quality (IDEQ) listed various stream reaches as impaired by sediment, high temperatures, and nutrients (IDEQ 2008). Multiple tributaries, along with the main Salmon River downstream from the Pahsimeroi River, are also listed on the 303(d) list as not supporting cold-water aquatic life for unknown reasons. This section of the Salmon River mainstem, for example, received low scores on IDEQ's combined biota and habitat bioassessments, but the specific pollutants causing the low scores are not known. IDEQ has written a Total Maximum Daily Load (TMDL) for sediment for Challis Creek, recommending a substantial reduction in streambank erosion. Temperatures in portions of the mainstem Salmon River migration corridor do not support the beneficial use "Cold Water Aquatic

Life"[7] (Table 5-1) which is likely to reduce the survival of adult Sockeye Salmon returning to the Sawtooth Valley in late July and August.

Table 5-1. Reaches of the mainstem Salmon River that do not support the beneficial use "Cold Water Aquatic Life" (Source: Table TT, IDEQ 2011).

Mainstem Reach	Reach	Pollutant
Upper Salmon	Fisher Cr to Decker Cr	Sedimentation/siltation
	Redfish Lake Cr to Valley Cr	Sedimentation/siltation/ Water temperature
	Valley Creek to Yankee Fork Creek	Sedimentation/siltation/ Water temperature
	Thompson Cr to Squaw Cr	Sedimentation/siltation/ Water temperature
Middle Salmon-Panther	Pahsimeroi to NF Salmon R (includes multiple assessed reaches)	"Cause unknown"

Eighty water bodies in the Salmon subbasin are classified as impaired under the guidelines of section 303(d) of the Clean Water Act (IDEQ 2011) (Figure 5-2). The primary parameters of concern are sediments, nutrients, flow alteration, water temperatures, and habitat alteration.

[7] IDEQ defines support of the beneficial use "Cold Water Aquatic Life" as water quality is appropriate for the protection and maintenance of a viable aquatic life community for coldwater species (e.g., salmon, steelhead, and bull trout).

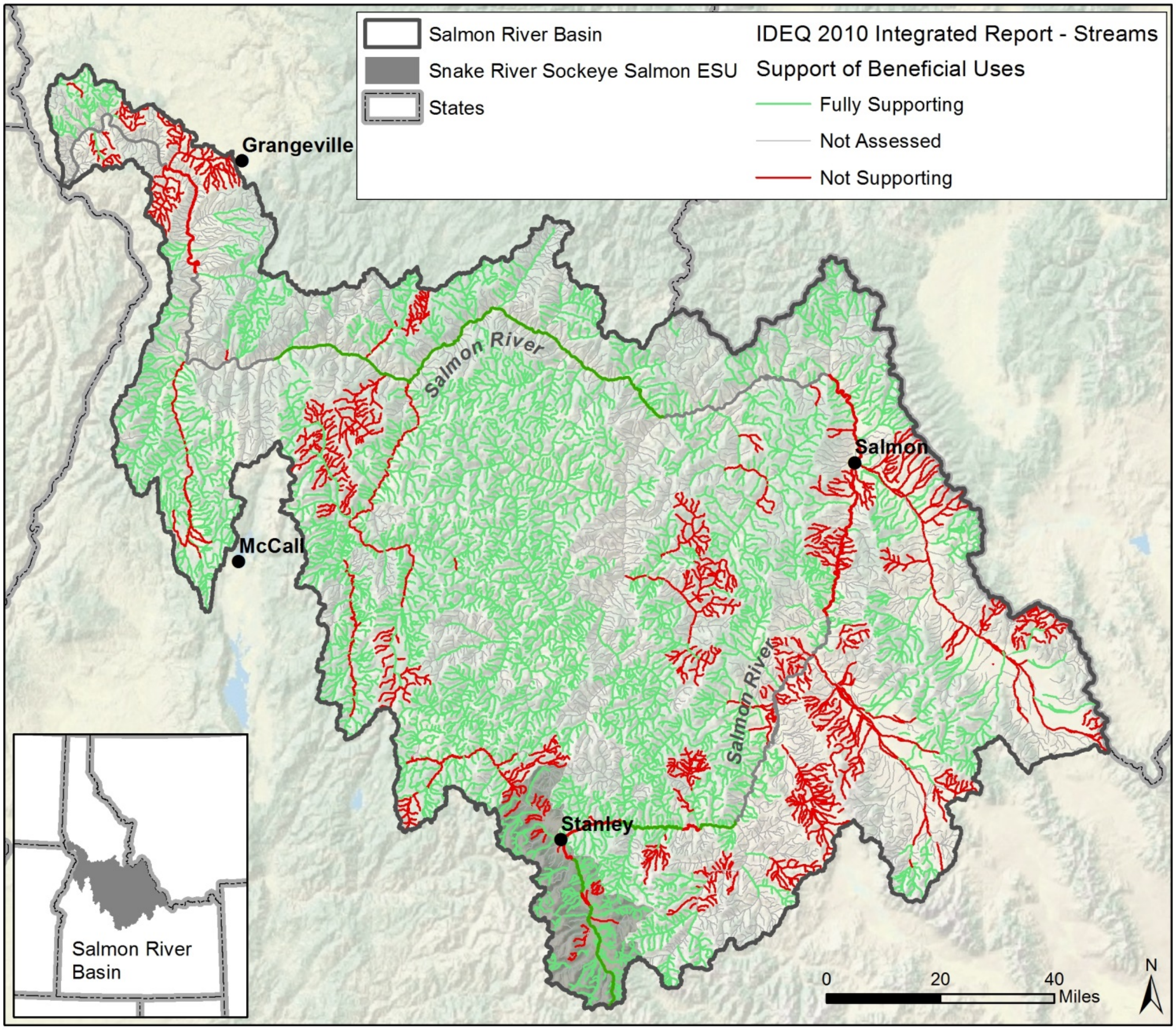

Figure 5-2. Streams in the Salmon subbasin, Idaho, that are included on the 303(d) list (Source: IDEQ 2011).

Introduction of non-native species

Smallmouth bass thrive in the lower Salmon River mainstem extending upstream to Salmon, Idaho. Introduced smallmouth bass, brook trout, hatchery steelhead, and hatchery rainbow trout compete with and prey upon emigrating juveniles (Peterson 2013b).

5.1.2.4 Summary of Salmon River threats and limiting factors

Threat: Irrigation withdrawals.
Potential limiting factors: Reduced baseflows, altered hydrologic regime, elevated water temperatures, and reduced refugia at tributary mouths reduce juvenile and adult Sockeye Salmon survival and impede migrations.

Threat: Toxic pollutants (See Section 5.7).
Potential limiting factors: Impaired fitness and research needed to assess potential impacts.

Threat: Historical and current land use, roads and erosion control, floodplain development, and mining activities.
Potential limiting factors: Degraded riparian habitat, elevated water temperatures, reduced floodplain connectivity, narrowed and simplified channels, barriers to migration, and elevated sediment levels.

Threat: Blocked access to migration corridor and natal lakes.
Potential limiting factor: Inability to spawn in historical habitat, restricted Sockeye Salmon spatial structure, and impacts to biological processes due to loss of connectivity into migration corridors and lakes.

Threat: Introduction and continued stocking of non-native fish species.
Potential limiting factors: Unfavorable changes in species composition; competition for food resources; predation on emigrating Sockeye Salmon juveniles by smallmouth bass, hatchery steelhead, rainbow trout, and brook trout.

Potential Future Threat: New pond development.
Potential limiting factors: Impacts to natal lake biological processes due to impacts from sediment delivery to streams; potential unfavorable changes to water quality, including temperature; potential introduction of aquatic invasive species.

5.1.3 Lower Mainstem Snake River to Lower Granite Reservoir

The Salmon River joins the lower Snake River at river kilometer (RKm) 302 (river mile (RM) 188). The Grande Ronde River also contributes flow to this reach, along with some smaller tributaries, including the Imnaha River and Asotin Creek. The channel widens near RKm 290 (RM 180), with gently sloping shorelines. Downstream of the Salmon and Grande Ronde Rivers there are long, deep pools and runs and low-gradient rapids (Groves and Chandler 1999). The free-flowing reach ends at RKm 236 (RM 147), where it enters the Lower Granite Reservoir near Lewiston, Idaho.

5.1.3.1 Altered flows

Although unimpounded, flows in this reach of the lower Snake River have been altered by power peaking operations at the Hells Canyon Complex (Snake River RKm 398, RM 247) since the 1960s. Flow fluctuations can strand or entrap juveniles in shallow water areas. There is no indication that this is a significant issue for Snake River Sockeye Salmon which migrate quickly through the mainstem and spend limited time in nearshore areas. PIT-tag and radiotelementry studies during the 2012 and 2013 outmigration season showed that median travel time for Sawtooth and Oxbow Hatchery Sockeye Salmon was approximately 7 days from the Sawtooth Valley to Lower Granite Dam (Axel et al. 2013, 2014).

The fluctuations in flow caused by the upstream Hells Canyon Dam complex have altered riparian vegetation in this free-flowing reach of the lower Snake. Over the decades, this has created a large degraded riparian zone along each side of the river where the vegetation community and associated prey communities are highly altered. The food is now dominated by phytoplankton and zooplankton instead of the prey produced in the floodplain, but the effect of this change on juvenile Sockeye Salmon growth, condition, and survival has not been studied.

5.1.3.2 Water quality

The potential effects of toxics in this reach are discussed in Section 5.7 Toxics.

High water temperatures may be a limiting factor in this reach. IDEQ has begun a TMDL for temperature for the lower mainstem reach (Zaroban 2011). A preliminary comparison of USGS temperature gage data from 1999 to 2005 found peak summer water temperatures in the Salmon River and the mainstem Snake quite similar, reaching 24°C (75°F) in both (Zaroban 2011).

Sockeye Salmon adults migrate upstream during summer in depleted flows and warm temperatures. Arthaud et al. (2010) estimated spring flows of the Snake and Columbia Rivers were depleted about 30-50%, although peak runoff exceeded historical averages some years. Summer depletions of the upper Salmon River may also reach 10-30% (Rothwell 2009). From 1999 to 2012, survival of PIT-tagged adult Sockeye Salmon from Lower Granite Dam to Sawtooth return sites was closely and negatively related ($r^2 = 0.53$) to water temperature of the Snake River (Arthaud 2012). When Snake River (at Anatone, Washington gage) average July water temperatures exceed 22^{o}C (71.6°F), the percent conversion was less than 20%, yet reached 90% as temperature declined to 18^{o}C (64°F). Current efforts to control summer water temperatures in the lower Snake River include regulating outflow temperatures at Dworshak Dam.

5.1.3.3 Adjacent land uses

Dryland and irrigated farming and livestock grazing are widespread in the lower Snake River subbasin. Lands adjacent to the river are mostly privately owned (NPCC 2004b). Riparian vegetation tends to be absent or degraded (NPCC 2004b.). The Lewiston-Clarkston area near the mouth of the Snake River is the only significant industrial, commercial, and residential development in the subbasin.

5.1.3.4 Summary of lower mainstem Snake River to Lower Granite Reservoir threats and limiting factors

Threat: Upstream dam operations.
Related limiting factors: Altered flows, riparian function, and food webs

Threat: Land uses adjacent to Snake River and tributaries.
Related limiting factors: Degraded water quality, altered thermal regime.

5.1.4 Mainstem Migration Corridor

Moving downstream, the mainstem Columbia and Snake River migration corridor runs from the contiguous reservoirs formed by Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams on the lower Snake River; through McNary, John Day, The Dalles, and Bonneville Dams on the lower Columbia River; and on through the estuary and plume to the ocean. Hydrosystem modifications to the mainstem habitat are significant, affecting both juvenile and adult migration. Hydropower and flood control have altered stream habitat conditions through the creation of passage barriers, conversion of riverine habitat to reservoirs, and water withdrawals. The effects of the hydrosystem are discussed in Section 5.2.

5.1.5 Estuary and Plume

As stream-type salmonids, Snake River Sockeye Salmon are assumed to move relatively quickly through the estuary; however data are sparse because of their small numbers. They, like PIT-tagged Chinook salmon and steelhead tracked from below Bonneville Dam to the mouth of the Columbia River, may pass through this area within two to three days (McMichael et al. 2011), but this hypothesis has not been tested. Snake River Sockeye Salmon may stay in the plume before moving to the ocean but only limited information exists regarding this potential habitat use.

5.1.5.1 Diking and reduced spring flows

In the lower Columbia River and estuary, diking and reduced peak spring flows have eliminated much of the shallow water and low velocity habitat needed by juvenile salmonids for feeding, growth, refuge from predators, and to complete the physiological transition to salt water. Dikes are constructed to protect agriculture and other development in riparian areas; spring flows are managed in the FCRPS and upper Snake hydrosystems for power production, flood control, navigation, fish and wildlife, and other purposes (Hydro Module, NMFS 2014a and Estuary Module, NMFS 2011a).

Changes in the volume and timing of Columbia River flow caused by upstream water management have altered both the size and structure of the plume during the spring and summer months. Reductions in spring freshets and associated sediment transport processes have permanently changed the food web in the estuary and plume (Casillas 1999 cited in the Estuary Module, NMFS 2011a).

5.1.5.2 Water temperature

Higher water temperatures have reduced habitat quality for salmonids that use the estuary during summer months. Since 1938, average summer water temperatures entering the estuary at Bonneville Dam have increased 2.2°C (4° F) (Lower Columbia Fish Recovery Board 2004). Among-year variability in temperature has been reduced by 63% since 1970 (Lower Columbia Fish Recovery Board 2004).

5.1.5.3 Latent mortality

Mortality of juveniles after passing Bonneville Dam that would not occur in a free-flowing river is called differential latent mortality (Williams et al. 2005). Latent mortality could result from injuries, stress, disease, or depletion of energy reserves caused by passage through the hydropower system. However, it can also result because of other factors, including conditions in the subbasins that produced the fish and contributed to their age, fitness and arrival time at Bonneville Dam, and/or environmental factors that the fish could also experience in a free-flowing system. Because there are no mortality estimates for the reference condition (no mainstem dams), latent mortality cannot be measured directly. Currently, the range of estimates of latent mortality is extremely wide (0.01 to 64%) and depends on strong, but unverifiable assumptions (ISAB 2007; NMFS 2014a). The degree to which mortality in the estuary and ocean is caused by prior experience of juveniles passing through the FCRPS (delayed or latent mortality) remains unknown.

5.1.5.4 Summary of estuary and plume threats and limiting factors

Threat: Dikes and levees that have disconnected the river from its historical floodplain.
Related limiting factors: Lack of access to floodplain habitat; altered food web.

Threat: FCRPS flow management: reduced spring flows and other flow alterations.
Related limiting factors: Flow-related changes in access to off-channel habitat and the size of the plume; reduced macrodetrital inputs and increased microdetrital inputs.

5.1.6 Ocean

Ocean conditions and food availability contribute to the health and survival of Sockeye Salmon returning to the Columbia Basin, and eventually the Sawtooth Valley. Poor ocean conditions in 1977 through the late 1990s probably contributed, together with other factors, to drive the stock to a very small remnant population (NMFS 2008b).

Once Sockeye Salmon enter the ocean they immediately began migrating north; no sockeye salmon from the Columbia River (Snake River Sockeye Salmon and unlisted Upper Columbia River Sockeye Salmon) have been caught south of the river's mouth in 16 years of sampling in the Northern California Current. In May and June, Columbia River sockeye salmon are most abundant off the coast of Washington but some fish have migrated as far north as North and Central British Columbia (Tucker et al. 2009). As the Sockeye Salmon leave the Northern California Current, they likely move north into the Gulf of Alaska (GOA), Bering Sea, and up the coast into Alaska. By winter, the fish have disappeared from coastal areas and have entered the GOA (Tucker et al. 2009). In general, maturing Sockeye Salmon are distributed in the GOA and into the Bering Sea but are migratory within this region (Burgner 1991; Myers et al. 1996). Water temperatures affect the distribution of fish in the GOA with warmer temperatures pushing fish further north, thereby increasing the distance fish migrating south to the Columbia River will need to travel on their return journey. A study by Myers et al. (1996) found six maturing sockeye salmon from the Columbia River in the GOA.

As the fish mature in the GOA and Bering Sea region, they eventually begin their return migration to the Snake River. Water temperatures during the last months of ocean residence affect their body size at return, with warmer temperatures leading to a smaller body size (Pyper and Peterman 1999). The date when Snake River Sockeye Salmon begin their return migration is likely a population specific trait that is independent of where the fish are at sea (Hodgson et al. 2006). Water temperature also plays an important role in determining when the fish arrive back to coastal areas near the mouth of the Columbia River. The Ocean Module provides additional information on ocean-related threats and limiting factors for Snake River Sockeye Salmon, including potential effects related to future climate change.

5.2 Hydropower

Dam development and operations have affected the viability of Snake River Sockeye Salmon and other Columbia River basin anadromous salmon and steelhead. This section summarizes the general effects of the mainstem hydropower system on Snake River Sockeye Salmon. The Hydro Module also describes the impacts in more detail. The goal in this section is to consider specific effects these factors may have on Snake River Sockeye Salmon.

Compared to Snake River spring/summer Chinook salmon, there is relatively little route-specific information on the survival of Snake River Sockeye Salmon through the FCRPS. Most available reach survival estimates — especially in the lower Columbia River — are relatively imprecise because sample sizes of migrants from the Snake River are small (NMFS 2008c).

5.2.1 Migrating Juveniles

Federal Columbia River Power System

Juvenile Snake River Sockeye Salmon enter the mainstem hydropower corridor in Lower Granite Reservoir. Three U.S. government agencies ─ the Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation, also called, collectively, the “Action Agencies” ─ collaborate to run the Federal Columbia River Power System (FCRPS), under various congressional authorities, as a coordinated system for power production, flood control, and other purposes. The 31 Federally owned multipurpose dams on the Columbia, Snake River and tributaries that make up the FCRPS provide about 60% of the hydroelectric generating capacity in the northwestern United States. The dams supply irrigation water to more than a million acres of land in Washington, Oregon, Idaho, and Montana. The river is used for barge navigation from the Pacific Ocean to Lewiston, Idaho, 748 km (465 miles) inland.

A substantial proportion of juvenile Sockeye Salmon can be killed while migrating through the dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation which leave fish more susceptible to predation and disease, resulting in delayed mortality. Concerns include:

- Juvenile mortality while passing through the mainstem lower Snake and lower Columbia River hydropower system.
- Scarcity of cover in mainstem reservoirs as refuge from fish predators such as smallmouth bass and northern pikeminnows.
- Increased mortality from cormorants and other avian predators.

- Altered seasonal flow and temperature regimes.

The Action Agencies have implemented a number of actions in recent years to improve conditions in the migration corridor for all listed Columbia Basin salmon and steelhead species. By 2009, each of the eight mainstem lower Snake and lower Columbia River dams was equipped with a surface passage structure (spillbay weirs, powerhouse corner collectors, or modified ice and trash sluiceways). Smolts primarily migrate in the upper 20 feet of the water column in the lower Snake and Columbia Rivers. Water is drawn through these surface passage routes from the same depths as juveniles migrate, whereas conventional spillbays or turbine unit intakes draw water from depths greater than 15 meters (50 feet). The surface passage routes provide a safe and effective passage route for migrating smolts by reducing migration delay (time spent in the forebay of the dams) and increasing the proportion of smolts passing the dams via the spillway rather than via the turbines or juvenile bypass systems (spill passage efficiency). Changes have included the relocation of juvenile bypass system outfalls to avoid areas where predators collect; as well as other operational and structural changes. Other changes include changes to spill operations, the installation of avian wires to reduce juvenile losses to avian predators, as well as changes to reduce dissolved gas concentrations that might otherwise limit spill operations. Together, these factors have improved the inriver survival of Snake River Sockeye Salmon (NMFS 2014c).

5.2.2 Migrating Adults

While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, adults migrate more quickly through the relatively slow velocity reservoir environments. Large upstream water storage and flood control projects and mainstem run-of-river hydropower projects have affected the thermal regime of the mainstem Snake and Columbia Rivers. Together, they have generally increased minimum winter temperatures, delayed spring warming, reduced maximum summer temperatures, and delayed fall cooling. These alterations may benefit Sockeye Salmon adults that migrate during the spring and summer, but may negatively affect those migrating in the late summer and fall by increasing their exposure to relatively high temperatures. To mitigate for (or, in some instances, enhance) these thermal effects, Dworshak Dam, on the North Fork Clearwater River, releases cool water during July, August, and September to reduce mainstem Snake River temperatures.

Adult fish passage, in the form of fish ladders, is provided at each of the eight mainstem projects in the lower Snake and lower Columbia Rivers. In general, these adult passage facilities are highly effective, but average survival from Bonneville to McNary dams (including the reservoirs) is lower than that in the Snake River reach (Table 4-2). Section 4 discusses recent Sawtooth Valley-to-Sawtooth Valley smolt-to-adult return rates for Snake River Sockeye Salmon.

The FCRPS 2014 Supplemental Biological Opinion included actions to add adult detectors at The Dalles and/or John Day Dam to better understand where these losses are occurring in the lower Columbia

River. This information should help managers identify the factors likely contributing to these losses and develop corrective actions (NMFS 2014c).

Conditions at the dams can affect Sockeye Salmon adult migration in some years. In late July 2013, low summer flows, high temperatures, and a period of little or no wind created conditions that allowed Lower Granite reservoir to thermally stratify to a greater extent than had been the case for many years. The result was warmer water entering the ladder exit, and a refusal by adult Snake River Sockeye Salmon (and summer Chinook salmon and steelhead) to pass the project for more than a week. NMFS worked with the Corps, IDFG, the tribes, and other co-managers to resolve this issue. However, unadjusted PIT-tag based conversion rate estimates from Ice Harbor to Lower Granite Dam indicated that a substantial proportion of the migrating adult Sockeye Salmon (~30%) failed to successfully pass Lower Granite Dam and most likely died without spawning (NMFS 2014c). NMFS and other co-managers continue to develop short- and long-term measures to resolve this passage problem.

5.2.3 Summary of Hydropower Threats and Limiting Factors

Threat: Impaired mainstem passage conditions for migrating juveniles.
Related limiting factors: Reduced spring flows and the existence and operation of mainstem hydropower projects directly (dam passage) or indirectly (exposure to predators, delayed migration, etc.) can increase mortality and injury rates of juveniles compared to migrants in a free-flowing reach.

Threat: Impaired mainstem passage conditions for migrating adults.
Related limiting factors: Fish ladders operating outside criteria, high flows, high spill levels, and thermal blockages can impair adult passage through the mainstem migration corridor resulting in increased pre-spawning mortalities.

Threat: Large storage reservoirs in the upper Columbia and on the Clearwater River in the Snake basin reduce annual peak spring flows and increase late summer mainstem temperatures.
Related limiting factors: Water withdrawals reduce spring and summer flows, contributing to increased travel times and exposure to elevated summer water temperatures. This exposes adult Sockeye Salmon (especially those migrating during late July and August) to factors that can delay migration past the dams and cause pre-spawning mortality and outbreaks of virulent disease.

5.3 Hatcheries

Several things are unique about artificial propagation programs (*hereafter* referred to as hatcheries) relative to the other factors addressed in this section. First, hatcheries can reduce extinction risk in the short-term; second, no two hatcheries are alike; and third, there remains substantial uncertainty over the efficacy and the effects of hatcheries on salmon and steelhead recovery.

Although it is generally accepted that hatcheries may contribute to the conservation of salmon and steelhead, it is unclear whether or how much hatchery propagation during the recovery process will compromise the distinctiveness of natural populations. Artificial propagation has been an important element in recovery plans for several species, including plants such as Knowlton's cactus (*Pediocactus knowltonii*), birds such as the peregrine falcon (*Falco peregrinus*), mammals such as the black-footed ferret (*Mustela nigripes*), and fishes, including pupfishes (*Cyprinodon spp*.) and several trouts (*Oncorhynchus spp*.).

For salmon and steelhead, the presence of hatchery fish can positively affect the overall status of an ESU or DPS by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. Conversely, a hatchery program can adversely affect an ESU or DPS by reducing adaptive genetic diversity and by reducing reproductive fitness and productivity (Griswold et al. 2012; NMFS 2005c). Although the Snake River Sockeye Salmon captive broodstocks are apparently functioning well at this time, NMFS recognizes that most hatchery efforts are likely to eventually result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations (Rand et al. 2012). Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations. That risk is outweighed under circumstances where demographic or short-term extinction risk to a natural population is greater than risks to population diversity and productivity. However, the extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. Recently, the Columbia River Hatchery Scientific Review Group (HSRG) expanded on theories developed by Ford (2002) to develop scenarios for managing hatchery- and natural-origin salmon and steelhead. The HSRG developed possible population-specific solutions for integrating hatchery- and natural-origin fish that minimize potential impacts to wild populations associated with hatchery selection.

Consequently, NMFS believes hatchery intervention is a legitimate and useful tool to help avert, at least in the short term, salmon and steelhead extinction, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish as they implement a plan for transitioning from current practices to those consistent with recovery of listed populations, implementation of treaty Indian fishing rights, and harmony with other applicable laws and policies.

5.3.1 Snake River Sockeye Salmon

The goal of this Snake River Sockeye Salmon Recovery Plan is the restoration of natural Sockeye Salmon populations in Sawtooth Valley lakes. The captive broodstock hatchery program has provided a useful tool towards achieving this goal; indeed, Snake River Sockeye Salmon might be extinct if not for the captive broodstock hatchery program. The natural stock reintroduction and adaptation strategy for Sockeye Salmon is evolving and has three phases: prevent extinction and build genetic resources using a captive broodstock program in Phase 1; secure the Redfish Lake population and develop strategies to support Sawtooth Valley Sockeye Salmon reintroduction in Pettit Lake and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning residual outmigrants from Alturas Lake in Phase 2; and reduce hatchery releases and transition the program to follow integrated broodstock guidelines and build local natural adaptation in Phase 3. The program was initiated in 1992 and is now ready to transition from Phase 1 to Phase 2.

Before Sockeye Salmon were protected under the ESA, one, one, and zero fish returned to the Sawtooth Valley in the three preceding years. For the four most recent years (2011-2014), natural-origin Sockeye Salmon returns have been 145, 52, 79, and 453 fish respectively, and total returns for the ESU (natural and hatchery-origin returns combined) have been 1,117, 257, 272, and 1,579 adults. Between 1991 and 1998, all 16 of the natural-origin adult Sockeye Salmon that returned to the Sawtooth Valley were incorporated into the captive broodstock program. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and progeny, and has produced several hundred thousand eggs and juveniles, as well as several hundred adults for release into the wild to spawn naturally.

In addition to "standard" hatchery production releases of both pre-smolt and full-term smolts to Sawtooth Valley waters, the program also has used "natural production" release strategies by out-planting both pre-spawn adults and fertilized eyed-eggs. Progeny produced from adults that spawn naturally as well as juveniles that successfully hatch from eyed egg releases are better adapted to lake environments and avoid potential hatchery selection concerns that are typically associated with hatchery environments. Parentage analyses are used to determine first generation pedigrees for all fish in the population, genetic importance, and relative relatedness (Kozfkay et al. 2007). Spawning plans for the hatchery also consider heterozygosity and genetic diversity among and within individuals. The development and implementation of a spawning matrix has allowed the program to spawn the least genetically related individuals within the population (Baker et al. 2011; Kozfkay et al. 2007). Monitoring results to date show that patterns of genetic variation have not changed significantly as a result of the hatchery program.

The Redfish Lake Sockeye Salmon Captive Broodstock Program has been vital to helping the population avoid extinction. For groups of Redfish Lake Sockeye Salmon in captive broodstock culture, eyed-egg survival has averaged about 80% over the last decade and fry-to-adult survival also averages about 80%. The fish culture successes for the Redfish Lake program have resulted in the production of over 10,000 adult descendants from the 16 wild adult Sockeye Salmon that returned to the Sawtooth Valley during the 1990s. Almost 4,300 adults have returned from the ocean to collection sites in the Sawtooth Valley; over 250 times the number that returned from wild spawners during the entire decade of the 1990s. The genetic focus of the program, and adherence to various central tenets of conservation aquaculture, has enabled program managers to retain approximately 95% of the original founding genetic variability of the population.

The hatchery program has been successful in its purpose of conserving genetic resources (Kalinowski et al. 2012) and reducing extinction risk, in the short term, and it is now ready to transition to a larger scale supplementation program. The next step is to secure the primary population in Redfish Lake and amplify the number of fish available for reintroduction into the ESU's former range.

The program is now transitioning to Phase 2, with an emphasis on supporting relatively high levels of anadromous return spawners in Redfish Lake. IDFG completed construction of the Springfield Hatchery in 2013. This new Sockeye Salmon smolt-rearing hatchery will be capable of producing up to one million full-term Sockeye Salmon smolts annually (IDFG 2013). Eggs for the expanded smolt program will be produced at the IDFG Eagle Fish Hatchery broodstock station and from increased production from NMFS' facilities in Washington State. Using a conservative smolt-to-adult return rate of 0.50% for hatchery-reared and released smolts (based on empirical program information), managers anticipate that a release of up to one million smolts from the Springfield Hatchery could consistently return an annual average of 5,000 anadromous adults to Redfish Lake, and to other lakes as determined through the adaptive management nature of the reintroduction strategy.

The program will move to Phase 3, local adaptation, when program triggers are reached, signaling that five-year running average returns are more than 2,150 Sockeye Salmon adults, including over 750 natural-origin adults. During this phase the program transitions to an integrated broodstock management program that follows a sliding scale to meet escapement and broodstock objectives. These expansion efforts are consistent with expectations established through the Biological Opinion developed by NMFS to address risks associated with the operation of the Federal Columbia River Power System.

5.3.2 Summary of Hatchery Threats and Limiting Factors

Threat: Hatchery fish interbreed with natural-origin spawners.
Related limiting factors: Potential loss of genetic diversity.

Pre-smolts being released into Redfish Lake. *Photo: T. Brown, IDFG.*

5.4 Fisheries

The potential exists for Snake River Sockeye Salmon to be incidentally caught in fisheries throughout the migration corridor, from the ocean to natal lakes (NMFS 2008c). For the near term, fisheries that currently impact Snake River Sockeye Salmon through incidental harvest should be managed, with accompanying adequate monitoring programs, to minimize their impacts on the ESU. Fishery-related limiting factors and threats are summarized here and discussed in more detail in the Harvest Module (NMFS 2014b).

5.4.1 Natal Lake Fisheries

Sport fisheries targeting kokanee occur in Redfish Lake from Memorial Day through the first week in August. One goal, or reason, for the fishery is to crop the kokanee population in the lake because kokanee compete with Sockeye Salmon for food. Once kokanee leave the lake to spawn in tributary streams, the fishery is closed to protect Sockeye Salmon. Creel surveys are conducted to estimate the number of juvenile Sockeye Salmon encountered incidental to the kokanee fishery. Sport-caught kokanee are sampled (by removing a small piece of fin) for DNA analysis to estimate the proportion of Sockeye Salmon taken in the fishery. Analysis to date shows that the fishery removes significant numbers of kokanee without depleting the Sockeye Salmon ESU. In addition, residual Sockeye Salmon that live in Pettit Lake are subject to sport harvest, as are the native kokanee in Alturas and Stanley Lakes.

5.4.2 Salmon River and Snake River Fisheries

There are no fisheries targeting Sockeye Salmon. There are fisheries targeting hatchery spring/summer Chinook salmon and steelhead and these fisheries are managed to protect Sockeye Salmon. ESA biological opinions require appropriate monitoring and evaluation of the fisheries; when Sockeye Salmon are encountered or show up in the catch the IDFG fisheries are closed (NMFS 2011c) and the Shoshone-Bannock Tribes operate with a one percent ESA limit, although Sockeye Salmon have yet to be encountered in that fishery (NMFS 2013).

State fishery management agencies and tribes submit to NMFS a Fishery Implementation Plan (FIP) each year as part of ESA compliance. FIPs are used pre-season by NMFS to determine if year-specific fishery plans are consistent with Fishery Management and Evaluation Plans (FMEPs) and Tribal Resource Management Plans (TRMPs) that have ESA authorization, and to confirm ESA compliance in the long term for the duration of the respective biological opinion. FIPs describe year-specific pre-season details for fisheries in the Snake River that affect ESA-listed species, such as harvest numbers and ESA take that is expected on a given year, and that may have occurred in prior years under a given biological opinion.

Annual Snake River spring/summer Chinook fisheries are a good example of how fisheries are managed under the ESA. States and tribes submit FIPs to NMFS each year describing year-specific projected fishing season goals based on pre-season run size estimates. Post season, States and tribes report to NMFS fishery-related ESA take based on creel surveys, and this includes any projected incidental take of Sockeye Salmon. Snake River spring/summer Chinook fisheries are carefully managed to avoid any potential take of Sockeye Salmon and no incidental take has been reported thus far.

5.4.3 Mainstem Columbia River Fisheries

Within the mainstem Columbia River, treaty tribal net fisheries and non-tribal fisheries directed at Chinook salmon do incidentally take a small percentage of Sockeye Salmon. Mainstem Columbia River fisheries are managed under an abundance-based harvest rate schedule that limits the resulting ESA take (Table 5-3). Because of stock composition in the mainstem Columbia River, most of the Sockeye Salmon harvested are from the upper Columbia River (Canada and Lake Wenatchee), but an equal proportion of Snake River Sockeye Salmon are taken incidentally to mainstem fisheries directed at Chinook salmon. Fishery impact rates in the 1980s increased briefly due to directed Sockeye Salmon fisheries on large runs of upper Columbia River stocks (Table 5-2).

Table 5-2. Historical Sockeye Salmon harvest (WDFW 2012[7]).

Year	Columbia River Mouth[1]	Non-Treaty Catch[2]	Bonn. Dam Count	Treaty Catch[3]	Snake River Sockeye Salmon: At Col R. Mouth	Non-Treaty Catch[2]	Treaty Catch[3]	Lower Granite Esc.[4]	Escapement: Wenatchee[5]	Okanogan[6]
1980	58,886	4	58,882	636	108	0	1	96	22,752	26,573
1981	56,037	0	56,037	1,507	236	0	6	218	16,490	28,234
1982	50,319	100	50,219	775	261	1	4	211	23,732	19,005
1983	100,628	83	100,545	3,349	241	0	8	216	60,345	27,925
1984	161,886	9,345	152,541	24,616	148	9	23	105	35,795	81,054
1985	200,724	32,213	166,340	49,969	59	10	15	35	49,137	52,989
1986	59,963	1,840	58,123	6,672	28	1	3	20	16,077	34,788
1987	145,546	28,553	116,993	39,560	55	11	15	29	29,558	40,120
1988	99,757	17,632	79,714	30,990	45	8	14	23	15,069	33,978
1989	47,475	36	41,884	2,138	4	0	0	4	21,184	15,976
1990	49,754	173	49,581	2,716	1	0	0	1	34,847	7,609
1991	76,484	3	76,481	3,271	10	0	0	9	35,094	27,490
1992	85,000	8	84,992	2,185	2	0	0	2	26,555	41,951
1993	91,710	64	80,178	5,020	18	0	1	17	37,311	27,849
1994	12,858	1	12,678	472	3	0	0	3	9,314	1,666
1995	9,662	1	8,773	445	5	0	0	5	4,474	4,892
1996	30,896	25	30,255	1,414	3	0	0	3	7,559	17,701
1997	47,470	12	46,927	2,046	18	0	1	17	11,064	25,754
1998	13,220	2	13,218	425	4	0	0	3	3,379	4,669
1999	17,878	1	17,877	704	20	0	1	18	4,260	12,388
2000	93,755	364	93,391	2,910	352	1	11	337	19,084	59,944
2001	120,314	1,688	114,933	7,300	49	1	3	45	38,618	74,490
2002	50,461	14	49,610	2,564	77	0	4	73	31,946	10,659
2003	39,375	0	39,375	1,090	28	0	1	26	4,424	28,820
2004	129,932	672	123,320	4,317	117	1	4	113	25,328	77,492
2005	77,329	0	72,448	2,766	20	0	1	19	15,656	53,218
2006	37,067	1	37,066	1,596	79	0	3	16	9,756	22,064
2007	26,059	0	24,376	1,414	58	0	3	55	4,439	22,282
2008	214,402	821	213,607	9,017	983	4	41	907	32,396	165,334
2009	178,959	1,160	177,823	9,731	1,625	11	88	1,406	29,724	134,937
2010	387,858	242	386,355	26,125	2,596	2	175	2,406	42,672	291,764
2011	187,307	1,708	185,796	12,849	1,919	18	132	1,502	14,015	111,508

1. Upriver run is larger of (Bonn. Count + Zones 1-5 harvest) or (Priest Rapids count + Snake River count + Zones 1-6 harvest).

2. Non-Treaty harvest may include kept fish and incidental release mortalities in Zones 1-6.

3. Treaty harvest includes Sockeye Salmon kept in Zones 1-6, which includes harvest downstream of Bonneville Dam.

4. Prior to 1992, Lower Granite Dam Sockeye Salmon counts may include kokanee. Since 1992 video counts or length measurements are used to identify true Sockeye Salmon.
5. Beginning in 1979, the Wenatchee estimate is based on Rock Island or Priest Rapids Dam counts minus Rocky Reach Dam totals, except Priest Rapids count minus Wells count in 1995.
6. The Okanogan estimate is based on the Rocky Reach Dam counts until 1966. Wells Dam counts are used beginning with 1967.
7. Source: http://wdfw.wa.gov/publications/01354/wdfw01354.pdf.

Fisheries in the mainstem Columbia River that affect Snake River Sockeye Salmon are currently managed subject to the terms of the *U.S. v. Oregon* Management Agreement for 2008-2017. These fisheries are managed to ensure that the incidental take of ESA-listed Snake River Sockeye Salmon does not jeopardize the Sockeye Salmon ESU. Management provisions for Sockeye Salmon in the 2008 *U.S. v. Oregon* Management Agreement are the same as those in the 2005-2007 agreement. Non-Indian fisheries in the lower Columbia River are limited to an incidental take rate of 1% of the Snake River Sockeye Salmon adults reaching the Columbia River mouth, and Treaty Indian fisheries are limited to an incidental take rate of 5 to 7%, depending on the run size of upriver Sockeye Salmon stocks (Table 5-3). Actual incidental take rates ranged from zero to 1.41% (non-Indian), and 2.8 to 6.9% (Treaty Indian fisheries) in the 10-year period 1998-2007.

Table 5-3. Sockeye Salmon harvest rate schedule (Harvest Module, NMFS 2014b).

River Mouth Sockeye Salmon Run Size	Treaty Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate
< 50,000	5%	1%	6%
50,000 -75,000	7%	1%	8%
> 75,000	7% *	1%	8% *

*If the upriver Sockeye Salmon run size is projected to exceed 75,000 adults over Bonneville Dam, any party may propose harvest rates exceeding those specified in Part II.C.2. or Part II.C.3. of the 2008-2017 Management Agreement. The parties shall then prepare a revised biological assessment of proposed Columbia River fishery impacts on ESA-listed Sockeye Salmon and shall submit it to NMFS for consultation under Section 7 of the ESA.

5.4.5 Ocean Fisheries

Ocean fisheries do not significantly affect Snake River Sockeye Salmon. Research indicates that the migration path and ocean distribution of Snake River Sockeye Salmon is such that the fish are not present in near shore areas where ocean salmon fisheries traditionally occur (NMFS 2014b). Also, Sockeye Salmon are not attracted to baits or lures; they are plankton feeders, and thus they are rarely caught in commercial or recreational fisheries. There are no net fisheries in the ocean that target salmonids.

5.4.6 Summary of Fishery-related Threats and Limiting Factors

Threat: Ongoing Columbia River harvest.
Related limiting factors: Reduced abundance/productivity due to incidental take.

5.5 Predation and Disease

This section summarizes predation on Snake River Sockeye Salmon from the natal lakes in the Sawtooth Valley, through the Salmon River, lower Snake River, Columbia River mainstem and estuary, and ocean.

5.5.1 Sawtooth Valley Lakes

Several fish species that occupy the Sawtooth Valey lakes potentially prey on Sockeye Salmon, including bull trout, northern pikeminnow, and brook trout. Research shows that Sockeye Salmon and kokanee are part of the diet of bull trout and northern pikeminnow.

Bull trout are believed to be the top native piscivorous predator of the Sawtooth Valley lakes fish community. Based on limited information, a 1984 study estimated that native bull trout (*Salvelinus confluentus*) and introduced rainbow trout (*Oncorhynchus mykiss*) consumed up to 60% of Sockeye Salmon eggs, fry, and pre-smolts in Alturas Lake (Bowles and Cochnauer 1984). The estimated predation rate was based on the multi-species impact and apparent high predation abundance and used to model Sockeye Salmon production potential in Alturas Lake. Monitoring associated with Sockeye Salmon habitat and limnological research has found that the bull trout diet is composed primarily of fish prey (Taki et al. 1999), with juvenile Sockeye Salmon and kokanee found in the stomach contents of bull trout from Pettit Lake in February 2004 (Taki et al. 2006). Bull trout, however, were ESA-listed as a threatened species in 1998. Any predation by the species on Sockeye Salmon is considered a natural process and no control measures will be implemented.

Concern has been expressed about the potential predation of northern pikeminnow on juvenile Sockeye Salmon. Northern pikeminnow are known to prey on juvenile salmon and are the subject of control efforts in the mainstem Columbia and Snake Rivers. Northern pikeminnow are also one of the most abundant species found in the Sawtooth Valley lakes. Despite their abundance, diet analysis has only positively identified Sockeye Salmon/kokanee in the stomach of one northern pikeminnow (Taki et al. 2006). A 1998 study found no salmonids, including kokanee/Sockeye Salmon, in the stomachs of any of the northern pikeminnow or brook trout sampled in four of the lakes (Lewis et al. 1998). Since the juvenile Sockeye Salmon tend to stay in the deeper areas and northern pikeminnow are found in the littoral areas, the northern pikeminnow may have limited opportunities for predation on Sockeye Salmon in these lakes (Taki et al. 2006).

Other species that prey on Sockeye Salmon include mink, otter, and several bird species including grebes, mergansers, and osprey (Peterson 2013c). Research is needed to document the extent and impact of predation.

Introduced invasive species can also negatively impact juvenile Sockeye Salmon survival. The parasite (*Myxobolus cerebralis*) which causes whirling disease has been detected in the headwaters of Alturas Lake Creek and is being monitored by the U.S. Forest Service. This parasite affects juvenile salmonids and causes skeletal deformation and neurological damage. Fish “whirl” forward in an awkward pattern instead of swimming normally, find feeding difficult, and are more vulnerable to predators.

5.5.2 Salmon River

Snake River Sockeye Salmon juveniles migrate relatively quickly from the upper Salmon basin to the Snake River. Little is currently known regarding predation in this reach, but potential predators include smallmouth bass (*Micropterus dolomieui*), bull trout, northern pikeminnow (*Ptychocheilus oregonensis*), juvenile steelhead, and rainbow trout.

Recent tagging studies and associated observational data conducted through a collaborative effort between NMFS and IDFG indicate that predation may be responsible for some of the juvenile mortality that occurs during outmigration. Researchers have observed multiple predation events on recently released PIT-tagged juvenile Sockeye Salmon during the studies. In 2013, common merganser, osprey, double-crested cormorant, and western grebe were actively feeding in Little Redfish Lake, located below the release site, as fish were moving through the area. Bull trout were also preying on juvenile Sockeye Salmon as they migrated through Little Redfish Lake (Axel et al. 2014). Predation also likely contributes to losses of juvenile Sockeye Salmon migrants in the upper Salmon River reach known as Deadwater Slough. This reach is one of east-central Idaho’s best birding locations due to quality riparian habitat, good water quality, and adjacent diverse upland habitats for raptors and other species. Flow in the reach is visibly slower and juvenile Sockeye Salmon travel at a considerably reduced rate in the reach, increasing their risk to predation (Axel et al. 2014).

5.5.3 Lower Snake River

Smallmouth bass are the most abundant predator on salmonids in the lower Snake River reservoirs. The reservoir habitat formed by the dams creates slow backwater areas and warmer water temperatures benefiting non-native species such as smallmouth bass and channel catfish (*Ictaluras punctatus*). Additional research, monitoring, and evaluation is needed to quantify the impacts of this predation on Snake River Sockeye Salmon recovery efforts.

5.5.4 Lower Columbia River and Estuary

Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species. Some of the predator species’ abundance levels have increased dramatically, particularly in localized areas, with associated changes in predation of juvenile and adult Sockeye Salmon as well as other species of salmon and steelhead (LCREP 2006).

5.5.4.1 Avian predation

Ecosystem alterations attributable to hydropower dams and modification of estuarine habitat have increased predation on Snake River salmon and steelhead populations. In the estuary, the number and/or effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species has increased because of habitat modification (LCREP 2006; Fresh et al. 2005). Caspian tern predation has decreased in recent years because of management efforts reducing available island habitat, but double-crested cormorant predation has increased (Collis and Roby 2011). The draft 2010 season summary of Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River (Collis and Roby 2011) estimates that double-crested cormorants nesting on East Sand Island near the mouth of the Columbia River consumed 19.2 million juvenile salmonids in 2010.

Yearling type juvenile salmonids like Sockeye Salmon are vulnerable to avian predation in the estuary because they use deep-water habitat channels that have relatively low turbidity and are close to island habitats. Recent information on cormorant consumption of Sockeye Salmon smolts in the estuary indicates that Snake River Sockeye Salmon smolts were taken by cormorants at an annual rate of 1.3% during 1998 to 2012 (NMFS 2014c).

Tern, cormorant, and gull colonies on islands in the Columbia River and the lower Snake River also prey on juvenile salmonids, but predation in the estuary is an order of magnitude greater (NMFS 2014c). In the Columbia Plateau region, 2012 PIT-tag-derived predation rates by double-crested cormorants nesting on Foundation Island indicated that predation rates were highest on Snake River Sockeye Salmon (2.5%) (Roby et al. 2012). Data on PIT-tag deposition rates for American white pelicans nesting at the colony on Badger Island are not currently available. Minimum predation rate estimates (not corrected for PIT-tag deposition rates) indicate that American white pelicans consumed less than 0.3% of the available smolts in 2012, regardless of species (Roby et al. 2012).

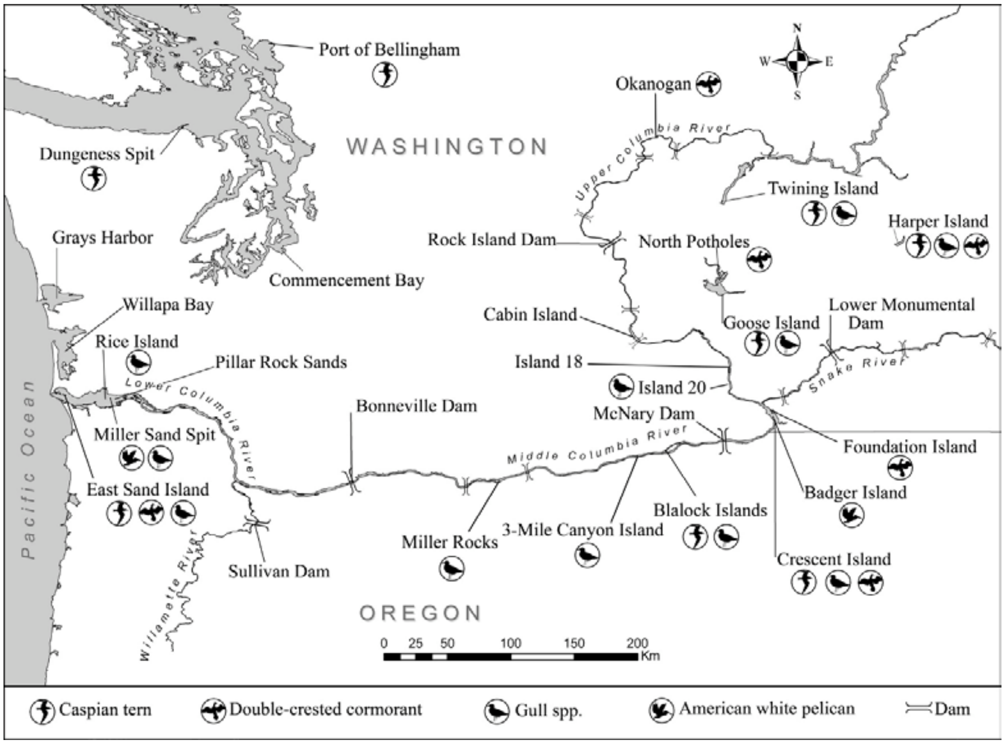

Figure 5-3. Shows locations of breeding colonies of piscivorous birds in estuary and Columbia River basin (Collis and Roby 2011).

5.5.4.2 Piscivorous fish predation

There is no specific information on predation rates on Sockeye Salmon in the Columbia Basin but habitat modifications by the hydropower system have generally provided conditions that support both native and introduced piscivorous fish along the migratory route. Northern pikeminnows and non-native predatory species (e.g., smallmouth bass, walleye, channel catfish, etc.) congregate near dams or at hatchery release sites to feed on migrating smolts. Many of these species are also abundant in free-flowing river reaches and feed on rearing juveniles in these areas. Warmer water temperatures can enhance conditions for fish that prey on or compete with juvenile salmonids. Northern pikeminnow, walleye, smallmouth bass, and channel catfish were estimated to consume between 9 and 19% of the juvenile salmonids entering John Day Reservoir, with northern pikeminnow accounting for 78% of the loss (NMFS 2004). Bonneville Power Administration has implemented the Northern Pikeminnow Management Program since 1990. The program's goal of removing 10-20% of predatory-sized pikeminnow has been achieved in 18 of 22 years with an estimated 4.05 million fish removed from the lower Snake and Columbia Rivers by sport fishermen who receive monetary awards. BPA estimates that the program has reduced predation on juvenile salmonids by 37% (BPA 2013).

Within the Columbia River basin, juvenile Pacific salmon could encounter no fewer than eight documented non-native predator and competitor fish species en route to the estuary (Sanderson et al. 2009). Salmonids can compose up to 100% of the diets of various non-native predators, such as channel catfish, smallmouth bass, and walleye.

Predation by nonnative fishes on outmigrating smolts is roughly equivalent to the productivity declines attributed to habitat loss and degradation (Beechie et al. 1994). Although it is difficult to make direct comparisons between adult and juvenile mortality with respect to population impacts, predation rates on juvenile outmigrants are also similar in magnitude to harvest-related mortality rates on adults, 3% to 84% (McClure et al. 2003).

Beamesderfer and Nigro (1989) estimated that walleye annually consumed an average of 400,000 salmonids (250,000 to 2,000,000), or up to 2% of the salmonid run from 1983-1986. Abundance of walleye in the lower Columbia River appears highly variable, but losses of juveniles and smolts to walleye was estimated at up to 2 million fish per year, which compares to 4 million for pikeminnow (Tinus and Beamesderfer 1994).

Sculpins, suckers, and cyprinids (including northern pikeminnow) made up the majority of smallmouth bass diets in the John Day Reservoir; however, bass still ate a large number of salmonids, primarily young-of-the-year Chinook salmon that co-inhabit littoral areas in July and August (Poe et al. 1991). Downstream of Bonneville Dam, bass diets consisted of sculpins (46%), cyprinids (19%), suckers (16%), and salmonids (12%).

In the Snake River, Shively et al. (1991) and Nelle (1999) found lower consumptive rates of juvenile salmonids in the areas they studied compared to the Columbia River studies mentioned above. However, even though consumption rates are relatively low, the large number of individual predators can result in substantial losses of migrating juveniles.

5.5.4.3 Marine mammals

Predation by marine mammals is also a concern. Marine mammals (pinnipeds) prey on winter and spring migrating adult salmon and steelhead in the lower Columbia River including the tailrace of Bonneville Dam. There is no additional information available regarding pinniped predation rates on Sockeye Salmon.

5.5.5 Ocean

Although there is still much to be learned about the marine ecology of Sockeye Salmon, several major marine predators have been identified. Juvenile Sockeye Salmon are preyed on by sablefish (*Anoplopoma fimbra*) and murres (*Uria spp*.) (Sturtevant et al 2009; Ogi and Tsujita 1973). Juvenile *Oncorhynchus spp*. are fed upon by both murres (*Uria aalge*) and rhinocerrous auklets (*Cerorhinca monocerata*) (Lance and Thompson 2005). Older Sockeye Salmon are preyed on by mesopelagic daggertooth (*Anotopterus pharao*) that move into the epipelagic zone to forage on larger Sockeye Salmon (Welch et al 1991; Savinykh and Glebov 2003; Svirindov et al. 2004). Salmon sharks (*Lamna ditropis*) prey on larger Sockeye Salmon during their marine residence (Nagasawa 1998). Sockeye Salmon are also fed upon by lamprey during their oceanic migration (*Lampetra tridentate*) (Pelenev et al. 2008). Although these marine predators may limit Snake River Sockeye Salmon survival they are primarily natural forms of predation whose population size have not been increased by anthropogenic activities.

As maturing Sockeye Salmon near their natal rivers they become subject to harbor seal (*Phoca vitulina*) predation (Hauser et al. 2008; Forrest et al. 2009). In general, salmonids of the genus *Onchoryhnchus* are important prey items in the diet of Stellar sea lions (McKenzie and Wynne 2008). Resident killer whales (*Orca orcinus*) specialize in feeding on chinook and chum salmon; and thus far Sockeye Salmon have not been a significant component of their diet (Ford et al. 2006).

5.5.6 Summary of Predation and Disease Threats and Limiting Factors

Threat: Non-native and native fishes in Sawtooth Valley lakes and the mainstem Salmon, Snake, and Columbia Rivers.
Related limiting factors: Predation by non-native and native fishes could reduce Sockeye Salmon productivity.

Threat: Predation by birds in the Sawtooth Valley lakes; mainstem Salmon, Snake, and Columbia Rivers; and estuary.
Related limiting factors: Predation could reduce Sockeye Salmon abundance.

Threat: Predation by marine mammals in the Columbia River and estuary and ocean
Related limiting factors: Predation could reduce Sockeye Salmon productivity

Threat: Introduction of invasive parasite that causes whirling disease in salmonids in natal lakes and other water bodies
Related limiting factors: Infestation by parasite can reduce Sockeye Salmon productivity

5.6 Competition

Competition can refer to competition among salmonids or other species for food resources, or competition between hatchery fish and wild fish for food or spawning areas.

5.6.1 Natal Lakes

In sockeye salmon systems, intraspecific competition is much stronger than interspecific competition (Burgner 1987). In Takala Lake in British Columbia, Canada, a comparison of the diet and distribution of kokanee (resident form) and anadromous sockeye salmon detected no significant niche differences between the two forms (Wood et al. 1999) suggesting high intraspecific competition. Both density and fertilization experiments have demonstrated that sockeye salmon compete intraspecifically for available food resources (Hartman and Burgner 1972; Reiman and Myers 1992; Rich et al. 2009; Hyatt and Stockner 1985).

This intraspecific competition also appears to be the case in the Sawtooth Valley lakes, where like Sockeye Salmon, kokanee tend to stay in the deeper areas and feed almost entirely on zooplankton prey species. There is no indication the two life history forms in Redfish Lake compete for spawning habitat, as the listed anadromous fish are lake spawners and the sympatric kokanee are stream spawners that spawn earlier than the anadromous fish. It is the aforementioned competition among juveniles for food and space that leads to the conclusion that kokanee in the Sawtooth Valley lakes may limit the growth and survival of Snake River Sockeye Salmon during the lake rearing phase of their life cycle.

Historical actions for the management of game fish in the Sawtooth Valley lakes reduced the available habitat for Sockeye Salmon for a period of some 60 years and introduced competition for food resources. Kokanee salmon were stocked by the IDFG in Redfish Lake as early as the 1920s (Bowler 1990). Since then, measures to control kokanee have been implemented in Redfish Lake to reduce intraspecific competition. Various fishery and limnological parameters have been monitored in association with these strategies (Taki et al. 2006). IDFG maintains sport fishing seasons on kokanee for the purpose of having anglers harvest them to decrease competition with Sockeye Salmon.

Potential competition for food occurs between anadromous Sockeye Salmon and planted rainbow trout and kokanee although recent studies by Taki et al. (2006) found no overlap in diet between rainbow trout and Sockeye Salmon in Pettit Lake. Age-zero Sockeye Salmon, the life stage of primary interest, fed almost exclusively on zooplankton while rainbow trout diets consisted of aquatic insects (Taki et al. 2006).

5.6.2 Salmon River

Non-native species, including smallmouth bass, hatchery steelhead, and rainbow trout both prey upon Sockeye Salmon and reduce Sockeye Salmon productivity by competing with outmigrating juveniles for limited food and space in the mainstem Salmon River. Competition for limited food sources also likely occurs between outmigrating juvenile Sockeye Salmon and steelhead and Chinook salmon from hatchery releases. Limited information currently exists on competition in the Salmon River. Additional research, monitoring, and evaluation are needed to better determine the extent of this threat to Snake River Sockeye Salmon viability.

5.6.3 Mainstem Migration Corridor, Estuary, Plume and Ocean

The migratory corridor and marine environment present additional opportunities for intraspecific and interspecific competition to limit the ESU. In the lower Snake and Columbia River migratory corridor, Snake River Sockeye Salmon potentially encounter both reservoir-rearing kokanee and anadromous sockeye salmon smolts from the upper Columbia migrating to the sea.

Upon entering the ocean and migrating north, they will be placed in competition with hatchery and natural sockeye salmon stocks originating along the entire North Pacific rim. Although salmon use only a small percentage of the North Pacific's food resource, they are major factors in the epipelagic zone resources they do use. In a survey of the epipelagic nekton in the western North Pacific Ocean, the most abundant species (68% by number) were the six species of Pacific salmon (Ishida et al. 1999). Pacific salmon have also been observed to be a dominant daytime biomass in offshore surface waters (Beamish et al. 2005). Given this abundance and limited forage base, it is not surprising that both intraspecific and interspecific competition have been observed in the marine environment. Using growth and abundance data, Pyper and Peterman (1999) demonstrated intraspecific competition for food resources in sockeye salmon in the North Pacific Ocean. The observation of Bugaev et al. (2001) that the size of sockeye salmon returning to the Ozernaya River is reduced in years when sockeye salmon abundance in the marine environment is high also supports the concept of intraspecific marine competition. These observations indicate that in years when food resources in the North Pacific ecosystem are scarce the release of hatchery fish from lower Columbia River species into the ecosystem may have the potential to limit Snake River Sockeye Salmon marine growth and survival.

Sockeye Salmon are believed to face their greatest interspecific marine competition from pink and chum salmon. Research indicates diet overlap between these three species can be high for small and medium size fish and moderate for large salmon (Zavolokin et al. 2007). Depending on season and location, the dietary overlap between Sockeye Salmon and chum salmon rearing in the Bering Sea ranges from low to high (Davis et al. 2003). As expected, studies indicate the Sockeye Salmon, pink, and chum dietary and habitat use is diverging in a manner that reduces interspecific competition (LeBrasseur 1966; Kanno and Hamai 1971; Azuma 1995). Research indicates that Sockeye Salmon marine growth and survival is reduced in years of high pink salmon abundance (Bugaev et al. 2001; Ruggerone and Nielsen 2004; Ruggerone et al. 2005). This suggests that hatchery releases of pink and chum salmon into the North Pacific may have the potential to limit Snake River Sockeye Salmon growth and survival.

5.6.4 Summary of Competition Threats and Limiting Factors

Threat: Competition with planted rainbow trout and kokanee in the Sawtooth Valley lakes.
Related limiting factors: Competition for limited food could reduce Sockeye Salmon productivity.

Threat: Potential competition with non-native fishes and hatchery salmonids in the Salmon, Snake, and Columbia Rivers and ocean.
Related limiting factors: Competition for limited food supplies could reduce Sockeye Salmon productivity.

5.7 Toxics

Although Snake River Sockeye Salmon spawn and rear in an undeveloped area with very little industry or cropland, they have the longest migration of any Sockeye Salmon, traveling 1,448 km (900 miles) inland. Much of the migratory path includes waters listed as impaired on the 303(d) lists for Oregon and Washington; Figure 5-4 shows 303(d) listed streams and NPDES permit sites in the region. These waters are contaminated by drift and runoff from both agricultural and urban areas. Exposure to toxic chemicals during adult and juvenile migration may contribute to low survival and impede recovery of this stock.

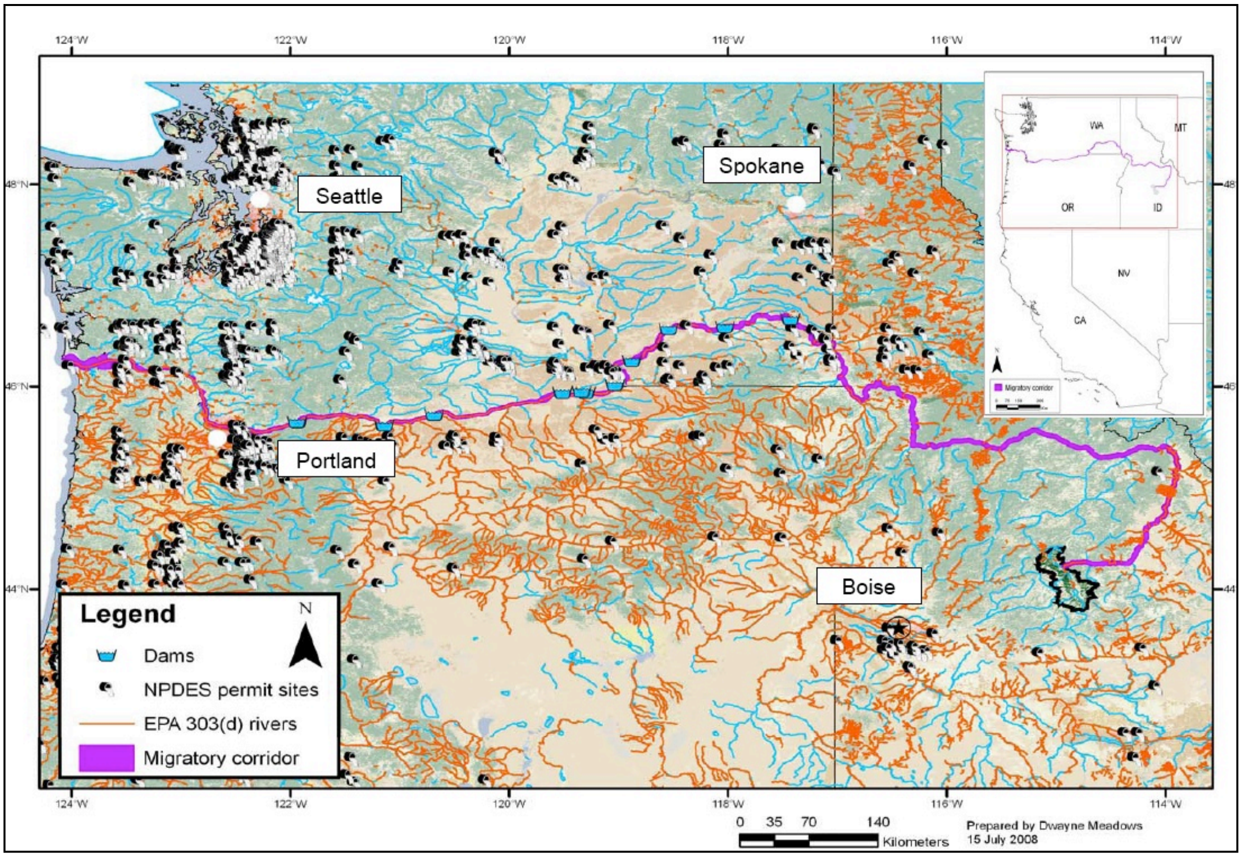

Figure 5-4. NPDES permit sites and 303(d) listed streams in Snake River Sockeye Salmon migratory corridor. (Source: NMFS 2009).

5.7.1 Sawtooth Valley Lakes

Most of the historical spawning and rearing area for Sockeye Salmon in Redfish, Pettit, Alturas Stanley, and Yellowbelly Lakes, lies within an undeveloped wilderness area. For example, only about 1% of the land surrounding Redfish Lake has been developed, and another 1% is used for agriculture, primarily hay and pasture (NMFS 2010a). No areas within the spawning habitat of the ESU are designated for water quality violations due to the presence of toxic contaminants. However, Stanley Lake, Pettit Lake, and Yellowbelly Lake, as well portions of Alturas Creek, Redfish Lake Creek, Pettit Lake Stream, and Stanley Creek are listed on IDEQ's 303 (d) list as Category 3 water bodies for which there are insufficient data on water quality, including toxics, to determine if beneficial uses are being met (IDEQ 2014).

Some monitoring for toxic metals has been conducted in resident fish from the Sawtooth Valley lakes. The Idaho Department of Environmental Quality sampled kokanee, rainbow trout, and bull trout in Alturas and Yellowbelly Lakes for mercury, selenium, and arsenic (Essig and Kosterman 2008). Results showed that selenium concentrations ranged from 0.23 to 0.34 mg/kg wet weight at Yellowbelly Lake and from 0.30 to 0.37 mg/kg wet wt in fish from Alturas Lake. All these samples were well below Idaho's proposed draft fish tissue criterion of 7.91 mg/kg dry wt or 1.58 mg/kg wet wt for protection of aquatic life for selenium, as well as the 1.0 ug/g wet wt threshold proposed by Lemly (1996, 2002) for protection of larval fish. Arsenic concentrations were below detection limits in all samples from Yellowbelly Lake, but in fish from Alturas Lake, total arsenic ranged from 0.12 to 0.35 mg/kg wet, the highest arsenic concentration observed in any samples from the study. Biochemical effects such as changes in enzyme activity have been reported in carp with tissue arsenic concentrations in this range (Ventura-Lima et al. 2009), and increased mortality and reduced growth have been observed in rainbow trout at tissue concentrations in the 0.38-0.4 range (Dixon and Sprague 1981; Erickson et al. 2011), suggesting this might be a cause for concern if Snake River Sockeye Salmon were reintroduced to this lake. Mercury levels ranged from 103 to 162 ug/kg in fish sampled at Yellowbelly Lake and from 76 to 163 ug/kg in fish sampled from Alturas Lake. These levels are all below Idaho's human health criterion for mercury of 300 ug/kg wet wt, as well as the estimated effects threshold for fish of 200 ug/kg wet wt proposed by Beckvar et al. (2005). Overall, these results suggest that Snake River Sockeye Salmon would not be at risk for toxic injury due to these metals, although there is some uncertainty about whether these criteria would be protective for both lethal and sublethal effects to all life stages of salmon that may be present.

The recent NMFS Biological Opinion on the Idaho water quality criteria for toxic pollutants (NMFS 2014d) found that approval of the proposed chronic water quality criterion for mercury would likely cause adverse modification to critical habitat or lethal and sublethal effects to Snake River Sockeye Salmon, and supports Idaho's human health fish tissue criterion as a reasonable means of protecting Snake River Sockeye Salmon until a more protective water quality criterion can be established. This Biological Opinion also found that approval of the chronic water quality criteria for arsenic, copper, cyanide, and selenium, as well as calculation of metals toxicity levels using the 25 mg/l proposed hardness floor, would result in jeopardy for the Snake River Sockeye Salmon ESU. According to the Opinion, the chronic mercury, arsenic, and selenium criteria would not protect salmon against adverse effects on growth, reproduction, and survival mediated through food chain contamination and uptake of these metals in the diet. The acute and chronic copper criteria could have adverse behavioral effects from loss of sense of smell. The cyanide acute criterion could lead to lethality under cold winter temperatures, while the cyanide chronic criterion is close to threshold for adverse effects on swimming ability and reproduction.

The NMFS Biological Opinion on the Oregon water quality criteria for toxic pollutants (NMFS 2012a) similarly found that the proposed criteria for arsenic, copper, and selenium would not be protective of Snake River Sockeye Salmon. This Biological Opinion additionally found that adoption of the proposed criteria for aluminum, ammonia, lindane, cadmium, dieldrin, endosulfan-alpha, endosulfan-beta, endrin, nickel, pentachlorophenol, silver, tributyltin, and zinc could jeopardize the recovery of Snake River Sockeye Salmon, based on the potential of these contaminants to contribute to mortality at the population level. It should be noted that the NMFS decisions on these criteria do not necessarily indicate that waters in the Sawtooth Valley lakes or other critical habitat are currently impaired by these compounds, but that the proposed criteria would not prevent such impairment from occurring. Adoption of the reasonable and prudent alternatives proposed in these two Biological Opinions on Oregon and Idaho water quality should provide additional protection for Snake River Sockeye Salmon against the potential adverse effects of these toxic compounds.

Several other potential threats associated with toxic contaminants are present within the area. First, the Redfish Lake area has become a popular recreational destination (Selbie et al. 2007). It is unlikely that nearshore camping and a hotel facility contribute to pollution via wastewater contaminants because sewage, the main source, is removed from the area by contained sanitation systems (Gross et al. 1998). Fuel spills from recreational boats present in the lake are another potential hazard, which could have especially serious effects on early life stages of Snake River Sockeye Salmon. Larval exposure to certain polycyclic aromatic hydrocarbons (PAHs) can cause cardiac developmental toxicity that may result in death or, at lower exposure concentrations, lead to heart defects that can reduce swimming speed and fitness and contribute to increased mortality later in life (Incardona et al. 2009; Hicken et al. 2011). Fuel spills associated with motorized boating could also be a concern for Snake River Sockeye Salmon re-introduced to Stanley and Pettit Lakes; motorized boating is prohibited at Yellowbelly Lake.

In Yellowbelly, Pettit, and Stanley Lakes, there is the possibility of toxaphene contamination. In the mid-1950s, based on very low levels of adult Sockeye Salmon returns to Stanley, Pettit, and Yellowbelly Lakes, the IDFG made the decision to develop these lakes for resident species sport fisheries (IDFG 1959). Yellowbelly (1961), Pettit (1961), and Stanley (1954) Lakes were chemically treated with Toxaphene, but Alturas and Redfish Lakes were not. Stanley Idaho resident John Rember reports that the 1961 fish kill extended down the upper Salmon River as far as the town of Stanley (Rember 2003), which suggests that a cohort of smolts from all the lakes may have been depleted by the poisoning. Yellowbelly Lake was poisoned a second time in 1990 using rotenone, and again the fish kill extended down the outlet creek and then down the Salmon River approximately 4 miles (Curet et al. 2010). Yellowbelly Lake was poisoned again in the late 1990s (Kline 2013). It is possible that Toxaphene is still present in lake sediments and biota, but no monitoring data are available.

As more than 50% of the ESU's critical habitat is composed of evergreen forests, forestry pesticide uses may affect spawning and rearing activities. Researchers have conducted some studies on herbicides that may be used in forested and riparian areas for weed control. Stehr et al. (2009) screen six herbicides (picloram, clopyralid, imazapic, glyphosate, imazapyr, and triclopyr) and several technical formulations (Tordon K, Transline, Habitat, Plateau, Garlon 3A, and Renovate) for developmental toxicity using zebrafish as a model system. No developmental toxicity was observed in response to the six individual herbicides or the different technical formulations. On this basis, the authors concluded that noxious weed control activities were not likely to pose a direct threat to the health of salmonids at early life stages.

The Sawtooth National Forest recently (SNF 2012) completed consultation on herbicide treatment using 11 active ingredients (Aminopyralid, 2,4-D, Chlorsulfuron, Clopyralid, Triclopyr, Dicamba, Glyphosate, Imazapic, Metsulfuron methyl, Picloram, and Diflufenzopyr). NMFS concluded that the applications proposed by the U.S. Forest Service were likely to have only short-term, non-lethal effects on salmonids including Sockeye Salmon.

Use of fire retardants to fight forest fires might also pose a threat to this habitat. These products are normally applied by aircraft and are specifically intended for terrestrial application, but fire retardants have incidentally entered aquatic habitats and resulted in fish kills. The toxicity of these chemicals to salmon is currently under investigation in joint studies conducted by the U.S. Forest Service, USGS, and NMFS. Dietrich et al. (2010, 2013) examined the lethal and sub-lethal effects of two currently approved fire retardants, PHOS-CHEK 259F and LC-95A. These retardants contain diamonium phosphates and ammonium polyphosphates, and their toxic mode of action is similar in many aspects to ammonia. Concentrations of the products that caused 50% mortality (LC50 or 'median lethal dose') were 140.5 and 339.8 mg/L for 259F and LC-95A, respectively, levels that could occur during accidental drops into aquatic habitats. Sub-lethal exposure to PHOS-CHEK significantly reduced salmon survival during a study which tested juvenile salmon's ability to adapt to saltwater, suggesting that exposure to this fire retardant could interfere with smoltification. Exposed fish also displayed some unusual behavior, such as swirling and apparent disorientation, that could increase their susceptibility to predation. Because Redfish Lake is located in a watershed that is 92% Federal land, any forestry uses of the chemicals are being considered in consultations with the U.S. Forest Service.

5.7.2 Salmon River Migration Corridor

Water quality problems in the Salmon River basin are generally associated with factors such as temperature or siltation rather than toxic contaminants (IDEQ 2002, 2003, 2011), although there is also some risk of toxic exposure in the region, including metals contamination from mine wastes in the Middle Salmon-Panther subbasin (IDEQ 2001). Arsenic, cobalt, and copper are three metals of concern in this subbasin (IDEQ 2001). Historically, the Blackbird Mine in the Middle Salmon-Panther watershed released high concentrations of these and other metals into the environment, and several creeks near the mine have been listed under section 303(d) of the Clean Water Act for impairment due to copper and other metals. This reach of the Salmon River itself is not listed as impaired due to metals contamination, although some portions have been listed as impaired due to unknown contaminants (IDEQ 2011). The Blackbird Mine was listed as a superfund site in 1993 and cleanup and remedial actions are ongoing (see: http://yosemite.epa.gov/r10/cleanup.nsf/sites/blackbird), but because of historical releases there may still be some potential for Snake River Sockeye Salmon exposure to toxic metals in the Salmon River migration corridor. Copper is especially problematic, as even short-term exposure to at relatively low concentrations of copper in the water column can affect salmon olfaction and related behaviors (Sandahl et al. 2007; Hecht et al. 2007). By interfering with critical activities such as prey capture, predator avoidance, and homing, copper exposure could reduce adult spawning success and juvenile growth and survival (Hecht et al. 2007; Baldwin et al. 2011).

Mercury is a concern in the Salmon River, as mercury at concentrations sufficient to impair fish health and be a risk to humans and wildlife have been reported in bass and northern pike minnow from some sites in the area (Hinck et al. 2006; Essig 2010). However, concentrations of mercury in the toxic range appear to be restricted to longer-lived, piscivorous fish. Reported concentrations in salmonid species including trout and mountain white fish are relatively low (Essig 2010), suggesting that the risk to Snake River Sockeye Salmon is limited.

Exposure to current-use pesticides, including organophoshates, carbamates, herbicides, and fungicides is another also a possible risk in the Salmon River (NMFS 2008d, 2009, 2010a, 2011d). NMFS (2008d, 2009) stated that areas where exposure to these pesticides was most likely included dryland agricultural areas within the lower Salmon River basin. While most of the pesticides reviewed in NMFS' Biological Opinions were considered to be of low risk to Snake River Sockeye Salmon populations, NMFS found that exposure to the compounds chlorpyriphos, diazanon, malathion, naled, and 2,4-D was likely to jeopardize the continued existence of the ESU and recommended a reasonable and prudent alternative (NMFS 2008d, 2010a, 2011d). As a high proportion of the Salmon River migration corridor is comprised of forested lands, concerns about forestry pesticides and fire retardants would apply to this area as well as the Sawtooth lakes region.

Legacy pesticides may be less of a concern in the Salmon River than current use pesticides, although data are limited. For example, Clark and Maret (1998) found DDTs in resident large-scale sucker from the Salmon River only at relatively low concentrations (600 ng/g lipid), well below concentrations associated with health effects for DDTs in fish (Beckvar et al. 2005). For Snake River Sockeye Salmon, which are present in the area for a limited time during migration, uptake of DDTs and related legacy pesticides would likely be even lower. However, there is no information on concentrations of these chemicals in juvenile Snake River Sockeye Salmon to confirm this.

5.7.3 Lower Snake River and Columbia River Migration Corridor

Snake River Sockeye Salmon are unique compared to other sockeye salmon populations. Sockeye Salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea (approximately 1,500 km or 900 miles) to a higher elevation (1,982 meters or 6,500 ft.) than any other sockeye salmon population (Bjornn et al. 1968). The length of and duration of their migration puts them at increased risk for exposure to agricultural and industrial chemicals.

Throughout the Snake and Columbia River migration corridor, agricultural land uses may affect Snake River Sockeye Salmon. Irrigation began on lands adjacent to the Snake River around 1880. Irrigated agriculture is developed in a band several miles wide on either side of the river, and agriculture is a predominant land use to this day. Agricultural runoff returns to the river and also recharges the aquifer. It may carry various contaminants from pesticides, fertilizers, and/or animal wastes, but water quality monitoring data on current use of pesticides in the lower Snake River is limited (Watson et al. 2008). Bio-accumulative legacy pesticides are also a concern in this region. A recent study by the Washington State Department of Ecology sampled resident fish (bluegill, channel catfish, common carp, largemouth bass mountain whitefish, northern pikeminnow, peamouth, pumpkinseed, smallmouth bass, and yellow perch) at several sites on the Snake River between Clarkston and the Ice Harbor Dam (Seiders et al. 2011). All five sites showed water quality violations for the legacy pesticides DDTs, dieldrin, and toxaphene, based on concentrations of these contaminants in fish. However, concentrations in sediments appear to be declining (Watson et al. 2008).

The mainstem Columbia River from its confluence with the Snake River near Pasco, Washington to its mouth also serves as a migration corridor for Snake River Sockeye Salmon. Like the Snake River, the Columbia River passes through agricultural lands, and receives pesticides, fertilizers and animals in both the mainstem and tributaries. In the 198-km (123-mile) reach of the Columbia River between the McNary and Dalles Dams, dominant land uses are irrigated and non-irrigated agriculture, livestock grazing, and timber harvest, and agricultural and forest pesticides, biological wastes, fertilizers, and pharmaceuticals are all considered potential contaminants of concern (CBFWA 2008). The region exhibits a number of water quality issues including elevated concentrations of water-soluble pesticides and herbicides and elevated concentrations of organochlorine pesticides including DDTs in both bed sediment and fish (Clark et al. 1998; Williamson et al. 1998; Hinck et al. 2006; Wagner et al. 2006; McCarthy and Gale 2001; Johnson and Norton 2005; Watson et al. 2008). The USGS found particularly high concentrations and detection frequencies for current-use pesticides in the Pasco, Washington area (Williamson et al. 1998).

In the Columbia Gorge, in the reach of the river bounded by Bonneville Dam at river kilometer 233 (river mile 145) and The Dalles Dam at river kilometer 307 (river mile 191), pesticide usage is also high, especially in the Hood River basin (Jenkins 2003; Jenkins and Catignoli 2004). Various current use pesticides and herbicides have been detected at various sites in the Hood River subbasin, including at the mouth of the Hood River at its confluence with the Columbia River (Temple and Johnson 2011). Agricultural pesticides enter the lower Columbia River, below Bonneville Dam, at various locations, including the confluence with the Willamette River. The Willamette River basin is a region of heavy pesticide use (Anderson et al. 1996; Wentz et al. 1998), and may be also source of pesticide contamination in the Columbia River. Throughout the Columbia Gorge and lower Columbia River, there are reaches that are listed as impaired under section 303(d) of the Clean Water Act because of high concentrations of DDTs in resident fish (Davis et al. 1998; Coots 2007; Seiders et al. 2007). In both the Columbia Gorge and lower Columbia River and estuary, much of the region is forested, and most contaminants in this region isare low (Anderson et al. 1996; Johnson and Norton 2005); however, they could contribute some forestry herbicides and insecticides, similar to those described in earlier sections of this Plan.

In addition to agricultural chemicals, Snake River Sockeye Salmon may be exposed to contaminants from urban and industrial sources at many points in their migration corridor. The Snake River passes through Lewiston, Idaho, Clarkston, Washington, and the tri-cities of Kennewick, Pasco, and Richland Washington, before its confluence with the Columbia River. These population centers are sources of contaminants associated with urban and industrial activity. A recent study by Washington State Department of Ecology sampled resident fish (bluegill, channel catfish, common carp, largemouth bass mountain whitefish, northern pikeminnow, peamouth, pumpkinseed, smallmouth bass, and yellow perch) at several sites on the Snake River between Clarkston and the Ice Harbor Dam (Seiders et al. 2011). All five sites showed water quality violations for polychlorinated biphenyls (PCBs) and dioxins, based on concentrations of these contaminants in fish. Polybrominated diphenyl ethers (PBDEs) may also be a problem at some locations; Arkoosh et al. (2011) reported some accumulation of PBDEs in spring Chinook salmon during passage through reaches of the Snake River close to population centers such as Lewiston before reaching Lower Granite Dam. The Columbia River between the McNary and The Dalles dams is influenced by inputs of contaminants from urbanized and industrial areas of the Tri-Cities and Hanford. At a site near Pasco, Hinck et al. (2006) reported high concentrations of mercury and selenium in resident fish. A recent Washington State Department of Ecology report (Sandvick 2010) reported concentration of PCBs near McNary Dam that exceeded Washington State and EPA national water quality criteria. Higher than average levels of PBDEs in sediments and resident fish have also been reported near the Tri-Cities by EPA (Watson et al. 2008).

Industrial chemicals are generally found at lower concentrations in the Columbia Gorge, but some portions of the Columbia River in this reach are listed as impaired water bodies under section 303(d) of the Clean Water Act due to elevated concentrations of PCBs in resident fish or in the water column (Coots 2007; Seiders and Deligeannis 2009). Bradford Island, on the Oregon side of the Columbia River, and part of the Bonneville Dam facility in Cascade Locks, is a source of PCB contamination in the Columbia Gorge region (URS 2010). In the past, an old landfill at Bradford Island served as a disposal site for electrical components and other materials containing PCBs. The Oregon Department of Environmental Quality is currently working with the Army Corps of Engineers to clean up PCB wastes at this site. In resident fish sampled from Cascade Locks, Hinck et al. (2006) found mercury, PCBs, and tetra-chlorinated dibenzo-p-dioxins (TCDDs).

Urban and industrial contaminants are present at especially high concentrations in the lower Columbia River and estuary near the confluence of the Columbia and Willamette Rivers, as this region contains multiple population centers, including Portland, the largest city in Oregon, and Vancouver, the fourth largest in Washington. Because of its high population density and industrialization, this area has major impacts on water quality. The majority of wastewater discharges, as well as non-point source runoff from paved roads and urban areas, originate in the region (USEPA 2009). Major classes of contaminants that have been detected in water, sediments, and fish in this area include PAHs, PCBs, dioxins, various semi-volatile industrial organic compounds, and metals (e.g., see Tetra Tech 1996; Buck et al. 2005; McCarthy and Gale 2001; Johnson and Norton 2005; Fuhrer et al. 1996; Weston 1998; Sethajintanin et al. 2004; Hinck et al. 2006; Sandvick 2010; LCREP 2007; Johnson et al. 2007, 2013); and there is evidence that other contaminants of emerging concern, including polybrominated diphenyl ethers (PBDEs) and pharmaceuticals, personal care products, and surfactants present in wastewater may be entering the river as well (Morace 2006, 2012; LCREP 2007; Sloan et al. 2010). There is also some evidence of contamination in some stretches of the Columbia River below Portland and Vancouver. Reaches near the Cowlitz and Lewis Rivers are listed as impaired water bodies because of elevated concentrations of PCBs in resident fish from these water (Davis et al. 1998; Coots 2007). High concentrations of PAHs, PCBs, and PBDEs were also detected in juvenile fall Chinook salmon from sites near Columbia City and Beaver Army Terminal (LCREP 2007; Sloan et al. 2010; Johnson et al. 2013).

5.7.4 Contaminant Exposure, Uptake, and Risk in Snake River Sockeye Salmon

Land use activities and available data on contaminant concentrations in areas designated as critical habitat for Snake River Sockeye Salmon suggest that although a substantial proportion of their spawning habitat is relatively undeveloped, both juveniles and adults are likely at risk for exposure to several classes of contaminants, including mercury, legacy and current use pesticides, industrial contaminants such as PCBs and PBDEs, and wastewater contaminants during juvenile outmigration and adult spawning migration. However, very little is known about actual exposure to and uptake of contaminants in outmigrant juvenile Snake River Sockeye Salmon, or returning adults, and no data are available on contaminant body burdens in this species. Moreover, water quality data for much of this ESU's habitat is incomplete. For example, there are only three USGS National Water-Quality Assessment (NAQWA) monitoring sites within the migration corridor of Snake River Sockeye Salmon, and no sites within the spawning and rearing habitat (NMFS 2011d). Water quality assessments are lacking for several lakes that comprise historical spawning habitat. In general, toxics monitoring in the Columbia Basin has been concentrated primarily in the lower Columbia River and estuary, and data for the middle and upper Columbia, Snake River and Salmon River basins are lacking (USEPA 2009).

Snake River Sockeye Salmon juveniles generally move rapidly downstream and spend little time rearing in the migration corridor. Consequently, they may be especially at risk from contaminants such as current use pesticides, which can affect behavior and other endpoints after only short-term exposure (NMFS 2008d, 2009, 2010a, 2011d). In a series of biological opinions, NMFS evaluated the likely impacts of a wide range of current use pesticides, including fifteen organophosphate insecticides, three carbamate insecticides, four herbicides, and two fungicides, on Snake River Sockeye Salmon (NMFS 2008d, 2009, 2010a, 2011d). NMFS concluded that individual Snake River Sockeye Salmon would likely show some reductions in viability due to use of most of the reviewed pesticides. For a more limited number of pesticides (diazinon, chlorpyriphos, malathion, 2,4-D, and nalad), NMFS determined that there was a risk of jeopardy to Snake River Sockeye Salmon if these chemicals were applied imprudently (NMFS 2008d, 2009, 2010a, 2011d).

Like current-use pesticides, dissolved copper may be a particular risk for Snake River Sockeye Salmon because of its ability to affect olfactory function and behavior after relatively short-term exposure (Hecht et al. 2007). A variety of studies have shown that copper in the water column may have sublethal effects on juvenile salmonids at concentration in the 1-4 ug/L range (Hecht et al. 2007; Mebane and Arthaud 2010), concentrations that are not uncommon in the Snake and Columbia Rivers (Morace 2006, 2012; Anderson 2009). This suggests that some short-term effects on olfaction and behavior are likely for Snake River Sockeye Salmon juveniles and adults, but it is difficult to know if their exposure to variable concentrations would be of sufficient severity or duration to affect growth, mortality, or population viability.

Snake River Sockeye Salmon may also be exposed to PAHs during both juvenile and adult migration. While no data are available on this stock, PAH metabolites in bile have been measured in juvenile fall Chinook salmon from the lower Columbia River and Estuary (Yanagida et al. 2011) and in juvenile spring Chinook salmon samples from the Snake and Middle Columbia Rivers between the Lower

Granite and Bonneville Dams (Arkoosh et al. 2011). Of the bile samples collected from spring Chinook salmon collected from the Snake and Middle Columbia by Arkoosh et al. (2011), 36% exceeded the PAH-metabolite effect threshold estimated by Meador et al. (2008), while 47% of fall Chinook salmon samples collected from sites in the lower Columbia River exceeded the threshold (Yanagida et al. 2011). Moreover, in both studies, levels of PAH metabolites above threshold concentrations were observed at multiple sites throughout the sampling areas, suggesting that exposure may be occurring throughout the region. This suggests that PAH exposure is highly likely in Snake River Sockeye Salmon moving through the Snake and Columbia River migration corridor, although there is much uncertainty about whether the duration of exposure would be sufficient to have health impacts on these fish.

Because of the Snake River Sockeye Salmon's stream-type life history strategy, their likelihood of accumulating high concentrations of bioaccumulative contaminants such as PCBs, PBDEs, and DDTs may be limited in comparison to ocean-type stocks such as Snake River fall Chinook salmon, which use the migration corridor and estuary as a rearing environment. Studies with Snake River spring Chinook salmon, another stream-type stock, indicated that juvenile Snake River spring Chinook salmon accumulated DDTs and related agricultural pesticides during outmigration through the Snake and Columbia Rivers, but showed less uptake of PCBs and PBDEs, industrial chemicals present in especially high concentrations in the lower Columbia River and estuary (Sloan et al. 2010; Arkoosh et al. 2011; Johnson et al. 2012). However, because of lipid loss during outmigration, lipid-adjusted concentrations of all three classes of contaminants, which are better predictors of toxicity than wet weight concentrations, increased, putting some fish at risk for toxic effects. Concentrations of DDTs as high as 8700 ng/g lipid and PCBs as high as 3100 ng/g lipid were reported, levels above those associated with toxic effects in juvenile salmon (Meador et al. 2002; Arkoosh et al. 2011; Johnson et al. 2013). Comparable results might be expected for juvenile Snake River Sockeye Salmon, but this is uncertain.

No specific information is available on concentrations of the PCBs, DDTs, and related bioaccumulative contaminants in adult Snake River Sockeye Salmon, but the EPA has collected some information on concentrations these contaminants in adult spring Chinook salmon, which have a somewhat comparable life history. The average concentrations of DDTs and PCBs in whole body samples were 225 ng/g lipid and 333 ng/g lipid, respectively, given an average lipid content of 12% of these fish (USEPA 2002). Thus, risks of injury appear higher in outmigrant juveniles than in adult fish.

Mercury is also considered a contaminant of concern in the several reaches of the Salmon, Snake, and Columbia Rivers that are critical habitat for Snake River Sockeye Salmon. Concentrations are not especially high in resident fish species captured from the Sawtooth Valley lakes, but high concentrations have been detected in resident fish from other areas in the Salmon, Snake, and Columbia Rivers (Hinck et al. 2006; Essig 2010). However, reported mercury concentrations are typically much lower in salmonids, including returning adults, than in resident piscivorous fish species (USEPA 2002; Essig 2010). Mercury has also been measured in egg samples of returning fall and spring Chinook salmon, and steelhead trout from various sites in the Columbia Basin, and levels were below detection limits in all samples (USEPA 2002). These data suggest that risks associated with mercury contamination are low for Snake River Sockeye Salmon. However, the lack of information on mercury levels in this species makes it difficult to be certain of the impacts.

In addition to these contaminants discussed above, there are many other contaminants of concern in the Snake and Columbia Rivers with potential effects on salmon (USEPA 2009). These include metals such as arsenic and lead; radionuclides; combustion byproducts such as dioxin; and “contaminants of emerging concern” such as pharmaceuticals and personal care products. Additional information, including toxicity evaluations and geographically targeted studies on these contaminants is needed to evaluate their potential risk to Snake River Sockeye Salmon.

5.7.5 Summary of Threats and Limiting Factors Related to Toxics

Threats: Agricultural runoff, legacy mining contaminants, urban and industrial runoff, effluent, and wastes in the migration corridor and legacy toxaphene in Sawtooth Valley lakes.
Related limiting factors: Contaminants such as DDTs, PCBs, PBDEs, toxaphene, mercury, copper, and other metals, current use agricultural and forest pesticides, wildfire retardants, radionuclides, dioxin, etc., causing mortality, disease, reduced fitness.

Threat: Recreational development.
Potential limiting factors: Unfavorable changes to water quality; interference in spawning areas could reduce Sockeye Salmon productivity.

Threat: Forestry pesticide and fire retardant use.
Potential limiting factors: Toxic runoff resulting in lake water pollution could reduce Sockeye Salmon productivity.

Threat: Legacy pesticide presence due to lake poisoning.
Potential limiting factors: Persistent and bioaccumuative toxicants (i.e., toxaphene) in lake sediments and biota could reduce Sockeye Salmon productivity by causing mortality, disease, or reduced fitness.

5.8 Climate Change

Likely changes in temperature, precipitation, wind patterns, and sea level height have profound implications for survival of Snake River salmon and steelhead, including Sockeye Salmon, in both their freshwater and marine habitats. Recent descriptions of expected changes in Pacific Northwest climate that are relevant to listed salmon and steelhead include Elsner et al. (2009), Mantua et al. (2009), Mote and Salathe (2009), Salathe et al. (2009), Mote et al. (2010), Chang and Jones (2010), and Crozier (2012, 2013). Reviews of the effects of climate change on salmon and steelhead in the Columbia River basin include ISAB (2007), NMFS (2010), Hixon et al. (2010), Dalton et al. (2013), and NMFS (2014c). The NMFS Northwest Fisheries Science Center will also be producing annual updates describing new information regarding effects of climate change relevant to salmon and steelhead as part of the FCRPS

Adaptive Management Implementation Plan. The following is a short summary of expected climate change effects on listed Snake River salmon and steelhead derived from the above sources.

Freshwater Environments

Climate records show that the Pacific Northwest has warmed about .07°C since 1900, or about 50% more than the global average warming over the same period (Dalton et al. 2013). The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1°C to 0.6°C per decade. While total precipitation changes are predicted to be minor (+1% to 2%), increasing air temperature will alter the snow pack, stream flow timing and volume, and water temperature in the Columbia Basin (Figure 5-5). Climate experts predict the following physical changes to rivers and streams in the Columbia Basin:

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snow pack will diminish, and stream flow volume and timing will be altered. More winter flooding is expected in transitional and rainfall-dominated basins. Historically transient watersheds will experience lower late summer flows.

A trend towards loss of snowmelt-dominant and transitional basins is predicted. Summer and fall water temperatures will continue to rise.

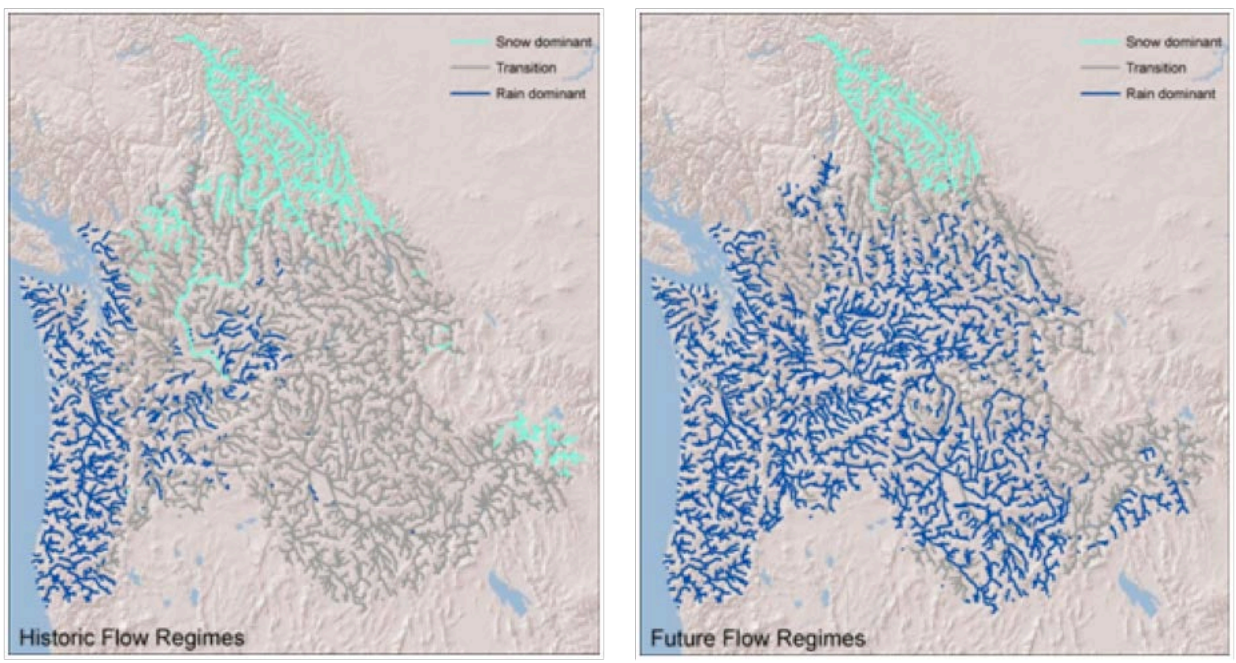

Figure 5-5. Preliminary maps of predicted hydrologic regime for (A) the period 1970-1999 and (B) the period 2070-2099 using emission scenario A1B and global climate model CGCM3.1(T47), based on classification of annual hydrographs as in (Beechie et al. 2006). Data from University of Washington Climate Impacts Group (http://www.hydro.washington.edu/2860/).

Recent intensive modeling of stream flow and temperature in the Pacific Northwest (Wu et al. 2012) indicates that the Salmon River basin and similar watersheds may be particularly impacted by climate change. The model simulations projected that climate change will have greater impacts on snow-dominant streams, such as those found in the upper Columbia Basin and Salmon and Clearwater basins. Increased water temperatures could affect migrating adult Sockeye Salmon by increasing the metabolic cost of swimming and holding prior to spawning, which can increase prespawn mortality (Crozier 2012).

An assessment by the Sawtooth National Forest also suggests that climate change may impact flows and water temperatures in the Salmon basin. The Sawtooth National Forest conducted a climate change vulnerability assessment (US U.S. Forest Service 2011) on winter peak and summer base flows, and water temperatures in the upper Salmon drainage on the Sawtooth National Recreation Area. Results include:

Summer Baseflows (Mean Summer)
Assessment results project a general trend of declining summer baseflows for the entire Sawtooth National Recreation Area as air temperatures and evapotranspiration increase. As discussed in the assessment (2011), increasing winter air temperatures will reduce the amount of snow (e.g., more precipitation falling as rain than snow), as already observed in several parts of the western United States. In addition, higher spring temperatures will also initiate earlier runoff and peak streamflows in snowmelt-dominated basins.

The prediction of lower baseflow is consistent with studies and empirical trends at flow gages on the Salmon National Forest. Since 1950, stream discharge in both the Colorado and Columbia River basins has decreased (Walter et al., 2004). Regonda et al. (2005) and Stewart et al. (2005) found that stream runoff steadily advanced during the latter half of the twentieth century and now occur 1 to 3 weeks earlier due largely to concurrent decreases in snowpack and earlier spring melt (Mote et al. 2005). These changes diminished recharge of subsurface aquifers that support summer baseflows (Hamlet et al. 2005). Luce and Holden (2009) found that three-fourths of the 43 gage records they examined from the Pacific Northwest exhibited statistically significant declines in summer low flows. Luce and Holden (2009) also found that the driest 25% of years are getting drier across the majority of the Pacific Northwest sites, with most streams showing decreases exceeding 29% and some showing decreases approaching 50% between 1948 and 2006. Sites on or near the Sawtooth National Forest showed similar declines in mean annual flow.

Summer Water Temperatures (Maximum weekly maximum temperature)
Assessment results predict that summer maximum weekly maximum water temperatures will increase over the next 70 years relative to 2008, with possible increases by +0.9 ^{o}C (2033), +1.1 ^{o}C (2040), +1.7 ^{o}C (2058), and +2.5 ^{o}C (2080) on the Sawtooth National Recreation Area.

These changes in air temperatures, river temperatures, and river flows are expected to cause changes in adult Sockeye Salmon migration rates and survival. Higher temperatures during adult migration in late summer may lead to increased mortality or reduced spawning success due to lethal temperatures, delay, increased fallback at dams, or increased susceptibility to disease and pathogens. Low late-summer flows in tributaries below natal lakes may preclude adult passage to spawning areas.

Effects of climate change on the limnology of natal lakes in the Salmon River is uncertain, so effects of climate change on Snake River Sockeye Salmon spawning, emergence, and juvenile rearing are currently unknown. If lakes are warmer during incubation, fry may emerge earlier, which could be either beneficial or detrimental, depending upon location and prey availability. If lake temperatures are warmer during juvenile rearing, metabolism will increase, which may either increase or decrease juvenile growth rates and survival, depending upon availability of food. Higher temperatures may also increase predation rates on juvenile Sockeye Salmon or favor food competitors of Sockeye Salmon.

In the Salmon, Snake, and Columbia Rivers, modified timing of the spring freshet may alter timing of smolt migration, such that there is a mismatch with ocean conditions and predators. Reduced flow in late spring may lead to delayed migration and higher mortality passing dams.

The degree to which phenotypic or genetic adaptations may partially offset these effects is being studied but is currently poorly understood. For example, potential impacts on Snake River Sockeye Salmon could be reduced if the fish continue to adjust their migration timing. Adult migration timing in Snake River and upper Columbia Sockeye Salmon has been progressing earlier in the year in the Columbia River over the 20th century. Crozier et al. (2011) explored how changes in river temperature and flow, as well as ocean conditions might be driving this advance. They found evidence that this trait evolved genetically due to mortality of late migrants exposed to higher Columbia River temperatures during the historical migration period. The fish also show a strong annual response to river flow, such that they migrate earlier in low-flow years. These two processes combined suggest both plastic and evolutionary responses are involved in an adaptive shift likely to continue in response to climate change (Crozier 2012).

Estuarine and Plume Environments

Climate change will also affect Sockeye Salmon in the estuarine and plume environments. In the estuary, Sockeye Salmon would be primarily affected by increased predation. Juvenile Sockeye Salmon and other stream-type salmonids move quickly through the estuary on their way to the plume and ocean and are less affected by the health of the estuarine ecosystem than are ocean-type salmonids. Juvenile Sockeye Salmon may be affected by habitat changes in the plume environment due to flow- or sediment-related changes; however, use of plume habitat by Sockeye Salmon remains poorly understood. Effects of climate change on Sockeye Salmon in the estuary and plume may include the following:

- Higher winter freshwater flows and higher sea levels may increase sediment deposition in the plume, possibly reducing the quality of rearing habitat.
- Lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of salmonid prey and predators.
- Increased temperature of freshwater inflows and seasonal expansion of freshwater habitats may extend the range of non-native, warm-water species that are normally found only in freshwater.

In all of these cases, the specific effects on Sockeye Salmon abundance, productivity, spatial distribution and diversity are poorly understood.

Marine Environments

Effects of climate change in marine environments include: increased ocean temperature, increased stratification of the water column, changes in intensity and timing of coastal upwelling, and ocean acidification. Hypotheses differ regarding whether coastal upwelling will decrease or intensify, but even if it intensifies, the increased stratification of the water column may reduce the ability of upwelling to bring nutrient-rich water to the surface. There are also indications in climate models that future conditions in the North Pacific region will trend toward conditions that are typical of the warm phases of the Pacific Decadal Oscillation, but the models in general do not reliably reproduce the oscillation patterns. Hypoxic conditions observed along the continental shelf in recent years appear to be related to shifts in upwelling and wind patterns that may be related to climate change.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids is currently poorly understood. A mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may reduce marine survival rates.

Ocean warming also may change migration patterns, increasing distances to feeding areas. Rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. This process of acidification is under way, has been well documented along the Pacific coast of the United States, and is predicted to accelerate with increasing greenhouse gas emissions.

Ocean acidification has the potential to reduce survival of many marine organisms, including Sockeye Salmon. However, because there is currently a paucity of research directly related to the effects of ocean acidification on salmon and their prey, potential effects are uncertain. Laboratory studies on salmonid prey taxa have generally indicated negative effects of increased acidification, but how this translates to the population dynamics of salmonid prey and the survival of salmon is uncertain. Modeling studies that explore the ecological impacts of ocean acidification and other impacts of climate change concluded that salmon landings in the Pacific Northwest and Alaska are likely to be reduced.

Conclusion

All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat as a result of climate change is expected to cause reductions in the numbers of naturally produced adult Sockeye Salmon. This possibility further reinforces the importance of achieving survival improvements throughout the entire life cycle.

Additional exposure to high water temperatures in the mainstem Salmon, Snake, and Columbia Rivers could pose a paramount concern for adult Snake River Sockeye Salmon, which generally migrate through the corridor in late summer when water temperatures are highest. For example, observations of high July through September 2013 Snake and Columbia River temperatures indicate dangerous conditions for adult Snake River Sockeye Salmon migrating through the FCRPS during that period. PIT-tag information indicates unusually low survival of adult Snake River Sockeye Salmon through the FCRPS in 2013 (Crozier 2013), particularly for Sockeye Salmon in July and August, which were exposed to the highest temperatures. The potential impacts on migrating Snake River Sockeye Salmon may be reduced if the fish continue to adjust their migration timing.

Recent research reinforces the importance of maintaining habitat diversity, conducting studies to document climatic effects on freshwater, estuary, and ocean productivity and adjust actions accordingly through adaptive management.

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Section 6: Recovery Strategy

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6. Recovery Strategy

The recovery strategy is designed to meet the recovery goal of ESA delisting, and the delisting goals are provided in Section 3. In this section, NMFS presents the reasoning behind the recovery program recommended for the Snake River Sockeye Salmon ESU. The recovery strategy links this program to the ESU's current status and limiting factors, described in preceding sections, and the recovery goals, biological viability criteria, and recovery scenario set by NMFS in cooperation with regional and local stakeholders.

The Snake River Sockeye Salmon ESU currently is still close to extinction. This ESU is now on the equivalent of life support, with a captive broodstock program sending hundreds of thousands of smolts on their migration to the sea. In recent years of favorable ocean conditions, hundreds of adult fish have returned, but natural production levels for anadromous returns remain extremely low for the species. As previously stated, the ESU cannot be said to have recovered until there is a self-sustaining, naturally spawning population likely to persist over the next century. We must first address the ESU's current high-risk status, while also anticipating future actions that can be implemented as natural production increases.

6.1 Analysis of Causes of Decline

The Idaho Department of Fish and Game, Shoshone-Bannock Tribes, NMFS, and many independent researchers have conducted decades of scientific research and analysis concerning Snake River Sockeye Salmon. Successive NMFS biological review teams have concluded that the decline of the ESU is the result of widespread habitat degradation, impaired mainstem and tributary passage, historical commercial fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, and poor ocean conditions. These combined factors reduced the number of Sockeye Salmon to the single digits. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity.

Based on this analysis, actions taken to improve, change, mitigate, and reduce those factors will result in reduced risks and increased survival. Because of the species' complex life cycle and the many changes that have taken place in its environment, the factors limiting its survival must be addressed in concert and in an integrated way. The work needs to occur both at a regional level, in terms of commitment to actions and funding, and at the local level, as reintroduction actions are implemented.

6.2 Basic Assumptions

In designing an effective recovery strategy, we make a number of assumptions, including the following:

1. *We have accurately identified the limiting factors and threats affecting the fish.*
    - This recovery strategy reflects the best technical information available and our current understanding of the limiting factors and threats that affect the fish throughout their life cycle.

2. *Addressing the limiting factors and threats will improve the viability of the existing population and the ESU.*
    - Multiple causes are responsible for the decline of this ESU due to limiting factors and threats throughout the entire life cycle. To improve population and ESU viability, our strategy focuses on a wide range of hatchery, habitat, fishery, and hydropower system-related actions to address the many threats that currently impact Snake River Sockeye Salmon recovery. The strategy also recognizes the many remaining unknowns regarding our understanding of the factors that affect the fish now, or might influence their recovery in the future. It recognizes the risks in taking various steps toward recovery. As a result, it directs actions to gain critical information regarding how different factors affect the fish and address potential risks linked to the recovery actions.

3. *This Plan is based on technically sound ecological principles and an effective adaptive management approach.*
    - Our recovery strategy recognizes that efforts to address habitat, fisheries, hatchery and hydropower system-related issues affecting Snake River Sockeye Salmon need to be planned and implemented with a clear understanding of ecological processes — including both biological and habitat processes — and how past and current activities affect these processes.
    - An understanding of these biological and habitat processes frames our approach to rebuild Snake River Sockeye Salmon viability. The ESU is at risk for extinction. The captive broodstock program has helped maintain the Sockeye Salmon population and prevent species extinction. We are now entering a new phase that will incorporate more natural-origin Sockeye Salmon returns in the hatchery-spawning program to maintain the genetic fitness of the natural population and to provide anadromous adults to recolonize available habitat in the natal lakes. Our goal is for the naturally produced population to achieve escapement goals in a manner that is self-sustaining in the wild and without the reproductive contribution of hatchery spawners. This will require a combination of efforts that support biological and habitat processes. Together, these efforts aim to provide sufficient fish to restore populations adapted to the specific conditions of lakes in the Sawtooth Valley, while also protecting and improving habitat conditions, and addressing passage, competition, and predation concerns, to support a self-sustaining population. Further, the Plan supports the conservation of native residual and resident

forms of *O. nerka.* We recognize that while the focus of this Plan is on the recovery of ESA-listed anadromous Sockeye Salmon, residual Sockeye Salmon and kokanee represent important life history and spatial diversity characteristics that may contribute to the recovery of the anadromous Sockeye Salmon.

4. *Through an understanding of each limiting factor, actions can modify the ESU's environment and result in a biological response (through improvements in productivity, abundance, spatial structure and diversity).*
   - The recovery strategies and subsequent actions reflect our current understanding of limiting factors and threats for the population and ESU. However, we acknowledge that actions may not yield the desired result, gaps in data may emerge, and recovery efforts may need to be adapted to new information. Acknowledging these limitations and integrating adaptive management into the recovery plan is an essential part of the recovery strategy. The recovery strategies will be reevaluated and updated as new information becomes available.

6.3 Recovery Strategy

Our strategic vision for recovery of Snake River Sockeye Salmon is to establish viable self-sustaining, naturally spawning populations in the wild that are sufficiently abundant, productive, and diverse and no longer need Endangered Species Act protection. As the species continues to recover over time, broader goals that go beyond achieving species recovery may also be met to provide multiple ecological, cultural, social, and economic benefits.

Overall, our strategy aims to reintroduce and support adaptation of natural Sockeye Salmon populations in the Sawtooth Valley lakes. An important first step toward that objective has been the successful establishment of anadromous returns from natural-origin Redfish Lake stock gained through a captive broodstock program. That program is transitioning as higher levels of anadromous Sockeye Salmon return to spawn in Redfish Lake. Ultimately, the program will transition to a third phase emphasizing natural adaptation and viability. The NMFS' five-year reviews will track our progress toward recovery and allow us to adjust actions in response.

Our strategic vision for recovery recognizes that reestablishing natural Sockeye Salmon populations in the lakes, as well as life history strategies and habitats, requires use of well-formulated, scientifically sound approaches. Since multiple causes are responsible for impairing population viability and disrupting ecosystem functions, limiting factors and threats across the entire life cycle will need to be addressed in concert. Development and implementation of management actions that lead to recovery will require a sound understanding of conservation biology principles and ecosystem management as well as integration of planning, funding, and monitoring such that each contributes to reaching our end goal.

We also recognize the importance of learning as we go and adjusting our efforts accordingly to achieve ESU recovery as quickly and effectively as possible. Thus, a key element of the approach to restoring natural production of Sockeye Salmon in the Sawtooth Valley is the adaptive nature of the recovery strategy. The strategy depends on implementation of an adaptive management framework that implements site-specific actions based on best available science, monitors to improve the science, and updates actions based on new knowledge. The ESA section 4(f) requires site-specific actions “as may be necessary to achieve the plan’s goals for conservation and survival of the species.” There are two types of site-specific actions in this plan: management actions (Section 7) and research, monitoring, and evaluation actions (Section 11). Our hypothesis is that the management actions will be effective in improving survival; however, we have uncertainties about whether they will be sufficient to achieve viability. Thus, this plan depends on an adaptive management framework as follows:

1. Establish recovery goals and viability and threats criteria for delisting (Section 3).
2. Determine the species’ present status and the gaps between the present status and viability criteria (Section 4).
3. Assess the threats and limiting factors in each of the major sectors that are contributing to the gaps between present status and viability criteria (Section 5). Also, assess the threats in the context of variable ocean conditions and emerging climate change.
4. Implement management actions (Section 7) that target the limiting factors and threats associated with each of the major sections.
5. Implement research, monitoring, and evaluation actions (Section 11) to evaluate the status and trend of the species and the status and trend of limiting factors and threats, including action implementation and action effectiveness.
6. Address key information needs. There are key information needs about the species status, effects of ongoing and proposed actions, the role of the ocean and climate change, and the best opportunities for further improving survival sufficiently to meet the viability criteria. These key information needs are described in Section 6.
7. Develop and apply criteria for prioritizing recovery actions and develop an implementation plan. We need to prioritize and stage the implementation of recovery actions so we can achieve recovery in a timely and effective manner. Section 7, Actions, describes prioritization considerations that will be used to develop prioritization criteria for management actions. Section 10, Implementation, discusses the process for developing the prioritization criteria and the implementation schedule and plan.
8. Establish a contingency process: We need to be prepared if the species’ status does not continue to improve in a timely manner, and also if there are significant declines in status. A contingency process should be established that sets intermediate goals and timeframes and also sets early warning indicators and significant decline triggers. As part of this process, additional actions should be developed that are “on the shelf,” if needed, to address long-term trends toward

recovery and to prevent precipitous declines. The contingency process is addressed in Section 10, Implementation.

9. Review progress and identify best opportunities for survival improvements. Regular major reviews of implementation progress, species response, and new information are needed. These progress reviews are addressed in Section 10, Implementation.
10. Adjust actions according to progress reviews. The success of this recovery plan depends on an implementation structure that takes action in response to the results of progress reviews.
11. Repeat the adaptive management cycle. Adaptive management should be a continuous loop of action implementation, monitoring and evaluation, new information, assessment of information and updated actions. Section 11 discusses the adaptive management process.

Achieving species recovery will require coordinated and collaborative management and implementation of actions at local, watershed, and regional levels as described in Section 10. Multiple causes are responsible for the decline of this ESU due to limiting factors and threats throughout the entire life cycle. Addressing these impaired conditions and factors will require management of hatcheries, habitat, fisheries, and hydro-related actions based on the following elements in this recovery strategy. In turn, this strategy recognizes the need to adaptively manage programs, agreements and actions over time as they are implemented and new information becomes available.

The strategies and actions identified in this Plan will also provide key information aimed to answer critical recovery strategy questions through an adaptive management process. Addressing these questions will increase the certainty that the underlying assumptions in the Plan are correct and that implementation of the proposed actions will lead to recovery of the species. Key questions include:

1. Will the proposed actions translate into the benefits expected?
2. Will the benefits achieved by the actions allow the populations and MPG to recover to desired levels where the species can be delisted?
3. Are survivals that result from current conditions and management actions enough to provide for life history survival through variations in ocean and climate conditions?

Section 11 describes the research, monitoring, and evaluation that will address these questions. The research, monitoring, and evaluation program is designed to assess the status of the listed species and their habitat, track progress toward achieving recovery goals, and provide information needed to refine recovery strategies and actions through the process of adaptive management.

The proposed recovery strategy for Snake River Sockeye Salmon contains elements to address limiting factors and threats at the local level (Sawtooth Valley and upper Salmon River) and the regional level (the mainstem lower Salmon, Snake and Columbia Rivers and estuary, and plume and ocean). The different elements are listed in Box 6-1 and discussed in Sections 6.3.1 and 6.3.2.

Box 6-1. Recovery strategy for Snake River Sockeye Salmon

At the local level (Sawtooth Valley and upper Salmon River):

- Conserve population genetic and life history diversity, and spatial structure.
- Increase naturally spawning Snake River Sockeye Salmon abundance.
- Improve Sockeye Salmon passage to natal lakes.
- Reestablish a self-sustaining anadromous Sockeye Salmon population in Redfish Lake.
- Investigate and develop strategies for future actions to support Sawtooth Valley Sockeye Salmon reintroduction and adaptation phases for Pettit Lake.
- Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning kokanee outmigrants from Alturas Lake.
- As sufficient numbers of natural-origin adults return, develop an integrated approach to manage natural- and hatchery-origin adults in the hatchery program and in the wild.
- As sufficient numbers of hatchery-origin anadromous adult's return to the basin, identify options for future harvest.
- Continue research and actions to reestablish natural populations in other natal lakes.
- Continue research on natal lakes' carrying capacity, nutrients, and ecology.
- Protect and conserve natural ecological processes at the watershed scale that support population viability.
- Protect, restore and manage spawning and rearing habitat.
- Maintain unimpaired water quality and improve water quality as needed.
- Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Snake River Sockeye Salmon.
- Monitor for predation, disease, aquatic invasive species, and competition and develop actions as needed.
- Create an adaptive management feedback loop to track progress toward recovery, monitor and evaluate key information needs, assess results, and refine strategies and actions accordingly.

At the regional level (the migration corridor, in the mainstem Salmon, Snake and Columbia Rivers; estuary; plume; and ocean):

- Implement 2008/2010 FCRPS BiOp's reasonable and prudent alternative, as modified in the 2014 Supplemental FCRPS BiOp to reduce mortalities associated with migration through the mainstem Salmon, Snake and Columbia Rivers, estuary and plume.
- Continue research and monitoring on Snake River Sockeye Salmon survival/mortality in mainstem Salmon, Snake and Columbia River migration corridor; estuary; plume; and ocean.
- Update Snake River Sockeye Salmon life cycle models using latest information on survival through mainstem Salmon, Snake, and lower Columbia River migration corridor; estuary; and plume.
- Manage to maintain current low impact fisheries and reduce fishery impacts in those fisheries that affect Snake River Sockeye Salmon.
- Protect and conserve natural ecological processes that support population viability.
- Improve degraded water quality and maintain unimpaired water quality.
- Address ecosystem imbalances in predation, competition, and disease through the strategies and actions in this Plan, the Estuary Module and reasonable and prudent alternatives identified in Biological Opinions.
- Respond to climate change threats by implementing research, monitoring and evaluation to track indicators related to climate change and by preserving biodiversity.
- Implement this recovery plan through effective communication, education, coordination, and governance.
- Continue research, monitoring and evaluation for adaptive management.
- Prioritize and address key information needs and create an adaptive management feedback loop to revise recovery actions as needed.

6.3.1 Strategies to Recover Snake River Sockeye Salmon at the Local Level (Sawtooth Valley and Upper Salmon River)

Sections 6.3.1.1 through 6.3.1.16 describe strategies at the local level to improve Snake River Sockeye Salmon viability.

6.3.1.1 Conserve population genetic and life history diversity and spatial structure

Conserving population genetic diversity of Snake River Sockeye Salmon will require a series of actions corresponding to the expanding scope of the reintroduction efforts. In the short term, the Snake River Sockeye Salmon captive broodstock hatchery program and associated research and monitoring actions should continue to be implemented under the current IDFG and SBSTOC work plan (IDFG 2010) to reduce ESU extinction risk and promote recovery until criteria and benchmarks are reached and the program can be phased out. The current program places emphasis on maximizing the effective population size and the annual development of genetically diverse broodstock. Fish culture variables (broodstock mating designs, in-hatchery survival, maturations success, fecundity, egg survival to eyed-egg stage, and fish health) are continuously monitored and evaluated to ensure maximum program success.

The existing captive broodstock program will transition to a recolonization phase with the development of expanded smolt production through the Springfield Sockeye Salmon Hatchery program. The recolonization phase will aim to establish a self-sustaining anadromous broodstock and reduce reliance on captive broodstock for population maintenance. The production program will use anadromous Sockeye Salmon adults collected at Sawtooth Valley weirs as broodstock. This new program will allow gene banking (while the captive broodstock is on station) and provide anadromous adults to recolonize available habitat. As the number of available hatchery returns increases, more adults will be released into Redfish Lake to boost natural production. Outplanting and broodstocking strategies will be adapted to encourage the development of localized adaptations to habitat conditions and to protect genetic fitness.

Initial efforts under the Snake River Sockeye Salmon recovery strategy aim to reestablish the Sockeye Salmon population in Redfish, Pettit, and Alturas Lakes. The hatchery program and related hatchery and genetic management plan (NMFS 2012b) focus actions primarily on Redfish Lake because of its high production potential. Continued actions are needed to develop a reintroduction plan for Pettit Lake (e.g., when the program would use Redfish Lake fish in Pettit Lake, what life stage(s) would be released, etc.). Captive broodstock (or, if available, hatchery anadromous) adults will be released into Pettit Lake initially. These releases will cease after a defined period and strategies will be refined based on the response of initial reintroductions and the performance of the Redfish Lake program. Information is also needed regarding Pettit Lake's production potential and whether targeted objectives for the lake can be achieved. Actions for Alturas Lake Sockeye Salmon recovery begin with identifying appropriate strategies for Alturas Lake anadromous Sockeye Salmon recovery, including (1) trap and transport of any anadromous adults of Alturas Lake origin for release in Alturas Lake and (2) possibly implementing a hatchery program for the population. As natural-origin adults begin returning from the reintroduction efforts in each lake, upstream passage and weir management strategies will be implemented to support continued adaptation to local conditions within each lake.

Actions will also be taken to protect Sockeye Salmon population genetic makeup and fitness. Activities include evaluating the best possible broodstock sources, capturing broodstock throughout the return and spawning period, and using genetic testing to maintain the genetic diversity of the broodstock used in the hatchery program. Release strategies will be designed to support reestablishing natural populations adapted to local conditions. The Alturas Lake population, for example, exhibits an earlier return time than the Redfish Lake population and maintaining this diversity is important. The Snake River Sockeye Salmon HGMP includes performance standards, indicators of performance, and monitoring and evaluation requirements.

In the last phase, hatchery supplementation programs will transition to a longer-term role consistent with maintaining genetic variability. NMFS will develop guidance for how to recover *O. nerka* life history forms for Snake River Sockeye Salmon. Long-term guidelines will be developed that support and maintain localized adaptations within and among populations in the Sawtooth Valley. Section 6.4 Key Information Needs, expands on this discussion. Section 11 Research, Monitoring, and Evaluation for Adaptive Management, outlines actions to address the uncertainties.

Recovery strategy questions:

- What was the historic genetic diversity and heterozygosity of Snake River Sockeye Salmon?
- What are the benefits/risks to genetic diversity of maintaining stocks adapted to each lake in the ESU?
- How can remnant anadromous Sockeye Salmon gene resources that exist in other Sawtooth Valley lakes other than Redfish Lake be used for recovery efforts on a lake specific basis?
- Is the current Redfish Lake Sockeye Salmon captive broodstock genetic structure appropriate for use in rebuilding efforts in other Sawtooth Valley lakes? What will be the role of beach vs. stream spawning types?

6.3.1.2 Increase naturally spawning Sockeye Salmon abundance

As discussed in Section 3, the long-term recovery scenario for Snake River Sockeye Salmon is to restore at least two of the three historical lake populations in the ESU to highly viable, and one to viable status. The recovery scenario focuses on Redfish Lake, Alturas Lake, and Pettit Lake. As recovery efforts progress over time, expansion of reintroductions into Yellowbelly Lake and Stanley Lake will be considered.

Our recovery strategy aims to achieve viable, naturally spawning self-sustaining Sockeye Salmon populations by increasing the number of anadromous adults that spawn naturally in the Sawtooth Valley lakes. The strategy builds on the current captive broodstock program and incorporates population recolonization programs for Redfish, Pettit, and Alturas Lakes. It implements a coordinated hatchery program to increase smolt production to increase the number of anadromous returns and subsequently the number of spawners in Redfish and Pettit Lake habitat. The program will emphasize supporting high levels of anadromous return spawners to Redfish Lake. The working hypothesis behind the approach assumes that the natural production that will result from the high levels of anadromous hatchery returns will lead to increases in relative productivity and downstream survivals sufficient to allow for transition to a third phase emphasizing natural adaptation. As natural-origin returns increase, smolt production and hatchery-origin returns would be reduced.

Natural production in Pettit Lake will be achieved through volitional spawning and short-term releases of captive broodstock. Initial hatchery releases to Pettit Lake will cease after a defined period and be revised based on natural production response. Volitional spawning of anadromous adults originating from Pettit Lake will continue. This program is discussed in Section 6.3.1.5.

Natural production of anadromous Sockeye Salmon in Alturas Lake will be restored through steps that safeguard the early-spawning residual population's spatial structure and genetic diversity. This program is discussed in Section 6.3.1.6.

The programs for the different Sawtooth Valley populations include steps to safeguard against potential risks. In the Sawtooth Valley lakes, potential risks associated with increased hatchery production include genetic and ecological risks to the residual populations (Griswold et al. 2012). Additional risks include disease and competition with residual Sockeye Salmon and kokanee, and competition within lakes for zooplankton resources, particularly with naturally produced fish. Increased hatchery production may also serve to increase the density of prey and attract predators. In addition, the effects that occur early in life history, especially those that impact growth, may impact survival at later life stages (Griswold et al. 2011b). Redfish Lake residual Sockeye Salmon are a unique ecotype and it is not clear how they have developed or are maintained (Griswold et al. 2012). Consequently, it will be important to monitor the effects of increased hatchery production on the residual Sockeye Salmon populations.

One of the primary overriding questions concerning Snake River Sockeye Salmon recovery is whether the survivals that result from current conditions and management actions will be enough to provide for life history survival through variations in ocean and climate conditions. As discussed in Section 5, climate experts project a warming trend for the Pacific Northwest over the next century. They predict that increasing air temperatures will alter the snow pack, stream flow timing and volume, and water temperature in the Columbia Basin. They also predict changes in ocean conditions due to climate change. Such likely changes in temperature, precipitation, wind patterns, and sea-level height could have profound implications for survival of Snake River Sockeye Salmon in both their freshwater and marine habitats, and need to be taken into consideration.

Recovery strategy questions:

- Is the hatchery program going to work?

- Is the current Redfish Lake Sockeye Salmon captive broodstock genetic structure appropriate for use in rebuilding efforts in other Sawtooth Valley lakes?
- Are the effects of the primary factors limiting the status of the populations increasing, decreasing or remaining stable?
- Can we get enough returning fish from outplants in the lakes to see natural production increase to levels needed for a self-sustaining population?
- How is the hatchery program influencing abundance, productivity, and diversity of the natural populations?
- Given regional temperature and precipitation patterns projected from climate models, how would potential changes in stream temperature and flows affect life-stage survivals and life-history characteristics for Snake River Sockeye Salmon?

6.3.1.3 Improve Sockeye Salmon passage to natal lakes

Improving fish passage throughout the Sockeye Salmon migration route and reestablishing access to historical spawning areas in natal lakes is a key recovery strategy. Improving habitat connectivity and allowing fish to occupy habitat over a wider landscape will improve ESU spatial distribution and reduce the risk of extinction due to catastrophic environmental events. This strategy is supported in conservation biology literature, which identifies reconnecting isolated habitat as the second most important element (after protecting and maintaining habitat) in a recovery strategy hierarchy of potential actions to improve salmon viability (Roni et al. 2002). Section 5 describes several limiting factors related to blocked access at different Sockeye Salmon life stages.

This strategy aims to improve Sockeye Salmon passage to the natal lakes by addressing passage barriers caused by artificial barriers, low stream flow, and other factors. It identifies actions to improve fish passage at the Sawtooth Hatchery weir on the Salmon River. It calls for actions to revise adult holding and handling practices at the Sawtooth Hatchery and Redfish Lake Creek trapping facilities to increase returns to Redfish, Pettit, and Alturas Lakes. The strategy also calls for actions to examine and address the lake trout management issue for Stanley Lake. Currently, an existing barrier on Stanley Lake Creek at the outlet of Stanley Lake prevents Sockeye Salmon migration into the lake; however, the barrier does not prevent lake trout in Stanley Lake from possibly moving to other tributaries and lakes in the basin. Any efforts to reintroduce Sockeye Salmon to Stanley Lake must include addressing the lake trout issue before the barrier can be removed. The strategy also aims to improve Sockeye Salmon passage survival in the Salmon and lower Snake Rivers, as well as Sockeye Salmon passage to Yellowbelly Lake.

Recovery strategy questions:

- How do we restore Sockeye Salmon migration to Stanley Lake without allowing lake trout movement to other tributaries and lakes in the basin?
- How do we prevent lake trout from spreading to other Sockeye Salmon natal lakes in the Sawtooth Valley?

- Under what migratory conditions (e.g., timing, water flows, temperatures) and how often can Sockeye Salmon currently migrate through the lag deposit boulder field at the outlet of Yellowbelly Lake?
- Are stream flows in the Salmon River above the Sawtooth Hatchery adequate to sustain migration of Sockeye Salmon to Alturas, Pettit and Yellowbelly Lakes during summer low flow conditions?
- How do SARs vary among lakes, years, natural vs. hatchery, and residual vs. anadromous Sockeye Salmon?
- Do high water temperatures in the lower Salmon and Snake Rivers affect upstream and downstream Sockeye Salmon survival and life-history characteristics?
- Is the mortality of adult returning anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam related to natural causes (e.g., competition, predation, environmental conditions) or are extraneous causes involved?
- Are there local areas (hot spots) where mortality is concentrated during adult migration for anadromous Sockeye Salmon in the area between Lower Granite Dam and the upper Snake River basin, or are mortality rates uniform over the migration distance?

6.3.1.4 Reestablish a self-sustaining anadromous Sockeye Salmon population in Redfish Lake

Currently, Redfish Lake supports the only remaining substantial run of Snake River Sockeye Salmon. Our strategy aims to achieve viable, naturally spawning self-sustaining population(s) by increasing the number of anadromous adults that spawn naturally in Redfish Lake.

The basis for the adaptive management strategy for Redfish Lake is laid out in detail in the Springfield Hatchery Master Plan and associated documents (IDFG 2010; ISRP 2011; IDFG 2013b). A key element of the approach to restoring natural production of Sockeye Salmon in the Sawtooth Valley is the adaptive management nature of the reintroduction strategy. Current plans are based on assumptions regarding a number of key factors including anticipated juvenile production relationships (productivity and density dependence) and survivals during migration and ocean rearing.

Phase 2 of the Snake River Sockeye Salmon natural stock reintroduction and adaptation program focuses efforts on securing the Redfish Lake population. During this recolonization phase, adequate and consistent returns of anadromous adults will allow managers to phase out the use of Redfish Lake captive broodstock and recolonize the naturally spawning Sockeye Salmon population in Redfish Lake. The existing captive broodstock program will transition to a new phase with an emphasis on supporting relatively high levels of anadromous return spawners to Redfish Lake using anadromous adults as broodstock. The path leading to long-term population viability will consist of a series of population status benchmarks, which if met will trigger the next level of recovery actions. For example, once the number of naturally produced fish in the population has stabilized to a certain level, measures will be taken to reduce the frequency of hatchery fish in the naturally spawning population. This staged approach to recovery is conceptually similar to the application of the sliding-scale hatchery management protocol already being implemented for other Snake River ESA-listed species.

Recovery strategy questions:

- Can we get enough returning fish from outplants in Redfish Lake to see natural production increase to a level needed for a self-sustaining population of 1,000 natural-origin spawners (Section 3.2.2. Biological Criteria)?
- What is the adult spawning carrying capacity for anadromous Sockeye Salmon in Redfish Lake?
- Will the production of lake rearing parr and outmigrant smolts increase as the result of anadromous spawning in Redfish Lake? As natural-origin returns begins to contribute to spawning, are there indications of an increased pre-smolt per spawner rate relative to hatchery-origin fish?
- How does the lake's juvenile carrying capacity affect pre-smolt per spawner production rates and abundance targets? How does it fit with recovery needs to address spatial structure and diversity needs?
- Has the Redfish Lake strategy been successful in preventing deleterious effects to the population from domestication, and has population productivity increased to a level where the dominant gene flow is moving from the natural population to the hatchery population?

Redfish Lake. *Photo: Andy Kohler, Shoshone-Bannock Tribes.*

6.3.1.5 Investigate and develop strategies for future actions to support Sawtooth Valley Sockeye Salmon reintroduction and adaptation phases for Pettit Lake

The ultimate objective of the Snake River Sockeye Salmon Recovery Plan is the restoration of natural Sockeye Salmon populations in Sawtooth Valley lakes. An important *first step* toward that objective has been the successful establishment of anadromous returns originating from natural-origin Redfish Lake stock amplified through a captive broodstock program. That program is poised to transition to a *second phase* with an emphasis on supporting relatively high levels of anadromous return spawners in Redfish Lake. The working hypothesis behind this approach assumes that the introduction of increasing numbers of hatchery-origin spawners in Redfish Lake will result in increasing natural production of outmigrant smolts. Inherent in that hypothesis is an assumption that the smolt production capacity of Redfish Lake is sufficient to achieve natural-origin return targets. Those smolts will produce adult natural-origin returns that, if downstream and upstream survivals are sufficient, should allow for transition to a *third phase* emphasizing natural adaptation (local adaptation phase). As natural-origin returns increase in this phase, hatchery-origin returns would be reduced by reducing the number of released smolts.

The fact that there are multiple lakes in the Sawtooth Valley that historically supported anadromous Sockeye Salmon affords an opportunity to diversify the reintroduction strategy to promote the chances of sustainable natural production. The Snake River Sockeye Salmon Technical Committee that guided development of this Recovery Plan has worked together with NMFS' scientists to develop the following strategy for the initial reintroduction phase for Pettit Lake, which is intended to complement the Redfish Lake strategy (described in Section 6.3.1.4).

The following proposed interim strategy for reintroductions to Pettit Lake will be further developed and refined as the Redfish Lake strategy is implemented. The Recovery Plan's Implementation and Science Team, which will guide future Sockeye Salmon recovery reintroductions to Pettit Lake, will update this proposed interim strategy over time.

1. Allow anadromous adults to return to Pettit Lake for volitional migration and spawning. Adults trapped at Sawtooth Fish Hatchery weir can be transported to their lake of origin and released, or passed over the weir and allowed to migrate. Anadromous adults trapped at the Sawtooth Hatchery weir may represent an important component of the proposed release strategy (e.g., of Pettit Lake origin).
2. Release captive broodstock adults into Pettit Lake that represent the entire genetic diversity of the broodstock for several years.
3. After several years of direct outplanting of adults sourced from the Redfish Lake population, adult stocking would cease to allow for evaluation of the natural production response; continue to allow anadromous adults originating from Pettit Lake to return to Pettit Lake for volitional spawning.
4. Evaluation of the results of this reintroduction program will guide the future course of the Pettit Lake Sockeye Salmon program. Monitoring data will include relative trends in anadromous and

resident production in Pettit Lake, as well as data that show whether hatchery inputs from the Redfish Lake stock are successful at increasing natural-origin production. Based on the results of this evaluation, the future action plan for Pettit Lake would be determined. Contingencies could include increasing Pettit Lake natural-origin returns without additional supplementation, using some Pettit Lake natural-origin returns to establish a broodstock to increase the rate of production, or using available hatchery returns from the Redfish Lake stock program to augment production. Sockeye Salmon could be added t in future years or not added based on the results of future reintroduction strategies.

5. A key step in the progression towards naturally adapted anadromous production from Pettit Lake will be the restoration of access to the lake for returning adults. Options for improving Sockeye Salmon passage to natal lakes above the Sawtooth Hatchery weir are being investigated and strategies are described in Section 6.3.1.3.

Recovery Strategy Questions:

- Will the resident component (residual Sockeye Salmon and non-native kokanee) in Pettit Lake persist over time after stocking of adult Redfish Lake anadromous broodstock ends?
- Will anadromous Sockeye Salmon intermingle and spawn with resident Sockeye Salmon on the spawning grounds, and does this affect the presence and magnitude of anadromy in the Pettit Lake population over time?
- What are the smolt-to-adult returns (SARs) of Pettit Lake outmigrants and are there systematic differences in production from anadromous vs. resident parents?
- Will the production of outmigrant smolts increase as a result of returning adult Sockeye Salmon spawning in Pettit Lake?
- As pre-smolt production increases, is there evidence of density dependent limitations?
- How do zooplankton populations respond to potential shifts in grazing pressures as the proportion of fish with anadromous and resident life histories changes? How sensitive are zooplankton production dynamics in Pettit Lake to the size composition of O. nerka (e.g., is zooplankton biomass and species composition primarily influenced by the density of larger O. nerka)?
- How does lake productivity respond to external out-of-basin inputs of salmon derived nutrients?
- What is the adult spawning carrying capacity for anadromous Sockeye Salmon in Pettit Lake?

Pettit Lake. *Photo: Andy Kohler, Shoshone-Bannock Tribes.*

6.3.1.6 Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning kokanee outmigrants from Alturas Lake.

Alturas Lake currently supports a kokanee population. This early stream spawning type is similar to the Fishhook Creek kokanee population and different from the Redfish Lake late shoal spawning population. Accounts indicate that the lake once also supported Sockeye Salmon. Evermann observed stream spawning Sockeye Salmon in 1895 and 1896. He left the lake in both years before shoal spawning would have been underway, but did observe one pair of Sockeye Salmon on an Alturas Lake shoal as he was preparing to leave in 1895 (Evermann 1896). Since maintaining spatial structure, diversity, and capturing the benefits of local adaptation are critically important, careful steps will be taken to identify appropriate strategies for Alturas Lake anadromous Sockeye Salmon recovery efforts. Alternative strategies for the early-spawning Alturas Lake kokanee population might include the following options, beginning with No. 1 below, with the option to subsequently implement No. 2 and/or No. 3 at the same time or later. These options need to be refined in the future and the Sockeye Salmon Implementation and Science Team and Stanley Basin Sockeye Technical Oversight Committee (SBSTOC) will make future reintroduction recommendations.

1. Trap and transport any anadromous adults identified as Alturas Lake kokanee to Alturas Lake. Release the trapped ocean returning adults for volitional spawning. Radio telemetry should be

considered as one means to identify spawning locations. Following the completion of the Sockeye Salmon juvenile rearing responsibilities at the Sawtooth Hatchery (tentatively June, 2015), managers can consider allowing Alturas Lake-destined anadromous adults to volitionally migrate. If the lake of origin cannot be determined in a timely fashion, unmarked adults should be passed above the Sawtooth weir and allowed to volitionally migrate.

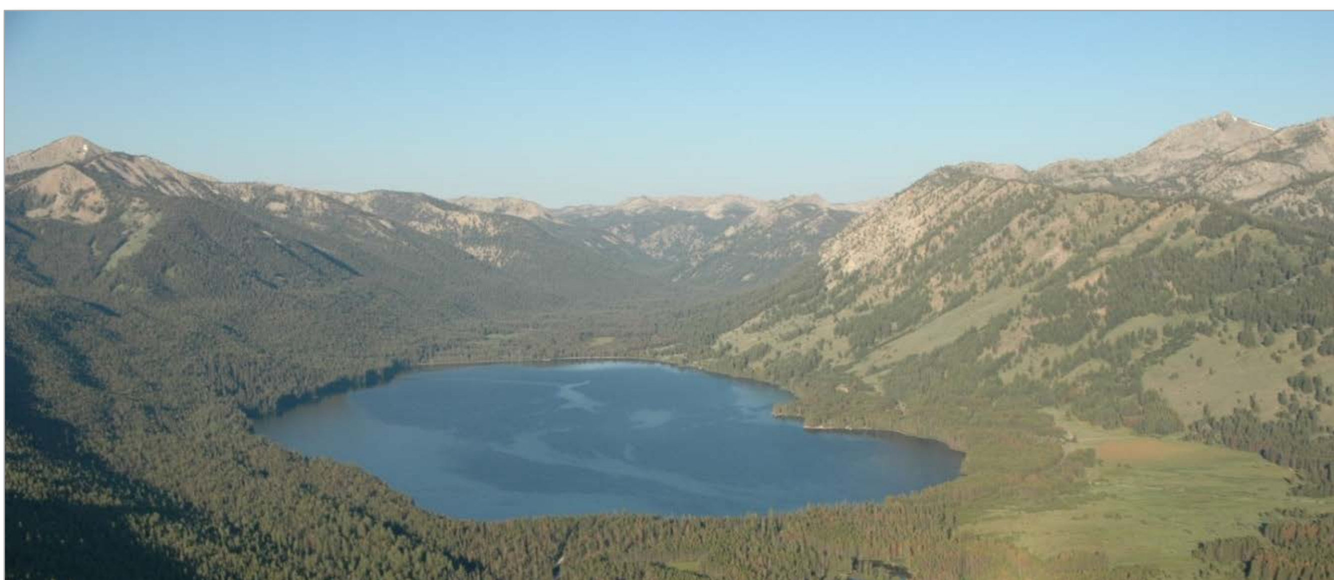
2. Trap and transport any ocean returning adults identified as Alturas Lake kokanee to the IDFG Eagle Fish Hatchery for holding and spawning to establish a new hatchery program for Alturas Lake anadromous Sockeye Salmon, or transport ocean returning adults to Alturas Lake for volitional spawning. For the hatchery program, following spawning at the IDFG Eagle Fish Hatchery, the eggs and juveniles would be reared at the new Springfield Hatchery to the smolt stage. At the appropriate time, these smolts can be transported to and released into the outlet of Alturas Lake. Sufficient number of juveniles would be marked (genetic marks and PIT-tags) to facilitate the collection of life history information and to ensure that adults produced in the Alturas Lake hatchery program can be identified. If insufficient adults of both sexes are not available for effective artificial spawning, then adults would be transferred and released into Alturas Lake. One variation on this option would be to incorporate maturing, resident Alturas Lake kokanee in the spawning design along with ocean returning residual Alturas adults trapped at the Sawtooth weir. Juvenile outmigration and adult return success could be independently evaluated for progeny and F1 returning adults produced from anadromous or resident parents.
3. Establish a full-term captive broodstock to help amplify Alturas Lake *O. nerka* components (similar to Redfish Lake program). Follow guidelines for "2" above except, at smoltification, continue to rear fish to maturity in a captive broodstock facility. At this point, options include transferring all or a portion of maturing adults to Alturas Lake for release. Or, holding all or a portion of maturing adults for spawning at the hatchery. A portion of adults released to volitionally spawn could be fitted with radio transmitters to facilitate tracking and the identification of spawning locations. If adults are retained in the hatchery for spawning, eyed-eggs should, preferably, be transferred to the IDFG Springfield Hatchery for final incubation and rearing through the smolt stage of development. Second generation smolts would be released in the outlet of Alturas Lake at an appropriate time.

In the interim while decisions are being made regarding anadromous Alturas Lake Sockeye Salmon recovery efforts, any ocean returning Sockeye Salmon identified as of Alturas Lake origin will be transported to Alturas Lake and released.

Recovery strategy questions:

- What are the benefits and/or risks of alternative strategies for recovering the extant and/or historical life-history pattern in Alturas Lake?
- What stock, or combination of stocks, is most appropriate for reintroduction into Alturas Lake?

- What strategy or combination of strategies should be used for reintroduction into Alturas Lake to achieve abundance goals of 1,000 natural-origin spawners (Section 3.2.2 Biological Criteria)?
- What are the uncertainties or key assumptions that need to be addressed?
- Will the proposed actions listed above influence (e.g., establish) a residual life history strategy in Alturas Lake (not previously observed)?
- Will the production of lake rearing parr and outmigrant smolts increase as the result of anadromous spawning in Alturas Lake?
- As pre-smolt production increases, is there evidence of density dependent limitations?
- What are smolt-to-adult returns of Alturas Lake outmigrants and are there systematic differences for production from anadromous vs. resident parents?
- How do zooplankton populations respond to potential shifts in grazing pressures as the proportion of fish with anadromous life histories changes? How sensitive are zooplankton production dynamics in Alturas Lake?
- How does lake productivity respond to external out-of-basin inputs of salmon derived nutrients?
- What is the adult spawning carrying capacity for anadromous Sockeye Salmon in Alturas Lake?



Alturas Lake. *Photo: Andy Kohler, Shoshone-Bannock Tribes.*

6.3.1.7 As sufficient numbers of natural-origin adults return, develop an integrated approach to manage natural- and hatchery-origin adults in the hatchery program and in the wild

In its last phase, Phase 3, the Sockeye Salmon recovery strategy will be adapted to transition to an appropriate longer-term role consistent with maintaining genetic variability and limiting domestication. In this phase, the program will move toward the development of an integrated program. The Columbia River Hatchery Scientific Review Group considers a hatchery program to be an integrated program when the intent is for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the wild (HSRG 2004). The approach centers on meeting the proportionate natural influence (PNI) criteria established by the Hatchery Scientific Review Group.

During Phase 3, the hatchery program for Redfish Lake Sockeye Salmon will be converted into an integrated conservation program using broodstock returning to Redfish Lake. The program has three objectives in this phase: protecting the genetic resources of Snake River Sockeye Salmon, developing a composite hatchery and natural population in Redfish Lake that is locally adapted to the environmental conditions, and providing surplus adult hatchery fish to Pettit Lake to support initial Sockeye Salmon recovery. The Plan includes using research, monitoring, and evaluation to assess the effectiveness and outcomes of the program, and trigger movement to the next phase of program implementation.

We recognize that the overall program assumes that the fitness of the natural populations can be improved by restoring Sockeye Salmon to their native habitat and by following the Hatchery Scientific Review Group guidelines for integrated hatchery programs. Continued research is needed to track these and other assumptions and fill critical data gaps. These needs are further discussed in Section 6.4, Key Information Needs and in Section 11, Research, monitoring, and evaluation for Adaptive Management.

Recovery strategy questions:

- Are we getting enough returning fish from outplants in the lake(s) to see natural production increase to the level needed for a self-sustaining Sockeye Salmon population?
- Will managing the proportion of hatchery-origin spawners on the spawning grounds improve population fitness?
- Is the status of each population trending toward the recovery criteria?

6.3.1.8 As sufficient numbers of hatchery-origin anadromous adults return to the basin, identify options for future fisheries

As the Sockeye Salmon recovery program transitions from the re-colonization phase into the local adaptation phase, the return of first generation adults is expected to generate large returns of anadromous hatchery-origin Sockeye Salmon to the Sawtooth Valley. These returns will be beyond levels needed to effectively manage broodstock composition, as well as spawner composition in the habitat. The natural production that will result from these high levels of anadromous hatchery returns is expected to lead to increases in relative productivity and overall life cycle survival. Resource managers will adaptively adjust the number of smolts released to help manage returning numbers of fish, yet having the added flexibility to use harvest as a tool will likely be needed. Future actions will include identifying options for potential state and tribal fisheries on Snake River Sockeye Salmon.

Fisheries affecting Snake River Sockeye Salmon have been closed or severely constrained for decades. With the Springfield Hatchery coming online smolt production will increase fivefold over the next two or three years. Careful management of the resulting returns will provide the opportunity to accelerate the rebuilding process toward recovery. At some point in the rebuilding continuum it may be appropriate to relax current harvest constraints to provide access to otherwise harvestable fish. A new abundance-based harvest management strategy should be developed that relies on pertinent benchmarks related to species status in the Recovery Plan and calibrates varying harvest levels in such a way that it does not impede recovery.

Recovery strategy questions:

- Should harvest in the Snake basin be used as an action to reduce the number of Sockeye Salmon hatchery fish in the naturally spawning population?
- What is the annual incidental harvest rate on natural-origin Snake River Sockeye Salmon that occurs outside the ESU?
- What is the annual incidental harvest rate that occurs on natural-origin Snake River Sockeye Salmon within the ESU?
- What is the cumulative incidental harvest rate on natural-origin Snake River Sockeye Salmon due to all fisheries (from within and outside of ESU)?
- What effect does total incidental harvest have on the abundance, productivity, and diversity of natural-origin Snake River Sockeye Salmon?

6.3.1.9 Continue research and actions to reestablish natural populations in other natal lakes

Snake River Sockeye Salmon rear in their natal lakes for one to three years. Protecting existing good quality habitat in Redfish, Pettit, and Alturas Lakes will benefit the spawning and rearing life stages. NMFS supports the ICTRT’s recommendation that the long-term recovery scenario should include restoring at least two of the three historical lake populations in the ESU to highly viable, and one to viable status, using Redfish Lake, Alturas Lake, and Pettit Lake. As recovery efforts progress over time, managers will consider reintroducing anadromous Sockeye Salmon into other natal lakes.

The Snake River Sockeye Salmon recovery scenario includes potential Sockeye Salmon reintroductions to Stanley and Yellowbelly Lakes. Currently, more information and consideration is needed to determine the potential benefits and risks associated with reintroduction to Stanley Lake. As discussed previously, efforts to reintroduce Sockeye Salmon to Stanley Lake must include developing a lake trout management strategy and removing the existing barrier on Stanley Lake Creek, at the outlet of Stanley Lake, which currently prevents Sockeye Salmon immigration. This is the only remaining artificial barrier to a natal lake in the Sawtooth Valley.

Currently, stocking Sockeye Salmon in Yellowbelly Lake is not a priority. This may change as adult returns increase and passage to the upper Salmon River basin is restored. It is likely that Sockeye Salmon may return to Yellowbelly Lake through straying and natural recolonization by either early stream spawners (Alturas stock) and/or late shoal spawners (Redfish and Pettit stock).

Recovery strategy questions:

- What is the carrying capacity of Stanley Lake for juveniles and spawning adults?
- How much zooplankton is available to support juvenile rearing and survival?
- Will the production of lake rearing parr and outmigrant smolts increase as the result of anadromous spawning in Stanley Lake?
- How much spawning habitat is available in lakes and streams not currently used by anadromous Sockeye Salmon?
- What spawning areas will be important as fish abundance recovers?
- What will be the role of beach vs. stream spawning types?
- Will competition for food resources or spawning areas restrict efforts to reestablish natural Sockeye Salmon populations in the lakes?
- How should lake trout be managed in Stanley Lake?
- How do we reestablish a Sockeye Salmon population in Stanley Lake without encouraging lake trout movement to other tributaries and lakes in the basin?

6.3.1.10 Continue research on natal lakes' carrying capacity, nutrients, and ecology

This strategy addresses the continuing need to understand the limnological characteristics of the Sawtooth Valley lakes and a lake's relative carrying capacity for Sockeye Salmon production. The strategy builds upon the important research carried out for many years by the Shoshone-Bannock Tribes regarding assessing the period and frequency of lake stratification and subsequent turnover, together with research on lake algal productivity.

The carrying capacity of the natal lakes is often density dependent and linked to zooplankton levels. Changes in zooplankton levels in the lakes have contributed to the decline of Sockeye Salmon production in the lakes (Selbie et al. 2007). Low zooplankton densities can restrict growth rates and, ultimately, the ability of Sockeye Salmon to achieve a level of fitness needed to survive the long migration to the ocean from their nursery lakes. Reductions in the lakes' zooplankton communities developed after the Sockeye Salmon population declined and other fish (trout, non-native kokanee) were introduced.

The Shoshone-Bannock Tribes have carried out nutrient supplementation to increase carrying capacity in Redfish, Pettit, and Alturas Lakes. Nutrient supplementation of the lakes may be creating short-term growth benefiting the lake-dwelling fish. Ongoing studies of lake water quality seek to determine the current characteristics and carrying capacity of the lakes.

Recovery strategy questions:

- What can be derived from limnological monitoring data regarding potential for juvenile anadromous Sockeye Salmon growth and survival in the different natal lakes?
- What is the carrying capacity of the different natal lakes?
- Is nutrient supplementation increasing carrying capacity in the lakes?
- Will competition with kokanee for food resources or spawning areas restrict efforts to reestablish natural Sockeye Salmon populations in the natal lakes?
- Develop a time-table strategy for a whole-lake nutrification efforts compatible with reintroduction plans.

6.3.1.11 Protect and conserve natural ecological processes at the watershed scale that support population viability

This recovery strategy is founded on the concepts presented in several salmonid habitat recovery planning documents and scientific studies (e.g., Beechie and Boulton 1999; Roni et al. 2002; Beechie et al. 2003; Roni et al. 2005; Stanley et al. 2005; Isaak et al. 2007; Roni et al. 2008; Beechie et al. 2010). These studies demonstrate that habitat conditions and aquatic ecosystems function are a result of the interaction between watershed controls (such as geology and climate), watershed processes (such as hydrology and sediment transport), and land use. Scientists and resource managers recognize that restoration planning that carefully integrates watershed or ecosystem processes is more likely to be successful at restoring depleted salmonid populations (Beechie et al. 2003).

Actions to protect and improve watershed processes to support Snake River Sockeye Salmon viability play a key role in Sockeye Salmon recovery. Since much of the area surrounding the lakes is already designated as wilderness and in near pristine condition, the strategy focuses on maintaining current protection and consistently applying best management practices and existing laws to protect and conserve natural ecological processes. The strategy also supports protection and conservation through land acquisition and purchase of conservation easements, and actions that improve public understanding and support through education.

The recovery strategy also addresses potential disturbance to biological processes that could be associated with movement of lake trout from Stanley Lake to areas in the Salmon River and other natal lakes.

Recovery strategy questions:

- What is the risk that wildfire will have negative effects on sockeye habitat in historic natal lakes and their inlet/outlet streams?

6.3.1.12 Protect, restore and manage spawning and rearing habitat

Protecting existing high quality habitat and restoring damaged habitat will specifically benefit Snake River Sockeye Salmon in the spawning and rearing life stages. Improved spawning and rearing means that more fish will reproduce, more juveniles will survive to migrate, and consequently more adults will return to the Sawtooth Valley.

The strategy includes maintaining current wilderness protection in the natal lakes watersheds in the Sawtooth National Recreation Area, conserving rare and unique habitats, addressing water quality concerns, and consistently applying best management practices and existing laws to protect and improve habitat conditions. It supports land acquisition and purchase of conservation easements to protect habitats. The strategy also directs actions to determine if spawning and rearing habitat at the different lakes is adequate to meet Sockeye Salmon abundance goals, and to learn more about the potential roles of beach vs. stream spawners in reaching viability.

Recovery strategy questions:

- What is the spawning capacity of the natal lakes?
- What habitat areas will be important as fish abundance recovers?
- What will be the role of beach vs. stream spawning types?

6.3.1.13 Maintain unimpaired water quality and improve water quality as needed

Limnology studies have been conducted in Stanley, Redfish, Yellowbelly, Pettit, and Alturas Lakes since 1991. The studies have examined water temperature, oxygen, light, chlorophyll, phytoplankton, and zooplankton in each lake from May through October. Generally, the results from limnological sampling indicate that water quality in all five lakes provides suitable rearing habitat for juvenile Sockeye Salmon, although the lakes vary considerably in the species composition and abundance of zooplankton.

The limnology studies show that surface water temperatures can reach 18°C (64°F) in all lakes during summer months (Griswold et al. 2011a). The effects of temporary surface water temperature spikes above 15°C (59°F) on Sockeye Salmon generally depend on exposure time. The effects may be minimal, particularly if the Sockeye Salmon can escape to deeper waters or to areas where groundwater inflow or shade reduce temperatures. However, in some cases, high water temperatures may make Sockeye Salmon more susceptible to disease and infection or promote fungal, bacterial or secondary wound infections that leave the Sockeye Salmon more susceptible to pre-spawning mortality (USBR 2007).

Where unimpaired, protecting and maintaining current water quality of the lakes, tributary streams and Salmon River are essential to providing suitable spawning and rearing habitat for Sockeye Salmon. Where elevated water temperatures have been identified, or other water quality standards are not being attained, this strategy promotes the use of best management practices, improved land use strategies, designation of minimum instream flows, and habitat restoration to address elevated water temperatures, and impaired sediment processes.

Recreational use at the lakes and along the Salmon River poses potential concerns to water quality. Access roads and recreational use on shores and waterways can increase sediment input, or result in a potential chemical spill. The strategy calls for continued management of recreational use and motorized boat activity to minimize these risks.

Recovery strategy questions:

- Do temporary surface water temperature spikes affect Sockeye Salmon carrying capacity in the different lakes?
- Do reduced streamflows and high water temperatures in the lower Salmon and Snake Rivers affect upstream Sockeye Salmon survival?

6.3.1.14 Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Snake River Sockeye Salmon

Protecting and restoring the migration corridor for Snake River Sockeye Salmon will require efforts on public and private lands in the lower Snake River mainstem above Lower Granite Dam and in the mainstem Salmon River. Currently, the stretch of the Salmon River from Redfish Creek to Valley Creek is listed on IDEQ's 2010 303(d) list as not supporting the beneficial use "cold water aquatic life." The pollutants are identified as water temperature and sediment/siltation.

High water temperatures in the Salmon River impact migrating Snake River Sockeye Salmon. Adult Sockeye Salmon usually arrive in the Salmon River during baseflow conditions when water temperatures are highest. Adult Sockeye Salmon migration survival is inversely related to water temperature. High water temperatures may also limit survival of migrating Sockeye Salmon in the lower Snake River above Lower Granite Dam. Low flows in some years also affect juvenile Sockeye Salmon that migrate down the Salmon River in early summer. High temperatures can also affect fish in localized reaches, especially where temperatures are at or near their thermal tolerance levels, and increase susceptibility to predators and pathogens.

Actions under this strategy are designed to improve water quantity and quality to support juvenile and adult migrations, with an emphasis on addressing flow, high summer temperature and sediment load concerns in the upper reaches of the mainstem Salmon River and mainstem lower Snake River. They are also designed to gain needed information on the magnitude of Sockeye Salmon mortality in the Salmon River, as well as determining where and why mortality is occurring.

Recovery strategy questions:

- Do fluctuations in flows and water temperatures reduce Sockeye Salmon survival in the Salmon River?
- What role do water diversions on the mainstem Salmon River and tributaries above the Sawtooth Hatchery contribute to elevated water temperatures and reduced fish passage and rearing habitat in the Salmon River?

6.3.1.15 Monitor for predation, disease, aquatic invasive species and competition and develop actions as needed

This strategy supports current state, Federal and tribal programs to monitor and control non-native fish, wildlife and aquatic species in the Sawtooth Valley and upper Salmon River mainstem that prey, compete, transmit diseases or otherwise reduce the productivity of Snake River Sockeye Salmon.

Predation and disease

Several fish species occupy the natal lakes that potentially prey on Sockeye Salmon, including bull trout, northern pikeminnow, and brook trout. Sockeye Salmon may also experience predation from smallmouth bass, northern pikeminnow and other fish species while migrating through the Salmon River. The non-native fish may reduce Sockeye Salmon survival by preying on juvenile Sockeye Salmon and/or Sockeye Salmon eggs, or introducing disease.

Aquatic invasive species

Invasive species are often harmful non-native plants, animals, and pathogens that could negatively impact Sockeye Salmon recovery. To date, no zebra and quagga mussels, Eurasian water Milfoil, and Chytrid fungus have been detected in the Sawtooth National Recreation Area. New Zealand mud snails have only been found in a small pond on private property near Squaw Creek. Whirling disease was detected in the headwaters of Alturas Lake Creek. The Idaho Department of Agriculture coordinates activities across the state to prevent aquatic species infestations by working with state and Federal agencies, local governments and non-governmental organizations. The greatest risk of aquatic species infestations to the upper Salmon region comes from boats launching in Redfish, Alturas, Stanley, and Pettit Lakes; floatboaters on the Salmon River, and public fishing. Since 2009, the Sawtooth National Forest has worked with the Idaho Department of Agriculture to maintain a seasonal boat inspection station at the Redfish Lake Sandy Beach boat ramp. It is critically important that these efforts be maintained to prevent introduction of highly invasive aquatic species, such as quagga and zebra mussels.

Competition

Competition with planted trout and kokanee for limited food supplies in the Sawtooth Valley lakes could potentially reduce Sockeye Salmon productivity. Brook trout, for example, can aggressively defend feeding territories and may outcompete juvenile Sockeye Salmon. Much remains unknown regarding the competitive effects of kokanee and Sockeye Salmon within the lakes. Redfish and Alturas Lakes contain native kokanee. Kokanee are also native to Pettit Lake; however, genetic analyses indicate that the native kokanee population in this lake may have been replaced by non-native kokanee introduced from northern Idaho. Efforts to control the kokanee populations and reduce competition with Sockeye Salmon are restricted because native kokanee are currently allowed to exist within the lakes without active control measures. A fishery exists to passively control the kokanee populations. Information about carrying capacity within the lakes and future evaluations regarding biomass (trawl, hydro-acoustics coupled with genetic analyses to determine composition of the two forms) will help determine overall competition between the forms and appropriate management actions.

Recovery strategy questions:

- Do juvenile Sockeye Salmon compete with kokanee in oligotrophic lakes?
- Do we need to manage the kokanee population to make room for Sockeye Salmon recovery?
- Will competition for food resources or spawning areas restrict efforts to reestablish natural Sockeye Salmon populations in the natal lakes?
- What habitat areas will be important as fish abundance recovers?
- To what degree do juvenile Sockeye Salmon compete with other fish besides Sockeye Salmon in Sawtooth Valley lakes and how does this affect *O. nerka* carrying capacity estimates in each lake? Are additional watercraft inspection stations needed to protect lakes and streams from aquatic invasive species? If yes, where should they be located?

6.3.1.16 Create an adaptive management feedback loop to track progress toward achieving recovery goals, monitor and evaluate key information needs, assess information, and refine strategies and actions

Adaptive management will play a key role in the reintroduction strategy to restore natural production of Sockeye Salmon in the Sawtooth Valley. Current plans are based on assumptions regarding a number of key factors including anticipated juvenile production relationships and survivals during migration and ocean rearing.

Successful implementation of the strategy requires a process to track progress, define weaknesses and adjust course appropriately. Section 11 describes research, monitoring evaluation to support adaptive management for the recovery of the Snake River Sockeye Salmon ESU. Section 10 describes a proposed framework for coordinated implementation of this Plan. It describes the key implementation teams that are part of this framework, including the Snake River Sockeye Salmon Implementation and Science Team, which will be responsible for coordinating implementation of the Adaptive Management and Research, monitoring, and evaluation Plan.

NMFS will work with the Snake River Sockeye Salmon Implementation and Science Team and others to prioritize the key information needs identified in Section 6.4. It will also seek resources and form partnerships to address the key information needs during recovery plan implementation.

6.3.2 Strategies to Recover Snake River Sockeye Salmon at the Regional Level (Migration Corridor in the Mainstem Salmon, Snake, and Columbia Rivers; Estuary; Plume; and Ocean)

Sections 6.3.2.1 through 6.3.2.11 describe regional-level elements of the recovery strategy to improve Snake River Sockeye Salmon viability.

6.3.2.1 Implement the FCRPS BiOp's Reasonable and Prudent Alternative to reduce mortality associated with migration through the mainstem Salmon, Snake, and Columbia Rivers, estuary and plume

Mainstem Salmon River

Both juvenile and adult Sockeye Salmon are lost in the 462-mile Salmon River migration corridor between the natal lakes and Lower Granite Dam. While the factors responsible for the losses are not fully understood, they are believed to be influenced by stream flow, temperature, and predation. Adult Sockeye Salmon are often exposed to low flows and elevated water temperatures in the Salmon River, usually arriving in the river during baseflow conditions when water temperatures are highest. Juvenile Sockeye Salmon can also be affected by low flows; especially during dry years when irrigation withdraws can reduce streamflow in the Salmon River by early May, slowing migration rates for downstream migrating juvenile Sockeye Salmon and increasing exposure to predators and pathogens.

Although the 2008/2010 FCRPS BiOp RPA as modified by the 2014 FCRPS Supplemental BiOp (*hereafter* 'FCRPS RPA') does not require the Action Agencies to increase habitat quality or survival for Snake River Sockeye Salmon through tributary habitat improvements, it does identify water transactions in the mainstem Salmon River to improve conditions for Snake River spring/summer Chinook salmon and steelhead. These actions will likely also improve the survival of adult migrant Sockeye Salmon returning to the Sawtooth Valley in July and August. Examples are projects in Pole Creek, Fourth of July Creek, Alturas Lake Creek, Beaver Creek, and the Salmon River. Improving flows in this area during late summer is likely to improve water temperature by increasing in-stream flow volume and velocity in this part of the adult Sockeye Salmon migration corridor.

Under the ESA, the Action Agencies are required to ensure that their actions are not likely to jeopardize the continued existence of listed salmon or adversely modify critical habitat, and that they seek NMFS' opinion in the course of doing so. NMFS summarizes its findings in a Biological Opinion, or BiOp. The Biological Opinion issued on May 5, 2008 (NMFS 2008c), and supplemented on May 20, 2010 (NMFS 2010b) and on January 17, 2014 (NMFS 2014c), governs how the Columbia and Snake River mainstem dams (and upstream water storage facilities) are operated and configured through 2018. These documents are available at: http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm.

The FCRPS RPA includes hydro, habitat, hatchery, harvest and predation measures to address the biological needs of salmon and steelhead in every life stage within human control. The FCRPS RPA is the product of collaboration between NMFS, the Action Agencies, and the regional state and tribal sovereigns as ordered by the District Court. It is based on a comprehensive analysis of the salmon life cycle. The "Reasonable and Prudent Alternative Table" in the 2008 FCRPS Biological Opinion, as amended by the 2010 Supplemental FCRPS Biological Opinion and modified by the 2014 Supplemental FCRPS Biological Opinion, describes actions that NMFS expects will positively affect the viability of the Snake River Sockeye Salmon ESU.

The recovery strategy also proposes a number of actions to improve Snake River Sockeye Salmon viability by addressing the effects of Columbia and Snake River hydro operations. The proposed actions include those summarized in the FCRPS Biological Opinion (NMFS 2008c) and the Hydro Module (NMFS 2014c). The actions are designed to improve juvenile and adult fish passage and to reduce predation. The release of cool water from Dworshak Dam to reduce lower Snake River temperatures per FCRPS RPA Action 4 is an example of such actions. Additional survival improvements may also result through the ongoing FCRPS adaptive management process. Amendments added to the FCRPS Adaptive Management Implementation Plan through the 2010 Supplemental BiOp and a new study implemented through the 2008 BiOp’s adaptive management approach are addressing the high fish ladder temperatures at Lower Granite Dam in 2013 that temporarily blocked Sockeye Salmon passage. Short-term and longer-term measures adopted through these processes should substantially reduce, if not eliminate, the likelihood of future blocked passage at the project.

Lower Columbia River Estuary, Plume, and Ocean

As described in NMFS’ Estuary Module (2011a), habitat conditions in the Columbia River estuary are considerably degraded and those in the plume are altered compared to 200 years ago. In terms of absolute size, the estuary tidal prism is about 20% smaller than it was when Lewis and Clark camped along the lower Columbia. This reduction in estuary size is due mostly to dike-and-fill practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Spring flows entering the estuary have decreased 44% and the annual timing, magnitude, and duration of flows have also changed. The changes are attributed to hydrosystem regulation; water withdrawal for agricultural, municipal, and industrial purposes; and climate fluctuations. Further alterations in flow are likely to occur during the next century as a result of climate change, the effects of which are expected to include more precipitation falling as rain rather than snow. In the estuary this is likely to result in higher peak flows and reduced late-summer/early-fall stream flows (ISAB 2007).

Historically, vegetated wetlands within the floodplain supplied the estuary with its base-level food source: macrodetritus. The changes in flow volume and timing and the separation of the river from its floodplain by dikes and levees have altered the food web by reducing macrodetrital inputs (Bottom et al. 2005). In addition, access to and use of floodplain habitats by juveniles that rear in the estuary have been compromised through alterations in the presence of and access to these critical habitats.

At the same time, upstream dams have prevented sediments from entering the estuary, while dredging activities have exported sand and gravel out of the estuary. Studies have shown that sand is exported from the estuary at a rate three times higher than that at which it enters the estuary. The full impact of these changes is unknown; however, sediment transport is a primary habitat-shaping force that determines the type, location, and availability of habitats distributed in the estuary. In addition, decreases in suspended sediments have improved water clarity which increases the effectiveness of predators that consume juvenile and adult salmon and steelhead.

The Estuary Module (NMFS 2011a) identifies 23 management actions to improve the survival of salmon and steelhead migrating through and rearing in the estuary and plume environments. These address changes in flow, habitat quality and availability, water quality, and prey resources. The BPA and Corps’ estuary restoration strategy is described in the Columbia Estuary Ecosystem Restoration Program 2012 Strategy Report (BPA and USACE 2012).

The FCRPS Action Agencies are reconnecting tidal influence through breaching dikes and levees and replacing culverts, bridges, and tidegates, enhancing the quantity and quality of tidal channels, removing invasive species, and restoring riparian habitat conditions (BPA and USACE 2013). These projects are providing juvenile Sockeye Salmon access to quality habitat (Bottom et al. 2011, Roegner et al. 2012) and allowing the export of salmon prey (dipteran insects and the amphipod *Americorophium*) to the deeper water channel (Diefenderfer et al. 2012).

Recovery strategy questions:

- How effective are hydropower management activities across the observed range of hydrologic conditions? Across a projected range of hydrologic conditions associated with climate change?
- How effective are estuary habitat improvement activities?

6.3.2.2 Continue research on Snake River Sockeye Salmon survival/mortality in mainstem Salmon, Snake and Columbia River migration corridors; estuary; plume; and ocean

Mainstem Salmon River

As discussed previously, both juvenile and adult Sockeye Salmon are lost in the 743 km (462-mile) Salmon River migration corridor between Redfish Lake and Lower Granite Dam. The factors responsible for the losses are not fully understood. More research is needed to determine where and why mortality occurs in the migration corridor between the natal lakes and Lower Granite Dam.

FCRPS BiOp RPA-directed studies to evaluate the feasibility of transporting adult Sockeye Salmon from Lower Granite Dam to the Sawtooth Valley to avoid high mortality in that reach are resulting in a more detailed assessment of where adult losses are occurring along the entire Bonneville-to-Sawtooth migration route and a correlative analysis of factors, including water temperature, that may be responsible for adult Sockeye Salmon mortality. This study is ongoing (NMFS 2014c).

Federal Columbia River Power System

As discussed in Section 6.3.2.1, actions described in the FCRPS RPA and the Hydro Module, as well as any further improvements for fish survival that may result from the ongoing FCRPS adaptive management process, represent the near-term hydropower recovery strategy for Snake River Sockeye Salmon and other listed Columbia Basin salmonids. In 2009, after expansion of the Snake River Sockeye Salmon production facilities (FCRPS RPA Action 42), the Corps of Engineers was able to start PIT-tagging sufficient numbers of juvenile fish from this ESU to directly assess the survival of inriver migrants from the point of release in the Sawtooth Valley through the hydropower system to Bonneville Dam (FCRPS RPA Action 52). The Corps has also begun to compare the adult Snake River Sockeye Salmon return rates of fish that migrated inriver to those that were transported from the Snake River collector projects. Prior to this, estimates for unlisted Sockeye Salmon from the upper Columbia (Lake

Wenatchee and Okanogan River ESUs), or even from other species (e.g., Snake River spring/summer Chinook salmon), were used as surrogates for Snake River Sockeye Salmon in this reach. Transportation effects could not be assessed using data for Upper Columbia River Sockeye Salmon, because fish from the upper Columbia are not transported.

The increasing availability of smolts from the Snake River Sockeye Salmon production and supplementation program is further increasing the sample sizes of these studies, improving estimates of survival through the FCRPS and allowing the assessment of transport effects under current operations. Researchers have now analyzed PIT-tag data from 920 adults that were detected at Bonneville Dam from 2008 through 2013. During this period, Snake River sockeye survival from Bonneville Dam to the Sawtooth Weir ranged from 60% down to 13% (Crozier et al. 2014). The researchers used the PIT-tag data to examine several factors that might contribute to migration survival. These factors include juvenile history (hatchery origin, juvenile transportation, and age of adult return), migration characteristics (arrival timing, travel time, and fallback), and river environment (temperature, flow, spill, and percentage of dissolved gas) in the river reaches between Bonneville Dam and the Sawtooth Valley. They also used the data to explore the implications of potential triggers for Snake River Sockeye Salmon transportation. Research results to date indicate that the most important predictors of survival across reaches and years may be thermal exposure and fish travel time, with higher temperature exposure contributing to higher fallback rates and lower survival. As mentioned previously, adult Snake River Sockeye Salmon migrate through this long, strenuous river reach in July and August – the hottest time of year. The PIT-tag data show that migration survival dropped below 50% when the river surpassed 18°C. While additional years of PIT-tag data collection and analysis will improve research findings, the current data suggest that migration survival varies strongly as a function of temperature and that temperature should be considered in any decision to initiate fish transportation (Crozier et al. 2014).

This strategy includes actions to investigate the observed SAR differential between Snake River Sockeye Salmon and Lake Wenatchee and Okanogan River Sockeye Salmon. Information gained from these investigations will inform further actions that could improve SARs for the Snake River ESU.

Lower Columbia River Estuary, Plume, and Ocean

As discussed in 6.3.2.1, actions described in the FCRPS RPA and the Estuary Module, as well as any further improvements for fish survival that may result from the ongoing FCRPS adaptive management process, represent the near-term estuary and plume recovery strategy for Snake River Sockeye Salmon and other listed Columbia Basin salmonids. Under FCRPS RPA Actions 58-61, BPA and the Corps have been investigating fish and habitat status and trends in the estuary and developing estuary classification mapping layers to inform selection of habitat improvement projects. They are increasing the level of "action effectiveness" research to evaluate how fish and habitat actually respond to the improvement actions compared to pre-project predictions. The Expert Regional Technical Group (ERTG) considers and incorporates these new scientific findings into its habitat improvement scoring process. The group also assigns survival benefit units for ocean- and stream-type juvenile salmon for estuary habitat actions implemented by the Action Agencies.

The purpose of the plume and nearshore ocean research program has been to help understand the mechanisms by which the ocean and climate affect survival to increase the likelihood that Columbia Basin salmonid populations will persist over the full range of environmental conditions they are likely to encounter.

Recovery strategy questions:

- What are survival rates of juvenile and adult Snake River Sockeye Salmon through the mainstem Salmon River, lower Snake and Columbia Rivers, estuary, plume, and nearshore ocean?
- How and where do water quality and quantity conditions in the Salmon River affect Sockeye Salmon migrants between Lower Granite Dam and the natal lakes? What other factors (predation, competition, toxics) are causing juvenile Sockeye Salmon mortality during migration through the Salmon River?
- How do fluctuations in annual river flows (Columbia, Snake, and Salmon Rivers) affect survival through each of these stages?
- How are juvenile Snake River Sockeye Salmon using the estuary and plume (residence times, growth rates, survival to next life stage)?
- How do conditions in the estuary affect Sockeye Salmon rearing (residence times, growth rates and survival)?
- Does exposure to contaminants and bioaccumulation of contaminants in the estuary affect Snake River Sockeye Salmon survival?
- Is the mortality of juvenile outmigrating and adult returning anadromous Sockeye Salmon in the area between the Sawtooth Valley and Lower Granite Dam related to natural causes (e.g., competition, predation, environmental conditions) or effects of human activities?
- Are there local areas (hot spots) where mortality is concentrated during juvenile smolt and adult return migration for anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam, or are mortality rates uniform over the migration distance?
- What are the effects of transportation on juvenile Sockeye Salmon survival?
- What estuary and ocean indicators (biological and physical) correlate with Sockeye Salmon growth rates and life stage survival and with SARs?

6.3.2.3 Update Snake River Sockeye Salmon life cycle models using latest information on survival through mainstem Salmon, Snake, and lower Columbia River migration corridor; estuary; and plume

Update appropriate life-stage inputs in the life cycle model and test hypotheses regarding whether strategies described in this plan, including those in Section 6.3.2.1, will be adequate to achieve recovery objectives for the ESU.

6.3.2.4 Manage to maintain low impact fisheries and reduce fishery impacts in those fisheries that affect Snake River Sockeye Salmon

The strategy to reduce fishery impacts on Snake River Sockeye Salmon centers on the use of existing management agreements and monitoring activities. No fisheries directly target Snake River Sockeye Salmon; however, the fish are caught in fisheries targeting other species.

In the Sawtooth Valley, sport fisheries in Redfish Lake targeting kokanee and rainbow trout may catch small numbers of Sockeye Salmon. DNA analysis of sport-caught fish, however, shows that the fishery removes significant numbers of kokanee but not Sockeye Salmon; therefore without negatively impacting the Sockeye Salmon ESU.

Fisheries in the mainstem Salmon and Snake Rivers target hatchery spring/summer Chinook salmon and steelhead but the fisheries are managed to protect Sockeye Salmon. ESA biological opinions require substantial monitoring and evaluation of the fisheries; when Sockeye Salmon are encountered or show up in the catch the fisheries are closed.

Treaty tribal net fisheries and non-tribal fisheries in the lower Columbia River, i.e., below the confluence of the Snake River, that target Chinook salmon and steelhead also incidentally take small numbers of Snake River Sockeye Salmon. Most of the Sockeye Salmon harvested in these fisheries are from the upper Columbia River, but very small numbers of Snake River Sockeye Salmon are taken incidental to summer fisheries directed at Chinook salmon. Fisheries in the mainstem Columbia River that affect Snake River Sockeye Salmon are managed subject to the terms of the *U.S. v. Oregon* Management Agreement for 2008-2017. These fisheries are managed to ensure that the incidental take of ESA-listed Snake River Sockeye Salmon does not jeopardize the ESU.

Ocean fisheries may also take small numbers of Sockeye Salmon, but are not believed to significantly affect the Snake River Sockeye Salmon ESU. Ocean harvest is under the jurisdiction of the Pacific Fisheries Management Council and the Pacific Salmon Commission and is managed according to agreements through these jurisdictions.

The recovery strategy calls to continue managing mainstem Columbia River and lower Snake River fisheries through the 2008-2017 *U.S. v. Oregon* Management Agreement, which retained the 2005-2007 Interim Management Agreement to ensure that the incidental take of ESA-listed Snake River Sockeye Salmon does not exceed specified harvest rates. The strategy also implements monitoring and evaluation programs to ensure that fisheries minimize their impacts on this ESU.

Tributary fisheries are managed to ensure that the incidental take of ESU-listed Snake River Sockeye Salmon does not exceed specific harvest rates. In addition, the strategy calls for actions to investigate the use of new technologies (PIT-tags and PIT-tag detectors, Parentage Based Tagging) to better manage inseason mainstem fisheries and assess seasonal harvest objectives and limitations.

Recovery strategy questions:

- Can we achieve recovery under the current *U.S. v. Oregon* sliding-scale fishery harvest regime, together with actions in the other Hs?
- What are the effects of harvest on size selectivity and size of fish returning to spawn?
- What research is needed to understand the role of Columbia River fishery harvest on adult Sockeye Salmon survival? Based on this research, what management actions can be taken to minimize take of Snake River Sockeye Salmon?

6.3.2.5 Protect and conserve natural ecological processes that support population viability

Actions to protect and improve habitat and fish passage in the Columbia/Snake River mainstem and estuary play a key a role in the overall recovery strategy for Snake River Sockeye Salmon. Protecting existing high quality habitat and restoring damaged habitat will specifically benefit Snake River Sockeye Salmon in the juvenile and adult migration life history stages. The Estuary Module describes strategies and actions to protect and conserve natural ecological processes to support salmonid viability in the lower Columbia River, estuary, and plume. The 2008 FCRPS Biological Opinion and 2010 Supplemental FCRPS BiOp also provide direction for improving natural ecological processes in the mainstem Columbia and Snake Rivers.

Relatively little information is available concerning Snake River Sockeye Salmon use of mainstem Snake and Columbia River habitat above Bonneville Dam, aside from passage through the dams. NMFS believes it is important to assess nearshore mainstem habitat and cold-water refugia in the mainstem Columbia and lower Snake Rivers and to explore opportunities for, and potential benefits from, restoration and protection of these areas.

Recovery strategy questions:

- Are there shoreline, main channel, and/or cold-water refugia areas in the estuary that provide habitat for juvenile Snake River Sockeye Salmon during their migration?
- What habitat conditions in the plume contribute to Sockeye Salmon viability?
- Where is predation on Sockeye Salmon occurring in the estuary and what changes in ecological conditions contribute to increased predation?
- What estuary and ocean indicators (biological and physical) correlate with Sockeye Salmon growth rates, life-stage survival, and with SARs? Protect existing high quality habitat and restore mainstem shoreline habitat (riparian and wetlands) in lower Snake and lower Columbia River reaches?

6.3.2.6 Improve degraded water quality and maintain unimpaired water quality

Summer water temperatures in portions of the mainstem Salmon River and the lower Snake River reach levels during late July and August that may affect the survival of migrating Snake River Sockeye Salmon. Besides delaying migration and/or causing direct or delayed Sockeye Salmon mortality, the high temperatures may also make Sockeye Salmon more susceptible to disease and infection if they are not able to escape to deep pools or other habitats with cooler temperatures. Higher water temperatures may also reduce the quality of shallow water estuarine habitats used by juvenile and adult Sockeye Salmon and other salmonids during summer months. Adult Sockeye Salmon have been known to suffer stress and disease as they are exposed to warm water in estuaries, waiting for cool runoff conditions in their natal stream (ISAB 2007). Warmer temperatures may also cause changes in the estuarine food web (NMFS 2011a).

Sections of the mainstem Salmon, Snake, and Columbia Rivers are also contaminated by drift and runoff from both agricultural and urban areas. Exposure to these chemicals during adult and juvenile migration may contribute to low survivorship and impede recovery of this stock. As discussed in Section 5, juvenile and adult Snake River Sockeye Salmon are likely at risk for exposure to several classes of contaminants, including mercury, legacy and current use pesticides, industrial contaminants such as PCBs and PBDEs, and wastewater contaminants their respective migrations. Currently, however, very little is known about the actual exposure to and uptake of contaminants in outmigrant juvenile Snake River Sockeye Salmon, or returning adults, and no data are available on contaminant body burdens in this stock. Moreover, water quality data for much of this ESU's habitat is incomplete. Toxics monitoring in the Columbia Basin has been concentrated primarily in the lower Columbia River and estuary, and data for the middle and upper Columbia River, Snake River, and Salmon River basins are lacking (USEPA 2009).

The Estuary Module lists several management actions that could improve water quality in the estuary for all Snake River Sockeye Salmon and other salmonids.

- Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.
- Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.
- Restore or mitigate contaminated sites.
- Implement stormwater best management practices in cities and towns.

In addition, the strategy supports actions by IDEQ, Idaho Department of Water Resources, Oregon DEQ and Washington Department of Ecology to address water temperature concerns for the Salmon and lower Snake Rivers. The strategy calls for monitoring studies to determine how high temperatures and other water quality issues in the Salmon and lower Snake Rivers may be affecting Sockeye Salmon survival and viability.

Recovery strategy questions:

- How do high water temperatures in the lower Salmon and Snake Rivers affect upstream and downstream Sockeye Salmon survival and viability?

- In what reaches of the lower Salmon and Snake Rivers are Sockeye Salmon particularly vulnerable to high water temperatures, and potential increases in predation by warm-water fish?
- How does exposure to contaminant and bioaccumulation affect Snake River Sockeye Salmon survival?

6.3.2.7 Address ecosystem imbalances in predation, competition, and disease through the strategies and actions in this Plan, the Estuary Module and reasonable and prudent alternatives identified in Biological Opinions

Predation

Avian Predation
While extensive research on predation and efforts at predator control in the Columbia Basin has been undertaken for decades, little is known regarding the extent of avian predation on Snake River Sockeye Salmon. Actions continue to reduce predation by cormorants and other birds. For example, altering habitat on Rice Island to prevent tern and cormorant nesting reduced avian predation in the estuary. The 2008 FCRPS Biological Opinion (NMFS 2008c) recommended further reduction in bird habitat on East Sand Island. The Estuary Module and FCRPS RPA recommend further development of plans to control Caspian terns and double-crested cormorants that nest in the estuary and on islands upstream of Bonneville Dam. The Corps of Engineers plans to continue implementing “avian deterrent actions” at the lower Snake and Columbia River dams.

Piscivorous Fish Predation
Although predation of juvenile Sockeye Salmon undoubtedly occurs, there is little direct evidence that piscivorous fish in the Columbia River consume juvenile Sockeye Salmon (NMFS 2008c). Control of piscivorous predation has focused largely on targeted sports fisheries to remove more of the predators and /or direct removal by physical or chemical means (NMFS 2008c).

A report by the Independent Scientific Advisory Board for the NPCC (ISAB) indicates that the methods of controlling non-native piscivores have not been sufficient, and that maintaining and restoring habitat is actually the better strategy. The ISAB report states “when native species are provided with habitat for which they are best adapted, they have an improved chance of out-competing or persisting with non-native species” (ISAB 2008). NMFS supports this conclusion. Based on its report, the ISAB recommended that the NPCC urge state agencies to relax (or eliminate) fishing regulations that may be perpetuating populations of non-native species (both predators, such as walleye, smallmouth bass and channel catfish, and competitors, such as shad and brook trout); especially those that directly or indirectly interact with juvenile and adult salmonids.

Competition
Evaluating the factors that influence how competition with hatchery fish and other species affects natural-origin populations under varying freshwater conditions and ocean conditions is an important area

of future research. This is addressed in more detail in Appendix C of the 2008 FCRPS Biological Opinion (NMFS 2008c).

Disease

Disease in salmonids is caused by multiple factors and probably cannot be directly addressed by recovery actions, except in specific instances of known causal factors. It is more likely that nearly all of the recommended recovery actions that improve spawning, rearing, and passage conditions for Sockeye Salmon and increase the survival, abundance, and productivity of naturally produced fish will result in decreasing incidence of disease.

The Estuary Module, FCRPS BiOp, and other Biological Opinions, and this Plan identify strategies and actions to monitor and control predation, competition, and invasive species in the mainstem Columbia and Snake Rivers and estuary. The documents also direct additional research, monitoring, and evaluation activities to quantify the impacts of predation and competition on Snake River Sockeye Salmon recovery efforts.

Recovery strategy questions:

- What is the predation rate and predatory effect of native and non-native fishes in the nursery lakes and migration corridor on Snake River Sockeye Salmon?
- What is the effect of predation from avian and fish predators in the Columbia River migration corridor on juvenile Snake River Sockeye Salmon?
- What is the effect of predation from marine mammals in the Columbia River migration corridor on adult Snake River Sockeye Salmon?

6.3.2.8 Respond to climate change threats by implementing research, monitoring, and evaluation to track indicators related to climate change and by preserving biodiversity

Likely changes in temperatures, precipitation, wind patterns and sea-level height due to climate change have profound implications for survival of Snake River Sockeye Salmon. All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat due to climate change can be expected to cause a reduction in the number of naturally produced Sockeye Salmon returning to the ESU. This possibility reinforces the importance of implementing research, monitoring, and evaluation to track indicators and adapt actions to respond to climate change. It also reinforces the importance of maintaining habitat diversity and achieving survival improvements throughout the entire life cycle.

The ISAB (2007) developed strategies and recommendations to incorporate climate change considerations into restoration and recovery planning. This Plan adopts the ISAB’s general strategy and recommendations as they apply to Snake River Sockeye Salmon. The strategy is three-pronged, addressing climate change concerns in freshwater habitats, the mainstem Snake/Columbia River corridor, and the ocean.

- For freshwater lake habitats, the strategy is to: (1) conduct research and monitoring to predict and determine if climate change is affecting food supplies, predation and competition rates, spawning/rearing conditions and survival in the lakes; and (2) if so, determine if there are actions that can be implemented to reduce the effects of climate change.
- For freshwater tributary migratory corridors, the strategy is to: (1) minimize increases in summer temperatures in affected streams by implementing measures to retain shade along stream channels and augment summer flow; (2) help alleviate both elevated temperatures and low stream flow in affected streams during summer and autumn by managing water withdrawals to maintain as high a summer flow as possible; and (3) provide mitigation for declining summer flows by protecting and restoring wetlands, floodplains, and other landscape features that store water.
- For the mainstem Snake and Columbia migration corridor, the strategy includes releasing cool water from reservoirs during critical periods, improving juvenile passage through warm dam forebays, improving temperatures in adult fish passage structures, and reducing warm-water predators. For the estuary, removing dikes to open backwater, slough, and other off-channel habitats can increase flow through these areas and encourage hyporheic flow.
- For the ocean, the climate change strategy is primarily to review mechanisms for timing arrival of smolts to avoid a mismatch with marine predators and prey and to review harvest practices to ensure that harvest quotas are adjusted to reflect changing conditions.

Strategies and actions identified in this plan - including the research, monitoring, and evaluation plan - define steps to track and guard against the effects of climate change. Strategies and actions identified in the Estuary and Hydro Modules, FCRPS BiOp, and other Biological Opinions also protect and improve habitats that could be affected by climate change. The climate change strategy necessitates a strong monitoring and evaluation program, along the lines of that included in the FCRPS Adaptive Management Strategy. The program will help detect physical and biological changes associated with climate change and determine the efficacy of responsive measures.

Recovery strategy questions:

- Given regional temperature and precipitation patterns projected from climate models, how would potential changes in stream temperature and flows affect the limnology of lakes used for spawning and rearing of Snake River Sockeye Salmon?
- Given regional temperature and precipitation patterns projected from climate models, how might potential changes in limnology of the lakes affect Sockeye Salmon food supplies, predation and competition threats, migration timing and survival?
- Given regional temperature and precipitation patterns projected from climate models, how would potential changes in tributary and mainstem stream temperature and flows affect migration timing and survival of juvenile and adult Snake River Sockeye Salmon?

What reaches are most vulnerable to potential increases in water temperature due to climate change? In particular:

- Will stream flows in the Salmon River above the Sawtooth Hatchery be adequate to sustain migration of Sockeye Salmon to Alturas, Pettit, and Yellowbelly Lakes under projected changes from climate change?
- Are there management strategies and actions that can affect life history survival across different climate and environmental conditions?

6.3.2.9 Implement the Snake River Sockeye Salmon Recovery Plan through effective communication, education, coordination and governance

Recovery of Snake River Sockeye Salmon depends on the collective action of citizens and stakeholders in the region. Recovery actions will need to be implemented by diverse organizations, tribes, state and Federal agencies, landowners, private entities and the public.

Implementation of recovery actions, research, and monitoring projects will build upon ongoing Sockeye Salmon recovery efforts carried out by the Stanley Basin Sockeye Technical Oversight Committee, IDFG, Shoshone-Bannock Tribes, U.S. Forest Service, NMFS and other partners that have prevented the extinction of this ESU. Implementation will need the continued coordinated actions and funding from diverse parties including IDFG, Shoshone-Bannock Tribes, Bonneville Power Administration, NMFS, U.S. Forest Service, counties, state and Federal agencies, private landowners, and individuals. NMFS will work with these various partners to define agreement on how best to implement the Snake River Sockeye Salmon recovery plan, especially regarding recovery action coordination, public education and interpretation, action tracking and reporting, scientific oversight, and adaptive management.

6.3.2.10 Continue research, monitoring, and evaluation for adaptive management

Research, monitoring, and evaluation play a critical role in the recovery of the Snake River Sockeye Salmon ESU and are discussed in more detail in Section 11. As will be discussed in Section 6.4, Key Information Needs, many questions exist regarding the effects of the hydrosystem, fisheries, and land and water uses on survival of Snake River Sockeye Salmon in the mainstem migration corridor, estuary, and ocean. We remain unsure whether Sockeye Salmon survivals resulting from current conditions and current and proposed management actions will be enough to provide for life history survival through variations in ocean and climate conditions.

Strategies and actions in the FCRPS Biological Opinion, Hydro Module and Estuary Module identify research, monitoring, and evaluation activities that will aid recovery of Sockeye Salmon. In addition, the research, monitoring, and evaluation program discussed in Section 11 of this Plan provides direction to assess the status of the species and its habitat, track progress toward achieving recovery goals, and gain information needed to refine recovery strategies and adjust course as appropriate through the process of adaptive management.

6.3.2.11 Prioritize and address key information needs and create an adaptive management feedback loop to revise recovery actions as needed

Successful implementation of the recovery plan requires a process to refine direction and adjust course appropriately. Section 10 describes a proposed framework for coordinated implementation of this Plan. It describes the key implementation teams that are part of this framework, including the Snake River Sockeye Salmon Implementation and Science Team, which will be responsible for coordinating implementation of the Adaptive Management and Research, Monitoring, and Evaluation Plan.

NMFS will work with the Snake River Sockeye Salmon Implementation and Science Team and others to prioritize the key information needs identified in Section 6.4. It will also seek resources and form partnerships to address the key information needs during recovery plan implementation.

6.4 Key Information Needs

This section summarizes the key information needs to evaluate the status of Snake River Sockeye Salmon and identifies the high priority data gaps to guide recovery actions to support a future naturally spawning population. Key information needs include scientific investigations of critical assumptions and unknowns that constrain effective recovery plan implementation. They include pieces of information required for informed decision making, proper allocation of fish resources, or to decrease risks to Sockeye Salmon and their habitat that are not available at this time. They also include information needed to improve the outcome of fish supplementation and habitat enhancement projects.

Key information needs are first identified in the Section 5, which identifies hypotheses for how we think limiting factors and threats affect Sockeye Salmon, data gaps in our knowledge and understanding of Sockeye Salmon, and research needs to understand the factors affecting viability at each life stage. Section 6 describes the local and regional-level recovery strategies to address these limiting factors, together with relevant recovery strategy questions and information needs.

This section does not list all the recovery strategy questions in Section 6; however, the intent of this section is to focus on those key information needs that are essential, timely and of high priority to guide recovery actions for this ESU. This section highlights the key priority information needs for the recovery actions in Section 7 and research, monitoring, and evaluation actions in Section 11.

Strategy: Conserve population genetic and life history diversity, and spatial structure.
Several Sawtooth Valley lakes are believed to have supported Sockeye Salmon production historically. The last documented returns of Sockeye Salmon from the region were associated with Redfish Lake. The lakes vary in size and there may be important differences in environmental conditions and zooplankton communities. Limnological evaluations, juvenile growth studies and hatchery outplant survival evaluations can be used along with study results from Sockeye Salmon lakes outside of the Snake River basin to gain a better understanding of the opportunities to restore Sockeye Salmon production.

1. *Broodstocks* - The current captive broodstock for Snake River Sockeye Salmon is exclusively composed of Redfish Lake fish/gene resources from an anadromous lineage adapted to beach spawning in the fall (late September through October).
   - Is the current Redfish Lake Sockeye Salmon captive broodstock genetic structure appropriate for use in rebuilding efforts in other Sawtooth Valley lakes?
   - Do remnant anadromous Sockeye Salmon gene resources exist in other Sawtooth Valley lakes and could they be utilized for recovery efforts on a lake-specific basis?
   - Is the current Redfish Lake Sockeye Salmon captive broodstock late September through October spawn timing structure appropriate for water temperature regimes in other Sawtooth Valley lakes?
   - Is the current Redfish Lake Sockeye Salmon captive broodstock beach spawning propensity appropriate for rebuilding efforts in other Sawtooth Valley lakes, or would populations keyed to potential stream spawning habitats be more appropriate?

2. *Structure and size of restored natural spawning populations* - Opportunities to restore Sockeye Salmon production in the lakes will depend greatly on their carrying capacity. The lakes differ in size, limnological condition, water quality, zooplankton communities, and other features that will determine the size and structure of a restored Sockeye Salmon population. We need a better understanding of the potential of different sites within each lake to support spawning. For example, there is strong evidence that Sockeye Salmon in Alturas Lake may spawn in the tributaries as well as along the lake shoreline, typical of Sockeye Salmon in other lakes. Consequently, the priorities for Sockeye Salmon production in the different lakes should be continually revisited as information from carrying capacity and survival rate studies becomes available.
   - Spatial Structure and Diversity: What are the options for population structure and diversity for restoration of a naturally spawning population(s)?
   - What are the benefits/risks of alternative strategies for recovering extant and/or historical life-history patterns in the natal lakes (e.g., Alturas and Pettit)?

Strategy: Increase naturally spawning Snake River Sockeye Salmon abundance.
A key element of the plan for restoring natural production of Sockeye Salmon in the Sawtooth Valley lakes is its adaptive nature that allows opportunities to diversify reintroduction strategies for the lakes to promote the chances of successful reintroduction of sustainable natural production.

- What is the potential of the individual lakes to support natural Sockeye Salmon production?
- What are the key constraints in each candidate lake?
- How can additional limnological or experimental outplants be used to reduce uncertainties regarding restoration?

Strategy: Improve Sockeye Salmon passage to natal lakes.

Juvenile outmigration survival for Snake River Sockeye Salmon between the upper Snake River basin and Lower Granite Dam has ranged from about 20-80% and has been highly variable between years, release sites, origins, and rearing strategies. Likewise, adult upstream survival from Lower Granite Dam to the upper Snake River basin has ranged between a low of about 20% and a high of about 90%, and has been variable over years. Researchers have suggested that higher flows during the spring runoff period likely contribute to shorter travel times and higher survival to Lower Granite Dam. Lower stream flows and higher water temperatures may contribute to delayed upstream migration.

- Is the mortality of juvenile outmigrating and adult returning anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam related to natural causes (e.g., competition, predation, environmental conditions) or are extraneous causes involved?
- Are there local areas (hot spots) where mortality is concentrated during juvenile smolt and adult return migration for anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam, or are mortality rates uniform over migration distance?

Strategy: Investigate and develop strategies for future actions to support Sawtooth Valley in reintroduction and adaptation phases for Pettit Lake.

Evaluation of the initial reintroduction program will guide the future course of the Pettit Lake Sockeye Salmon program. This will depend greatly on the relative trends in anadromous and resident *O. nerka* production in Pettit Lake.

- Will the resident component (residual Sockeye Salmon and non-native kokanee) in Pettit Lake persist over time after stocking with Redfish Lake anadromous broodstock ends?
- Will anadromous Sockeye Salmon intermingle and spawn with resident Sockeye Salmon on the spawning grounds? Does this impact the presence and magnitude of anadromy in the Pettit Lake population over time?

Strategy: Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon for returning residual outmigrants from Alturas Lake.

Information suggests that some of the Kokanee in Alturas Lake produce anadromous smolts that are genetically unique from the anadromous population found in Redfish Lake.

- What stock, or combination of stocks, is most appropriate for reintroduction into Alturas Lake to support the development of an anadromous *O. nerka* population?

Strategy: Continue research on natal lakes' carrying capacity, nutrients, and ecology.

The Sawtooth Valley has a total of 1,267 surface hectares of lake habitat potentially available for anadromous Sockeye Salmon spawning and rearing (615 for Redfish Lake, 338 for Alturas, 160 for Pettit, 81 for Stanley, and 73 for Yellowbelly). Some primary questions of concern focus on how and if these potentially available habitats can be best used for recovery of Snake River Sockeye Salmon, including:

1. *Lake rearing capacity*
    - What is the carrying capacity for adult spawning and juvenile rearing for anadromous Sockeye Salmon in each of the Sawtooth Valley lakes?
    - How do these carrying capacities fit with recovery planning needs to address the abundance, productivity, spatial structure, and diversity of the ESU (e.g., is spawning and rearing capacity a limiting factor)?
    - What can be derived from limnological monitoring data regarding the potential for juvenile anadromous Sockeye Salmon growth and survival in the various Sawtooth Valley lakes?
    - How much zooplankton is available to support juvenile rearing and survival?
    - We need to improve our understanding of the relationship between variability in zooplankton abundance and species composition vs. Sockeye Salmon juvenile density, survival, and anadromy vs. residency.
    - How would differing lake carrying capacity estimates affect the abundance targets?

2. *Competition*
    - Do juvenile sockeye compete with kokanee for food resources in the oligotrophic lakes of the Sawtooth Valley? Do we need to address the non-native kokanee population to make room for Sockeye Salmon recovery?
    - Are other fish populations in Sawtooth Valley lakes limiting the production of juvenile anadromous Sockeye Salmon (e.g., does competition for food limit growth and survival)?

Strategy: Protect, restore and manage spawning, rearing, and migration habitat.

1. *Habitat: spawning and rearing*
    - Uncertainty about the availability of spawning habitats. Is spawning capacity limiting in the natal lakes?
    - What habitat areas will be important as Sockeye Salmon numbers increase? What will be the role of beach vs. stream spawning types?

2. *Habitat: migration*
    - What are the causes of juvenile mortality for fish leaving natal lakes/ Sawtooth Valley?
    - What are the causes of mortality of adults in certain reaches?

3. *Habitat: estuary/ plume near shore*
    - How are juvenile Snake River Sockeye Salmon using the estuary and plume (arrival timing, residence times, habitat use, and prey consumption)?
    - Effects of conditions in estuary and plume on growth, condition, and survival?
    - What amount of benefit will this ESU gain from recovery actions in estuary?
4. *Toxics*
    - Determine the sources of contaminant exposure and levels in body tissues in Snake River Sockeye Salmon.
    - Gather toxics monitoring data from critical habitats for many contaminants.
    - Gather information about the interactions of contaminants with other stressors.

Strategy: Implement FCRPS BiOp to reduce mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects.

- Improve FCRPS passage survival rates.
- Continue survival studies for transported juveniles and in river migrants.
- Determine different survival rates through FCRPS system.
- Query existing tag information on survival to determine what happens during different climate/ocean conditions.
- Determine the physical and biological indicators of environmental conditions (in the mainstem and ocean) and how they are correlated with survival. Generate hypotheses of underlying mechanisms and where under human control, test alternatives.

Strategy: Maintain current low impact fisheries and reduce fishery impacts in those fisheries that affect the viability of the Snake River Sockeye Salmon ESU.

Harvest rate estimates of natural-origin fish are based on analyses of hatchery fish with Coded Wire Tags (CWTs).

1. *Accuracy of harvest rate estimates*
    - Are estimates of harvest rates of natural-origin fish accurate? Are we meeting the sliding scale numbers in *US v Oregon*?

2. *Potential effects of size selectivity*
    - What are the effects of harvest management on size selectivity and size of fish returning to spawn?

Strategy: Respond to climate change threats by implementing research, monitoring, and evaluation to track indicators related to climate change and by taking actions designed to preserve biodiversity.

1. *Climate effects*

    - Given regional temperature and precipitation patterns projected from climate models, how would potential changes in stream temperature and flows impact the survival of Snake River Sockeye Salmon at different points in the life cycle (e.g., natal lakes to lower Snake River, lower Snake River to lower Columbia, estuary and plume)?

Table 6-1. Monitoring and evaluation programs for Snake River Sockeye Salmon.

Types of Programs	Activity	Description	Responsible Entities	Status
Status and Trends Monitoring	Natural and hatchery origin adult returns to Redfish Lake	Trap counts at Redfish Lake	IDFG, SBT	Ongoing
	Adult returns to Lower Granite Dam	Ladder counts & PIT detections	WDFW, IDFG	Ongoing
	Adult returns to Bonneville Dam	PIT detections	Corps of Engineers (COE)	Ongoing
	Juvenile abundance at Redfish Lake, Lower Granite Dam	Outmigrant trapping	IDFG and NOAA	Ongoing
	Smolt to adult survival studies	Lower Granite smolt to adult returns.	NOAA and IDFG	Ongoing
Hydro Evaluations	Downstream passage survival	Representative PIT-tagging and monitoring		Ongoing
	Upstream passage survival	Adult counts, PIT-tag monitoring	IDFG, NOAA, COE	Ongoing
Hatchery	Supplementation	Parr per spawner production from Redfish Lake outplants, other lakes as they are initiated	IDFG, SBT	
		Parr to outmigrant survivals	IDFG	

Types of Programs	Activity	Description	Responsible Entities	Status
Harvest				
Habitat	Salmon River migration survival	Annual survivals of emigrant smolts from lakes to Lower Granite Dam, impact of environmental influences and annual survival rates of returning adults from Lower Granite Dam to the natal lakes	COE, IDFG,NMFS	Ongoing
	Lake production capacity evaluations	Limnological studies, prey dynamics, spatial temporal distribution of kokanee vs. anadromous presmolts	SBT, IDFG	Ongoing
	Status and trend of habitat conditions within historic Sockeye Salmon tributaries	Five year rotating panel design monitoring of key habitat, riparian water quality, and water temperature variables	USFS (PIBO)	Ongoing
Other				

Section 7: Site-Specific Actions

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7. Site-Specific Actions

This section describes a suite of recommended actions that may be necessary to achieve recovery of the Snake River Sockeye Salmon ESU. These actions address the limiting factors and threats described in Section 5. They are also linked to the local and regional recovery strategies described in Section 6. This section begins by acknowledging the importance of recovery actions that have been implemented over the last 20 years. The proposed recovery actions are then summarized briefly, with specific recovery actions identified in Table 7-1. These proposed actions are designed to be integrated with current, ongoing programs and regulations that may benefit Sockeye Salmon and that are described in this Plan, such as current fishery management regulations, state water quality regulations, and U.S. Forest Service forest management practices. Recovery actions addressing research and monitoring for adaptive management are included in Section 11.

Setting Priorities to Implement Recovery Strategies and Actions

Priorities for recovery actions should be guided by viability criteria, best available scientific information concerning ESU status, the role of populations in meeting ESU viability, limiting factors and threats, and likelihood of action effectiveness. In addition, financial resources to implement recovery actions are limited which emphasizes the need to set priorities. Given the numerous recovery actions identified in this Plan, it is critically important to identify priorities for recovery action implementation to guide selection of near-term recovery actions.

Several key principles derived from conservation biology and ecosystem management help frame these priorities. Several scientific studies have illustrated the principle that habitat conditions and aquatic ecosystem function are the result of the interaction between watershed controls (such as geology and climate), watershed processes (such as hydrology and sediment transport), and land use. Scientists and resource managers have recognized that restoration planning that carefully integrates watershed or ecosystem processes is more likely to be successful at restoring depleted salmonid populations (Beechie et al. 2003). The strategy used in this recovery plan focuses on the concepts presented in several salmonid habitat recovery planning documents and scientific studies (e.g., Beechie and Boulton 1999; Roni et al. 2002; Beechie et al. 2003; Roni et al. 2005; Stanley et al. 2005). These principles for sound salmon recovery include:

- Assess, protect and maintain biological and habitat processes.
- Reconnect isolated habitat to increase spatial structure.
- Restore ecological processes.
- Restore degraded habitat used throughout the life cycle.
- Evolutionary processes must be conserved or restored.
- Develop goals and objectives based on a deep understanding of ecological properties of the system.
- Management must be adaptive and minimally intrusive.

The current endangered status of the ESU also frames our recovery efforts. The Plan's goal is to have viable independent populations in at least three or more natal lakes to expand spatial distribution and diversity, and protect the relatively healthy habitat conditions in the Sawtooth Valley. The following features of our recovery strategy continue to influence the sequencing of recovery action implementation:

- **Implement the current captive broodstock program** actions to support conservation of life histories and genetic attributes as described in Section 6.3.1.1.
- **Reestablish self-sustaining anadromous Sockeye Salmon populations in Redfish, Pettit, and Alturas Lakes.** Actions that enhance viability and protection of multiple Sockeye Salmon populations through continued implementation of the Redfish Lake program, implementation of introduction strategies for Pettit Lake and Alturas Lake, and reconnection of isolated habitat to improve spatial structure and diversity as described in Sections 6.3.1.4, 6.3.1.5, and 6.3.1.6. Develop action prioritization criteria and then apply these criteria to develop a multi-year action implementation plan or schedule.
- **Protect and enhance existing habitat conditions and conserve natural ecological processes** that support the viability of the extant populations and their primary life history strategies throughout their entire life cycle. Continued implementation of the Management Plan for the Sawtooth National Recreation Area, together with continued wilderness protections in the Sawtooth Valley will protect habitat processes for the natal lakes watersheds. Additional habitat protection and restoration actions for the migration corridor are identified in Sections 6.3.14 and 6.3.2.5.
- **Improve survival for all life stages in the migration corridor as described in Section 6.3.2.1.**
- **Carry out research, monitoring, and evaluation actions** that provide critical information needed to assess fish viability responses and make adaptive management decisions as needed based on this information. Section 11 identifies the adaptive management approach, together with research, monitoring, and evaluation actions to continually adapt recovery actions over time.

Strategy and Action Prioritization Considerations

Priorities for implementation of recovery strategies and management actions must consider the scientific complexities of addressing the different factors and threats, as well as diverse policy issues and economic implications. Priorities must be science based, but are ultimately policy choices. The following considerations will be used as guidance for the development of criteria, and prioritization and implementation of management strategies and actions for recovery of the Snake River Sockeye Salmon ESU and populations.

Highest priority actions:

- Actions that provide long-term protection of habitat conditions and conservation of natural ecological processes that support the viability of priority populations and their primary life history strategies throughout their entire life cycle. A population is considered a priority if it is critical for ESU viability.
- Actions that protect or enhance viability of multiple Sockeye Salmon populations.
- Actions that support conservation of unique and rare functioning habitats, habitat diversity, life histories, and genetic attributes.
- Actions that target the limiting factors and that contribute the most to closing the gap between current status and desired status of priority populations.
- Actions that provide immediate benefits to enhancing the viability of priority populations.
- Actions that provide critical information needed for assessing success and making adaptive management decisions.

High priority actions, but less than highest:

- Actions that enhance the habitat conditions and restore natural ecological processes of priority populations and their primary life history strategies throughout the entire life cycle.
- Actions that enhance the viability across the entire life cycle of priority populations.
- Actions that are required to protect and enhance habitats for potential populations that are not critical for ESU viability but where reintroduction efforts may be implemented.

Other things being equal, actions that demonstrate the following have enhanced priority:

- Actions where opportunity for success is high (rather than those of limited feasibility).
- Actions that likely produce a large (rather than small) improvement in viability attributes.
- Actions that support restoration of normative ecological processes rather than short-term substitutions for normative processes.
- Actions that are complementary to other land management, water quality, environmental management, and recreational objectives as specified in fish management, conservation, recovery or other plans developed with and supported by regional and subbasin stakeholders (rather than those that are isolated, stand-alone efforts).
- Actions that have regional and local support and generate increased participation.
- Actions that demonstrate cost effectiveness relative to alternative means of achieving the same objectives.
- Actions that have high degree of certainty in effectiveness and outcome.

7.1 Building on Current Efforts

Important recovery actions for Sockeye Salmon are already being implemented. The Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing the BPA, IDFG, the Shoshone-Bannock Tribes, and NMFS, coordinates the ongoing captive broodstock program. This Sockeye Salmon captive broodstock program has been vital to helping the species avoid extinction, and remains an important part of this recovery plan.

In addition, numerous habitat conservation efforts have taken place over the past 20 to 30 years to protect, conserve, and restore Snake River Sockeye Salmon in Idaho. These conservation actions have balanced the biological and ecological needs of the species with the growing economic and resource management demands of the region. Water and land managers, private landowners, public interest groups and others have completed many tributary habitat restoration projects in the Sawtooth Valley and Snake River and Salmon River watersheds using a variety of funding sources. Implementing entities include BPA, Bureau of Reclamation, Natural Resource Conservation Service (NRCS), soil and water conservation districts, the Shoshone-Bannock Tribes, IDFG, U.S. Forest Service, irrigation districts, private landowners, and several public interest groups. Because of the collective habitat and hydropower improvements and education efforts by these various partners, instream, riparian, and upland habitat conditions in many parts of these watersheds continue to improve.

Much of the Salmon River watershed displays near pristine habitat conditions, largely due to the many conservation efforts that have already taken place to protect, conserve, and restore habitats on public and private lands. As a result, the natural ecological processes needed to support a viable Sockeye Salmon population already exist in many areas. In the Sawtooth Valley, Sockeye Salmon natal lakes lie within the Sawtooth National Recreation Area and much of the headwaters of each drainage is designated as wilderness. Overall, habitat conditions for Snake River Sockeye Salmon in these high mountain lakes remain in excellent shape and therefore this important habitat is relatively pristine.

Steps to manage fisheries that could potentially affect Snake River Sockeye Salmon are also in place. Currently there are no fisheries targeting Snake River Sockeye Salmon. Incidental take of Sockeye Salmon in fisheries targeting other species is limited through careful monitoring and evaluation. Actions identified here build on fishery management efforts in the Salmon River basin.

Important hydropower-related efforts that will benefit recovery of Snake River Sockeye Salmon are also underway. As discussed in Section 6, the current mainstem hydro operations, the effects of which are summarized in the Hydro Module (NMFS 2014a), and any further improvements for fish survival that may result through the ongoing FCRPS collaborative process, represent the hydropower recovery strategy for Snake River Sockeye Salmon and all listed salmonids that migrate through the mainstem Columbia River.

NMFS acknowledges the important contributions made through these different efforts and recognizes their crucial role in Snake River Sockeye Salmon recovery. NMFS plans to work with all entities and interested landowners to effectively implement this recovery plan. Achieving recovery will require a cooperative local, regional, and ESU-specific approach that addresses threats to species viability throughout the life cycle — including those that affect tributary and estuary habitats, as well as harvest, hatcheries, and hydropower development and operations. Section10 describes a proposed organizational framework to implement and track implementation of proposed actions described in this recovery plan. Prioritizing recovery actions for Snake River Sockeye Salmon in Idaho would be a primary task of the proposed implementation teams (see Section 10); developed with local input from groups currently doing recovery work.

7.2 Site-Specific Actions to Recover Snake River Sockeye Salmon at the Local Level (Sawtooth Valley and upper Salmon River)

Actions identified in this section address local limiting factors and threats to recovery of the Snake River Sockeye Salmon ESU. The proposed actions are directly linked to the recovery strategies identified in Section 6.3.1. This section is organized by strategy with corresponding actions in the same order presented in Section 6.3.1.

Sections 7.2.1 through 7.2.16 briefly describe the recovery strategies and actions to recover Snake River Sockeye Salmon at the local level (Sawtooth Valley and upper Salmon River). Table 7-1 defines the specific actions proposed under each strategy to address problems for Sockeye Salmon in the natal lakes and upper Salmon River. The table identifies the actions as well as the sites, VSP parameters, limiting factors, and threats that each action targets. The tables also provide estimated costs and potential implementing entities for each action, and priority for implementation. The actions address the limiting factors and threats identified in Section 5.

7.2.1 Conserve Population Genetic and Life History Diversity, and Spatial Structure

The goal of this Snake River Sockeye Salmon Recovery Plan is the restoration of natural Sockeye Salmon populations in Sawtooth Valley lakes. Hatchery production has played a central role in the initial phase of the recovery strategy for the Snake River Sockeye Salmon ESU. Without the reproductive contribution that hatchery fish have made to natural production through the captive broodstock program, this ESU would likely be extinct.

The Redfish Lake Sockeye Salmon Captive Broodstock Program has been vital to helping the population avoid extinction. The captive broodstock program is modeled, to the extent possible, on the population structure, mating protocol, growth, morphology, nutrient cycling, and other biological characteristics of the naturally spawning population. The number of program fish currently released at each life stage is conservative when considered in the context of the system's historical carrying capacity. Paleolimnological information also indicates that the planned release of up to one million smolts from the Springfield Hatchery is also consistent with historical carrying capacity. The genetic focus of the program, and adherence to various central tenets of conservation aquaculture, has enabled program managers to retain approximately 95% of the original founding genetic variability of the population (Kalinowski et al. 2012).

The existing captive broodstock program is now transitioning to a production program that will use anadromous Sockeye Salmon adults collected at Sawtooth Valley weirs as broodstock. This new program will allow gene banking (while captive adults are available) and provide high levels of anadromous adult returns to recolonize available habitat in Redfish Lake, Pettit Lake, and possibly other Sawtooth Valley lakes. Springfield Hatchery will play a central role in this new program. This new Sockeye Salmon smolt-rearing hatchery is capable of producing up to one million full-term smolts annually. Eggs for the expanded smolt program will be produced at the IDFG Eagle Fish Hatchery broodstock station and from increased production from NMFS' facilities in Washington State. Using a conservative smolt-to-adult return rate of 0.50% for hatchery-reared and released smolts (based on empirical program information), managers anticipate that a release of up to one million smolts from the Springfield Hatchery could consistently return an average of 5,000 anadromous adults to the Sawtooth Valley annually. This level of adult returns will help jumpstart demographic processes for the Sockeye Salmon population in Redfish Lake. These expansion efforts are consistent with expectations established through the Biological Opinion developed by NMFS to address risks associated with the operation of the Federal Columbia River Power System. The recovery strategy includes the implementation of this conservation hatchery program, with the intent to balance the adverse short-term impacts on diversity and adaptation to captivity versus the long-term risk of population extirpation.

Captive broodstock (or, if available, hatchery anadromous adults) will also be released into Pettit Lake for a defined period. Steps will be taken to ensure that these adults represent the entire genetic diversity of the broodstock for several years. These initial hatchery releases into Pettit Lake will cease after a few years to evaluate natural production response and refine the reintroduction program (see Section 6.3.1.5).

The recovery strategy for the Alturas Lake population aims to maintain the population's genetically unique early stream spawning characteristics. Actions to restore this early spawning population will be developed based on recommendations from the Sockeye Salmon Implementation and Science Team and SBSTOC and as outlined in Section 6.3.1.6.

Table 7-1 describes proposed hatchery recovery actions to address limiting factors and threats identified in Section 5.3 and Recovery Strategy 6.3.1.1. *Conserve population genetic and life history diversity, and spatial structure.* Proposed hatchery actions include:

1. Continue expansion of Snake River Sockeye Salmon captive brood program.
    a. Fund and support infrastructure needs to increase smolt program to one million smolt release (i.e., at the Springfield Hatchery).
    b. Describe conditions under which trapping would occur at various locations, including Lower Granite Dam.
    c. Fund improvements to temporary adult holding capability at Sawtooth hatchery and Redfish Lake Creek (i.e., associated with operations of the weir).

2. Investigate alternatives and develop actions to support and enhance anadromy of the residual Alturas Lake population.

7.2.2 Increase Naturally Spawning Snake River Sockeye Salmon Abundance

The recovery strategy aims to achieve viable, naturally spawning self-sustaining Sockeye Salmon populations by increasing the number of anadromous adults that spawn naturally in the Sawtooth Valley lakes. The strategy builds on the current captive broodstock program. It implements a coordinated conservation hatchery program focused primarily on achieving population recolonization goals for Redfish Lake. The program includes implementation of the 2011 Springfield Sockeye Salmon Hatchery Master Plan through construction of a new Sockeye Salmon smolt production hatchery (completed in 2013) and implementation of associated program management goals. The Master Plan targets efforts to secure the Redfish Lake population.

The recovery strategy also aims to increase spatial structure of the ESU by restoring natural production of Sockeye Salmon in Pettit, Alturas, and other Sawtooth Valley lakes. Programs for these lakes will be developed to promote the chances of successful reintroduction of sustainable natural production.

The proposed actions involve converting operations to Springfield Hatchery facilities that are capable of rearing up to one million Snake River Sockeye Salmon juveniles to the full-term smolt stage of development. Fish produced at the hatchery will be transported and released in the outlet of Redfish Lake. Adults produced through the captive broodstock program will also be released into Pettit Lake for a defined period. As adult run size increases, the goal is to eliminate redundant facilities (e.g., those needed for captive broodstock) and transition the program to the next phase of implementation.

The program includes monitoring the effects of increased hatchery production on the residual Sockeye Salmon populations. Monitoring will also be used to safeguard against potential risks, including potential genetic and ecological risks, and address uncertainties.

7.2.3 Improve Sockeye Salmon Passage to Natal Lakes

Proposed actions will improve Sockeye Salmon passage to the natal lakes by addressing passage barriers caused by artificial barriers, low stream flow, hatchery practices, and other factors. The actions improve fish passage at the Sawtooth Hatchery weir on the Salmon River. They aim to revise adult holding and handling practices at Redfish Lake Creek to increase returns to Redfish Lake. The proposed actions also seek to examine and address the lake trout management issue for Stanley Lake. They also address concerns regarding Sockeye Salmon passage survival in the Salmon and lower Snake Rivers.

7.2.4 Reestablish a Self-sustaining Anadromous Sockeye Salmon Population in Redfish Lake

Actions to secure the Redfish Lake Sockeye Salmon population form the centerpiece of Phase 2 of the Snake River Sockeye Salmon natural stock reintroduction and adaptation program. Phase 1 focused on establishing anadromous returns from natal origin Redfish Lake Sockeye Salmon stock through a captive broodstock program. That program is poised to transition to Phase 2, with an emphasis on supporting relatively high levels of anadromous return Sockeye Salmon to Redfish Lake. Proposed actions will convert hatchery operations to Springfield Hatchery facilities that are capable of rearing up to one million Snake River Sockeye Salmon juveniles. The actions aim to reestablish a naturally spawning self-sustaining population in Redfish Lake by increasing the number of anadromous adults in the lake. The working hypotheses behind this approach assumes that the natural production that will result from relatively high levels of anadromous hatchery returns will lead to increases in productivity and downstream survivals sufficient to allow for transition to Phase 3, emphasizing natural adaptation. As adult run size to Redfish Lake increases, the goal is to transition to a phase that would focus on maintaining genetic variability and limiting domestication.

7.2.5 Investigate and Develop Strategies and Implement Actions to Support and Enhance Sawtooth Valley Sockeye Salmon Reintroduction and Adaptation Phases for Pettit Lake

Initially, Sockeye Salmon reintroduction efforts will focus primarily on the Redfish Lake population because of its high production potential and the availability of a hatchery stock derived from natal resident production. Adults produced through the captive broodstock program will also be released into Pettit Lake for a defined period based on the recovery strategy described in Section 6.3.1.5. Based on the response to the initial reintroductions and the performance of the Redfish Lake program in promoting natural production, the program for Pettit Lake will also be refined to reestablish a locally adapted population in Pettit Lake. This would include determining whether additional inputs of Redfish Lake fish in Pettit Lake would be warranted, and monitoring programs to track outmigrants and returning spawners.

7.2.6 Investigate and Evaluate the Potential for Restoring Natural Production of Anadromous Sockeye Salmon from returning Kokanee Outmigrants from Alturas Lake

Based on the recovery strategy for reintroduction to Alturas Lake that will be refined in the future, proposed actions may include (1) trap and transport any anadromous adults identified as Alturas Lake origin to Alturas Lake, and the option to subsequently implement a hatchery program at the same time or later by (2) identifying appropriate donor stocks and strategies to establish a new hatchery/captive broodstock program for anadromous Alturas Lake Sockeye Salmon recovery efforts (Section 6.3.1.6). Managers will investigate several alternative strategies for the Alturas Lake kokanee population that will support and enhance anadromy. In the interim, while decisions are being made regarding anadromous Alturas Lake Sockeye Salmon recovery efforts, any ocean-returning Sockeye Salmon identified as of Alturas Lake origin will be transported to Alturas Lake and released.

7.2.7 As Sufficient Numbers of Natural-Origin Adults Return, Develop an Integrated Approach to Manage Natural and Hatchery-Origin Adults in the Hatchery Program and in the Wild

In Phase 3 of the Sockeye Salmon recovery strategy, hatchery activities to assist Sockeye Salmon reintroduction efforts will be transitioned to an appropriate longer-term role emphasizing natural adaptation consistent with maintaining genetic variability and limiting domestication. As natural-origin returns increase, hatchery-origin returns will be reduced by reducing the number of hatchery-origin smolts released. Triggers will be used to determine when hatchery-origin releases should be reduced or eliminated, thereby decreasing risk of the program to the natural population. Research, monitoring, and evaluation activities will also be implemented to assess the effectiveness and outcomes of the program. Collectively, information from these activities will be used to manage the hatchery program adaptively on a yearly basis.

7.2.8 As Sufficient Numbers of Hatchery-Origin Anadromous Adults Return to the Basin, Identify Options for Future Fisheries

As the Sockeye Salmon recovery program is implemented, the return of first generation adults is expected to generate large returns of anadromous hatchery-origin Sockeye Salmon to the Sawtooth Valley. These returns will be beyond levels needed to effectively manage broodstock composition as well as spawner composition in the habitat. The natural production that will result from these high levels of anadromous hatchery returns is expected to lead to increases in relative productivity and overall life cycle survival. Managers can adjust the number of smolts released to manage numbers of returning adults. However, another useful tool to manage returning fish is the potential for state and tribal fisheries on hatchery Snake River Sockeye Salmon.

As returns increase, NMFS will work with the appropriate co-managers to develop a new abundance-based harvest management framework for Snake River Sockeye Salmon. Harvest levels will be calibrated to indicators of species' status that are identified in the Recovery Plan and the operation and planning objectives of the Springfield Hatchery. A new harvest management framework will require decisions about where the harvest may occur along various points in the migration corridor and in the terminal areas. Those allocation choices will be developed by the state and tribal co-managers. Resulting recommendations will be consistent with provisions of the ESA, NEPA, and the *U.S. v. Oregon* Agreement.

7.2.9 Continue Research and Actions to Reestablish Natural Populations in Other Natal Lakes

The Recovery Plan prioritizes the implementation of actions in Redfish Lake, the lake with the greatest production potential. The Recovery Plan also identifies high priority actions in Pettit Lake and Alturas Lake. Considering these priorities and when appropriate, managers will consider potential Sockeye Salmon reintroductions to Stanley and Yellowbelly Lakes. Currently, more information and consideration is needed to identify the role each of these lakes might play in future phases of the reintroduction efforts. For example, in the interim, as anadromous returns increase and connectivity to the upper Sawtooth Valley lakes is restored, it is anticipated that natural recolonization of Yellowbelly Lake may occur. In addition, more planning and evaluation is required to address uncertainties related to the presence of lake trout in Stanley Lake. Reintroduction efforts for Stanley Lake Sockeye Salmon include developing a lake trout management strategy and removal of the barrier at the outlet of Stanley Lake that currently prevents Sockeye Salmon immigration, as well as immigration of other species (e.g., bull trout, suckers, pikeminnow). In addition, more information is needed to understand how varying flow regimes affect Sockeye Salmon migration and passage below and above Yellowbelly Lake. Further actions are also needed to investigate habitat capacity in the lakes, and potential predation and competition issues with non-native trout and kokanee in the lakes.

7.2.10 Continue Research on Natal Lakes' Carrying Capacity, Nutrients, and Ecology

Actions under this strategy continue research and monitoring to understand the limnological characteristics of the Sawtooth Valley lakes and the lakes' carrying capacities for Sockeye Salmon production. The actions build upon research carried out for many years by the Shoshone-Bannock Tribes to assess the period and frequency of lake stratification and subsequent turnover, together with research on lake algal productivity.

The carrying capacity of the natal lakes is believed to be linked to zooplankton levels. Since 1995, the Shoshone-Bannock Tribes have been supplementing Pettit and Alturas Lakes with nitrogen and phosphorus, and controlling non-native kokanee salmon in some years, which compete with Sockeye Salmon for food resources. Based on water quality and biological sampling described in their annual reports (e.g., Kohler et al. 2008), these management strategies are increasing the carrying capacities of the lakes for rearing juvenile Snake River Sockeye Salmon (based on newer genetic information, controlling kokanee salmon populations has been discontinued in Alturas Lake):

- Continue limnological and ecological research and evaluations of the lakes.
- Address nutrients as limiting factors in all lakes used for Sockeye Salmon recovery and study relationship to prey base in natal lakes.
- Research possible competition for food resources or spawning areas in natal lakes.
- Develop a time table and strategy for whole-lake nitrification efforts compatible with reintroduction plans.

7.2.11 Protect and Conserve Natural Ecological Processes at the Watershed Scale that Support Population Viability: Salmon River Habitat and Natal Lakes Watershed

Much of the area surrounding the lakes is designated as wilderness and displays near pristine habitat conditions, largely due to the many conservation efforts that have already taken place to protect, conserve, and restore habitats on public and private lands. As a result, the natural ecological processes needed to support a viable Sockeye Salmon population already exist in many areas. Actions aim to maintain current protection and consistently apply best management practices and existing laws to protect and conserve natural ecological processes. Actions to apply best management practices will also work to improve natural ecological processes and functions in degraded areas.

These recommended recovery actions have been compiled from available publications (e.g., hatchery operating plan, listing decisions, agency work plans, sub-basin plans, FCRPS BiOp actions and USFS forest management plans, and from meetings and discussions with local biologists and natural resource specialists from IDFG, Shoshone-Bannock Tribes, USFS, NRCS, SWCD, BPA, and others).

7.2.12 Protect, Restore, and Manage Spawning and Rearing Habitat

Actions that protect and conserve natural ecological processes will also act to protect spawning and rearing habitats in the natal lakes. These actions include maintaining current wilderness protection in the natal lakes watersheds in the Sawtooth National Recreation Area. Additional actions aim to conserve rare and unique habitats for Sockeye Salmon. The actions will also improve water quality and address other concerns by consistently applying best management practices and existing laws. In addition, research and monitoring actions will help determine if spawning and rearing habitat at the different lakes is adequate to meet Sockeye Salmon abundance goals.

7.2.13 Maintain Unimpaired Water Quality and Improve Water Quality as Needed

Limnology studies conducted in Stanley, Redfish, Yellowbelly, Pettit, and Alturas Lakes since 1991 indicate that water quality in all five lakes generally provides suitable rearing habitat for juvenile Sockeye Salmon, although zooplankton levels in the lakes can vary considerably. There is always a potential risk, however, that recreational use on the lakes and lakeshores could result in a chemical spill, or otherwise damage Sockeye Salmon spawning and rearing habitat. In addition, some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment levels that could restrict Sockeye Salmon production and survival.

Recovery actions call to maintain current protection and consistently apply best management practices and existing laws to protect unimpaired water quality, improve degraded water quality, and minimize potential risks.

7.2.14 Investigate and Improve Conditions in Salmon River and Tributaries to Support Increased Survival of Migrating Snake River Sockeye Salmon

Adult Sockeye Salmon usually arrive in the Salmon River when flows are low and water temperatures reach their highest levels. Monitoring efforts suggest that high water temperatures in some reaches of the Salmon River may be impacting adult Sockeye Salmon migration survival; however, it is not clear where this occurs. Currently, the stretch of the Salmon River from Redfish Creek to Valley Creek is included on IDEQ's 2010 303(d) list due to elevated water temperatures and sediment levels above levels needed to support cold-water aquatic life. High water temperatures may also limit survival of migrating Sockeye Salmon in the lower Snake River above Lower Granite Dam.

Juvenile Sockeye Salmon losses also occur in the Salmon River, particularly in reaches between release sites and the North Fork Salmon confluence. Predation appears to be a primary cause for these losses but other factors contribute to the losses.

Recovery actions call for continued investigation to determine the impact of high water temperatures on the survival of migrating adult Sockeye Salmon in the Salmon and lower Snake Rivers. They also call for continued investigations of juvenile Sockeye Salmon migration to determine where and why losses are occurring. Actions will also improve stream tributary habitat leading from natal lakes to the Salmon River in the Sawtooth Valley through habitat restoration on public and private lands. Actions will also be taken to restore habitat along the lower Snake River mainstem above Lower Granite Dam.

Further, new information on the best methods for improving salmon habitat in the face of climate change will be used to help define and prioritize habitat restoration actions. New climate change research, such as Beechie et al. (2012), describes the best methods to apply for restoring salmon habitat in particular types of environments. Researchers found that restoring floodplain connectivity, restoring stream flow regimes, and regrading incised channels are the actions most likely to ameliorate stream flow and temperature changes, and increase habitat diversity and population resilience.

7.2.15 Monitor and Control Predation, Disease, Aquatic Invasive Species, and Competition and Develop Actions as Needed

Actions that reduce predation, disease, and competition by introduced stocks on Snake River Sockeye Salmon should enhance the probability that the ESU can be recovered to a self-sustaining population. Ecological theory and confirming studies on Sockeye Salmon indicate that competition for food resources is greater within, than between species (Hartman and Burgner 1972, Reiman and Myers 1992, Rich et al. 2009, Hyatt and Stockner 1985). This suggests that population growth of anadromous Snake River Sockeye Salmon in Sawtooth Valley lakes may be limited by intraspecific competition for food resources with native and introduced kokanee (resident life history strategy). Actions proposed to reduce introduced kokanee numbers in lakes targeted for recovery of Snake River Sockeye Salmon should enhance the survival of the listed ESU by reducing food resource competition. Similarly, actions to reduce the number of other introduced species that compete with or prey on anadromous Snake River Sockeye Salmon should also enhance the ESU’s chances for recovery. Actions to continue evaluations of the carrying capacity within the different lakes and biomass will help determine overall levels of competition between kokanee and Sockeye Salmon and identify appropriate management actions.

Actions also address concerns regarding invasive species, such as zebra and quagga mussels, Eurasian water Milfoil, and Chytrid fungus. The Idaho Department of Agriculture coordinates activities across the state to prevent aquatic species infestations by working with state and Federal agencies, local governments and non-governmental organizations. The Sawtooth National Forest works with the Idaho Department of Agriculture to maintain a seasonal boat inspection station at the Redfish Lake Sandy

Beach boat ramp. It is critically important that such efforts continue to prevent introductions of highly invasive aquatic species, such as quagga and zebra mussels.

7.2.16 Create an Adaptive Management Feedback Loop to Track Progress and Refine Strategies and Actions

This Plan identifies actions to track progress, define weaknesses, and adjust course appropriately. Section 11 describes research, monitoring, and evaluation actions to support adaptive management for the recovery of the Snake River Sockeye Salmon ESU. Section 10 describes a proposed framework for coordinating implementation of the Plan and identifies the teams that will oversee implementation. The Snake River Sockeye Salmon Implementation and Science Team will be responsible for coordinating implementation of the Adaptive Management and Research, Monitoring, and Evaluation Plan.

Table 7-1. Summary of proposed local-level (Sawtooth Valley and upper Salmon River) recovery actions (see Box 6-1 for recovery strategies listed below).

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	VSP* Parameter Addressed	Limiting Factors Addressed	Threats Addressed	Life Stages Affected	Estimated Costs ($K/year)	Timing (near, mid and long-term)	Potential Implementing Entity**	Comments
Recovery Strategy 7.2.1: Conserve population genetic and life history and spatial structure										
7.2.1-1	1. Continue to fund annual operation of the Sockeye Salmon captive broodstock propagation program.	Sawtooth Valley	A, D	Reduced abundance	Reduced abundance	All life stages	3,014	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-2	2. Fund modifications to Sawtooth Hatchery weir to improve Sockeye Salmon trapping efficiency and provide adult access to upper salmon nursery lakes.	Sawtooth Valley	A, SS, D	Reduced abundance, straying	Hatchery weir operation	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	Capital project; Could be reduced abundance if fish don't enter the trap and stray or spawn in other locations.
7.2.1-3	3. Determine additional detection needs (e.g., PIT-tag detectors) in the Salmon River.	Salmon River	A	Reduced migration survival	Downstream mortality	Juvenile outmigrants; adult returns	To be Determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-4	4. Describe conditions under which trapping would occur at various locations, including Lower Granite Dam.	Snake River	A, D	Reduced migration survival	Upstream mortality	Adult returns			IDFG, NMFS, Shoshone-Bannock Tribes	This is currently being developed.
7.2.1-5	5. Determine changes in marking/tagging levels for increased precision to	Salmon R.	A	Reduced migration survival	Downstream mortality	Juvenile	To be Determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	

	evaluate downstream sources of mortality.									
7.2.1-6	6. In the near term at Sawtooth Hatchery, identify ways to improve handling of adults to collect genetic data of fish returning to Alturas Lake, Pettit Lake or Redfish Lake.	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Hatchery weir operation	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-7	7. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to return to natal lake of origin.	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Hatchery weir operation	Juvenile outmigrants; adult returns	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	Also a predation issue.
7.2.1-8	8. Maintain current marking/tagging levels.	Sawtooth Valley	A	Reduced migration survival	Reduced population structure	Juvenile		Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-9	9. Identify lake of origin for adults returning to basin collection facilities.	Sawtooth Valley	SS, D	Reduced population structure	Reduced population structure	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-10	10. Mark sufficient numbers of outmigrants from each lake to enable collection of returning spawners specific to lake of origin.	Sawtooth Valley	SS, D	Reduced population structure	Reduced population structure	Juvenile outmigrants	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-11	11. Continue to sort returning adults at basin	Sawtooth Valley	SS, D	Reduced population	Reduced population	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-	

	weirs based on marks identifying lake of origin.			structure	structure				Bannock Tribes	
7.2.1-12	12. Transport returning adults to lake of origin or to hatchery program based on lake of origin or allow passage of adults.	Sawtooth Valley	SS, D	Reduced population structure	Reduced population structure	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.1-13	13. Develop guidance and recommendations for a preferred recovery strategy (ies) for *O. nerka* life history forms of Snake River Sockeye Salmon.	Sawtooth Valley	D,SS	Reduced population structure	Reduced population structure	All life stages	Not Applicable	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	Technical staff and policy action.
7.2.1-14	14. Develop long-term guidelines to support and maintain localized adaptations within and among populations.	Sawtooth Valley	D,SS	Reduced population structure	Reduced population structure	All life stages	Not applicable	Near-term	NMFS	Technical staff and policy action.
7.2.1-15	15. Investigate and address known or potential spawning security threats from lake and lakeshore recreation uses and/ or developments.	Sawtooth Valley Lakes	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading recreation uses	Adult spawning, incubation, early juvenile	To be determined	Mid-term	USFS, NMFS, IDFG	
Recovery Strategy 7.2.2: Increase naturally spawning Snake River Sockeye Salmon abundance										
7.2.2-1	1. Manage Springfield Hatchery to meet Sockeye Salmon	Sawtooth Valley	A	Reduced abundance	Reduced abundance	All life stages		Near-term	IDFG	Springfield Hatchery opened in 2013.

	recovery goals.									
7.2.2-2	2. Increase annual hatchery smolt releases to 1 million through funding of additional hatchery facility(ies).	Sawtooth Valley	A	Reduced abundance	Reduced abundance	All life stages		Near-term	IDFG, BPA	
7.2.2-3	3. Replace Redfish Lake weir and trap to allow handling and holding of larger adult returns 3.5. Modify the Sawtooth Hatchery weir to improve Sockeye Salmon trapping efficiency and provide adult access to upper salmon nursery lakes.	Redfish Lake	A,P	Hatchery-related adverse effects	Hatchery operations' limited space	Adult returns	To be Determined	Near-term	IDFG, BPA	
7.2.2-4	4. Increase adult holding capacity at Sawtooth Hatchery to provide separate holding for Sockeye Salmon and improve fish passage so fish more readily enter the trap.	Sawtooth Valley	A, SS, D	Reduced abundance, straying, Hatchery-related adverse effects	Hatchery weir operation, Hatchery operations' limited space	Adult	To be determined	Near-term	IDFG	
7.2.2-5	5. Develop plan describing objectives for Pettit Lake, e.g., will the program use Redfish Lake fish in Pettit Lake,	Pettit Lake	SS, D	Reduced population structure	Reduced abundance; Reduced population structure	All life stages	Not Applicable	Near-term	IDFG, Shoshone-Bannock Tribes	Technical staff and policy issue.

	and what life stage(s) to release into Pettit Lake.									
7.2.2-6	6. Mark sufficient numbers of outmigrants from Pettit and Alturas Lakes to enable collection of returning spawners specific to this lake.	Pettit Lake	SS, D	Reduced population structure	Reduced abundance	Juvenile outmigrants	To be determined	Near-term	IDFG, Shoshone-Bannock Tribes	
7.2.2-7	7. Transport returning adults identified as originating from Pettit and Alturas Lakes to that lake, or pass above weir for volitional migration, or retain as broodstock specific for Pettit and Alturas Lake releases.	Pettit Lake	SS, D	Reduced population structure	Reduced abundance; Reduced population structure	Adult	To be determined	Mid-term	IDFG	
Recovery Strategy 7.2.3: Improve Sockeye Salmon passage to natal lakes										
7.2.3-1	1. In the near term at Sawtooth Hatchery, identify ways to improve adult holding and handling of fish returning to Alturas Lake, Pettit Lake, or Redfish Lake.	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Hatchery weir operation	adult returns	Not Applicable	Near-term	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue; technical staff and policy issue.
7.2.3-2	2. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to enter	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Hatchery weir operation	adult returns	To be determined	Near-term	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue.

	natal lakes.									
7.2.3-3	3. Reestablish adult passage at Stanley Lake.	Stanley Lake	SS, D	Impaired fish passage	Barrier	Adult returns; juvenile outmigrants	To be determined	Mid-term	IDFG, BPA, USFS	
7.2.3-4	4. Manage lake trout in Stanley Lake to minimize threats to Sockeye Salmon and remove barrier to volitional Sockeye Salmon passage.	Stanley Lake	SS, D	Impaired fish passage	Barrier	Adult returns; juvenile outmigrants	Not applicable	Mid-term	IDFG, USFS, Shoshone-Bannock Tribes, NMFS	Technical staff and policy issue.
7.2.3-5	5. Investigating passage survival and mortality factors during migration between natal lakes and Lower Granite Dam.	Salmon River Lower Snake River	SS,D	Impaired fish passage, Impaired water quality, predation	Irrigation diversions and land use practices	Adult returns; juvenile outmigrants	To be determined	Near-term	IDFG, NMFS, IDEQ	
7.2.3-6	6. Improve instream flows in the Salmon River above the Sawtooth Hatchery to Alturas Lake Creek by improving irrigation efficiencies, using IDWR water bank and other conservation tools.	Sawtooth Valley	SS, D	Impaired fish passage and water quality	Irrigation diversions and land use practices	Adult returns; juvenile outmigrants	To be Determined	Mid-Term	IDFG, IDWR, NMFS, USFS, Custer/Blaine Counties	
7.2.3-7	7. Collect information about new pond development and stream flow in the Sawtooth	Sawtooth Valley	SS, D	Impaired fish passage; water quality	Irrigation diversions, land use practices,	Adult returns; juvenile outmigrants	To be determined	Mid-Term	IDFG, IDWR, NMFS, USFS	

	Valley and identify next steps to address these issues.				pond development					
Recovery Strategy 7.2.4: Reestablish a self-sustaining anadromous Sockeye Salmon population in Redfish Lake										
7.2.4-1	1. Manage Springfield Hatchery to meet Sockeye Salmon recovery goals.	Redfish Lake	A	Reduced abundance	Reduced abundance	All life stages		Near-term	IDFG	Springfield Hatchery opened in 2013.
7.2.4-2	2. Replace Redfish Lake weir and trap to allow handling and holding of larger adult returns.	Redfish Lake	A,P	Hatchery-related adverse effects	Hatchery operations' limited space	Adult returns	To be determined	Near-term	IDFG	
7.2.4-3	3. Once adequate and consistent returns of anadromous adults are achieved, phase out the use of Redfish lake captive broodstock.	Redfish Lake	A, D			Adult returns	To be determined		IDFG, NMFS	
7.2.4-4	4. Implement Redfish Lake Complex Road and Bridge Reconstruction: Redfish Road relocation, phase II; Redfish Northshore reconfiguration/ reconstruction; Visitors Center parking relocation; replace in-channel vehicle bridge with pedestrian bridge.	Redfish Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading land use practices	Adult spawning, incubation, early juvenile	To be determined	Near-term	USFS	NEPA planning complete. Outcomes include core objectives to reconfigure the entire North Shore / VA facilities to restore and maintain appropriate shoreline conditions. Listed in prerequisite order.

7.2.4-5	5. Complete Sockeye Campground renovation.	Redfish Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading land use practices	Adult spawning, incubation, early juvenile	To be determined	Near-term	USFS	NEPA planning complete. Would improve shore conditions within facility adjacent to Sockeye Beach. Includes sockeye interpretive facilities.
7.2.4-6	6. Implement active restoration objectives at Sandy Beach boat launch/day use.	Redfish Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading land use practices	Adult spawning, incubation, early juvenile	To be determined	Mid-term	USFS	Would reverse deteriorating shoreline conditions within facility adjacent to Sockeye Beach.
7.2.4-7	7. Implement physical and administrative changes at Redfish Inlet Campground, dispersed camping, and trailhead area.	Redfish Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading land use practices	Adult spawning, incubation, early juvenile	To be determined	Mid-term	USFS	Would reverse deteriorating shoreline conditions within facility adjacent to Sockeye Beach.
7.2.4-8	8. Implement Redfish Lake complex trail system.	Redfish Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat degrading land use practices	Adult spawning, incubation, early juvenile	To be determined	Mid-term	USFS	Would reverse deteriorating shoreline conditions adjacent to inlet spawning areas.
7.2.4-9	9. Identify impacts due to mooring and coordinate with County to develop mitigation plan.	Redfish Lake	A, P	Degraded water quality, ecological processes	Potential habitat degrading land use practices, pollutant risks	Spawning, incubation, early juveniles		Near-term	USFS and county	

Recovery Strategy 7.2.5: Investigate and develop strategies for future actions to support Sawtooth Valley Sockeye Salmon reintroduction and adaptation for Pettit Lake										
7.2.5-1	1. Release adults produced through the captive broodstock program into Pettit Lake for a defined period.	Pettit Lake	A,P,SS	Reduced population structure	Reduced population structure	All life stages	To be determined	Near-term	IDFG, NMFS	
7.2.5-2	2. Refine program as needed to reestablish a locally adapted population in Pettit Lake.	Pettit Lake	SS,D	Reduced population structure	Reduced population structure	All life stages	To be determined	Mid-term	IDFG, NMFS	
7.2.5-3	3. Investigate and address potential water quality threats from lakeshore recreation residences.	Pettit Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential introduction of toxics	Adult spawning, incubation, early juvenile	To be determined	Long-term	USFS, IDEQ	Could require new infrastructure or relocation of some facilities.
7.2.5-4	4. Complete removal of former barrier.	Pettit Lake	A, P	Potential loss/ degradation of high quality habitat	Habitat degrading facilities	Juvenile outmigrants; adult returns	To be determined	Long-term	Shoshone-Bannock Tribes, USFS	Remove remaining barrier abutments, etc., that occupy streamside habitats.
Recovery Strategy 7.2.6: Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning kokanee outmigrants from Alturas Lake										
7.2.6-1	1. Determine appropriate strategies and actions for restoring natural production in Alturas Lake. Options may include trap and transport or establishing a new hatchery program.	Alturas Lake	SS,D	Reduced population structure	Reduced population structure	All life stages		Near-term	NMFS, IDFG, SBSTOC	This is a key information need that will also be included in Section 11 RM&E. Same as # 14 above.
7.2.6-2	2.Determine whether	Alturas Lake			Reduced		To be			

	Alturas Lake still contains anadromous or residual genetic resources.		SS,D	Reduced population structure	population structure	All life stages	Determined	Near-term	NMFS, IDFG, SBSTOC	
7.2.6-3	3. Implement Smokey Bear Campground and boat launch shoreline protections.	Alturas Lake	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Habitat degrading facilities; potential habitat degradation land use practices	Spawning, incubation, early juvenile, juvenile outmigrants, adult returns	To be determined	Near-term	USFS	Would reverse deteriorating shoreline habitat conditions adjacent to historic shoal spawning areas.
Recovery Strategy 7.2.7: As sufficient numbers of natural-origin adults return, develop integrated approach to manage natural- and hatchery-origin adults in the hatchery program and the wild										
7.2.7-1	1. Examine the benefits and/or risks of alternative strategies for recovering extant and/or historical life-history patterns in the natal lakes.	Sawtooth Valley	SS,D	Reduced population structure	Reduced abundance	All life stages	Not applicable		Shoshone-Bannock Tribes, IDFG, NMFS	Technical staff and policy issue.
7.2.7-2	2. Develop long-term guidelines to support and maintain localized adaptations within and among populations.	Sawtooth Valley	D,SS	Reduced population structure	Reduced population structure	All life stages	Not Applicable	Near-term	NMFS, IDFG	Technical staff and policy issue.
7.2.7-3	3. Manage Springfield Hatchery to meet Sockeye Salmon recovery goals.	Redfish Lake	A	Reduced abundance	Reduced abundance	All life stages		Near-term	IDFG	Springfield Hatchery opened in 2013.
7.2.7-4	4. Once adequate and consistent returns of anadromous adults are	Redfish Lake	A	Reduced abundance	Reduced abundance	Adults	To be determined	Mid-term	IDFG, NMFS, Shoshone-Bannock Tribes	

	achieved, phase out the use of Redfish lake captive broodstock.									
Recovery Strategy 7.2.8: As sufficient numbers of hatchery-origin anadromous adult's return to the basin, identify options for future harvest.										
7.2.8-1	1. Develop a new abundance-based harvest management framework for Snake River Sockeye Salmon.	Sawtooth Valley Salmon River	A	Reduced population structure	Competition Predation	Adults	To be determined	Mid-term	NMFS, IDFG, Shoshone-Bannock Tribes and other appropriate co-managers	
Recovery Strategy 7.2.9: Continue research and actions to reestablish natural populations in other natal lakes										
7.2.9-1	1. Develop plan describing objectives for Pettit Lake, e.g., whether or not the program would use Redfish Lake fish in Pettit Lake, and what life stage(s) to release into Pettit Lake.	Pettit Lake	SS, D	Reduced population structure	Reduced abundance; Reduced population structure	All life stages	Not applicable	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	Technical staff and policy issue.
7.2.9-2	2. Mark sufficient numbers of outmigrants from Pettit Lake to enable collection of returning spawners specific to this lake.	Pettit Lake	SS, D	Reduced population structure	Reduced abundance	Juvenile outmigrants	To be determined	Mid-term	Shoshone-Bannock Tribes; IDFG	Same as No. 1 above.
7.2.9-3	3. Construct juvenile/adult trapping structure in Alturas Lake Creek.	Alturas Lake Creek	A, P	Reduced population structure	Reduced abundance	Juvenile outmigrants	To be Determined	Mid-term	BPA, IDFG, Shoshone-Bannock Tribes	
7.2.9-4	4.Improve/replace	Pettit Lake	A, P	Reduced	Reduced	Juvenile		Mid-term	BPA	

	juvenile trapping structure in Pettit Lake Creek.	Creek		population structure	abundance	outmigrants	To be determined		Shoshone-Bannock Tribes	
7.2.9-5	5. Identify lake of origin from adults returning to basin collection facilities.	Sawtooth Valley	A, P	Reduced population structure	Reduced abundance	Adults	To be determined	Near-term	IDFG	
7.2.9-6	6.Continue to sort returning adults at Sawtooth weir, based on marks identifying source of outmigrant.	Sawtooth Valley	A, P	Reduced population structure	Reduced abundance	Adults	To be determined	Near-term	IDFG	
7.2.9-7	7.For returning spawners that are to spawn in upper basin lakes, pass for volitional migration or transport to appropriate lake.	Sawtooth Valley	A, P	Reduced population structure	Reduced abundance	Adults	To be Determined	Near-term	IDFG, Shoshone-Bannock Tribes	
7.2.9-8	8. Investigate strategies to enhance and support anadromy in extant Alturas Lake early stream spawning Sockeye Salmon.	Alturas Lake	A, P	Reduced population structure	Reduced abundance	Adult	Not applicable	Near-term	IDFG; SBSTOC, NMFS	Technical staff and policy issue.
7.2.9-9	9. Continue limnological and ecological research and evaluations of the lakes.	Sawtooth Valley lakes	A, P	Reduced population structure	Reduced abundance	Juvenile outmigrants		Near-term	Shoshone-Bannock Tribes	
7.2.9-10	10. Address nutrients as limiting factors in all lakes used for Sockeye	Sawtooth Valley lakes	A, P	Reduced population structure	Reduced abundance	Juvenile outmigrants		Near-term	Shoshone-Bannock Tribes	

	Salmon recovery and study relationship to prey base in natal lakes.									
7.2.9-11	11. Investigate and manage risks to native kokanee in Stanley Lake: i.e., outlet barrier, lake trout and non-native kokanee.	Stanley Lake	A, P	Reduced population structure	Reduced abundance	Juvenile outmigrants	To be determined	Near-term	IDFG, NMFS	
7.2.9-12	12. Research possible competition for food resources or spawning areas in natal lakes.	Sawtooth Valley lakes		Reduced population structure	Reduced abundance	All life stages	To be determined		Shoshone-Bannock Tribes	
7.2.9-13	13. Determine appropriate broodstock and strategies for recovery of Sockeye Salmon in Stanley Lake .	Stanley Lake	SS,D	Reduced population structure	Reduced population structure	All life stages	To be determined	Near-term	NMFS, IDFG, SBSTOC	This is a key information need that will also be included in Section 11 RM&E.
7.2.9-14	14. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to enter natal lakes.	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Hatchery weir operation	adult returns	Not applicable	Near-term	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue.
7.2.9-15	15. Manage lake trout in Stanley Lake to minimize threats to Sockeye Salmon and remove barrier to volitional Sockeye Salmon passage.	Stanley Lake	A, SS, D	Predation	Barrier	Adult returns	Not applicable		IDFG, USFS, NMFS	

7.2.9-16	16.Based on resolution of lake trout management , develop a program for Stanley Lake to support Sockeye Salmon recovery.	Stanley Lake	SS.D	Reduced population structure and distribution	Barrier	Adult returns; juvenile outmigrants	To be determined	Mid-term	SBSTOC, IDFG, NMFS	
7.2.9-17	17. Reestablish adult passage at Stanley Lake.	Stanley Lake	SS, D	Impaired fish passage	Barrier	Adult returns; juvenile outmigrants	To be determined	Mid-term	IDFG, BPA, USFS	
Recovery Strategy 7.2.10: Continue research on natal lakes' carrying capacity, nutrients and ecology										
7.2.10-1	1. Conduct limnological studies to evaluate nursery lake habitat conditions encountered by adult and juvenile Sockeye Salmon during freshwater phase.	Sawtooth Valley	A, P	Predator-Prey, Intraspecific Competition, Nutrient conditions	Current habitat conditions, Fish and wildlife management	Adult, juvenile		Near-term	Shoshone-Bannock Tribes	
7.2.10-2	2. Determine if lake fertilization is necessary for each lake used for Sockeye Salmon recovery, and, if warranted, develop and implement a plan to fertilize lakes to increase rearing habitat productivity.	Sawtooth Valley	A,P	Food availability; food quality	Food resource competition	Juvenile rearing		Near-term	NMFS, IDFG, Shoshone-Bannock Tribes	The selection of lakes to fertilize should align with the IDFG Master Plan and its implementation.
7.2.10-3	3. Develop and implement a study in	Yellowbelly Lake	A,P	Food availability;	Food resource competition	Juvenile rearing	To be Determined	Mid-term	Shoshone-Bannock Tribes	

	Yellowbelly Lake to evaluate lake carrying capacity of Sockeye Salmon in the absence of resident kokanee.			food quality						
7.2.10-4	4. Continue limnological and ecological research and evaluations of the lakes reduced population structure, distribution, abundance, diversity.	Stanley and Yellowbelly Lakes	A, P	Food availability; food quality	Food resource competition	Juvenile rearing		Near-term	Shoshone-Bannock Tribes	
Recovery Strategy 7.2.11: Protect and conserve natural ecological processes at the watershed scale that support population viability										
7.2.11-1	1. Construct and maintain NMFS-approved fish screens.	upper Salmon River	A, P	Altered hydrology	Irrigation withdrawals	Juvenile outmigrants; adult returns	To be determined	Near-term	NMFS, IDFG, SWCDs, Irrigation Districts	Identify costs based on each fish screen design and specifications.
7.2.11-2	2. Maintain current wilderness protection for the ESU in the Sawtooth Wilderness area and protect the currently pristine watershed habitat.	Sawtooth Wilderness area	A, P	Potential loss/ degradation of high quality habitats	Potential Recreation Disturbance	Juvenile outmigrants; adult returns		Mid-term	USFS	
7.2.11-3	3. Continue to implement the Sawtooth National Recreation Area's Management Plan and restoration actions.	Sawtooth National Recreation Area	A, P	Potential loss/ degradation of high quality habitats	Potential Recreation Disturbance	Juvenile outmigrants; adult returns		Mid-term	USFS	
7.2.11-4	4. Implement BMPs to protect and conserve	Sawtooth Valley	A, P	Potential loss/ degradation of	Potential Recreation	Juvenile outmigrants;	To be determined	Mid-term	USFS, SWCDs, Counties,	

	ecological processes.			high quality habitats	Disturbance	adult returns			landowners	
7.2.11-5	5. Implement public education and interpretation actions	Sawtooth Valley	A,P,SS, D	Potential loss/ degradation of high quality habitats	Potential disturbance	Juveniles and adults	To be determined		USFS, SWCDs, NMFS	
Recovery Strategy 7.2.12: Protect, restore and manage spawning and rearing habitat										
7.2.12-1	1. Maintain appropriate protections to manage lakeshore recreation to minimize any potential disturbance in areas where Sockeye Salmon spawn.	Sawtooth Valley	A, P	Potential loss/ degradation of high quality habitats	Recreation Disturbance	Adult spawning; incubation; early juvenile		Mid-term	USFS, IDFG	
7.2.12-2	2. Maintain appropriate protections to continue to protect, restore and maintain spawning and rearing habitat.	Sawtooth Valley	A,P	Potential loss/ degradation of high quality habitats	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns		Mid-term	USFS, county	
7.2.12-3	3. Maintain current wilderness protection in Sawtooth Wilderness Area.	Sawtooth Valley	A, P	Potential loss/ degradation of high quality habitats	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns		Mid-term	USFS	
7.2.12-4	4. Continue appropriate protections to manage other human development to restore or maintain native vegetation that provides	Sawtooth Valley	A, P	Potential loss/ degradation of high quality incubation and rearing habitat	Potential Recreation Disturbance	Adult spawning; incubation; early juvenile		Mid-term	USFS, IDFG	

	naturally resilient and productive shoreline habitat.									
7.2.12-5	5. Identify ways to maintain current protections for Sockeye Salmon critical habitat in the future, if ESU is delisted.	Sawtooth Valley	A, P	Potential loss/ degradation of high quality incubation, spawning, rearing habitat	Potential habitat-degrading land use practices	Adult spawning; incubation; early juvenile	To be determined	Mid-term	USFS, IDFG, County	This is important because critical habitat protection will no longer be designated when ESU is not listed.
Recovery Strategy 7.2.13: Maintain unimpaired water quality and improve water quality as needed										
7.2.13-1	1. Continue to manage recreational use and motorized boat activity to minimize the risk of fuel spill and introduction of wastewater contaminants into lakes.	Sawtooth Valley	A,P	Potential loss/Degradation of high quality spawning/incubation habitat	Potential introduction of Toxics	Adult spawning; incubation; early juvenile		Mid-term	USFS, IDFG	
7.2.13-2	2. Implement TMDLs for impaired water bodies in Salmon River watershed.	Salmon River watershed	A, P	Degraded water qual.; altered sediment routing	Agriculture development; irrigation, livestock grazing	Juvenile outmigrants; adult returns	To be determined	Near-term	IDEQ	
7.2.13-3	3. Monitor contaminants to determine whether there is residual contamination with Toxaphene in three lakes or arsenic contamination in Alturas Lake.	Sawtooth Valley	A,P	Potential loss/Degradation of high quality spawning/incubation habitat	Potential introduction of Toxics	Adult spawning; incubation; early juvenile	To be determined	Long-term	IDEQ	
7.2.13-4	4. Improve water quality	Salmon	A, P	Degraded	Agriculture	Juvenile	To be	Mid-term	SWCDs, USFS	

	(sediment) to maintain, enhance and restore fish habitat and passage.	River basin		water qual.; altered sediment routing	development; irrigation, livestock grazing	outmigrants; adult returns	determined			
7.2.13-5	5. Improve water quality (sed., temp.) between Redfish Lake Creek and East Fork Salmon River.	Salmon River	A	Degraded water qual.; altered sediment routing	Agriculture development; irrigation, livestock grazing, roadways	Juvenile outmigrants; adult returns	To be determined	Mid-term	SWCDs, IDFG, Shoshone-Bannock Tribes	
7.2.13-6	6. Increase stream flow to improve hydrology by implementing water conservation measures, improved water delivery, and improving water storage function of riparian areas and wetlands.	Salmon River (between East Fork confluence and the headwaters)	A	Altered hydrology, Elevated water temperature, Reduced stream flow	Irrigation withdrawals	Juvenile outmigrants; adult returns	To be determined	Mid-term	IDFG, SWCDs, Irrigation Districts, landowners	
7.2.13-7	7. Collect information about effects of new pond development on stream flow and water quality. Identify next steps to address these issues.	Sawtooth Valley and Salmon River	A,P	Degraded water quality, elevated temperature; altered sediment routing	Pond development	Spawning; incubation; juveniles; outmigrants, adult returns	To be determined		SWCDs, IDEQ, USFS	

7.2.13-8	8. Implement Stanley Lake Recreation Complex Reconstruction: Construct new upland campground loop; remove Stanley Inlet campground/ boat launch; construct sustainable shoreline trail system; configure dispersed recreation.	Stanley Lake	A, P	Potential loss/ degradation of high quality incubation, spawning and rearing habitat	Habitat degrading facilities; potential habitat degrading land uses	Spawning, incubation, early juvenile, outmigrants, adult returns	To be determined	Near-term	USFS	NEPA planning complete. Sustainable habitat restoration a core objective of project. Near-term to leverage current NEPA decision and funding opportunities. Listed in prerequisite order.
7.2.13-9	9. Investigate options for how to curtail threats from temperature pollutants via a moratorium on new pond development.	Sawtooth Valley	A, P	Degraded water quality, altered sediment routing	Residential/ agricultural pollutants	Juvenile outmigrants, adult returns	To be determined	Near-term	IDWR board, IDWR, USFS, IDEQ	Aesthetics, irrigation and stock ponds.
Recovery Strategy 7.2.14: Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Snake River Sockeye Salmon										
7.2.14-1	1. Protect and enhance stream tributary habitat leading from natal lakes to the Salmon River in the Sawtooth Valley.	upper Salmon River and tributaries	A	Potential loss/ degradation of high quality habitats	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns	To be determined	Near-term	USFS	
7.2.14-2	2. Protect and enhance watershed habitat to promote natural processes and watershed function.	Salmon and Lower Snake Rivers	A, SS	Potential loss/ degradation of high quality habitats	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns	To be determined	Near-term	USFS	
7.2.14-3	3. Implement existing agreements on Federal	upper Salmon	A, SS	Potential loss/ degradation of	Potential habitat-	Juvenile outmigrants;	Baseline	Near-term	USFS	

	lands in the Sawtooth Valley and Salmon River watersheds.	River and tributaries; Sawtooth Valley		high quality habitats	degrading land use practices	adult returns				
7.2.14-4	4. Identify specific actions and responsible parties/entities to improve water quantity and the quality of juvenile and adult migration corridor habitats and monitor the actions.	Especially in upper reaches of the mainstem Salmon River and mainstem lower Snake River	A, SS	Altered hydrology, Elevated water temperature, Reduced stream flow	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns	To be determined	Near-term	USFS	
7.2.14-5	5. Investigate the relatively high losses of juvenile and adult Sockeye Salmon in the Salmon River and identify actions that could reduce these losses.	Salmon River	A, SS	Altered hydrology, Elevated water temperature, Reduced stream flow	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns	To be determined	Near-term	NMFS, IDEQ	
7.2.14-6	6. Continue to implement monitoring efforts to understand juvenile and adult survival in the Salmon River.	Salmon River	A, SS	Altered hydrology, Elevated water temperature, Reduced stream flow	Potential habitat-degrading land use practices	Juvenile outmigrants; adult returns		Near-term	IDEQ, NMFS	
7.2.14-7	7. Implement TMDLs for impaired water bodies in	Salmon River	A, SS	Altered hydrology,	Potential habitat-	Juvenile outmigrants;	To be determined	Near-term	IDEQ	

	Salmon River watershed.	watershed		Elevated water temperature, Reduced stream flow	degrading land use practices	adult returns				
7.2.14-8	8. Improve instream flows in Stanley Lake Creek below SLC1 diversion through increased efficiencies, alternative sources, and/ or conservation tools.	Stanley Lake	SS, D	Impaired fish passage and water quality	Irrigation diversions and land use practices	Adult returns; juvenile outmigrants	To be determined	Mid-term	IDFG, IDWR, NMFS, USFS, Shoshone-Bannock Tribes, Custer County	
7.2.14-9	9. Investigate options to establish minimum stream flow on Salmon River above confluence with Alturas Lake Creek (aka Busterback reach).	Sawtooth Valley	A, SS, D	Reduced population structure and distribution	Irrigation diversions and land use practices	Adult returns, juvenile outmigrants	To be determined	Near-term	IDWR board, IDWR, USFS, IDEQ	Protect the substantial flow returned to the Salmon River currently from future appropriation.
7.2.14-10	10. Acquire land or easement protections on parcels with river/stream frontage (development risks).	Salmon River (EF to headwaters)	A	Degraded water quality, altered sediment routing	Residential/ agricultural development, irrigation, livestock grazing, roadways	Juvenile outmigrants, adult returns	To be determined	All terms	BPA, SWCDs, IDFG, ESFS, Shoshone-Bannock Tribes, NGOs	Acquisitions are often time sensitive.
7.2.14-11	11. Weed Management – protect healthy watersheds through controlling the spread and infestation of	Salmon River (EF to headwaters)		Degraded water quality, altered sediment routing	Habitat degrading facilities, potential habitat	Spawning, incubation, early juveniles	$20K/year	Near-term	USFS	Funds would facilitate monitoring and treatment. Treatments would comply with 2012 Sawtooth NF programmatic BA

	invasive plant species.				degrading land uses					requirement.
Recovery Strategy 7.2.15: Monitor and control predation, disease, invasive species and competition and develop actions as needed										
7.2.15-1	1. Implement plan for collection of returning spawners at Lower Granite Dam to reduce exposure to elevated temperatures in the mainstem Salmon River during late July and August.	Snake River	A	Reduced abundance	Reduced Abundance	Adult returns		Mid-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.15-2	2. Implement Idaho Department of Agriculture, U.S. Forest Service and IDFG whirling disease monitoring and control program.	Sawtooth Valley, upper Salmon River	A, P	Disease	Reduced Abundance	Juvenile rearing	$ 29,000/ year	Mid-term	IDA, USFWS, IDFG	Whirling Disease has been detected.
7.2.15-3	3. Implement Idaho Department of Agriculture, U.S. Forest Service and IDFG invasive species monitoring and control programs.	Sawtooth Valley, upper Salmon River	A,P	Potential loss/Degradation of high quality spawning/incubation habitat, water quality and reduced food source	Human activity that may introduce invasive species	Adult spawning; incubation; early juvenile	Same as No. 2 above	Near-term	IDA, IDFG, USFS	New Zealand mud snails have been detected in Salmon River mainstem.
7.2.15-4	4. Reduce non-native kokanee in lakes used	Pettit Lake, Stanley Lake	A, P, SS, D	Predation/ competition/	Food resource competition	Juvenile	To Be Determined	Mid-term	Shoshone-Bannock	

	for Sockeye Salmon recovery.			disease					Tribes; IDFG	
7.2.15-5	5. Evaluate the effects of lake trout on Sockeye Salmon, develop an eradication strategy, if appropriate, and implement strategy as necessary.	Stanley Lake	A, P	Predation/ competition/ disease	Non-native fish	Juvenile rearing	To be determined	Near-term	IDFG	
7.2.15-6	6. Develop strategy (ies) to prevent lake trout movement and colonization of additional Sockeye Salmon lakes.	Sawtooth Valley	A,P	Predation/competition	Non-native fish	Juvenile rearing	To be determined	Near-term	IDFG	
7.2.15-7	7. Evaluate the effects of cutthroat trout on Sockeye Salmon.	Yellowbelly Lake	A, P	Predation/ competition/ disease	Resource competition (vs. sympatry)	Juvenile rearing	To be determined	Mid-term	IDFG	
7.2.15-8	8. Develop and implement a study in Yellowbelly Lake to evaluate lake carrying capacity of Sockeye Salmon limiting factor in the absence of resident kokanee.	Yellowbelly Lake	A,P	Food availability; food quality	Food resource competition	Juvenile rearing	To be determined	Mid-term	Shoshone-Bannock Tribes	
7.2.15-9	9. Identify criteria for transitioning to passing selected adults above weirs to migrate naturally, and for opening	Sawtooth Valley	A, SS, D	Impaired fish passage; hatchery-related adverse	Disease; impaired habitat connectivity	Adult	Not applicable	Near-term	SBSTOC	Technical staff or policy issue.

	weirs to allow returns to distribute themselves naturally.			effects						
7.2.15-10	10. Identify ways to address predation at Sawtooth Hatchery weir.	Sawtooth Valley	A, SS, D	Predation due to impaired fish passage	Hatchery management	Adult	To be determined	Near-term	IDFG, NMFS, Shoshone-Bannock Tribes	
7.2.15-11	11. Aquatic invasive species (AIS) and prevention.	Alturas, Pettit, Stanley and Redfish Lakes		Degraded water quality, ecological processes	Potential introduction of AIS species to lakes	Spawning, incubation, early juveniles	$30/year	Near-term	USFS and IDA	
Recovery Strategy 7.2.16: Create an adaptive management feedback loop to track progress toward achieving recovery goals, monitor and evaluate key information needs, assess information, and refine strategies and actions.										
7.2.16-1	1. Implement Research, Monitoring and Adaptive Management Program.	Sawtooth Valley	A, SS, D, P	All	All	Juvenile rearing, Adult returns	To be determined	Near-term	IDFG, NMFS, BPA, Shoshone-Bannock Tribes	This is a key implementation action.

* Viable Salmonid Population (VSP) parameter abbreviations: A (abundance); P (productivity); SS (spatial structure); D (diversity).

** Potential implementing agencies abbreviations: BPA (Bonneville Power Administration); IDA (Idaho Department of Agriculture); IDFG (Idaho Department of Fish and Game); IDWR (Idaho Department of Water Resources); SBSTOC (Stanley Basin Sockeye Technical Oversight Committee); SWCDs (soil and water conservation districts); USFS (U.S. Forest Service); USFWS (U.S. Fish and Wildlife Service).

7.3 Actions to Recover Snake River Sockeye Salmon at the Regional Level (Migration Corridor in the Mainstem Salmon, Snake, and Columbia Rivers and Estuary, Plume and Ocean)

Actions identified in Section 7.3 address regional limiting factors and threats to recovery of the Snake River Sockeye Salmon ESU. The proposed actions are directly linked to the recovery strategies identified in Section 6.3.2. This section is organized by strategy with corresponding actions in the same order presented in Section 6.3.2.

Sections 7.3.1 through 7.3.11 briefly describe the recovery strategies and actions to recover Snake River Sockeye Salmon at the regional level (migration corridor in the mainstem Salmon, Snake, and Columbia Rivers and the estuary, plume, and ocean.) Table 7-1 defines the specific actions proposed under each strategy to address problems for Sockeye Salmon in the upper Salmon River. The table identifies the actions as well as the sites, VSP parameters, limiting factors, and threats that each action targets. The tables also provide estimated costs and potential implementing entities for each action, and priority for implementation. The actions address the limiting factors and threats identified in Section 5.

7.3.1 Implement the FCRPS BiOp's Reasonable and Prudent Alternative to Reduce Mortalities Associated with Migration Through the Mainstem Salmon, Snake and Columbia Rivers, Estuary and Plume

Mainstem Salmon River:

- Continue the current annual marking and tagging program as part of FCRPS BiOp to acquire consistent annual passage data.
- Evaluate pit tag program to determine SAR estimates.

Federal Columbia River Power System and Estuary:
Actions identified in the 2008/2010 RPA (NMFS 2008c, 2010), as modified by the 2014 Supplemental Biological Opinion (NMFS 2014c); the Hydro Module (NMFS 2012a); and the Estuary Module (NMFS 2011a) are currently being implemented to reduce Snake River Sockeye Salmon mortalities associated with passage through the mainstem Columbia and Snake River hydroelectric projects and estuary. The suite of actions is designed to improve fish passage, reduce predation, and enhance habitat conditions and fish survival. The modules are available on the NMFS Web site: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/snake_river/current_snake_river_recovery_plan_documents.html

The FCRPS RPA includes the following site specific actions to increase juvenile and adult survival:

- Flow and water quality operations at the FCRPS storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak)—these include regulating outflow.

temperatures at Dworshak Dam to control summer water temperatures in the lower Snake River.

- Configuration and operational changes at the run-of-river mainstem projects—these include short- and long-term measures to prevent a temperature block in the adult ladder at Lower Granite Dam.
- Spill and juvenile transport improvements at the run-of-river mainstem projects to improve inriver and system survival.
- Predation control measures at the run-of-river mainstem projects and in the Columbia River estuary.
- Water transactions in the mainstem Salmon River[8] and habitat improvements in the Columbia River estuary.

7.3.2 Continue Research and Monitoring on Snake River Sockeye Salmon Survival/Mortality in Mainstem Salmon, Snake, and Columbia Rivers Migration Corridor; Estuary; Plume; and Ocean

As discussed in 7.3.1, the FCRPS RPA, as well as any further improvements for fish survival that may result from the ongoing FCRPS RM&E and adaptive management process, represent the near-term recovery strategy for Snake River Sockeye Salmon and other listed salmonids that migrate through the mainstem Columbia and Snake Rivers. The "Reasonable and Prudent Alternative Table" in the 2008 FCRPS BiOp, as amended in the 2010 and modified in the 2014 Supplemental BiOps, respectively, describes research and monitoring actions that should demonstrate the success of these actions or the need to make adjustments or develop new measures to increase Snake River Sockeye Salmon survival during the migratory life stages.

Additional actions call for investigations concerning the apparent SAR differential between Snake River Sockeye Salmon and Lake Wenatchee and Okanogan River Sockeye Salmon. Information gained from these investigations will inform further actions that could improve SARs for the Snake River ESU.

- Determine changes in marking/tagging levels for more precise evaluations of downstream sources of mortality.

[8] The FCRPS Action Agencies are implementing these water transactions specifically to improve the survival of Snake River spring/summer Chinook and steelhead, but they are also likely to improve the survival of adult migrant Sockeye Salmon returning to the Sawtooth Valley in July and August (NMFS 2014c).

7.3.3 Update Snake River Sockeye Salmon Life Cycle Models Using Latest Information on Survival Through Mainstem Salmon, Snake and Lower Columbia River Migration Corridor; Estuary; Plume; and Ocean

Use updated life cycle model to test hypotheses regarding whether actions described in this plan, including those in Section 7.3.2, will be adequate to achieve recovery objectives for the ESU.

- Update appropriate life-stage inputs in life cycle model and test hypotheses regarding whether strategies described in this plan, including those corresponding recovery strategies in Section 6.3.2.1, will be adequate to achieve recovery objectives for the ESU.

7.3.4 Manage to Maintain Current Low Impact Fisheries and Reduce Fishery Impacts in Those Fisheries that Affect Snake River Sockeye Salmon: Fishery Management

A number of different entities currently manage fisheries that could potentially affect Snake River Sockeye Salmon. Tributary fisheries for Snake River species are implemented by state and tribal entities, and reviewed under the ESA by NMFS. Fisheries in the mainstem Columbia River that affect Snake River Sockeye Salmon are subject to the terms of the *U.S. v. Oregon* Management Agreement, and are managed to ensure that the incidental take of ESA-listed Snake River Sockeye Salmon does not jeopardize the ESU. Snake River Sockeye Salmon are also exposed to incidental take as bycatch in the ocean troll, purse seine, and gill net salmon fisheries off the coasts of Alaska, British Columbia, and Washington. However, these ocean fisheries are believed to pose minimal threat to the species since Sockeye Salmon are not attracted to baits or lures and, thus, are rarely caught in commercial or recreational fisheries.

This Plan supports current efforts under existing management agreements, including the 2008-2017 *U.S. v. Oregon* Management Agreement, to regulate fisheries. Actions to address fishery threats are identified by NMFS in the Harvest Module (NMFS 2014b). The Harvest Module is available on the NMFS Web site:
http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/snake_river/current_snake_river_recovery_plan_documents.html.

Additional actions call for investigating the use of new technologies (PIT-tags and PIT-tag detectors, genetic data) to better manage in-season mainstem fisheries and assess seasonal harvest objectives and limitations.

- Continue to implement the 2008-2017 *U.S. v. Oregon* Agreement in mainstem Columbia River fisheries.
- Define appropriate levels of incidental take of Sockeye Salmon in fisheries in the Snake and Salmon Rivers and upper Salmon River lakes, based on Sockeye Salmon status.
- Monitor ocean fisheries databases for incidental take of Snake River Sockeye Salmon.
- As a future action, evaluate use of the harvest management sliding scale to manage hatchery-origin fish and protect natural-origin spawners returning to natal lakes.

- Identify and evaluate potential future changes to Sockeye Salmon harvest management when *U.S. v Oregon* is renegotiated after 2018.
- Investigate loss of PIT-tagged adult Sockeye Salmon between Bonneville and McNary dams.

7.3.5 Protect and Conserve Natural Ecological Processes that Support the Population Viability

Actions to protect and conserve the natural ecological processes that support Snake River Sockeye Salmon viability will play a key a role in the overall recovery strategy. Protecting and improving natural processes and functions will help maintain high quality habitat and restore damaged habitat, with specific benefits in the juvenile and adult migration life history stages.

The Estuary Module describes strategies and actions that will protect and conserve natural ecological processes to support salmonid viability in the lower Columbia River estuary. The 2008 FCRPS Biological Opinion, 2010 Supplemental FCRPS BiOp, 2014 Supplemental FCRPS BiOp and the Hydro Module also provide direction for improving natural ecological processes in the mainstem Columbia and Snake Rivers.

- Assess nearshore mainstem habitat and cold-water refugia in the mainstem Columbia and lower Snake Rivers and explore opportunities for, and potential benefits from, restoration and protection of these areas.
- Protect intact riparian areas in the estuary and its tributaries and restore riparian areas that are degraded.
- Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.
- Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.
- Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.
- Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.

7.3.6 Improve Degraded Water Quality and Maintain Unimpaired Water Quality

Water quality issues affect Snake River Sockeye Salmon survival and viability in several areas of the migration corridor. In the lower Salmon and Snake Rivers, summer water temperatures in some reaches rise to levels that can restrict Sockeye Salmon production and survival. The high water temperatures can leave Sockeye Salmon more susceptible to disease and infection if they are not able to escape to deep pools or other habitats with cooler temperatures. Higher water temperatures also reduce habitat quality for Sockeye Salmon and other salmonids that use the estuary during summer months.

In addition, sections of the mainstem Salmon, Snake, and Columbia Rivers are also contaminated by drift and runoff from both agricultural and urban areas. Exposure to these chemicals during adult and juvenile migration may contribute to low survivorship and impede recovery of this stock.

The Estuary Module and FCRPS BiOp identify actions to improve reaches with degraded water quality and maintain reaches with good water quality in the mainstem corridor. Actions described in the Estuary Module include implementing best management practices to reduce the flow of nutrients and toxics to the estuary, and to restore or mitigate contaminated sites. The IDEQ is working with cities, counties, and landowners to implement actions that address water temperature concerns in the Salmon and lower Snake Rivers. This plan also call for monitoring studies to determine how high temperatures and other water quality issues in the Salmon and lower Snake Rivers may be affecting Sockeye Salmon survival and viability.

- Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.
- Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.
- Restore or mitigate contaminated sites.
- Implement stormwater best management practices in cities and towns.
- Address water temperature concerns for the Salmon and lower Snake Rivers.
- Conduct monitoring studies to determine how high temperatures and other water quality issues in the Salmon and lower Snake Rivers may be affecting Sockeye Salmon survival.
- Implement Water Quality Plan for Total Dissolved Gas (TDG) and water temperature in the Mainstem Columbia and Snake Rivers to meet ESA and Clean Water Act responsibilities.

7.3.7 Address Ecosystem Imbalances in Predation, Competition, Invasive Species, and Disease through the Strategies and Actions in this Plan, the Estuary Module, and Reasonable and Prudent Alternatives identified in Biological Opinions

Snake River Sockeye Salmon experience predation and competition from other fish and birds in the mainstem Columbia, Snake, and Salmon Rivers and the estuary and ocean. In the Salmon River, Sockeye Salmon encounter predation from bull trout. In the Columbia River migratory corridor, Snake River Sockeye Salmon encounter both reservoir-rearing kokanee and anadromous Sockeye Salmon smolts from the upper Columbia migrating to the sea. In the ocean, they must compete with hatchery and natural Sockeye Salmon stocks originating along the entire length of the North Pacific rim, as well as other salmon species. They are also exposed to a number of potential predators. Migrating Sockeye Salmon encounter predation from northern pikeminnow and other fish in the Columbia and lower Snake migration corridor. Predators in the estuary include Caspian terns, double-crested cormorants, and a variety of gull species. Currently, it is not clear if this potential predation poses a risk to Snake River Sockeye Salmon.

The potential threat to Sockeye Salmon viability and habitat from invasive aquatic species is also a concern. Invasion of these harmful, non-native plants, animals, and pathogens could damage the environment and negatively influence Sockeye Salmon recovery. The Plan supports current programs to monitor and control invasive species that are being carried out in Idaho, Oregon and Washington in the Salmon River mainstem, Snake and Columbia Rivers and Columbia River estuary. In particular, it is critically important that these efforts be maintained to prevent introduction of highly invasive quagga and zebra mussels and other invasive species that can influence biological processes throughout the Sockeye Salmon migration route and reduce Sockeye Salmon productivity.

Diseases in Sockeye Salmon also restrict efforts to recover the species. Diseases, however, can be caused by multiple factors and probably cannot be directly addressed by recovery actions, except in specific instances of known causal factors. It is more likely that nearly all of the recommended recovery actions that improve spawning, rearing, and passage conditions for Sockeye Salmon and increase the survival, abundance, and productivity of naturally produced fish will result in decreasing incidence of disease.

Actions identified in this Plan, the Estuary Module, Ocean Module, FCRPS BiOp, and other Biological Opinions aim to monitor and control predation, competition, and invasive species in the mainstem Columbia, and Snake Rivers and in the estuary and ocean. The documents, including this Plan, also direct additional research, monitoring, and evaluation activities to quantify the impacts of predation and competition on Snake River Sockeye Salmon recovery efforts.

- Investigate predation, disease, invasive species and competition; based on findings, implement actions in the migration corridor, estuary, plume and ocean.
- Evaluate the effectiveness and relative efficiency of a hook-and-line fishery at select dams on the mainstem Columbia and Snake Rivers to remove Northern Pikeminnow in areas inaccessible to sport-reward anglers.
- Continue to evaluate if inter-and intra-species compensation is occurring on surviving northern pikeminnow and other piscivorous species.
- Continue to conduct research on predation impacts of Columbia River avian predators on migrating juvenile salmonids, bioenergetics modeling, and habitat/population management strategies.
- Develop an avian management plan for other avian species as determined by RM&E for USACE owned lands and associated shallow-water habitat.
- Implement and improve deterrent devices and activities (e.g. bird wire, water cannons, hazing) at dams to keep avian predators away from bypass outfalls and other areas of juvenile salmonid concentration.

- Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.
- Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.

7.3.8 Respond to Climate Change Threats by Implementing Research, Monitoring, and Evaluation to Track Indicators Related to Climate Change and by Preserving Biodiversity

Projected changes in habitat conditions due to climate change could have profound implications for Snake River Sockeye Salmon survival and viability. All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and physical habitat due to climate change could hinder efforts to recover Snake River Sockeye Salmon to viability levels needed to delist the species under the ESA. For example, lower flows and higher water temperatures in the Salmon and lower Snake Rivers in late summer and early fall when adult Sockeye Salmon are returning to the natal lakes to spawn could further reduce Sockeye Salmon survival and the number of naturally produced Sockeye Salmon returning to spawn. This possibility reinforces the importance of gaining information needed to detect and respond to changes in population viability or habitats related to climate change. It also reinforces the need to maintain habitat diversity and achieve survival improvements throughout the entire life cycle.

Actions identified in this Plan, the Estuary Module, Hydro Module, FCRPS BiOp, and other Biological Opinions to protect and improve habitat conditions will help to preserve and improve biodiversity, and guard against the effects of climate change. The climate change strategy also directs monitoring and evaluation actions, including those identified in Section 11, Research, Monitoring, and Evaluation for Adaptive Management, to help detect physical and biological changes associated with climate change and determine the efficacy of responsive measures.

- Implement research, monitoring, and evaluation actions identified in Section 11.
- Implement measures to retain shade along stream channels and augment summer flow.
- Manage water withdrawals to maintain as high a summer flow as possible.
- Implement measures to protect and restore wetlands, floodplains, and other landscape features that store water.
- Release cool water from mainstem reservoirs during critical periods.
- Improve juvenile passage through warm dam forebays.
- Improve temperatures in adult fish passage structures.
- Take steps to reduce predation and competition with non-native species.
- Remove dikes to open backwater, slough, and other off-channel habitats and to increase flow through these areas and encourage hyporheic flow.

- Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Implement habitat actions that are most likely to ameliorate stream flow and temperature changes due to climate change and increase habitat diversity and population resilience. Such actions include restoring floodplain connectivity, restoring stream flow regimes, reaggrading[9] incised channels, removing barriers, and restoring riparian functions.

7.3.9 Implement the Snake River Sockeye Salmon Recovery Plan through Effective Communication, Education, Coordination, and Governance

Recovery of Snake River Sockeye Salmon depends on the collective action of citizens in the region. Recovery actions will need to be implemented by diverse organizations, tribes, state and Federal agencies, landowners, private entities, and the public — all striving for the common goal of Sockeye Salmon recovery.

Section 10 identifies an implementation framework to coordinate implementation of the Plan. Successful implementation of recovery actions, research, and monitoring projects will build upon the over twenty years of leadership and Sockeye Salmon recovery work carried out by the Stanley Basin Sockeye Technical Oversight Committee, together with IDFG, Shoshone-Bannock Tribes, U.S. Forest Service, NMFS, BPA, and other partners that have prevented the extinction of this ESU. Implementation will continue coordinated actions and funding from parties including IDFG, Shoshone-Bannock Tribes, Bonneville Power Administration, NMFS, U.S. Forest Service, counties, state and Federal agencies, private landowners, and individuals.

In addition, a key goal for the Sockeye Salmon recovery program is to engage the public as an active partner in implementing and sustaining recovery efforts. Actions to achieve this goal provide opportunities for public education and interpretation, and participation in recovery implementation activities. They also involve sharing information between scientists and the public as recovery projects and monitoring actions are carried out.

- Develop multi-media public education, interpretation, and outreach information designed to reach different audiences describing what needs to be done for Sockeye Salmon recovery and what the public and landowners can do to support recovery efforts. Post information on the web sites of cooperating agencies, entities, and tribes involved in Sockeye Salmon recovery actions.

[9] Aggradation is a term used in geology for the increase in land elevation due to deposition of sediment.

- Produce educational materials that can be used in schools and at fairs, festivals, or other venues to communicate current status of the ESU and potential recovery actions needed to protect and restore Sockeye Salmon.
- Develop and implement education and outreach programs directed at anglers and the public regarding the negative impacts of invasive species on native species, habitat, and ecosystems.
- Work with the U.S. Forest Service, IDFG, Shoshone-Bannock Tribes, and other relevant parties to develop materials, posters, and signage to educate visitors to the Sawtooth National Recreation Area about the need to recover Sockeye Salmon and the recovery actions being carried out in the recreation area.
- Develop a clearinghouse of information on funding sources. Support local entities, landowners, tribes, and agencies seeking funding for recovery actions.
- Present briefings and presentations on Sockeye Salmon recovery to relevant civic, business, trade, environmental, and conservation organizations.
- Lead seasonal tours of relevant sites so public and other interested groups can observe Sockeye Salmon and visit recovery projects.
- Educate and work with landowners to implement recovery actions on private property with willing landowners.

7.3.10 Continue Research, Monitoring, and Evaluation for Adaptive Management

Research, monitoring, and evaluation efforts that allow groups and managers to make informed decisions through an adaptive management process will play a critical role in the recovery of the Snake River Sockeye Salmon ESU. As discussed in Section 6, many questions exist regarding the effects of the hydrosystem, fisheries, and land and water uses on survival of Snake River Sockeye Salmon in the mainstem migration corridor, estuary and ocean. We remain unsure whether Sockeye Salmon survivals resulting from current conditions and proposed management actions will be enough to support the ESU through downturns in ocean and climate conditions.

The FCRPS BiOp, Hydro Module, and Estuary Module identify research, monitoring, and evaluation activities that will help aid recovery of Sockeye Salmon. In addition, Section 11 of this Plan lays out a research, monitoring, and evaluation program designed to assess the status of the species and its habitat, track progress toward achieving recovery goals, and gain information needed to refine recovery strategies and adjust course as appropriate through the process of adaptive management.

- Continue to implement the monitoring and evaluation programs to track progress on meeting these recovery goals and objectives.
- Research critical uncertainties, monitor and evaluate implementation and effectiveness, and adjust course as appropriate through adaptive management.

7.3.11 Prioritize and Address Key Information Needs, and Create an Adaptive Management Feedback Loop to Revise Recovery Actions as Needed

Successful implementation of the Recovery Plan requires a process to refine direction and adjust course appropriately. Section 10 describes a proposed framework for coordinated implementation of this Plan and identifies the implementation teams that are part of this framework. The Snake River Sockeye Salmon Implementation and Science Team will coordinate implementation of the Adaptive Management and Research, Monitoring, and Evaluation Plan. Section 11 describes the aspects of the adaptive management process and the research, monitoring, and evaluation activities that will be implemented to inform future decisions and adjust our course toward Sockeye Salmon recovery.

NMFS will work with the Snake River Sockeye Salmon Implementation and Science Team and others to prioritize the key information needs identified in Section 6.4. It will also seek resources and form partnerships to address the key information needs during recovery plan implementation.

- Work with the Snake River Sockeye Salmon Implementation and Science Team and others to prioritize the key information needs.
- Seek resources and form partnerships to address the key information needs during Recovery Plan implementation.

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Section 8: Potential Effects of Proposed Actions

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8. Potential Effects of Proposed Recovery Actions

This section describes a proposed approach to evaluate the effects of recovery actions on abundance and productivity of Snake River Sockeye Salmon in relation to the biological viability criteria described in Section 3.2. The ESU's current risk of extinction remains high with the ESU being maintained in a captive broodstock program. The goal of this Plan is to have enough self-sustaining natural-origin Sockeye Salmon spawning in the wild and surviving the full life cycle in such numbers to maintain targeted viability over time and under varying environmental conditions. Based on an understanding of limiting factors and threats, we hypothesize that the recovery actions described in this Plan will increase the number of anadromous adults returning to spawn in natal lakes over time. Proposed monitoring actions will document Sockeye Salmon survival rates at each life stage through variations in ocean and climate conditions.

Unlike effects analyses in other NMFS Columbia Basin recovery plans, we do not have an accurate understanding of past Sockeye Salmon productivity. In addition, the abundance of natural-origin fish is so low that modeling viability responses to recovery actions is not possible at this time. However, as numbers of natural-origin Sockeye Salmon increase, monitoring data will be available to calculate abundance and productivity over time

The following section proposes a framework for analyzing the effects of proposed recovery actions on Sockeye Salmon viability over time.

Hatchery Recovery Actions

These are the actions associated with the operation of the captive broodstock and conventional hatchery facilities to produce fish for reintroduction. These actions assume the demographic benefit hatchery production provides can be used to address abundance as a limiting factor. It is expected (hypothesized) that these actions will have the effect of increasing the number of naturally spawning anadromous Sockeye Salmon in the Sawtooth Valley basin. The actual effect of these actions can be tested by comparing long-term trends in reintroduction efforts and natural abundance. Redd counts, numbers of naturally produced spawners, and natural out-migrants are metrics that can be used to verify these actions generate the assumed effect and will lead to the end goal of producing a minimum of 1,000 natural spawners per year in Redfish and Alturas Lakes and 500 spawners per year in one of the smaller Sawtooth Valley lakes.

Reintroduction Recovery Actions

These actions are associated with populations chosen for amplification and the manner they are distributed to the available habitat. They assume that following the local adaptation concept during reintroduction actions will lead to increased spatial structure and diversity within the ESU. It is expected (hypothesized) that these actions will have the effect of increasing the number of natural spawning types (shoal and stream) and lake populations within the ESU. The actual effect of these actions can be tested by following long-term trends in number of Sawtooth Valley lakes and habitats supporting self-sustaining natural spawning populations of anadromous Sockeye Salmon. Location and number of redds and spawners can be monitored to verify that these actions lead to the increased numbers, productivity, spatial structure, and diversity associated with a low risk of extinction.

Migratory Corridor Recovery Actions

These actions are associated with reducing the physical, competitive, and predatory hazards in the migration corridor. They assume that reducing losses in the migratory corridor can be used to address abundance as a limiting factor. It is expected (hypothesized) that these actions will have the effect of increasing the number of anadromous Sockeye Salmon surviving to return to the Sawtooth Valley. The actual effect of these actions can be tested by comparing long-term trends in migration survival to the action implemented. Percentage of smolts surviving to Lower Granite Dam, percentage of adults surviving from Lower Granite Dam to the Sawtooth Valley, etc. can be monitored to verify that these actions lead to the end goal of producing a minimum of 1,000 natural spawners per year in Redfish and Alturas Lakes and 500 spawners per year in one of the smaller Sawtooth Valley lakes (Pettit, Stanley, or Yellowbelly Lakes).

Natal Lake Habitat Recovery Actions

These actions are associated with improving the physical and ecological condition of the natal lakes. They assume increasing the forage base and reducing predators, competitors, and pollutants will improve the overall abundance and productivity of anadromous Sockeye Salmon in the lakes. Enhancing the forage base, limiting kokanee competitors, controlling nonnative predators, and reducing pollutants is expected to increase anadromous spawner success, egg survival, fry carrying capacity, and smolt production. The actual effect of these actions can be tested by comparing long-term trends in these actions with natural abundance and productivity of anadromous Sockeye Salmon in the Sawtooth Valley lakes. Anadromous red counts, fry production, and smolt out-migrants numbers for each lake can be monitored to verify that these recovery actions will lead to the end goal of producing a minimum of 1,000 natural spawners per year in Redfish and Alturas Lakes and 500 spawners per year in one of the smaller Sawtooth Valley lakes with a population that is stable or increasing.

Fishery Recovery Actions

These are the actions associated with managing ocean, river, and lake fisheries to limit take of the listed species. They assume limiting incidental harvest of Snake River Sockeye Salmon will improve overall abundance. It is expected (hypothesized) that these actions will have the effect of increasing the number of fish surviving to reach the spawning grounds in the Sawtooth Valley. The actual effect of these actions can be tested by comparing fishery recovery actions and natural abundance on the spawning ground. Incidental harvest, dam counts, weir counts, and the numbers of adults on the spawning ground can be monitored to verify that these actions will lead to the end goal of producing a minimum of 1,000 natural spawners per year in Redfish and Alturas Lakes and 500 spawners per year in one of the smaller Sawtooth Valley lakes.

Section 9: Time and Cost

9.1 Cost Estimates

9.2 Time Estimate

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9. Cost and Time Estimates

ESA section 4(f)(1) requires that recovery plans, to the maximum extent practicable, include "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal" (16 U.S.C. 1531-1544, as amended). This section is intended to meet this ESA requirement.

9.1 Cost Estimates

This section provides five-year and total cost estimates as called for under ESA and NOAA Interim Recovery Planning Guidance, version 1.3, dated June 2010. Based on the limiting factors and threats identified in this Plan, the Sockeye Technical Advisory Committee made up of staff from NMFS, Northwest Fisheries Science Center, Idaho Department of Fish and Game, Shoshone-Bannock Tribes, Bonneville Power Administration, U.S. Forest Service, and other entities identified proposed actions to recover ESA-listed Snake River Sockeye Salmon. This list of recovery actions (Table 7-1) was developed using the most up-to-date assessment of current Snake River Sockeye Salmon status and recovery needs, without consideration of cost or potential funding.

In order to prepare cost estimates for recovery actions, NMFS worked with the Sockeye Technical Committee staff familiar with the current and proposed recovery actions to estimate costs where information was sufficient to allow reasonable estimates to be made. The approach taken to estimate the total cost of each project was to use the scale described for each action, where available, together with unit costs for each project type. For some actions, no scale estimate is available at this time, in which case no cost estimate is provided in Appendix A: Summary of Recovery Measures and Estimated Costs.

The Recovery Cost Summary Table in Appendix A of this document provides the estimated costs for actions set forth in this recovery plan for fiscal years 2014 through 2018, where information was sufficient to provide them. It is a guide for meeting the recovery goals outlined in this Plan. The table includes the action numbers, action descriptions, the parties responsible for the actions (either funding or carrying out), and estimated costs. In many cases, research, monitoring, and evaluation costs have yet to be determined. Those that can be estimated at this point are included in Appendix A.

Responsible parties are entities, agencies, or organizations with authority, responsibility, or expressed interest to implement a specific recovery action. The listing of a party in the table does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

All yearly costs identified in Appendix A are presented in present-year dollars (that is, without adjusting for inflation). Costs are estimates for the Fiscal Year (FY) in thousands of dollars ($K). The total costs are the sum of the yearly costs without applying a discount rate.

As stated in Section 1, a coordinated partnership of multiple entities has implemented the captive broodstock program since the ESU was listed as endangered 1991. The estimated total costs for past Snake River Sockeye Salmon recovery actions from 1991 to 2013, including the captive broodstock program, total approximately $68 million. These actions were implemented as part of existing mandates and regulatory obligations to recover Sockeye Salmon.

The estimated costs shown in the Summary of Recovery Measures and Estimated Costs Table in Appendix A correspond to proposed recovery actions in Section 7, Table 7-1. The actions range widely from relatively less expensive to more expensive projects. Actions also vary considerably in length of time over which they will take place. In some cases a length of time has yet to be determined.

Recovery Actions and Corresponding Cost Estimates

The Summary of Recovery Measures and Estimated Costs Table in Appendix A lists available cost estimates for actions identified in the Plan. The action categories are the following:

- *Baseline actions*: These are actions categorized as part of ongoing, existing programs that will be carried out regardless of this Plan. No cost estimate is provided for these actions because they do not represent new costs that are a direct result of this Plan.
- *Cost Estimate Exists*: These are actions for which an estimate and scale are available.
- *To Be Determined*: These are actions that need costs to be developed, need unit costs, and/or need project scale estimates to be sufficiently detailed to support a cost estimate.
- *Not Applicable:* These actions are generally policy actions requiring staff time and do not have separate costs associated with them.

In the implementation phase, NMFS will work with regional experts and local implementers to identify costs, scale or unit costs for actions that require more information. The Recovery Measures and Estimated Costs Table in Appendix A will be updated as new cost information becomes available.

The Appendix A cost table summarizes the available cost estimates for the actions proposed in the Snake River Sockeye Salmon Recovery Plan, covering all projects judged to be feasible and projected to occur over the initial five year period of implementing the recovery plan, FY 2014 to FY 2018. The overall total cost estimated for all actions during this five-year time period, where costs are available, is approximately $20,293,955. The total estimated cost of recovery actions for Snake River Sockeye Salmon over the next 25 years is about $101,469,775.

These costs do not include costs associated with implementing actions within the lower Columbia River, estuary, or Federal Columbia River Power System (FCRPS) because these are considered baseline actions. Preliminary research, monitoring, and evaluation costs have, in some cases, been estimated; however, these costs are not included at this time pending completion of research and monitoring plans and further development of each project.

There are several cautions that must be highlighted regarding these costs, because many of these costs may be incomplete in scope, scale, or magnitude until actions are better defined. Specifically, costs for potentially expensive projects such as land and water acquisition, water leasing, and research, monitoring, and evaluation have not yet been estimated for this ESU. For other projects, unit cost estimates or determination of project scale may also still need to be calculated. The Summary of Recovery Measures and Estimated Costs table in Appendix A presents summary costs for recovery actions identified that will help promote recovery (delisting) of this ESU. Costs estimates may be adjusted up or down, as unit cost estimates, scale of projects, total number of actions, and currently unforeseen costs for actions are determined.

9.2 Time Estimate

There are unique characteristics and challenges in estimating the time required for salmon and steelhead recovery given the complex relationship of these fish to their environment and to human activities in the water and on land. Examples of the uncertainties that preclude a more precise estimate of time include biological and ecosystem responses to recovery actions are the unknown impacts of future economic, demographic, and social developments.

NMFS estimates that recovery of the Snake River Sockeye Salmon ESU, like recovery for most of the ESA-listed Pacific Northwest salmon and steelhead, could take 50 to 100 years. While this recovery plan contains an extensive list of actions to recover Snake River Sockeye Salmon, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions, as well as long-term and future funding. While continued programmatic actions in the management of habitat, hatcheries, hydro, and harvest will warrant additional expenditures beyond the first five years, NMFS believes it is impracticable to estimate all projected actions and costs over 50 to 100 years, given the large number of economic, biological, and social variables involved. Consequently, NMFS believes it is appropriate to focus on the first 25 years of action implementation, with the provision that actions and costs will be estimated for subsequent years, to achieve long-term goals and to proceed until a determination is made that listing is no longer necessary.

NMFS believes that is may take longer than 25 years for the biological effects of management actions to be fully realized and for recovery of Snake River Sockeye Salmon to occur. Rather than speculate on conditions that may or may not exist that far into the future, this Plan relies on ongoing monitoring and periodic plan review regimes to add, eliminate, or modify actions through adaptive management as information becomes available and until such time as the protection under the ESA is no longer required.

NMFS believes it most appropriate to focus on the first five years of implementation and in five-year intervals thereafter, with the understanding that before the end of each five-year implementation period, specific actions and costs will be estimated for subsequent years.

Section 10: Implementation

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10. Implementation

This section describes a proposed framework for coordinated implementation of this Plan. Successful implementation of recovery actions, research, and monitoring projects will build upon the over twenty years of leadership and Sockeye Salmon recovery work carried out by the Stanley Basin Sockeye Technical Oversight Committee, together with IDFG, Shoshone-Bannock Tribes, U.S. Forest Service, NMFS, and their partners that have prevented the extinction of this ESU. Implementation will need the continued coordinated actions and funding from diverse parties including IDFG, Shoshone-Bannock Tribes, Bonneville Power Administration, NMFS, U.S. Forest Service, counties, state and Federal agencies, private landowners, and individuals.

Unlike other ESA-listed ESUs in the Pacific Northwest, the Snake River Sockeye Salmon ESU has not had a state-designated ESA recovery board (such as the SE Washington Snake River Recovery Board based in Dayton, Washington) that could take responsibility for developing a recovery plan. For that reason, NMFS is leading the development of this Plan in coordination with the state, tribes, and Federal agencies; however the process for implementing this Plan is yet to be determined.

NMFS will work with its Snake River Sockeye Salmon Technical Committee made up of representatives from the IDFG, the Shoshone-Bannock Tribes, U.S. Forest Service, BPA, and together with the Idaho Governor's Office of Species Conservation and other state and Federal entities to review this proposed implementation framework and agree on how this Plan will be implemented.

Although the ESA requires NMFS to develop recovery plans, NMFS will rely, to a great extent, on local citizens, agencies, tribes, and jurisdictions to voluntarily implement actions the plan recommends or proposes. NMFS' interim recovery planning guidance (NMFS 1996) acknowledges that recovery plans are not regulatory documents, and that it is not a requirement of ESA section 4(f) for any entity to implement the recovery strategy or specific actions in a recovery plan unless otherwise legally mandated. In many cases, the Plan acknowledges and recommends coordinating the pre-existing, ongoing recovery efforts and pre-existing laws or regulations that are expected to benefit the species and its environment, such as the ongoing hatchery, resource management, and habitat restoration activities of the IDFG, U.S. Forest Service, Shoshone-Bannock Tribes, soil and water conservation districts, and local land owners. Some of the ongoing actions that are in the Plan are required under other separate resource management regulatory processes, such as the implementation of forest practices, operation of fish hatcheries, and regulation of fisheries that may affect Snake River Sockeye Salmon.

While organizations and individuals are not required to implement the Plan, it is anticipated that entities will choose to participate to further their own goals and seek funding partnerships to implement actions. This Plan acknowledges the leadership, hard work and dedication of organizations, entities, tribes, and individuals that have worked for many years on salmon recovery programs. It is also recognized that there may be alternative actions to those proposed in this plan that may also attain recovery goals. Actions to achieve a specific recovery strategy may vary due to logistics, project opportunities, willingness of landowners to participate, funding constraints, or an organization's authorities and administrative processes. This Plan does not constrain or inhibit entities or individuals from implementing actions as opportunities or funding become available.

10.1 Implementation Framework

This recovery plan implementation framework is presented below to begin the discussion about the best way to implement this Plan and engage interested parties on how best to coordinate future work. This anticipates close working relationships with existing groups, builds on the important recovery work of the last twenty years, and seeks continued collaborative initiatives to recover Snake River Sockeye Salmon. The roles of each of these implementation teams and the recovery coordinator are described below for discussion with interested parties. Similar frameworks are being used to coordinate other recovery plan implementation efforts in Washington and Oregon.

The components of this implementation framework include the following (Figure 10-1):

- Snake River Sockeye Salmon Implementation and Science Team.
- Stanley Basin Sockeye Technical Oversight Committee (SBSTOC).
- NMFS's Snake River Coordination Group.

Snake River Sockeye Salmon Implementation and Science Team
The Implementation and Science Team is responsible for overall leadership, coordination, direction, agenda setting, and communication with the action implementers and all parties involved in recovery plan implementation. It coordinates at relevant Federal, state, and regional levels, identifies and represents Sockeye Salmon recovery plan implementation in the Snake River Coordination Group meetings. This Team is made up of representatives from IDFG, Shoshone-Bannock Tribes, U.S. Forest Service, BPA, NMFS, and other entities and stakeholders as identified. The team will develop criteria to prioritize recovery actions and apply these criteria as it develops a three-year implementation schedule and plan. It will report annual progress on implementation and monitoring actions to the public.

The team coordinates implementation of the Adaptive Management and Research, Monitoring, and Evaluation Plan described in Section 11. It will coordinate with the Stanley Basin Sockeye Technical Oversight Committee, NMFS' Northwest Fisheries Science Center's Recovery Implementation Science Team (RIST), IDFG, Shoshone-Bannock Tribes, and NMFS to design research, monitoring, and evaluation protocols and actions for research, data collection, and reporting. It monitors and reports on status of populations in relation to recovery goals. It coordinates with technical teams from other Snake River management units to ensure consistency of across-ESU/DPS project design, data collection and reporting through communication with the Snake River Coordination Group.

This Team will also provide science input and advice on full life cycle Sockeye Salmon actions, strategies, research designs, and research and monitoring priorities, including scoping science needs at the ESU-level. This Team will ensure that rigorous and "best available science" informs implementation and is applied in research and monitoring activities and assist in translating information into status of species viability. This Team will be critical to five-year reviews of the ESU. This Team will interact with the Stanley Basin Sockeye Technical Oversight Committee and may have members on both groups.

Implementation Plan and Contingency Process

The Implementation and Science Team will develop action implementation prioritization criteria and a three-year implementation schedule and plan. The prioritization criteria will build on the prioritization considerations described in Section 7, Actions. The ESA implementation schedule and plan will identify recovery actions, timeline and duration for completing the actions, lead agency/entity responsible for implementing the actions, and estimated cost over a specified period of time.

The team will also develop a contingency process as part of its recovery tasks. As discussed in Section 6.3, this contingency process will identify steps so we are prepared if the species' status does not continue to improve in a timely manner, and also if there are significant declines in status. A contingency process should set intermediate goals and timeframes, and also set early warning indicators and significant decline triggers. As part of this process, additional actions should be developed that are "on the shelf," if needed, to address long-term trends toward recovery and to prevent precipitous declines.

Stanley Basin Sockeye Technical Oversight Committee

In 1991, when Snake River Sockeye Salmon were listed as endangered under the Endangered Species Act, a cooperative effort began to conserve and rebuild the population. The Shoshone-Bannock Tribes and the IDFG initiated the Snake River Sockeye Salmon Broodstock Program with funding from the BPA. The goal of this program is to conserve genetic resources and to rebuild Snake River Sockeye Salmon populations in Idaho. Coordination of this effort is carried out under the guidance of the Stanley Basin Sockeye Technical Oversight Committee, a team of biologists and technical experts representing the agencies involved in the recovery and management of Snake River Sockeye Salmon. Coordinated by BPA, the Stanley Basin Sockeye Technical Oversight Committee meets quarterly and is comprised of representatives from IDFG, Shoshone-Bannock Tribes, NMFS, and BPA.

NMFS' Snake River Coordination Group

The Snake River Coordination Group, convened by NMFS, brings together representatives from the southeast Washington, northeast Oregon, and Idaho Snake River Recovery Plan management units and other relevant parties to coordinate policy and technical issues across the salmon and steelhead ESUs and DPS for the Snake River Recovery Plans. This Coordination Group provides organizational structure for communication and coordination on a tri-state and multi-tribal level across the Snake River recovery domain. This group will provide cross-species communication and provide input to NMFS on recovery plan issues as the different Snake River Recovery Plans are being written and then promote recovery plan implementation.

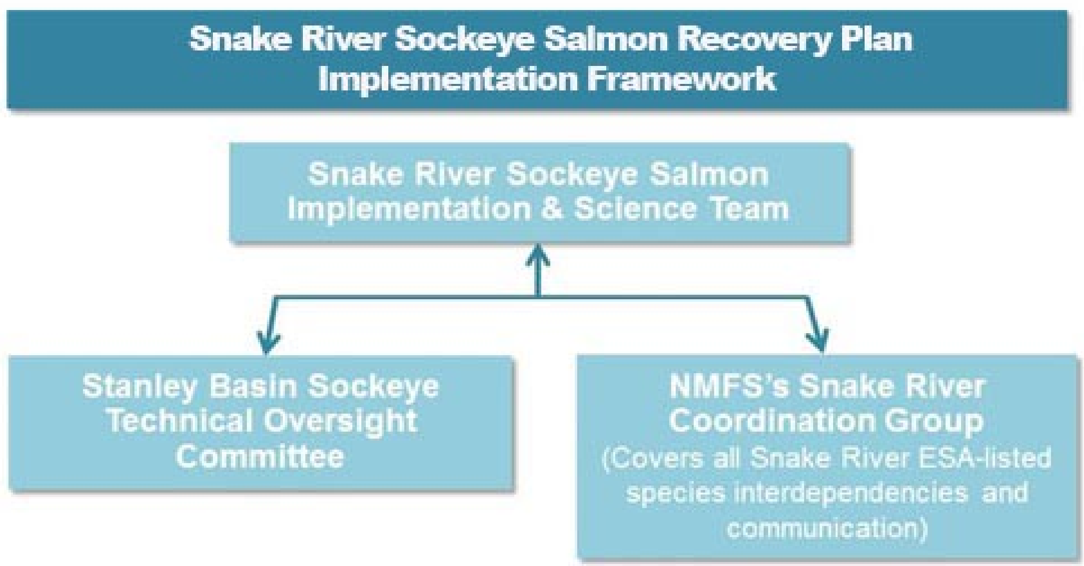

Figure 10-1. Snake River Sockeye Salmon recovery plan implementation framework.

10.2 Implementation Progress and Status Assessments

Evaluating a species for potential delisting requires an explicit analysis of population or demographic parameters (biological criteria) and also of threats under the five ESA listing factors in ESA section 4(a)(1) (listing factors (threats) criteria). Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B). This Plan summarizes the biological criteria and threats criteria that will be used to evaluate the Snake River Sockeye Salmon ESU for potential change in listing status or delisting.

Five-Year Reviews and ESU/DPS Status Assessments

The ESA requires that, at least every five years, the Secretary of Commerce shall conduct a review of all ESA-listed species and determine whether any species should: (1) be removed from such list; (2) be changed in status from an endangered species to a threatened species; or (3) be changed in status from a threatened species to an endangered species. Accordingly, at five-year intervals, NMFS will conduct reviews of the listed Snake River salmon ESUs and steelhead DPSs. These reviews will consider information that has become available since the most recent listing determinations, information specifically related to the limiting factors and threats identified in recovery plans, and make recommendations whether a change in listing status may be appropriate. Any status reviews will be based on the NMFS Listing Status Decision Framework and will be informed by the information obtained through implementation of monitoring, research, and evaluation programs in each management unit plan and the recovery modules.

Similarly, new information considered during five-year reviews may also compel more in-depth assessments of implementation and effectiveness monitoring and associated research to inform adaptive management decision at the management unit level.

Modifying or Updating the Recovery Plan

The ESA requires a review of all listed species at least once every five years. Guidance for these reviews developed jointly by NMFS and the U.S. Fish and Wildlife Service is on the NMFS website: http://www.nmfs.noaa.gov/pr/pdfs/laws/guidance_5_year_review.pdf. According to NMFS Interim Guidance (NMFS 2006), immediately following the five-year species review, an approved recovery plan should be reviewed in conjunction with implementation monitoring, to determine whether or not the plan needs to be brought up to date.

NMFS' Recovery Guidance provides three types of plan modifications: (1) an update; (2) a revision; or (3) an addendum. An update involves relatively minor changes. An update may identify specific actions that have been initiated since the plan was completed, as well as changes in species status or background information that do not alter the overall direction of the recovery effort. An update does not suffice if substantive changes are being made in the recovery criteria or if any changes in the recovery strategy, criteria, or actions indicate a shift in the overall direction of recovery; in this case, a revision would be required. Updates can be made by

NMFS' Interior Columbia Basin Office of the West Coast Region, which will seek input from the local stakeholder group prior to making any update. An update would not require a public review and comment period.

NMFS expects that updates will result from implementation of the adaptive management program for this Plan. Adaptive management depends on the flow of information from field staff to recovery managers and planners; hence, it requires frequent updates from monitoring and research on the effectiveness of recovery actions and the status and trends of the listed species. It may be most efficient to keep the Recovery Plan current by updating it frequently enough to forego the need for major revisions.

A revision is a substantial rewrite and is usually required if major changes are required in the recovery strategy, objectives, criteria, or actions. A revision may also be required if new threats to the species are identified, when research identifies new life history traits or threats that have significant recovery ramifications, or when the current plan is not achieving its objectives. Revisions represent a major change to the recovery plan and must include a public review and comment period.

An addendum can be added to a recovery plan after the plan has been approved and can accommodate minor information updates or relatively simple additions such as implementation strategies, or participation plans, by approval of the Area Office or NMFS' West Coast Region's Regional Administrator. More significant addenda (for example, adding a species to a recovery plan) should undergo public review and comment before being attached to a Plan. Addenda are approved on a case-by-case basis because of the wide range of significance of different types of addenda. NMFS will seek input from stakeholders on minor addenda to this Plan.

Section 11: Research, Monitoring, and Evaluation for Adaptive Management

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11. Research, Monitoring, and Evaluation for Adaptive Management

This section describes the proposed framework for research, monitoring, and evaluation supporting adaptive management for the recovery of Snake River Sockeye Salmon ESU. The section begins with an introduction of the importance of adaptive management as a key component of Sockeye Salmon recovery. It then presents a proposed framework for research, monitoring, and evaluation and concludes with a proposed framework for carrying out adaptive management.

Many different organizations, including state, tribal, Federal, local, and private entities, currently conduct programs and actions designed to improve survival across all "H's" for Snake River Sockeye Salmon as they travel from natal lakes to the ocean and back. These entities also conduct various kinds of monitoring. Coordination of these diverse local and regional monitoring actions will be essential for future NMFS status reviews of the Snake River Sockeye Salmon ESU and understanding the effects of recovery actions to improve ESU viability and promote recovery.

Adaptive Management

Adaptive management plays a critical role in recovery planning. The long-term success of recovery efforts will depend on the effectiveness of incremental steps taken to move this one remaining extant Snake River Sockeye Salmon population from its current status to a viable level. Adjustments will be needed if actions do not achieve desired goals, and to take advantage of new information and changing opportunities. Adaptive management provides the mechanism to facilitate these adjustments.

Adaptive management is a structured process designed to improve understanding and management by helping managers and scientists learn from the implementation and consequences of natural resource policy decisions (Holling 1978; Walters 1986; Lee 1993). Research, monitoring, and evaluation associated with recovery plans need to gather the information that will be most useful in tracking and evaluating implementation and action effectiveness, and assessing the status of listed species. Planners and managers then need to use the information collected to guide and refine recovery strategies and actions. This process is crucial for salmon recovery because of the complexity of the species' life cycle, the range of factors affecting survival, and the limits to our understanding of how specific actions affect species' characteristics and survival.

Adaptive management works by coupling decision making with data collection and evaluation. Most importantly, it offers an explicit process through which alternative approaches and actions can be proposed, prioritized, implemented, and evaluated. Successful adaptive management requires that monitoring and evaluation plans be incorporated into overall implementation plans for recovery actions. These plans should link monitoring and evaluation results explicitly to feedback on the design and implementation of actions. Figure 11-1 illustrates the adaptive management process. Section 11.2 describes the proposed adaptive management framework and approach.

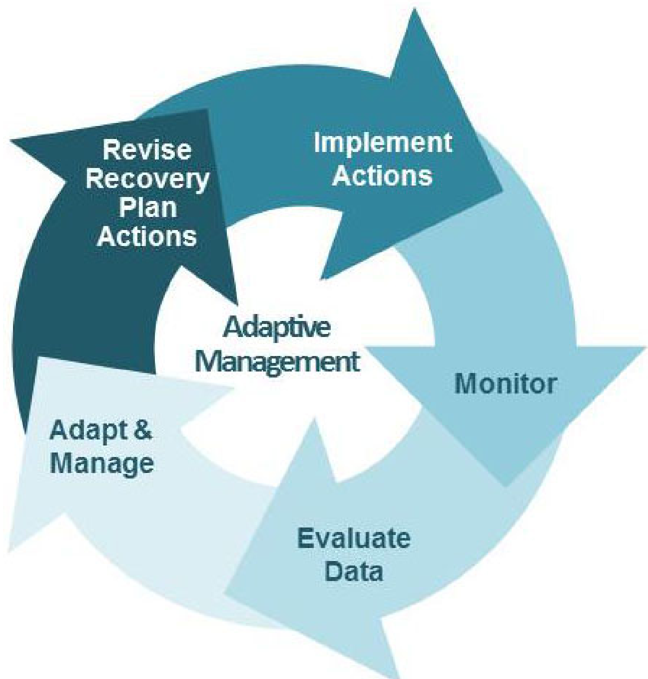

Figure 11-1. The adaptive management cycle.

The research, monitoring, and evaluation (RM&E) plan described below identifies the level of monitoring and evaluation needed to determine the effectiveness of recommended actions, and whether they are leading to improvements in population viability. The plan also identifies critical data gaps in species and habitat knowledge. The data obtained through RM&E plan implementation will be used to assess and, if necessary, correct current restoration strategies.

The Snake River Sockeye Salmon Implementation and Science Team will oversee implementation of an adaptive management plan in coordination with participating agencies, tribes, and entities (see Section 10). The group will:

- Confirm goals and objectives for Sockeye Salmon recovery;
- Compare monitoring results with performance measures within the RM&E plan;
- Review progress toward goals and objectives; and
- Identify and recommend needed changes in strategies and/or actions to better meet goals/objectives, and revise strategies and/or actions accordingly.

A major challenge facing the development and implementation of an effective adaptive management strategy for Snake River Sockeye Salmon is the large number of organizations that implement management actions, as well as the complexity in jurisdictional and management decision authority. These organizations include, but are not limited to, Idaho Department of Fish and Game, Idaho Governor's Office of Species Conservation, Shoshone-Bannock Tribes, state agencies, counties, irrigation districts, agriculture and private forest land managers, NMFS, U.S. Forest Service, BLM, other Federal agencies, utilities, citizen groups, and others. Adding to this complexity is the fact that there is no one single decision body that holds decision authority for management actions across all sectors (habitat, hatcheries, harvest, and hydro). It is unreasonable to expect centralization of all authorities and decision processes into a single decision framework. Therefore, the intent of this adaptive management plan is to develop a collaboration and coordination process that uses the current implementation structures and allows for sharing of information and decisions that influence recovery of Snake River Sockeye Salmon.

Pre-smolt Sockeye Salmon being released at Redfish Lake. *Photo: T. Brown, IDFG.*

11.1 Research, Monitoring, and Evaluation

This research, monitoring, and evaluation plan covers the Snake River Sockeye Salmon ESU. It describes the RM&E recommended for assessing the status and trends in population viability, statutory listing factors, and for evaluating the success of actions implemented to recover Snake River Sockeye Salmon. In addition, this plan identifies current efforts and additional RM&E

needs. Although logistical and monetary limitations exist, this plan will focus on the common goal of assessing success in population and ESU recovery.

This RM&E plan is based in part on principles and concepts laid out in the NMFS document *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed Under the Federal Endangered Species Act* (January 2011) and *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance* (May 1, 2007). These guidance documents provide a listing status decision framework, which is a series of decision-questions that address the status and change in status of a salmonid ESU, and the risks posed by threats to the ESU (Figure 11-2).

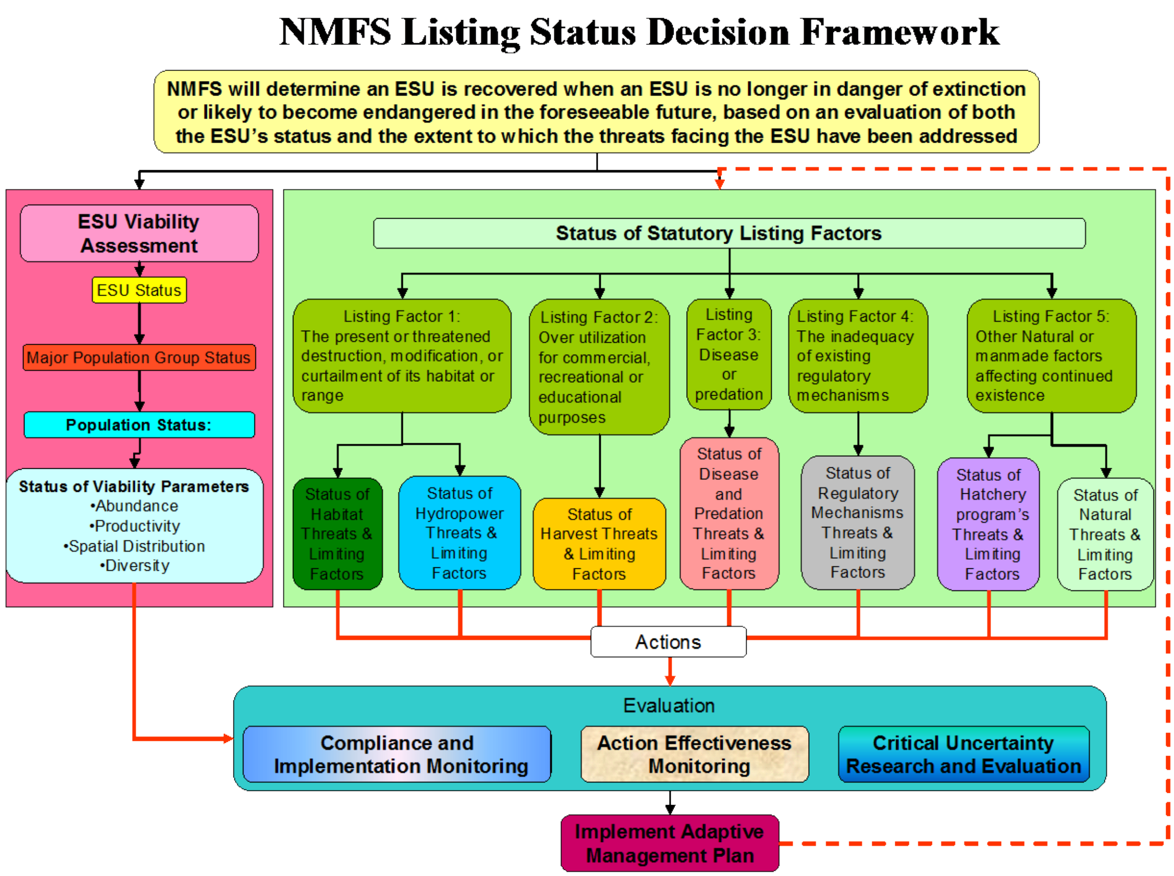

Figure 11-2. Flow diagram outlining the decision framework used by NMFS to assess the status of biological viability criteria and limiting factors criteria.

A Three-Phased Approach

Given the status of the Snake River Sockeye Salmon ESU (a single extant population) and the recommendation to establish at least three viable populations, a multiphase RM&E Plan is needed to determine if the ESU meets recovery criteria. Thus, this plan adopts a three-phase approach:

- Phase 1 – Captive broodstock development and gene rescue;
- Phase 2 – Re-colonization of Redfish and other lakes; and
- Phase 3 – Local adaptation.

The ultimate objective of the three-phase approach is the restoration of natural Sockeye Salmon populations in Sawtooth Valley lakes. A description of the three phases is summarized below.

A key element of the approach is the adaptive nature of the reintroduction strategy. Thus, evaluation of results will guide the course of future actions. Although the plan follows closely the phased approach associated with the hatchery program, it is important to note that in addition to monitoring the hatchery program, other environmental and biological conditions are monitored under each phase. That is, monitoring under each phase is not limited to monitoring the hatchery programs.

Phase 1

Phase 1 has not yet achieved Snake River Sockeye Salmon recovery objectives. Implementation of Phase 1 monitoring began in 1991 and focused on assessing best management practices for the captive brood program, genetic and phenotypic characteristics, reintroduction strategies, spawning success, limnological characteristics, and identification of factors limiting freshwater survival.

Phase 2

Phase 2 is being implemented to produce up to one million smolts at the Springfield Hatchery. The resulting anadromous returns from fish produced at the Springfield Hatchery will be used to meet re-colonization goals in Redfish Lake.

Phase 2 will also implement a temporary adult supplementation program in Pettit Lake using Redfish Lake captive broodstock adults, or eggs produced by those adults, and residual production within Pettit Lake. Anadromous adults will be released upstream of the Sawtooth Hatchery after juvenile Sockeye Salmon rearing at that facility has been terminated. The reintroduction strategy will be further developed and refined as the Redfish Lake strategy is implemented. The future course will depend on the relative trends in anadromous production and resident production in Pettit Lake (Section 6.3.1.5), and performance of the Redfish Lake reintroduction strategy.

In Phase 2 managers will evaluate and identify appropriate strategies for Alturas Lake Sockeye Salmon recovery (Section 6.3.1.6). This investigation will require careful steps to maintain the spatial structure and diversity of the Alturas Lake early stream spawning type, and capture the benefits of local adaptation. Alternative strategies for the early-spawning Alturas Lake residual population might include trap and transport of ocean-returning adults identified as Alturas Lake origin to Alturas Lake, or possibly to the IDFG Eagle Fish Hatchery to establish a new hatchery program for Alturas Lake anadromous Sockeye Salmon.

Phase 2 monitoring would continue Phase 1 monitoring and would be refocused as needed to assess the abundance and trends in adult Sockeye Salmon spawners, phenotypic and genetic characteristics, and biological and environmental factors that limit survival.

Phase 3
Hatchery- and natural-origin run sizes back to the Sawtooth Valley subbasin will be used to “trigger” management decisions such as reducing/eliminating the captive broodstock programs, reducing hatchery production, or shifting resources to new areas. As noted above, Pettit, Alturas, and Redfish Lake Sockeye Salmon restoration will require allocation of additional resources. Monitoring associated with Phase 3 will focus on determining if abundance, productivity, spatial structure, and diversity of Snake River Sockeye Salmon meet recovery criteria; tracking the status and trend in habitat conditions; assessing the effects of habitat actions on Sockeye Salmon survival; and assessing the effects of hydro operations, harvest, predation, disease, and the Phase 3 hatchery program on ESU viability. In addition, the Pettit and Alturas Lake strategies will be evaluated and refined to support naturally adapted anadromous production in the lakes.

11.1.1 Types of Monitoring Efforts

Several types of monitoring are needed to support adaptive management and to allow managers to make sound decisions.

Status and Trend Monitoring
Status monitoring describes the current state or condition of the population and their limiting factors at any given time. Trend monitoring tracks these conditions to provide a measure of the increasing, decreasing, or steady state of a status measure through time. Status and trend monitoring includes the collection of information used to describe broad-scale trends over time. This information is the basis for evaluating the cumulative effects of actions on fish and their habitats.

Action Effectiveness Monitoring
This type of monitoring addresses cause-and-effect. That is, action effectiveness monitoring is designed to determine whether a given action or suite of actions achieved the desired effect or goal. This type of monitoring is research oriented and therefore requires elements of experimental design (e.g., controls or reference conditions) that are not critical to other types of

monitoring. Consequently, action effectiveness monitoring is usually designed on a case-by-case basis. Action effectiveness monitoring provides funding entities with information on benefit/cost ratios and resource managers with information on what actions or types of actions improved environmental and biological conditions.

Implementation and Compliance Monitoring
Implementation and compliance monitoring determines if actions were carried out as planned and meet established benchmarks. This is generally carried out as an administrative review and does not require any parameter measurements. Information recorded under this type of monitoring includes the types of actions implemented, how many were implemented, where they were implemented, and how much area or stream length was affected by the action. Success is determined by comparing field notes with what was specified in the plans or proposals (detailed descriptions of engineering and design criteria). Implementation monitoring sets the stage for action effectiveness monitoring by demonstrating that the restoration actions were implemented correctly and followed the proposed design.

Key Information Needs Research
Research of key information needs includes scientific investigations of critical assumptions and unknowns that constrain effective recovery plan implementation. Uncertainties include unavailable pieces of information required for informed decision making, as well as studies to establish or verify cause-and-effect and identification and analysis of limiting factors.

11.1.2 Monitoring Framework

As discussed above, this framework consists of three phases that correspond to the phases of the hatchery program. Although monitoring of the hatchery program is a large part of the RM&E plan, other biological and environmental conditions are monitored in concert with the hatchery program. Below are the primary objectives associated with each of the monitoring phases.

Phase 1 Monitoring
The goal of the Phase 1 recovery effort is to develop captive broodstock for the purpose of preserving the genetic resources of the population. As an artifact of pursing this goal, eggs and fish not essential to this effort have been produced and re-introduced to the habitat using a “spread-the-risk” approach. Phase 1 recovery efforts were initiated in 1991 and much progress has been achieved in addressing the Phase 1 monitoring objectives. The objectives of Phase 1 monitoring are to:

- Develop best management practices for rearing Snake River Sockeye Salmon to maturation in the hatchery environment (in both fresh and sea-water environments).
- Maintain the genetic resources of the Redfish Lake Sockeye Salmon.

- Release eggs and fish not essential for the maintenance of the captive broodstock to the habitat using multiple reintroduction strategies.
- Determine adult spawning capacity in recovery lakes.
- Identify the relative success of the different reintroduction strategies.
- Determine if full-term and hatchery-origin anadromous adults released to the habitat spawn successfully.
- Describe the life history and phenotypic characteristics of Snake River Sockeye Salmon.
- Determine the limnological characteristics of the nursery lakes of the upper Salmon River basin and assess their ability to aid in recovery efforts.
- Determine what factors may be limiting freshwater survival of Snake River Sockeye Salmon.

Phase 2 Monitoring

In Phase 2, returning adults will be used in a conventional hatchery program to support relatively high levels of anadromous return spawners in Redfish Lake. Initial efforts will prioritize the re-colonization of Redfish and Pettit Lakes. Alturas Lake re-colonization objectives will be refined based on information gained during investigations. Yellowbelly and Stanley Lakes may experience some level of natural colonization during the implementation of Phase 2. An important component of this phase is to assess the capacity and production potential within the nursery lakes. The objectives of Phase 2 monitoring are to:

- Continue to implement elements of Phase 1 monitoring such as genetic and limnological monitoring, and determine the status and trend in habitat conditions for each population.
- Continue to assess the number of adults returning to adult traps and nursery lakes in the Sawtooth Valley.
- Continue to assess the number of returning anadromous adult Sockeye Salmon that spawn naturally in Sawtooth Valley lakes.
- Describe the life history and phenotypic characteristics of Sockeye Salmon in Sawtooth Valley lakes and evaluate strategies to recover Sockeye Salmon using existing populations in Pettit and Alturas Lakes.
- Determine if the five-year geometric mean (GM) of returning Snake River Sockeye Salmon adults (hatchery- and natural-origin) to the Sawtooth Valley meets adult abundance target objectives required to begin sun-setting captive broodstock programs (1,000 to sunset the NOAA programs and 2,150 to sunset the IDFG program).

- Determine if the five-year geometric mean (GM) of returning Snake River Sockeye Salmon natural-origin adults to Redfish Lake are sufficient to allow for transition to Phase 3 and integrated broodstock.

Phase 3 Monitoring

In Phase 3, the focus will be on natural adaptation. It is anticipated that once the populations build to self-sustaining numbers, the hatchery program will be phased out or greatly reduced. It may be necessary, however, to maintain a "safety-net" captive-broodstock program that will guard against environmental events that could cause large declines in the anadromous returns.

The ultimate goal of Phase 3 monitoring is to assess the long-term persistence of viable populations of naturally produced Snake River Sockeye Salmon within the Snake River Sockeye Salmon ESU. In order to determine if the desired outcome has been achieved, answers to two overarching questions need to be addressed:

- Is the status of each population trending toward the recovery criteria?
- Are the effects of the primary factors limiting the status of the populations increasing, decreasing, or remaining stable?

Although these two overarching questions provide the basis for developing Phase 3 of the RM&E plan, it is important to note that several specific objectives attend each of the two overarching questions. Below are the objectives associated with the two questions.

- Determine the status and trend in abundance and productivity of *O. nerka* spawners for each population.
- Determine the status of the spatial structure of each population based on current and historically used habitat.
- Determine the status and trend in life history, genotypic, and phenotypic diversity for each population.
- Determine the status and trend in conditions of habitat for each population.
- Determine the effects of habitat degradation and habitat restoration actions on the abundance, productivity, and spatial structure of the natural populations.
- Determine the influence of the Phase 3 hatchery program on the abundance, productivity, spatial structure, and diversity of the natural populations.
- Determine the effect of mainstem hydropower operations and operational improvements on viability of Snake River Sockeye Salmon populations.
- Determine the effect of harvest on the abundance, productivity, and diversity of the natural populations.
- Determine the effect of predation on the abundance and productivity of the natural populations.

- Determine the transmission and effects of disease on the abundance, productivity, and diversity of the natural populations.

This plan is designed to assess current monitoring efforts and test new strategies for the restoration and recovery of Snake River Sockeye Salmon. It is important to point out that there are several monitoring programs already in place that measure the status of Snake River Sockeye Salmon and several of its limiting factors. For example, there is an extensive plan to assess the hatchery program (IDFG 2010). In addition, current monitoring efforts include spawning ground surveys, assessments at weirs, limnological assessments, Columbia Habitat Monitoring Program (CHaMP) and the USDA PACFISH/INFISH Biological Opinion Monitoring Program (PIBO) habitat status and trend surveys in tributary streams, predator abundance estimates, genetic sampling, tagging studies, juvenile abundance estimates, juvenile smolt indices and smolt condition, adult ladder counts, adult conversion rates, juvenile survival rates, assessments of avian predators, measurements of mainstem environmental parameters (e.g., project flow; spillway flow; forebay and tailrace total dissolved gas levels; forebay, tailrace, and scrollcase temperatures; and turbidity), juvenile dam passage performance evaluations, and fishery assessments. Most of this work is conducted by IDFG, SBT, and NMFS. These monitoring programs, as they relate to each objective, are described below. Where there are gaps in monitoring, this plan intends to fill those gaps by building upon the existing monitoring efforts. Those additional efforts are also described below.

The following sections address the needed RM&E for each of the three monitoring phases. For each monitoring phase and objective, the plan identifies the type of monitoring needed (e.g., status and trend or implementation), key informational needs that were identified in Section 6, monitoring questions, performance metrics, possible approaches (monitoring methods), suggested analyses, and the status of monitoring associated with the objective. The approaches and analyses described for each objective are not exhaustive, but are intended to represent those actions considered to have potential to be implemented while recognizing logistical and monetary constraints. In addition, for many of the monitoring needs, regional review (e.g., ISRP) will suggest potentially different approaches and/or analyses. The intent of this Plan is to help standardize approaches and analyses for monitoring and evaluation purposes.

11.1.3 Phase 1 Monitoring

The purpose of Phase 1 monitoring is to determine if the captive brood program is preserving the genetic resources of the population and increasing adult abundance in both captive and natural environments. As noted above, Phase 1 monitoring includes more than just monitoring the success of the captive brood program. It also includes monitoring biological and environmental conditions. Much of the monitoring needed to address Phase 1 is described in IDFG (2010).

Objective 1. Develop best management practices for rearing Snake River Sockeye Salmon to maturation in the hatchery environment (in both fresh and sea-water environments).

Because of the precipitous decline of Snake River Sockeye Salmon, it was necessary to initiate a captive broodstock program with the primary goal of slowing the loss of critical population genetic diversity and heterozygosity, and to prevent extinction. The approach of the hatchery program under Phase 1 is to minimize inbreeding among closely related individuals and to slow the loss of critical genetic information.

Type of monitoring effort: Implementation and effectiveness monitoring

Key Information Needs:

- None

Monitoring questions:

- Are hatchery best management practices to rear all life stages of Sockeye Salmon adequately developed to address program objectives?
- What are the average life-stage survivals (e.g., green egg to the eyed-egg stage of development, first-feeding fry to maturation, etc.)?

Performance metrics:

- Number of fish collected for broodstock
- Life-stage survival in hatchery
- Number of fish spawned and released

Possible Approach:

Record broodstock (numbers, origin, sex); sample numbers of fish monthly through rearing; and record number of fish released.

Suggested Analysis:

Compare abundances and life-stage survival rates to standards from HGMP and other agreements.

Status:

Most of this work is being conducted by IDFG with funding from BPA. Results can be found in (Ford 2011; Baker et al. 2012).

Objective 2. Maintain the genetic resources of the Redfish Lake Sockeye Salmon.

To determine if the program is maintaining or slowing the loss of genetic diversity and heterozygosity, it is necessary to measure allelic diversity and heterozygosity, and track them over time.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- How can remnant anadromous Sockeye Salmon gene resources that exist in other Sawtooth Valley lakes be used for recovery efforts on a lake specific basis?
- Is the current Redfish Lake Sockeye Salmon captive broodstock genetic structure appropriate for use in rebuilding efforts in other Sawtooth Valley lakes?

Monitoring questions:

- What was the historic genetic diversity and heterozygosity of Snake River Sockeye Salmon?
- To what degree have the genetic diversity and heterozygosity of Snake River Sockeye Salmon changed since the captive brood program began in 1991?

Performance metrics:

- Indices of genetic diversity (allelic diversity, heterozygosity-microsatellites, single nucleotide polymorphisms)

Possible Approach:

Collect and analyze genetic samples from a representative sample of adult and juvenile *O. nerka*. Samples are obtained from broodstock, smolt traps, mid-water trawls, and adult returns. Identify and analyze historic genetic samples (e.g., taxidermy, samples from biological surveys, etc.) of *O. nerka* from the Sawtooth Valley lakes.

Suggested Analysis:

DNA tissue samples are analyzed using known genetic markers (including microsatellite loci and non-coding single nucleotide polymorphisms (SNPs), or base substitutions assayed via restriction enzyme analysis).

Status:

IDFG has been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013).

Objective 3. Release eggs and fish not essential for the maintenance and annual rebuilding of the captive broodstock to the habitat using multiple reintroduction strategies.

When adult returns are in excess of hatchery program needs, adults are released back into the natural environment. Additionally, eggs from spawning events to maintain the captive broodstock are produced in excess of what is needed to maintain the broodstock and these hatchery eggs have been reared to various stages for release into the natal habitat.

Type of monitoring effort: Effectiveness Monitoring.

Key information needs:

- None

Monitoring questions:

- Has the current “spread-the-risk” strategy of releasing eggs and fish to the habitat been sufficient to test the success of the different strategies used?
- Which release strategies result in the highest survival rate and successful spawning?
- Which release strategies improve spatial structure, life-history and genetic diversity, and productivity?

Performance metrics:

- Egg retention
- Distribution of spawners by release strategy
- Survival by release strategy
- Number of eggs or juveniles released

Possible Approach:

Record spawning data (sex, fecundity, release information per parent), numbers of fish monthly through rearing, and record number of fish released. Differentially mark fish at the time of release with physical marks or parentage-based tagging (PBT).

Suggested Analysis:

Compare life-stage survival for each release strategy. Quantify the number of eggs produced and the number of fish released per strategy.

Status:

The SBT, Biolines Environmental Consulting, and IDFG have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011), Peterson et al. (2013), and Baker et al. (2013). Griswold et al. (2012) provides an evaluation of parr releases in Redfish, Pettit, and Alturas Lakes.

Objective 4. Identify the relative success of the different Phase 1 reintroduction strategies.

Since there are different strategies being used in Phase I to increase the number of fish returning to the Sawtooth Valley, it is important to evaluate which one(s) may be the most successful.

Type of monitoring effort: Status and trend monitoring and effectiveness monitoring.

Key information needs:

- None

Monitoring questions:

- How many juvenile Snake River Sockeye Salmon from each of the different rearing/release strategies pass Lower Granite Dam?
- How many adult Sockeye Salmon from each of the different rearing/release strategies return to the two adult traps in the Sawtooth Valley?
- How many returning adult Snake River Sockeye Salmon from each of the rearing/release strategies spawn naturally?
- What is the productivity of Sockeye Salmon that were produced under each rearing/release strategy?

Performance metrics:

- Survival by rearing/release strategy
- Growth by rearing/release strategy
- Adult age structure/release strategy
- Adult return numbers/release strategy

Possible Approach:

Marks and tags can be used to identify fish from a specific rearing/release strategy, census of adult returns; origin of adults returning to natal lakes; conduct multiple spawning surveys within all populations (see Approach under Objective 1).

Suggested Analysis:

Associating a hatchery spawner with a specific rearing/release strategy is needed in order to estimate the proportion of adults returning from a particular strategy. Analysis of marks and tags can be used to identify the return and survival of fish from different rearing/release strategies. Marks, tags, and parentage based tagging (PBT) analyses are used to identify fish from specific release strategies. A simple approach is to compare the number of PBT marked fish that returned by release strategy to the number of fish released within each strategy. Additional productivity measures (SARs, recruits per spawner) can also be reported. The number of naturally produced spawners can be estimated by PBT tagging of the released parents and returning unmarked adults.

Status:

IDFG has been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013).

Objective 5. Determine if full-term (captive brood) and hatchery-origin anadromous adults released to the habitat spawn successfully.

Both full-term and hatchery-origin adults will be released into the system to spawn naturally. This objective will determine if these releases are successful and if one is more successful than the other.

Type of monitoring effort: Status and trend monitoring and effectiveness monitoring.

Key information needs:

- What are the various numerical adult spawning carrying capacities for anadromous Sockeye Salmon in the Sawtooth Valley lakes?
- How do these carrying capacity maximums fit with recovery planning needs to address abundance, spatial structure, and diversity needs (e.g., is spawning and rearing capacity a limiting factor)?

Monitoring questions:

- How many full-term and hatchery adult Sockeye Salmon spawn naturally on spawning grounds in the Sawtooth Valley lakes?
- How many redds are produced by full-term and hatchery adults?
- What is the spawn timing of full-term and hatchery adults in Sawtooth Valley lakes?
- How many adults return from full-term and hatchery adult Sockeye Salmon?
- How many residuals are observed on the spawning grounds?

Performance metrics:

- Number of full-term, hatchery, and residual spawners
- Number of redds
- Spawn timing
- Abundance of residual Sockeye Salmon

Possible Approach:

The number of full-term and hatchery-origin spawners will be estimated using redd surveys. The number of residual Sockeye Salmon spawners will be estimated using nighttime snorkel counts. Multiple redd surveys will cover the entire spawning areas.

Suggested Analysis:

Genetic data from emigrating juveniles or returning adults can be used to assign fish to full-term spawners, hatchery-origin spawners, and potentially residual spawners. Spawn timing can be estimated using the temporal distribution of observed redds. The number of naturally produced spawners can also be estimated using proportions of hatchery and naturally produced fish, total number of redds, and fish/redd ratio. If weirs are used, abundance is based on weir counts, proportions of hatchery and naturally produced fish, and pre-spawn survival rates.

Status:

The SBT, Biolines Environmental Consulting, and IDFG have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013).

Objective 6. Describe the life history and phenotypic characteristics of Snake River Sockeye Salmon.

For successful recovery of Snake River Sockeye Salmon to occur, fish will have to adapt to the local habitat conditions. Life history and phenotypic characteristics such as resident versus anadromous, size and age at migration, age at maturation, migration timing, and spawn timing can be affected by local habitat conditions.

Type of monitoring effort: Long-term status and trend monitoring.

Key information needs:

- Is the current Redfish Lake Sockeye Salmon captive broodstock genetic structure appropriate for use in rebuilding efforts in other Sawtooth Valley lakes (especially Alturas)?

- How can remnant anadromous Sockeye Salmon gene resources in other Sawtooth Valley lakes be used for recovery efforts on a lake-specific basis?
- What stock or stocks should be used for reintroduction into Alturas Lake?
- Is the current Redfish Lake Sockeye Salmon captive broodstock late September through October spawn timing structure appropriate for water temperature regimes in other Sawtooth Valley lakes?
- Is the current Redfish Lake Sockeye Salmon captive broodstock beach spawning propensity appropriate for rebuilding efforts in other Sawtooth Valley lakes, or would early stream spawning populations be more appropriate?
- What are the benefits/risks of alternative strategies for recovering extant and/or historical life-history patterns in the natal lakes?
- Do high water temperatures in the lower Salmon and Snake Rivers affect upstream and downstream Sockeye Salmon survival and life-history characteristics?
- What will be the role of beach vs. stream spawning types?
- Given regional temperature and precipitation patterns projected from climate models, how would potential changes in stream temperature and flows affect life-stage survivals and life-history characteristics for Snake River Sockeye Salmon?

Monitoring questions:

- What is the migration timing of adult Snake River Sockeye Salmon returning to the Snake River and adult trap sites in the Sawtooth Valley?
- What is the relationship between anadromous and residual Sockeye Salmon?
- Are residual populations viable?
- How long do adult Sockeye Salmon stage in Redfish Lake before spawning?
- What is the migration timing of juvenile Sockeye Salmon leaving Redfish, Pettit, and Alturas Lakes?
- At what size and age do juvenile Sockeye Salmon exit the Sawtooth Valley lakes?
- What is the condition factor and lipid content of emigrating juvenile Sockeye Salmon and how does this affect survival?
- What is the fecundity of captive, hatchery- and natural-origin adult Snake River Sockeye Salmon?
- What is that size and age at maturity of captive, hatchery- and natural-origin anadromous adult Sockeye Salmon?
- Do hatchery fish exhibit reductions in life-history and phenotypic diversity and will these affect extant natural/wild *O. nerka* populations?

Performance metrics:

- Adult migration and spawning timing
- Age and length at maturity
- Fecundity
- Smolt age and size

Possible Approach:

Evaluation of life history and phenotypic characteristics will be accomplished by sampling live fish at weirs and observing fish on spawning grounds. Migration timing can be assessed at Lower Granite Dam and at weirs. Multiple spawning surveys will be conducted within all populations to determine spawn timing. Live and dead fish will be sampled for size (fork length), origin, marks and tags, and age (from ageing structures and PBT). Adult females collected for the hatchery program can be used to assess fecundity. Age, size, and number of smolts will be measured at smolt traps located near the mouth of the lakes.

Suggested Analysis:

The migration timing of Sockeye Salmon can be described by analyzing the temporal distribution of adults observed at Lower Granite Dam and at weirs within the basin. Spawn timing can be evaluated by analyzing the temporal distribution of spawners. Comparisons can be made between returning natural- and hatchery-origin fish using cumulative frequency plots. Age and length by origin and sex can be evaluated using ANOVA. Data collected from smolt traps can be analyzed to estimate the number of smolts that migrate out of the lakes at different ages, their size, and timing of migration (i.e., beginning, peak, and end of migration).

Status:

IDFG and SBT have been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013) and Griswold et al. (2011). Powell et al. (2010) and Griswold et al. (2012) provided additional information on smolt condition and survival.

Objective 7. Determine the limnological characteristics of the nursery lakes of the upper Salmon River basin and assess their ability to aid in recovery efforts.

It is important to understand the current habitat conditions within the natal lakes that support Sockeye Salmon. Factors such as amount of spawning habitat, plankton composition, and *O. nerka* abundance are all important factors in understanding the probability of success of Sockeye Salmon reaching recovery levels.

Type of monitoring effort: Status and trend monitoring and effectiveness monitoring.

Key information needs:

- How do estimates of carrying capacity fit with VSP recovery criteria (e.g., is spawning and rearing capacity limiting such that VSP recovery criteria cannot be met)?
- What can be derived from limnological monitoring data regarding potential for juvenile anadromous Sockeye Salmon growth and survival in the various Sawtooth Valley lakes?
- How much zooplankton is available to support juvenile rearing and survival in the natal lakes?
- What is the relationship between variability in zooplankton abundance and species composition vs. juvenile *O. nerka* density, survival, anadromy v. residency?
- Will competition for food resources or spawning areas restrict efforts to reestablish natural Sockeye Salmon populations in the natal lakes?
- What habitat areas will be important as fish abundance recovers?
- To what degree do juvenile Sockeye Salmon compete with kokanee (or other fish) in Sawtooth Valley lakes and how does this affect *O. nerka* carrying capacity estimates in each lake?
- Do the numbers of kokanee need to be reduced in order to recover Sockeye Salmon?
- What are the key rearing and spawning constraints within each natal lake?

Monitoring questions:

- What are the limnological characteristics (e.g., water clarity, water chemistry, phytoplankton and zooplankton abundance and composition) of the nursery lakes?
- What is the diet, growth rate, and estimated survival of juvenile Sockeye Salmon in the nursery lakes?

- What is the carrying capacity for adult spawning and juvenile rearing within each nursery lake?
- What affects will anticipated increased adult returns of anadromous Sockeye Salmon have on resident *O. nerka* abundance and how will this affect lake productivity, zooplankton grazing pressure, and lake rearing capacities?

Performance metrics:

- Water quality
- Spawning and rearing habitat quality and quantity
- Limnological characteristics of lakes over time
- Primary productivity of lakes over time
- Zooplankton abundance over time
- Diet of juvenile Sockeye Salmon
- Growth and survival of juvenile Sockeye Salmon

Possible Approach:

Water quality and zooplankton abundance can be estimated from samples of water temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), Secchi depth (m), compensation depth (m), nutrient concentrations (µg/L), chlorophyll *a* concentrations (µg/L), phytoplankton density (cells/mL) and biovolume (mm^3/L), and zooplankton density (number/L) and biomass (mg/m^2) near the middle of each lake. Additional zooplankton samples can be collected from one or two other stations in each lake. Nutrients should be sampled in all lakes once per month in June, July, August, and October. Primary productivity estimates can be obtained and used with the Photosynthetic Rate Model to improve carrying capacity estimates. The Photosynthetic Rate Model carrying capacity estimates should be adjusted for kokanee grazing, which can be obtained using a bioenergetics model.

Juvenile fish abundance and density can be estimated by collecting hydroacoustic and trawl data. Mid-water trawl surveys provide biological data (e.g., length and weight at age and proportion of Snake River Sockeye Salmon vs. kokanee (based on genetic analysis)) necessary to estimate biomass, density, and age-specific abundance of *O. nerka* within Redfish, Alturas, and Pettit Lakes from hydroacoustic methodology. In addition, horizontal and vertical gillnet sampling and trawl surveys can be conducted to quantify fish population characteristics including: species composition, habitat use (pelagic versus littoral), and diet analysis. Growth of presmolt releases can be estimated by recapturing marked fish and measuring them to the nearest 0.1 grams and fork length (mm). Diet analysis is estimated by sampling fish stomachs collected from gillnet and trawl samples.

Zooplankton electivity indices can be developed from the relative proportion of zooplankton taxa in the lake environment and in stomach contents.

Suggested Analysis:

Target strengths and fish densities from hydroacoustic surveys can be processed using a Model 340 Digital Echo Processor and plotted with a Model 402 Digital Chart Recorder. Gillnet sampling can be used to estimate fish densities by using adjacent transects as replicates within a stratum (lake). Population estimates and variance for individual size classes can be obtained by using the equations found in Griswold et al. (2011) and Peterson et al. (2012) for hydroacoustic and mid-water trawl methods, respectively. Specific growth rates can be used to express growth relative to an interval of time and are commonly expressed as a percentage. Diet analysis can be estimated by enumerating zooplankton prey in a water bath under a compound microscope. Zooplankton could also be enumerated from vertical tows collected from the appropriate lakes during the same time period that stomachs are collected to develop electivity indices.

Status:

The SBT and Biolines Environmental Consulting have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013).

Objective 8. Determine what factors may be limiting freshwater survival of Snake River Sockeye Salmon.

To reach recovery goals, it will be necessary to identify and understand the factors that may be reducing survival of juvenile and adult Snake River Sockeye Salmon.

Type of monitoring effort: Status and trend monitoring and effectiveness monitoring.

Key information needs:

- Is the mortality of juvenile outmigrating and adult returning anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam related to natural causes (e.g., competition, predation, environmental conditions) or are extraneous causes involved?
- Are there local areas (hot-spots) where mortality is concentrated during juvenile smolt and adult return migration for anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam, or are mortality rates uniform over migration distance?

- What are the effects of transportation on juvenile Sockeye Salmon survival?[10]
- Have lake trout (presently in Stanley Lake) colonized other Sawtooth Valley Sockeye Salmon nursery lakes?
- Does exposure to contaminants and bioaccumulation of contaminants in the estuary affect Snake River Sockeye Salmon survival?

Monitoring questions:

- What effect do sympatric kokanee have on anadromous Sockeye Salmon in the Sawtooth Valley lakes?
- How does *O. nerka* density affect zooplankton abundance, and growth and survival of juvenile Sockeye Salmon/resident *O. nerka*?
- How does size/condition of outmigrants affect smolt survival and SAR?
- What non-native predators in nursery lakes and in the migration corridor potentially limit juvenile Sockeye Salmon survival?
- What is the risk that non-native predators (e.g., lake trout) will colonize additional Sockeye Salmon nursery lakes in the Sawtooth Valley?
- What native predators in nursery lakes and in the migration corridor potentially limit juvenile Sockeye Salmon survival?
- What is the predation rate and predatory impact of exogenous fishes on the Snake River Sockeye Salmon ESU?
- What is the effect of predation from piscine predators in the Columbia River migration corridor on Snake River Sockeye Salmon?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile Snake River Sockeye Salmon?
- What is the effect of predation from marine mammals in the Columbia River migration corridor on adult Snake River Sockeye Salmon?
- What is the effect of Columbia River hydropower operations on juvenile Snake River Sockeye Salmon?
- What is the effect of Columbia River hydropower operations on returning adult Snake River Sockeye Salmon?
- How do conditions in the estuary affect Sockeye Salmon rearing, residence times, growth rates, and survival?

[10] It would be useful if CSS included Sockeye Salmon in their analysis.

Performance metrics:

- Native and non-native predator abundance
- Juvenile and adult survival rates
- Kokanee abundance
- Lake productivity
- Water temperature
- Stream flows
- Total dissolved gas (TDG)

Possible Approach:

Kokanee abundance is estimated through hydroacoustic surveys, trawl and net sampling, spawner counts, and redd counts. Juvenile fish survival to Lower Granite Dam (and to detection sites downstream) can be determined through mark and recapture of juvenile Sockeye Salmon using radio and potentially PIT-tags. Temperature and TDG are recorded at various locations.

Suggested Analysis:

Juvenile survivals at each FCRPS facility can be estimated using the SURPH model. Juvenile survival from release points (e.g., at lake outmigration traps) to Lower Granite Dam can be estimated using mark-recapture methods. Adult survival between facilities can be estimated by comparing tag detections at adult ladders along the migration corridor. Rates can be expanded to population-level effects using the relative number of fish PIT-tagged and abundance estimates generated from mark-recapture studies. TDG levels and temperature at each facility will be compared to standards to determine timing and duration of exceedances. Active tags (radio and/or acoustic) can also be used to determine where mortality "hot spots" may be occurring.

Status:

This work is ongoing and being conducted by NMFS, IDFG, and SBT with funding from BPA. The most current results can be found in Axel et al. (2013), Peterson et al. (2013), and Griswold et al. (2011). Additional information regarding smolt condition and subsequent smolt survival can be found in Powell et al. (2010) and Griswold et al. (2012).

11.1.4 Phase 2 Monitoring

One main purpose of Phase 2 monitoring is to determine if returning adults from a conventional hatchery program are leading to increased natural production of outmigrating smolts consistent with achieving natural-origin return targets for Redfish Lake. Initial efforts will prioritize the re-colonization of Redfish Lake. Pettit and Alturas lake re-colonization strategies will be refined over time based on natural production responses. Yellowbelly and Stanley Lakes may experience some level of natural colonization during the implementation of Phase 2. Additional monitoring efforts will track life-stage survivals and assess environmental and biological conditions for spawning, rearing, and migration.

Objective 1: Continue to implement elements of Phase 1 monitoring such as genetic and limnological monitoring, and determine the status and trend in habitat conditions for each population.

As described above, the purpose of Phase 1 monitoring is to determine if the captive brood program is preserving the genetic resources of the population and increasing adult abundance in both captive and natural environments. In addition, it tracks life-stage survivals and environmental and biological conditions. All the monitoring associated with Phase 1 monitoring is described in Section 11.1.3. What follows is the monitoring needed to determine the status and trend in habitat conditions for each population.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- How does lake productivity change as adult escapement increases and salmon derived nutrients increase?
- How do zooplankton populations respond to altered grazing patterns associated with increased anadromy?
- How do changes in nutrients and food abundance affect lake carrying capacity estimates for juvenile *O. nerka*?
- What are the various numerical adult spawning carrying capacities for anadromous Sockeye Salmon in the Sawtooth Valley lakes?
- What is the quantity and quality of spawning habitats used by anadromous adults?
- Can lake trout (presently in Stanley Lake) be prevented from colonizing other Sawtooth Valley Sockeye Salmon nursery lakes?

Monitoring questions:

- What is the status and trend in spawning and rearing habitat conditions for each population?

- How does increased anadromous production affect lake productivity and *O. nerka* carrying capacity?

Performance metrics:

- Water quality
- Primary productivity
- Zooplankton abundance and species composition over time
- Limnological characteristics of the lakes over time
- Relative abundance of resident vs. anadromous *O. nerka*
- Habitat access
- Habitat quality and quantity
- Riparian condition
- Watershed condition

Possible Approach:

Lake rearing and spawning conditions can be assessed by monitoring habitat characteristics within the lakes. Water quality and zooplankton abundance can be estimated from samples of water temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), Secchi depth (m), compensation depth (m), nutrient concentrations (µg/L), chlorophyll *a* concentrations (µg/L), phytoplankton density (cells/mL) and biovolume (mm^3/L), and zooplankton density (number/L) and biomass (mg/m^2) near the middle of each Sawtooth Valley lake. Additional zooplankton samples can be collected from one or two other stations in each lake. Nutrients should be sampled in all lakes once per month in June, July, August, and October.

Habitat conditions for stream spawning and migration can be obtained by applying the protocols outlined in the Columbia Habitat Monitoring Program (CHaMP; Ward et al. 2012) or the USDA PACFISH/INFISH Biological Opinion Monitoring Program (PIBO; Archer et al. 2012). Although both programs collect habitat status and trend data, the two programs are designed somewhat differently, because of different objectives and goals. Nevertheless, the programs are currently working on merging their protocols so that habitat information can be shared between the two programs. Thus, information on instream habitat conditions, riparian conditions, and watershed conditions can be assessed under both programs.

Instream habitat variables to be measured include riparian cover, sinuosity, valley form, gradient, solar input, bankfull distance and height, geomorphic channel unit type, thalweg profile, channel depth, wetted width, substrate composition, undercut banks, woody debris, fish cover, pool tail fines, subsurface fines, conductivity, alkalinity, and macroinvertebrates. PIBO and CHaMP have developed databases, data dictionaries, meta-data support, and tools to help biologists collect, process, and store the habitat data.

Suggested Analysis:

Water quality and zooplankton abundance can be analyzed as a time series. The Photosynthetic Rate Model can be used to estimate carrying capacity. The Photosynthetic Rate Model can also be modified to account for competition with resident *O. nerka*. Relative zooplankton consumption by juvenile Sockeye Salmon versus mixed age classes of kokanee can be assessed using limnological data and a bioenergetics model. These results can be used to refine carrying capacity estimates. Instream and watershed habitat status can be analyzed with the Horvitz-Thompson or π-estimator and trend can be analyzed with multi-phase regression analyses. The database and GIS formatting of data will also allow associations with land use, land vegetation coverage, and many other attributes at watershed and population scales.

Status:

The SBT, Biolines Environmental Consulting, and IDFG have been performing most of the lake monitoring with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013). Additional funding will be needed to derive the information needed to specifically address this objective and to collect the necessary information from additional Sawtooth Valley lakes. Additional funding will also be needed to conduct instream and watershed monitoring if there are gaps in PIBO and CHaMP coverage in the Sawtooth Valley basin.

Objective 2: Continue to assess the number of adults returning to adult traps and nursery lakes in the Sawtooth Valley.

Abundance of returning adults to the Sawtooth Valley is an important indicator of success and an important component of VSP.

Type of monitoring effort: Long-term status and trend monitoring.

Key information needs:

- Is the mortality of adult returning anadromous Sockeye Salmon in the area between the upper Snake River basin and Lower Granite Dam related to natural causes (e.g., competition, predation, environmental conditions) or are extraneous causes involved?
- Are there local areas (hot-spots) where mortality is concentrated during adult migration for anadromous Sockeye Salmon in the area between Lower Granite

Dam and the upper Snake River basin, or are mortality rates uniform over the migration distance?

- What estuary and ocean indicators (biological and physical) correlate with Sockeye Salmon growth rates, life-stage survival, and with SARs?
- Do high water temperatures in the lower Salmon and Snake Rivers affect upstream Sockeye Salmon survival?
- How do SARs vary among lakes, years, natural vs. hatchery, and residual vs. Sockeye Salmon?

Monitoring questions:

- How many natural- and hatchery-origin adults return to the Sawtooth Valley adult traps and lakes annually?

Performance metrics:

- Number of returning adults (hatchery and natural-origin)

Possible Approach:

Adult abundance is determined by enumerating hatchery- and natural-origin adults trapped at Sawtooth Valley locations. The number of adults released to spawn naturally in Sawtooth Valley lakes is currently controlled and known.

Suggested Analysis:

Total abundance of returning hatchery and naturally produced fish is determined by summing the number of each stock (origin) collected at the adult traps. Regression analysis could be used to develop relationships between key environmental factors such as flow or water temperature and survival of upstream migrating adults.

Status:

IDFG has been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013) and Baker et al. (2013).

Objective 3: Continue to assess the number of returning anadromous adult Sockeye Salmon that spawn naturally in Sawtooth Valley lakes.

Not all adults that are enumerated at the adult traps will survive to spawn (i.e., pre-spawn loss). The productivity of each population is determined in part by knowing the number of successful spawners. Thus, the spawning escapement of hatchery and natural-origin Sockeye Salmon is one of the most important indicators of success.

Type of monitoring effort: Status and trend monitoring.

Key information needs:

- How much spawning habitat is available in lakes and streams not currently used by anadromous Sockeye Salmon?
- What spawning areas will be important as fish abundance recovers?
- What will be the role of beach vs. stream spawning types?
- Will competition for spawning areas restrict efforts to reestablish natural Sockeye Salmon populations in the natal lakes?

Monitoring questions:

- How many adult Sockeye Salmon spawn naturally in Sawtooth Valley lakes?
- What percentage of the spawning escapement consists of hatchery- and natural-origin anadromous Sockeye Salmon?
- How many residual Sockeye Salmon are observed on spawning grounds?
- How many kokanee are observed on spawning grounds?

Performance metrics:

- Number of hatchery and natural-origin spawners
- Number of residual Sockeye Salmon spawners
- Number of kokanee spawners

Possible Approach:

The number of spawners will be estimated using redd surveys. Multiple redd surveys will cover the entire spawning areas. Genetic samples collected from smolts and returning adults can be used to assess representation of spawners to offspring.

Suggested Analysis:

The number of naturally produced spawners is estimated using proportions of hatchery and naturally produced fish, total number of redds, and a fish/redd ratio. If weirs are used, abundance is based on weir counts, proportions of hatchery and naturally produced fish, and pre-spawn survival rates. Genetic analysis (see Objective 2 under Phase 1 Monitoring) will assign outmigrants and returning adults to spawners. As returning adults are assigned to spawners, percentage of hatchery and natural-origin fish that contribute to the return can be calculated.

Status:

IDFG and SBT have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013).

Objective 4: Describe the life history and phenotypic characteristics of Sockeye Salmon in Sawtooth Valley lakes.

See Objective 6 under Phase 1 monitoring.

Objective 5: Determine if the five-year geometric mean (GM) of returning Snake River Sockeye Salmon adults (hatchery- and natural-origin) to the Sawtooth Valley meets adult abundance target objectives.

To understand when the captive broodstock programs can be terminated, specific performance standards need to be met. This objective will enable managers to determine if performance metrics have been met and when it is appropriate to terminate these programs.

Type of monitoring effort: Long-term status and trend monitoring.

Key information needs:

- None

Monitoring questions:

- What is the number and origin of anadromous Sockeye Salmon that return to adult traps and lakes in the Sawtooth Valley annually?

Performance metrics:

- Number and origin of adult anadromous Sockeye Salmon

Possible Approach:

Adult abundance is determined by enumerating hatchery- and natural-origin adults trapped at Sawtooth Valley locations.

Suggested Analysis:

Total abundance of returning hatchery and naturally produced fish is determined by summing the number of each stock (origin) collected at the adult traps and sampling locations. Five-year running geometric means are then calculated and these estimates are compared to the target values.

Status:

IDFG has been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013). In addition, NMFS evaluates the status of the species every five years and the latest stock status can be found in Ford (2011).

Objective 6: Determine if the five-year geometric mean (GM) of returning Snake River Sockeye Salmon adults to the Sawtooth Valley exceeds the targets to transition to Phase 3.

To understand when it is appropriate to transition to Phase 3, specific performance standards need to be met. This objective will enable managers to understand when it is appropriate to make the transition.

Type of monitoring effort: Long-term status and trend monitoring.

Key information needs:

- None.

Monitoring questions:

- What is the number of naturally produced anadromous Sockeye Salmon that return to adult traps and lakes in the Sawtooth Valley annually?

Performance metrics:

- Number of naturally produced adult anadromous Sockeye Salmon

Possible Approach:

Adult abundance is determined by enumerating natural-origin adults trapped at Sawtooth Valley locations. Origin is confirmed genetically from tissue samples collected from all trapped adults.

Suggested Analysis:

Total abundance of returning hatchery and naturally produced fish is determined by summing the number of each stock (origin) collected at the adult traps and sampling locations. Five-year running geometric means are then calculated and these estimates are compared to the target values.

Status:

IDFG has been performing this work with funding from BPA. The most recent results can be found in Peterson et al. (2013). Additional funding may be needed to derive the information needed to specifically address this objective.

Objective 7: Determine the transmission and effects of disease on the abundance, productivity, and diversity of the natural populations.

A goal of the Phase 2 hatchery program will be to release large numbers of hatchery fish to support high levels of anadromous return spawners in Redfish Lake. It will be important to release fish into the system that are known to have a healthy disease history during rearing to minimize impacts on naturally and hatchery-produced fish.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.

Monitoring questions:

- What are the prevalence and level of pathogens in natural and hatchery-origin Snake River Sockeye Salmon?
- What are the magnitude and pathways of disease transmission between hatchery and natural-origin Snake River Sockeye Salmon?
- What are the magnitude and pathways of disease transmission between hatchery and residual Sockeye Salmon and kokanee?

Performance metrics:

- Number of infected hatchery and naturally produced fish
- Spatial distribution of disease

Possible approach:

The health of hatchery fish will be monitored starting with broodstock and continuing through rearing and release of juveniles. The health of naturally produced fish will be assessed on dead parr, smolts, and spawners encountered during monitoring activities. All sampling, diagnostic, and statistical analyses will comport with the Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection committee guidelines. All disease monitoring will be consistent with the IDFG fish health policy and the native fish conservation policy. In addition, dead, naturally produced fish collected as parr or smolts during smolt trapping and juvenile sampling will be examined for diseases. Hatchery fish are sampled before release, during spring outmigration from the lakes, and throughout their life cycle within the hatchery.

Suggested analysis:

Analysis of samples will follow standard protocols defined in the latest edition of the American Fisheries Society "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens (Blue Book)."

Status:

The IDFG Eagle Fish Health Lab has been doing comprehensive fish health work on Snake River Sockeye Salmon since 1991.

11.1.5 Phase 3 Monitoring

Once the program transitions to Phase 3, a robust monitoring phase will begin that focuses on the VSP parameters and recovery criteria. For this phase of RM&E, abundance, productivity, spatial structure, and diversity will be compared to the criteria that are described in Section 3 of this Plan to determine if Snake River Sockeye Salmon are trending towards or meeting the recovery objectives. Importantly, monitoring conducted under Phase 1 and 2 also applies to Phase 3. That is, in many cases, Phase 3 monitoring is a continuation of Phase 1 and 2 monitoring.

Objective 1: Determine the status and trend in abundance and productivity of *O. nerka* spawners for each population.

The status of a population is determined by estimating the VSP parameters. The status of adult abundance, population productivity, and growth rate is compared to the population-specific recovery criteria resulting in an overall determination of the status of the ESU. Tracking these parameters over time within each population also allows estimation of long-term trends. Monitoring long-term trends will be critical to assessing the performance of restoration projects.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.

Monitoring questions:

- Is the 10-year GM for natural-origin Snake River Sockeye Salmon spawners in each population greater than or equal to the recovery criteria for natural spawners?
- What are the current natural-origin spawner abundance and five-year trend in abundance for each population?
- What are the current and trend in the natural-origin spawner 20-year population growth rate for each population?

- What is the current productivity for each natural population compared to the delisting criteria?

Performance metrics:

- Number of spawners (hatchery plus natural)
- Number of natural recruits
- Recruits per spawner (smolts per spawner and spawner-to-spawner ratios)
- Age of returning adults

Possible Approach:

Adult abundance is determined by enumerating hatchery- and natural-origin adults trapped at Sawtooth Valley locations. Origin is confirmed genetically from tissue samples collected from all trapped adults. The number of adults released to spawn naturally in Sawtooth Valley lakes is currently controlled and known. Estimates of juvenile emigration are generated annually for Redfish, Pettit, and Alturas Lakes.

Suggested Analysis:

The number of naturally produced spawners is estimated using proportions of hatchery and naturally produced fish (confirmed using genetic analyses), total number of redds, and fish/redd ratio. If weirs are used, abundance is based on weir counts, proportions of hatchery and naturally produced fish (confirmed using genetic analyses), and pre-spawn survival rates. The latter can be determined by estimating the conversion rate from Lower Granite Dam window counts to the number of fish surviving post-release into the lake. The 10-year GM for abundance of naturally produced fish is calculated. Productivity is based on an evaluation of the most recent 20-year period of spawner abundance (hatchery plus natural fish) and an estimate of natural recruits based on a run re-construction that includes age structure and downstream fishery information. These abundance and productivity estimates are analyzed in a time series and compared to recovery criteria.

Status:

IDFG and SBT have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013). Additional funding may be needed to derive the information needed to specifically address this objective. In addition, NMFS evaluates the status of the species every five years and the most recent five-year review can be found in Ford (2011).

Objective 2: Determine the status of the spatial structure of each population based on current and historically used habitat.

Snake River Sockeye Salmon spawners can escape differentially to each watershed because of habitat conditions, migration barriers, pre-spawn mortality, hatchery programs, and stochasticity. The production of juveniles can vary among lake systems because of density-dependent and density-independent factors. Understanding the spatial and temporal variance in both spawner and juvenile distribution is therefore necessary to address uncertainties.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.
- What is the productivity of each population?
- What are the anadromous tendencies of each population and are they changing?

Monitoring questions:

- What is the spatial and temporal distribution of natural-origin spawners within each population?
- What is the density of natural-origin spawners within each population?
- What is the current spatial extent and distribution of spawning and rearing habitat used by natural-origin Sockeye Salmon within each population?

Performance metrics:

- Spawner distribution
- Redd distribution
- Spawn timing
- Juvenile distribution and density
- Smolt production

Possible Approach:

The above parameters are currently being investigated in Phase 1 and 2. Spawner success and redd distribution within Redfish Lake is currently estimated using ocular methods. This method is also being used to estimate redd distribution of residual spawners in Pettit Lake and kokanee in Alturas Lake. Spawn timing in the wild is currently compared to spawn timing within the captive broodstock. Juvenile abundance and density are estimated using mid-water trawl and hydroacoustic methods.

Suggested Analysis:

The spatial spawning distribution is based on ocular observations of redd distribution. Data can be analyzed as distribution data in a GIS format and compared to recovery criteria. Juvenile abundance and density methods and analyses are presented in Objective 7 under Phase I monitoring.

Status:

The SBT, Biolines Environmental Consulting, and IDFG have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013). Additional funding may be needed to derive the information needed to specifically address this objective or to collect the necessary information from all Sawtooth Valley lakes.

Objective 3: Determine the status and trend in life history, genotypic, and phenotypic diversity for each population.

The artificial propagation of Sockeye Salmon includes risks that may reduce the likelihood of recovery. It is important, therefore, to monitor the genetic characteristics of hatchery and natural-origin fish to ensure that the artificially produced fish resemble the naturally produced fish genetically, that adequate effective population sizes are maintained to prevent genetic drift, and that outbreeding depression does not reduce the reproductive success of the populations.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.

Monitoring questions:

- What is the population-level genetic composition of each population?
- What is the status and trend of life-history patterns and variation within each population?

Performance metrics:

- Adult run timing
- Size at maturity
- Age at maturity
- Adult sex ratio
- Spawn timing

- Effective population size
- Genetic variation
- Fecundity
- Spawning location (beach or stream)
- Juvenile age at migration
- Juvenile run timing
- Juvenile size at migration

Possible Approach:

Evaluation of life history, genotypic, and phenotypic characteristics will be accomplished by sampling live fish at weirs and at screw traps for juveniles. Multiple spawning surveys will be conducted within all populations (see Approach under Objective 1). Fish will be sampled for size (fork length), origin, marks and tags, age (from scales), and genetics (operculum punch or fin tissue for DNA analysis).

Suggested Analysis:

DNA tissue samples are analyzed using known microsatellite markers (including microsatellite loci and non-coding single nucleotide polymorphisms (SNPs), or base substitutions assayed via restriction enzyme analysis). Microsatellite loci are analyzed to estimate levels of gene flow and to identifying geographic areas that contain genetically differentiated populations. Data collected from rotary screw traps can be analyzed to estimate the number of smolts that migrate out of the populations, the size of migrants, and the timing of migration (i.e., beginning, peak, and end of migration). Parentage-based tagging is used to estimate the number of returning hatchery-origin adults that stray to trapping locations where they were not released as smolts.

Status:

IDFG and SBT have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013). Additional funding may be needed to derive the information needed to specifically address this objective and to collect information from other Sawtooth Valley lakes.

Objective 4: Determine the status and trend in conditions of habitat for each population.

The abundance, survival, and productivity of Snake River Sockeye Salmon are affected by the quantity and quality of spawning and rearing habitat. It is important to monitor changes in spawning and rearing habitat condition over time.

See Objective 1 under Phase 2 monitoring.

Objective 5: Determine the effects of habitat degradation and habitat restoration actions on the abundance, productivity, and spatial structure of the natural populations.

The Recovery Plan identifies restoration actions such as habitat restoration and protection, flow augmentation, and passage restoration that should increase natural productivity, abundance, and spatial structure of natural-origin Snake River Sockeye Salmon. There are several RM&E information needs that must be addressed if the benefits of these management actions are to be effectively detected.

Type of monitoring effort: Status and trend monitoring; implementation and compliance monitoring; and action effectiveness monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.
- How will managers prevent the colonization of other tributaries and lakes by lake trout?
- Can the Sawtooth Fish Hatchery weir be modified so that Sockeye Salmon will enter the trap and allow them access to the upper Sawtooth Valley lakes?

Monitoring questions:

- Status and Trend Monitoring—What is the current status and trend of Snake River Sockeye Salmon habitat within each population (see Objective 4)?
- Implementation and Compliance Monitoring—Was the habitat restoration action implemented in the prescribed manner and did it achieve its objectives?
- Action Effectiveness Monitoring—Have the habitat restoration actions improved the viability of the Snake River Sockeye Salmon populations?

Performance metrics:

- Abundance
- Distribution
- Survival
- Growth
- Condition
- Habitat characteristics
- Spawning time and location
- Zooplankton abundance over time
- Limnological characteristics of lake over time

Possible Approach:

Habitat status and trend monitoring was described under Objective 4. Compliance monitoring of restoration projects includes record keeping and reporting of activities. This type of monitoring is conducted by the implementing party and should include any parameters identified in work statements. All habitat restoration projects need to be monitored for compliance. Finally, action effectiveness monitoring should be conducted at both the project and population (lake system) scales. Action effectiveness monitoring designs should incorporate a before-after (BA) design, before-after-control-influence (BACI) design, or modified BACI designs (e.g., MBACI or MBACI(P)). Control or reference areas should be as similar as possible to the treatment site and must be independent of the influence of the treatment. Before-after designs can be used to monitor effects at larger spatial scales (e.g., population scale), but a long time series of before (pre-treatment) data are generally needed to tease out treatment effects. Entities implementing habitat restoration actions must coordinate with monitoring groups before scheduled activities, preferably years in advance to allow measurement of pre-treatment variables. Temporal scales must account for time lags related to life history and life-cycle timeframes.

Suggested Analysis:

Biotic and habitat data can be analyzed using time series analysis for before-after or intervention time series designs and ANOVA, t-tests, regression, or time series methods can be used with BACI designs. Randomization procedures, such as randomized intervention analysis, can also be used to analyze BACI designs. Data collected at the population scale should be compared directly with recovery criteria. Habitat data can also be included in fish-habitat models to assess the potential effects of habitat quantity and quality changes on potential fish survival and productivity.

Status:

This work, which is ongoing in Redfish, Pettit, and Alturas Lakes for zooplankton abundance and limnological characteristics, is being carried out by SBT and Biolines Environmental Consulting with funding from BPA. The most recent results can be found in Griswold et al. (2011). Additional funding will be needed to collect and analyze information for other Sawtooth Valley lakes. Information pertaining to abundance and distribution is currently being collected by IDFG with funding from BPA and the most recent results can be seen in Peterson et al. (2013). Additional funding will be needed to extend these efforts to other Sawtooth Valley lakes.

Objective 6: Determine the influence of the Phase 3 hatchery program on the abundance, productivity, spatial structure, and diversity of the natural populations.

The Phase 3 hatchery program is designed to play a critical role in providing reproductive support to depressed populations and thereby promote the conservation of the Snake River Sockeye Salmon populations. The program may also pose threats to natural-origin fish. Hatchery-induced genetic change may reduce the fitness of both hatchery and natural-origin fish in the wild, and hatchery-induced ecological effects (competition for food and space) can potentially reduce population productivity and abundance. Understanding the balance between the adverse long-term fitness impacts of the hatchery program and the benefits it may provide against demographic extinction is the crux of a successful monitoring and evaluation program.

Type of monitoring effort: Status and trend monitoring; implementation and compliance monitoring; and action effectiveness monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.
- What effects will increased returns of anadromous adults have on resident *O. nerka* abundance and how will this affect zooplankton grazing pressure and lake rearing capacity?

Monitoring questions:

- Do hatchery fish alter the life history or genetic characteristics of naturally produced fish?
- Do hatchery fish alter the abundance and productivity of naturally produced fish?
- What is the spatial and temporal distribution of hatchery-origin spawners?
- What effect do changes in phenotypic traits (e.g., size, age, and fecundity) observed in hatchery fish have on population viability?
- Do these potential effects on life history, genetic characteristics, or phenotypic traits change in utility or severity over time?

Performance metrics:

- Abundance
- Productivity
- Spatial structure
- Adult run timing
- Size at maturity

- Age at maturity
- Effective population size
- Genetic variation
- Fecundity
- Migration and spawning timing
- Spawning location (beach or stream)

Possible Approach:

Approaches needed to address this objective are described under Phases 1 and 2, and under Objectives 1, 2, and 3 under Phase 3.

Suggested Analysis:

Analysis of the effects of hatchery programs is basically the same as those presented earlier for monitoring Objectives 1, 2, and 3.

Status:

IDFG and SBT have been performing this work with funding from BPA. The most recent results can be found in Griswold et al. (2011) and Peterson et al. (2013). Additional funding may be needed to extend data collection to other Sawtooth Valley populations.

Objective 7: Determine the effect of mainstem hydropower operations and operational improvements on viability of Snake River Sockeye Salmon populations.

Snake River Sockeye Salmon are affected either directly (passage at a specific project) or indirectly (primarily through flow releases and water quality effects from upstream projects) by the hydrosystem. It is therefore important that all hydro-related effects be monitored.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Recovery Strategy Phase 1 and 2 monitoring.
- Effects of transportation on juvenile survival.

Monitoring questions:

- What is the effect of Columbia River hydropower operations on juvenile Snake River Sockeye Salmon?
- What are the effects of the Columbia River hydropower system on habitat quality, predation, and competition?

- What is the effect of Columbia River hydropower operations on returning adult Snake River Sockeye Salmon?
- What are the effects of Columbia River hydropower operations on temperature and dissolved gas concentrations in the river?
- What are the timing and duration of fish passage through the hydrosystem?

Performance metrics:

- Juvenile and adult survival
- Temperature
- Total dissolved gas (TDG)
- Water flow

Possible Approach:

Survival of migrating Sockeye Salmon is usually estimated with tags (PIT-tags, radio tags, or acoustic tags). Smolts can be PIT-tagged as they leave natal areas within the ESU. These PIT-tagged fish are then monitored for detections at FCRPS facilities along the migration corridor at both juvenile and adult life stages using DART and PTAGIS databases. Detection probabilities of juvenile salmonids migrating downstream at FCRPS facilities are modeled using the SURPH analytical tool (Survival with Proportional Hazards; Axel et al. 2013). Adult detection is currently available at ladders on several dams. TDG and temperature are measured hourly with calibrated electronic instruments at each FCRPS facility during fish passage.

Suggested Analysis:

Juvenile survivals at each FCRPS facility can be estimated using the SURPH model (Axel et al. 2013). Conversion rates between facilities can be estimated by comparing tag detections at adult ladders along the migration corridor. Rates can be expanded to population-level impacts using the relative number of fish PIT-tagged and abundance estimates generated from mark-recapture studies. TDG levels and temperature at each facility will be compared to standards to determine timing and duration of exceedances. Active tags may be needed to understand adult Sockeye Salmon entrance tendencies at hydroelectric projects under varying project operations. This will give managers information needed to pass adults quickly through the tailraces of the projects.

Status:

Currently, information pertaining to hydro operations and river characteristics are recorded through various programs like the Fish Passage Center’s Smolt Monitoring Program and results are listed on their website and others (e.g., Data Access in Real Time; DART), both of which are funded through BPA. In addition, there is currently a research program (Axel et al. 2013) that is collecting information on juvenile survival from the Sawtooth Valley to Lower Granite Dam that will partly inform this objective. Additional funding is needed to continue PIT-tag studies and to include them in the CSS suite of work.

Objective 8: Determine the effect of harvest on the abundance, productivity, and diversity of the natural populations.

Restoring and optimizing fishery opportunities are a primary goal of local and regional fisheries managers and are important to meet Tribal and treaty trust obligations. This can be challenging, however, because of changes in fishing effort, run sizes, catch and harvest that are likely to occur as environmental and anthropogenic conditions vary and the fisheries restoration program matures. In addition, fisheries are also managed to keep unintended impacts to natural and hatchery production and non-target species within acceptable limits. As Plan implementation progresses and we learn more about the recovery of the populations, under certain conditions, it may be desirable to use harvest to control the proportion of hatchery-origin spawners returning to the spawning grounds.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.
- Accuracy of harvest rates.
- Effects of harvest management on size selectivity and size of fish returning to spawn.

Monitoring questions:

- What is the annual incidental harvest rate on natural-origin Snake River Sockeye Salmon that occurs outside the ESU?
- What is the annual incidental harvest rate that occurs on natural-origin Snake River Sockeye Salmon within the ESU?
- What is the cumulative incidental harvest rate on natural-origin Snake River Sockeye Salmon due to all fisheries (from within and outside of ESU)?
- What effect does total incidental harvest have on the abundance, productivity, and diversity of natural-origin Snake River Sockeye Salmon?

Performance metrics:

- Fisher hours (effort)
- Catch

- Harvest
- Stock identification
- Spawning escapement
- Recruits/spawner
- Genetic composition

Possible Approach:

Outside the ESU, Snake River Sockeye Salmon can be incidentally harvested in two main fishery areas: ocean and Columbia River. Fishery-related mortality is reported for tribal and non-tribal ocean and Columbia River fisheries by the TAC of the Columbia River Compact. Within the ESU, incidental harvest rates on Sockeye Salmon are assessed during Chinook salmon roving creel surveys. Creel surveys should include angler counts; interviews to obtain information on catch rate, harvest rate, gear types, and angler demographics; and collection of biological and mark/tag information from the catch. This information can then be used to identify spatial and temporal relationships among fishing effort, catch, and harvest, and the incidental capture of Snake River Sockeye Salmon. Within the ESU, incidental take can occur within the existing kokanee fishery.

Suggested Analysis:

The number of *O. nerka* caught by interviewed anglers will be totaled and used for an expanded estimate of the number of fish caught throughout the season. Expanded estimates will be based on sample strata and proportional coverage rates. Catch per unit effort (CPUE) will be estimated directly from interview responses. Total fishing effort will be estimated based on time period, week period, and site encounter probabilities. For each population, natural-origin abundance and productivity will be calculated with and without incidental harvest to determine if incidental harvest reduces the likelihood of meeting recovery criteria. The proportion of Sockeye Salmon within the creel will be estimated based on genetic data.

Status:

Within the ESU, IDFG (Peterson et al. 2013), with funding through BPA, is currently collecting information that can address this objective. Outside of the ESU, information is collected in lower Columbia and Snake River fisheries from the co-managers (state agencies and Tribes) and is reported through the *U.S. v Oregon* ongoing litigation process.

Objective 9: Determine the effect of predation on the abundance and productivity of the natural populations.

Several fish species occupy the natal lakes that potentially prey on Sockeye Salmon, including non-native lake trout and brook trout, and native bull trout and northern pikeminnow. Sockeye Salmon may also experience predation from smallmouth bass, walleye, northern pikeminnow, and other fish species while migrating through the Salmon, Snake, and Columbia Rivers. These fishes may reduce Sockeye Salmon survival by preying on juvenile Sockeye Salmon and/or Sockeye Salmon eggs, or by introducing disease.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.
- Abundance and distribution of predators.

Monitoring questions:

- What is the predation rate and predatory effect of native and non-native fishes in the nursery lakes and migration corridor on Snake River Sockeye Salmon?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile Snake River Sockeye Salmon?
- What is the effect of predation from marine mammals in the Columbia River migration corridor on adult Snake River Sockeye Salmon?

Performance metrics:

- Number of juvenile Snake River Sockeye Salmon
- Number of predators
- Number of juvenile Snake River Sockeye Salmon consumed by piscine and avian predators
- Mortality rates
- Proportion of SAR associated with predation

Possible Approach:

Using appropriate sampling techniques, conduct annual sampling of exogenous piscine predators in the lakes and Salmon River to determine the abundance of predators (based on mark-recapture) and stomach contents. These data are then incorporated into a bioenergetics model to derive a population-level (or ESU-level) consumption estimate imposed by exogenous fishes. Sampling of predatory fish diets will occur during times and locations when and where their distribution overlaps with juvenile Sockeye Salmon. Interpretation of the predatory impact in the migration corridor should be conducted with methods established in the published literature (e.g., Fritts and Pearsons 2006).

To evaluate avian predation on juvenile Snake River Sockeye Salmon, bird colonies are monitored for the presence of PIT-tags originating from specific populations within the Snake River Sockeye Salmon ESU. Bioenergetics models are then used to expand tag recoveries at colonies to population-level impacts.

Collect trend data from spawning tributaries for native and non-native predator abundance in the Sawtooth Valley basin. Peak counts and total redds produced would provide data to determine if the populations are changing over time.

Suggested Analysis:

The proportion of SAR attributable to predatory mortality can be estimated from the bioenergetics modeling results.

Status:

Within the ESU, IDFG (Peterson et al. 2013), with funding through BPA, is currently collecting information that can address this objective. Outside of the ESU, information is collected in lower Columbia and Snake River by various researchers. For example, for avian predation estimates see Roby et al. (2012) and for piscine predators see Porter (2011).

Objective 10: Determine the transmission and effects of disease on the abundance, productivity, and diversity of the natural populations.

An important goal of the Phase 3 hatchery program will be to release fish into the system that are known to have a healthy disease history during rearing to minimize impacts on naturally and hatchery-produced fish.

Type of monitoring effort: Long-term status and trend monitoring.

Key Information Needs:

- Results from Phase 1 and 2 monitoring.

Monitoring questions:

- What are the prevalence and level of pathogens in natural and hatchery-origin Snake River Sockeye Salmon?

- What are the magnitude and pathways of disease transmission between hatchery and natural-origin Snake River Sockeye Salmon?
- What are the magnitude and pathways of disease transmission between hatchery and residual Sockeye Salmon and kokanee?

Performance metrics:

- Number of infected hatchery and naturally produced fish
- Spatial distribution of disease

Possible approach:

The health of hatchery fish will be monitored starting with broodstock and continuing through rearing and release of juveniles. The health of naturally produced fish will be assessed on dead parr, smolts, and spawners encountered during monitoring activities. All sampling, diagnostic, and statistical analyses will comport with the Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection committee guidelines. All disease monitoring will be consistent with the IDFG fish health policy and the native fish conservation policy. In addition, dead, naturally produced fish collected as parr or smolts during smolt trapping and juvenile sampling will be examined for diseases. Hatchery fish are sampled before release, during spring outmigration from the lakes, and throughout their life cycle within the hatchery.

Suggested analysis:

Analysis of samples will follow standard protocols defined in the latest edition of the American Fisheries Society "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens (Blue Book)."

Status:

The IDFG Eagle Fish Health Lab has been doing comprehensive fish health work on Snake River Sockeye Salmon since 1991.

11.2 Adaptive Management

Adaptive management provides a mechanism to incorporate the data obtained through RM&E into the design and implementation of an effective recovery strategy. It allows recovery planners to use monitoring and evaluation results to make adjustments on the path to recovery. Because of the large number of organizations in Idaho, and elsewhere in the basin, implementing management actions that affect Snake River Sockeye Salmon viability, the adaptive management strategy for the species outlines a collaboration and coordination process that uses the current implementation structures. The process allows for sharing of information and decisions that will influence recovery. What follows is a brief summary of the various management decision processes and associated adaptive management plans that affect management actions for tributary habitat, hatcheries, harvest, and the hydrosystem as they relate to Snake River Sockeye Salmon recovery.

11.2.1 Tributary Habitat

Several funding sources and various entities are involved with implementing tributary habitat restoration actions. In all cases, these entities have well established decision-making processes for prioritizing actions. It is beyond the scope of this document to identify and describe all the processes used. What follows are a few examples that illustrate ongoing decision processes.

Idaho Department of Fish and Game
Beginning in 1991 when Snake River Sockeye Salmon were listed as endangered, the Idaho Department of Fish and Game (IDFG) initiated a captive broodstock program to maintain Snake River Sockeye Salmon and prevent species extinction. Cooperating with NMFS, the Shoshone-Bannock Tribes, Oregon Department of Fish and Wildlife, and BPA on the overall recovery program, IDFG develops and maintains captive broodstock, conducts field monitoring and evaluations, such as investigating the success of outplanted groups. IDFG genetic staff provide genetics monitoring and support for the program, such as background genetic identify analysis and development of spawning designs. IDFG manages the Eagle Fish Hatchery captive broodstock program, the Sawtooth Hatchery and the Springfield Sockeye Salmon Hatchery. IDFG is a member of the Sockeye Technical Oversight Committee and the Technical Advisory Committee that developed this ESA Recovery Plan.

U.S. Forest Service
The U.S. Forest Service manages the Sawtooth National Recreation Area (Sawtooth NRA) which is located within the 2.1 million acre Sawtooth National Forest. The Sawtooth NRA consists of over 750,000 acres of protected land encompassing the Sawtooth Valley. The U.S. Congress established the Sawtooth NRA in 1972 with the passage of Public Law 92-400, which sought to preserve and protect the area's "natural, scenic, historic, pastoral and fish and wildlife values and to provide for the enhancement of the recreation values associated therewith." The U.S. Forest Service actively manages the Sawtooth NRA for multiple purposes to meet its mission, including habitat restoration and protection actions supporting Snake River Sockeye Salmon recovery. The U.S. Forest Service has actively participated in development of the Snake River Sockeye Salmon recovery plan through participation on the Technical Advisory Committee.

Idaho Office of Species Conservation
The state of Idaho Office of Species Conservation (OSC) coordinates policies and programs for the state of Idaho related to the conservation of threatened, endangered, and candidate species. The OSC, which is part of the Idaho governor’s office, heads the state´s actions on all ESA

recovery plans, management plans, public comment periods, biological opinions, guidance programs and species-specific recovery projects. Serving primarily as project coordinator, it works with various state natural resource agencies, including IDFG, IDEQ, IDWR, and Idaho Department of Lands, to implement recovery actions consistent with state laws and ongoing efforts. The OSC also coordinates and administers grant-funding programs that fund cooperative salmon habitat restoration for a wide variety of implementers. It leads project prioritization for funding consideration by the NPCC and BPA, and works to increase the reliable use of "best available data" in ESA recovery efforts. Adaptive management is implemented through strategic guidance, project review, and selection and prioritization processes.

Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes (SBT) implement tributary habitat actions and associated monitoring under an ESA Memorandum of Agreement with the Action Agencies for listed salmon and steelhead species. The SBT implements projects within the Salmon and upper Snake River subbasins to protect, restore and enhance ecosystem processes. These projects include the Snake River Sockeye Salmon Habitat and Limnological Research Project, which was implemented in 1991. The SBT receives funding from BPA and collaborates on the projects with NMFS, IDFG, and the University of Idaho. Project tasks include: 1) monitoring limnological parameters of the Sawtooth Valley lakes to assess lake productivity; 2) conducting lake fertilization in Pettit and Alturas Lakes; 3) reducing the number of mature kokanee salmon spawning in Alturas Lake Creek; 4) monitoring, enumerating, and evaluating Sockeye Salmon smolt migration from Pettit and Alturas Lakes; 5) monitoring spawning kokanee salmon escapement and estimating fry recruitment in Fishhook and Alturas Lake creeks; 6) conducting Sockeye Salmon and kokanee salmon population surveys; 7) evaluating potential competition and predation between stocked juvenile Sockeye Salmon and a variety of fish species in Redfish, Pettit, and Alturas Lakes; and 8) assisting IDFG with captive broodstock production activities.

Bonneville Power Administration and Northwest Power and Conservation Council Columbia Basin Fish and Wildlife Program

The Bonneville Power Administration (BPA) is a major funding source for salmon recovery projects in the Columbia Basin as part of its obligation to mitigate the effects of the operation of the FCRPS on fish and wildlife. Under the Columbia Basin Fish and Wildlife Program, the Northwest Power and Conservation Council recommends projects for funding by BPA. BPA currently provides funding for implementation of the Snake River Sockeye Salmon captive broodstock program and the associated monitoring and evaluation. Together, the two organizations function as coordinators of RM&E, both in terms of the habitat protection, restoration and RM&E actions they fund within the Salmon River and Sawtooth Valley, and the information-sharing processes they initiate and approve. Proposed projects undergo a rigorous scientific review (by an Independent Science Review Panel) and revision process to ensure the implementation of scientifically sound projects that are based on best available science and use state-of-the-art restoration approaches. For more information, see http://efw.bpa.gov/IntegratedFWP/anadfishresearch.aspx and http://www.nwcouncil.org/fw/.

Community-Level Partnerships
Several community-level organizations collaborate with state and Federal agencies to implement projects for the protection and restoration of tributary habitat, and to monitor the effectiveness of these efforts. A few of these organizations are described below.

Upper Salmon Basin Watershed Project
The Upper Salmon Basin Watershed Project is a community-driven partnership through which landowners work together with local, state, and Federal partners to protect and restore fish habitats. The group collaborates to improve habitat for salmon and resident fish while respecting and balancing the needs of irrigated agriculture and strengthening the local economy. The group's staff is affiliated with the Idaho Governor's Office of Species Conservation. It works with landowners to develop restoration projects, assists with the permitting process, oversees the work, and monitors outcomes. Additionally, the USBWP seeks and manages major funding support.

Soil and Water Conservation Districts
Idaho's soil and water conservation districts assist private landowners and land users in the conservation, sustainability, improvement, and enhancement of state natural resources. The Custer Soil and Water Conservation District implements projects in Custer County, including the Sawtooth lakes area. The SWCDs partner with the BLM, USFS, USFWS, NMFS, NRCS, and IDFG and others to evaluate and implement projects needed for fish recovery, including improving stream flows, riparian vegetation communities and water quality, and restoring fish passage.

Integration and Coordination
Although there are several funding sources and implementing entities that have prioritization processes and elements of adaptive management, there is a need to integrate and coordinate adaptive management for tributary habitat restoration associated with the recovery plan. This process of integration allows us to track and adjust our efforts effectively. Section 10 describes an implementation framework for this recovery plan. The framework is not intended to replace the other processes that are currently used. Rather, the framework is meant to improve coordination, collaboration, and sharing of information for decision making. Information, including successes and failures, will be shared through the framework (see Figure 10-1). This will result in the implementation of cost-effective projects throughout the basins.

11.2.2 Hatcheries

The Stanley Basin Sockeye Salmon Oversight Committee coordinates with regional state and Federal agencies, tribes and others to provide guidance that directs hatchery programs for Snake River Sockeye recovery. The program follows guidance from the Columbia Basin Hatchery Scientific Review Group. It works with NMFS through measures defined in a Hatchery and

Genetic Management Plan to minimize risks that could impair recovery of the species under the ESA.

Stanley Basin Sockeye Technical Oversight Committee (SBSTOC)

The Stanley Basin Sockeye Technical Oversight Committee guides new research, coordinates ongoing research, and actively participates in all elements of the Snake River Sockeye Salmon recovery effort. The committee is comprised of technical experts from IDFG, BPA, NMFS, ODFW, the University of Idaho, USFS, and the Shoshone-Bannock Tribes. The committee continuously reviews the methods and results from monitoring and evaluation projects that guide program direction. Based on these findings, it makes yearly recommendations that then direct spawning, broodstock sourcing, hatchery releases, and other aspects of program implementation.

Hatchery Scientific Review Group (HSRG)

The Hatchery Scientific Review Group, an independent scientific review panel, completed a review of the hatchery program for the Redfish Lake Sockeye Salmon population, and provided recommendations for the population. The HSRG recommendations were incorporated into the hatchery program. Guidance from the HSRG is being used to move the Snake River Sockeye Salmon program to an integrated conservation program where the natural environment drives the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the wild.

Hatchery and Genetic Management Plans (HGMPs)

Take prohibitions do not apply to activities associated with artificial propagation programs, provided a Hatchery Genetic Management Plan has been approved by NMFS as meeting a list of criteria that are specified in the 4(d) rule which only applies to threatened species (NMFS 2000). The HGMP must provide adequate monitoring and evaluation to detect and evaluate the success of the hatchery program and any risks potentially impairing the recovery of listed ESUs/DPSs. An adaptive management processes is needed to provide for the evaluation of the data and include the potential to revise the assumptions, management strategies, or objectives of the hatchery program. In addition, NMFS is required to evaluate on a regular basis the effectiveness of the HGMP in protecting and achieving a level of productivity commensurate with the conservation of the listed species. If the HGMP is ineffective, NMFS identifies ways in which the program needs to be altered.

A HGMP has been completed for the Snake River Sockeye Salmon hatchery program. The HGMP is a “living document” meant to guide the current and near-term programmatic activities associated with Snake River Sockeye Salmon. Program activities and recommendations will continue to change as recovery plans and species delisting criterion are established for this population.

11.2.3 Harvest

Fishery managers use complex management frameworks to restrict annual mortality rates on Snake River Sockeye Salmon and other ESA-listed salmon. They manage fisheries in the Columbia River estuary and mainstem Columbia and Snake Rivers through a combination of laws, policies, and guidelines established to coordinate fisheries and control impacts on ESA-listed Columbia River salmonids. Fisheries in the Salmon River and natal lakes are also designed to control impacts on Snake River Sockeye Salmon and other ESA-listed species. The different fishery managers coordinate research, monitoring, and evaluation efforts. In the future, fishery managers may consider using fisheries to control the number of hatchery-origin spawners returning to the natal lakes.

Mainstem Columbia River

Fisheries in the mainstem Columbia River that affect Snake River Sockeye Salmon are managed subject to the terms of the *U.S. v. Oregon* Management Agreement for 2008-2017. The management agreement defines harvest limits thought to be sufficiently protective to allow for the recovery of ESA-listed species. The strategy also implements research, monitoring, and evaluation programs to ensure that fisheries minimize their impacts on the Snake River Sockeye Salmon ESU. The objective of monitoring and research is to improve the accuracy and precision of harvest management. As identified in the agreement, these data are essential for adaptive management. A Technical Advisory Committee, which is comprised of biologists from state, Federal, and tribal management agencies, develops, analyzes, and reviews data and provides reports and technical recommendations regarding harvest management. The parties to the agreement agreed to work together to maintain and seek funding for the research and monitoring programs.

Additional monitoring and adaptive management of harvest in the Columbia River mainstem is provided by the ESA Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Treaty Indian and Non-Indian Fisheries in the Columbia River Basin subject to the 2008-2017 *U.S. v. Oregon* Management Agreement (*hereafter* Fisheries BiOp) (NMFS 2008e). Several Reasonable and Prudent Measures are identified in Section 13.4 of the Fisheries BiOp that emphasize in-season management actions, which ensure that incidental take of ESA-listed species remain consistent with the Fisheries BiOp. The monitoring of harvest impacts on listed species is an essential component of the Fisheries BiOp.

Idaho's Recreational Fisheries Regulation Process

Idaho's Statutes and Rules, Title 36 of the Idaho Code, describe procedures for development and implementation of angling regulations. This rule requires the department to continually monitor the status of fisheries resources, and report to the Director and Commission any serious or abnormal changes in health or abundance of the resource. Currently, no fisheries directly target Snake River Sockeye Salmon; however, the fish are occasionally taken in fisheries targeting other species. State fishery managers conduct substantial monitoring and evaluation during these fisheries and restrict harvest at times when Sockeye Salmon are present. In the future, fishery managers may consider using fisheries to manage the number of hatchery-origin spawners returning to natal lakes.

Fisheries Management and Evaluation Plans

Currently no state of Idaho fisheries target Snake River Sockeye Salmon. If the fish population's viability reaches a level that can support harvest, the state would need to complete a NMFS-approved Fisheries Management and Evaluation Plan (FMEP) before implementing a fishery. Take prohibitions do not apply to activities associated with fishery harvest activities provided the fisheries are managed in accordance with a NMFS-approved FMEP. The FMEP must meet several specific criteria described in the 4(d) Rule.

NMFS developed a template for preparing FMEPs that meet the required criteria. Section 3.5 of the template requires the applicant to include a schedule and process for reviewing and modifying fisheries management under the FMEP. There are two evaluation review processes identified in the FMEP: (1) a regular review of fisheries and (2) a comprehensive assessment of the overall effectiveness of the FMEP. The evaluation must assess the effectiveness of the FMEP in meeting the stated objectives over a long time and must account for any new information that may require revision of assumptions or management strategies.

The FMEP describes the process and schedule that is used on a regular basis (annually) to evaluate the fisheries, and, if necessary, revise management assumptions and targets. The FMEP also includes a description of the process and schedule that occurs every five years to evaluate whether the FMEP is accomplishing the stated objectives. Section 3.5 includes the conditions by which revisions to the FMEP will occur and how the revisions will be accomplished.

NMFS also requires that the fisheries managers notify and provide to NMFS any proposed fishery regulation changes that affect fisheries within the FMEP. NMFS then evaluates the proposed changes to determine if the changes constitute additional negative effects that were not contemplated during the review and evaluation of the submitted FMEP. Depending on the species and fishery involved, changes in regulations by IDFG can occur annually or in-season.

Tribal Resource Management Plans

Currently no tribal tributary fisheries directly target Snake River Sockeye Salmon. There are fisheries targeting hatchery spring/summer Chinook salmon and steelhead, and these fisheries are managed to protect Sockeye Salmon. If the fish population's viability reaches a level that can support harvest, the tribes would need to complete a NMFS-approved Tribal Resource Management Plan (TRMP) before implementing a fishery. In the future, such a fishery may be used to control the number of hatchery-origin spawners returning to natal lakes.

11.2.4 Mainstem Hydropower System

The Federal Columbia River Power System Biological Opinion describes steps to integrate adaptive management with hydrosystem operations.

Federal Columbia River Power System Biological Opinion

The FCRPS RPA recommends that the Action Agencies (Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation) collaborate with states and tribes in the implementation of the FCRPS RPA actions, progress reporting, and adaptive management using regional forums. FCRPS RPA Actions 1 through 3 identify the general requirements governing the Action Agencies' development of implementation plans and reporting requirements. The Action Agencies are required to submit implementation plans to NMFS in December of 2009, 2013, and 2016 that describe their commitments to implement FCRPS RPA actions. The Action Agencies are also required to submit Annual Progress Reports to NMFS for the period 2009 through 2018. In addition, in 2013 and 2016, the Action Agencies will submit Comprehensive RPA Evaluation Reports to NMFS. These reports will review all implementation activities through the end of the previous year and compare them to scheduled completion dates in the BiOp, or as modified through the Implementation Plans. The Comprehensive Evaluation will also describe the status of the physical and biological factors identified in the FCRPS RPA, and compare these with the expected survival improvements identified in the Comprehensive Analysis. Included in the Comprehensive Evaluation will be a plan to address any shortcomings of current survival improvements as compared to the original survival estimates identified in the Comprehensive Analysis.

The FCRPS BiOp includes RPA Actions (50 through 73) for research, monitoring, and evaluation. RM&E is required in the following areas: fish population status and trend monitoring, hydropower RM&E, tributary habitat RM&E, estuary and ocean RM&E, harvest RM&E, hatchery RM&E, and predation management RM&E. Data from RM&E will provide information needed to support planning and adaptive management, and to demonstrate accountability related to the implementation of hydropower and offsite actions.

A Regional Implementation and Oversight Group (RIOG) provides a high-level policy forum for discussing and coordinating the implementation of the FCRPS BiOp and related BiOps. The purpose of the RIOG is to inform Federal, state, and tribal agencies engaged in recovery efforts. The RIOG will serve as a forum where policy issues and concerns related to the implementation of the BiOps will be discussed in a collaborative manner, and to provide a forum for enhanced accountability and transparency. The group does not supplant existing Federal, state, or tribal decision-making authorities, and no agency or sovereign is required to participate in the group. Participation is by interest and choice.

The implementation and oversight group is supported by senior technical teams for hydro, habitat, hatcheries, and RM&E integration and by additional technical teams. Technical information and recommendations flow from the technical teams to the senior technical teams to the group. Policy guidance and technical assignments flow from the group to the senior technical teams and technical teams. The implementation and oversight group and technical groups ensure that actions required by the FCRPS BiOp are implemented effectively, performance standards are achieved, disputes are resolved, and other regional processes are considered during the period of the BiOp.

11.2.5 Integration of Adaptive Management Processes

Integration of the many adaptive management processes will occur within the implementation management framework described in Section10 and illustrated in Figure 10-1. The Sockeye Salmon Implementation and Science Team, Stanley Basin Sockeye Technical Oversight Committee, and Snake River Science Team will serve key roles in incorporating new knowledge into future management guidance and direction. These teams will not only provide input for adaptive implementation of hatchery programs and tributary habitat actions, they will also provide input into other related regional decision-making forums.

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Appendix A: Summary of Recovery Measures and Estimated Costs

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Appendix A. Summary of Recovery Measures and Estimated Costs

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
Recovery Strategy 7.2.1: Conserve population and genetic life history and spatial structure									
7.2.1-1	1. Continue to fund annual operation of the Sockeye Salmon captive broodstock propagation program.	Sawtooth Valley	IDFG, NMFS, BPA, ODFW		3,014	3,014	3,014	3,014	3,014
7.2.1-2	2. Fund modifications to Sawtooth Hatchery weir to improve Sockeye Salmon trapping efficiency and provide adult access to upper salmon nursery lakes.	Sawtooth Valley	IDFG	Capital project; Could be reduced abundance if fish don't enter the trap and stray or spawn in other locations	To be determined				
7.2.1-3	3. Determine additional detection needs (e.g., PIT-tag detectors) in the Salmon River.	Salmon River	SBSTOC, IDFG		To be determined				
7.2.1-4	4. Describe conditions under which trapping would occur at various locations, including Lower Granite Dam.	Snake River	Corps, IDFG,SBSTOC	This is currently being developed.	To be determined				
7.2.1-5	5. Determine changes in marking/tagging levels for increased precision to evaluate downstream	Salmon R.	IDFG, Shoshone-Bannock Tribes		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	sources of mortality.								
7.2.1-6	6. In the near term at Sawtooth Hatchery, identify ways to improve handling of adults to collect genetic data of fish returning to Alturas Lake, Pettit Lake or Redfish Lake.	Sawtooth Valley	IDFG, USFWS		To be determined				
7.2.1-7	7. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to return to natal lake of origin.	Sawtooth Valley	IDFG, USFWS, Shoshone-Bannock Tribes	Also a predation issue	To be determined				
7.2.1-8	8. Maintain current marking/tagging levels.	Sawtooth Valley	IDFG, Shoshone-Bannock Tribes						
7.2.1-9	9. Identify lake of origin for adults returning to basin collection facilities.	Sawtooth Valley	IDFG		To be determined				
7.2.1-10	10. Mark sufficient numbers of outmigrants from each lake to enable collection of returning spawners specific to lake	Sawtooth Valley	IDFG, Shoshone-Bannock Tribes		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	of origin.								
7.2.1-11	11. Continue to sort returning adults at basin weirs based on marks identifying lake of origin.	Sawtooth Valley	IDFG		To be determined				
7.2.1-12	12. Transport returning adults to lake of origin or to hatchery program based on lake of origin or allow passage of adults.	Sawtooth Valley	IDFG		To be determined				
7.2.1-13	13. Develop guidance and recommendations for a preferred recovery strategy (ies) for *O. nerka* life history forms of Snake River Sockeye Salmon.	Sawtooth Valley	NMFS, SBSTOC	Technical staff and policy action	Not Applicable				
7.2.1-14	14. Develop long-term guidelines to support and maintain localized adaptations within and among populations.	Sawtooth Valley	NMFS	Technical staff and policy action	Not Applicable				
Recovery Strategy 7.2.2: Increase naturally spawning Snake River Sockeye Salmon abundance									
7.2.2-1	1. Manage Springfield Hatchery to meet Sockeye Salmon recovery goals.	Sawtooth Valley	IDFG	O&M costs/Springfield Hatchery opened in 2013	891	918	964	1,027	

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
7.2.2-2	2. Increase annual hatchery smolt releases to 1 million through funding of additional hatchery facility(ies).	Sawtooth Valley	IDFG, BPA	See 7.2.2-1 above	To be determined				
7.2.2-3	3. Replace Redfish Lake weir and trap to allow handling and holding of larger adult returns.	Redfish Lake	IDFG, BPA		To be determined				
7.2.2-4	4. Modify the Sawtooth Hatchery weir to improve Sockeye Salmon trapping efficiency and provide adult access to upper salmon nursery lakes.	Redfish Lake	IDFG, BPA		To be determined				
7.2.2-5	5. Increase adult holding capacity at Sawtooth Hatchery to provide separate holding for Sockeye Salmon and improve fish passage so fish more readily enter the trap.	Sawtooth Valley	IDFG		To be determined				
7.2.2-6	6. Develop plan describing objectives for	Pettit Lake	IDFG, Shoshone-	Technical staff and policy issue.	Not applicable				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	Pettit Lake, e.g., will the program use Redfish Lake fish in Pettit Lake, and what life stage(s) to release into Pettit Lake.		Bannock Tribes						
7.2.2-7	7. Mark sufficient numbers of outmigrants from Pettit and Alturas Lakes to enable collection of returning spawners specific to this lake.	Pettit Lake	Shoshone-Bannock Tribes		To be determined				
7.2.2-8	8. Transport returning adults identified as originating from Pettit and Alturas Lakes to that lake, or pass above weir for volitional migration, or retain as broodstock specific for Pettit and Alturas Lake releases.	Pettit Lake	IDFG		To be determined				
Recovery Strategy 7.2.3: Improve Sockeye Salmon passage to natal lakes									
7.2.3-1	1. In the near term at Sawtooth Hatchery, identify ways to improve adult holding and handling of fish returning	Sawtooth Valley	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue; technical staff and policy issue	Not applicable				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	to Alturas Lake, Pettit Lake, or Redfish Lake.								
7.2.3-2	2. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to enter natal lakes.	Sawtooth Valley	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue	To be determined				
7.2.3-3	3. Reestablish adult passage at Stanley Lake.	Stanley Lake	IDFG, BPA, USFS		To be determined				
7.2.3-4	4. Reconciling lake trout management in Stanley Lake and remove barrier to volitional Sockeye Salmon passage.	Stanley Lake	IDFG, USFS, Shoshone-Bannock Tribes, NMFS	Technical staff and policy issue	Not applicable				
7.2.3-5	5. Investigating passage survival and mortality factors during migration between natal lakes and Lower Granite Dam.	Salmon River Lower Snake River	IDFG, NMFS, IDEQ		To be determined				
7.2.3-6	6. Improve instream flows in the Salmon River above the Sawtooth Hatchery to Alturas Lake Creek by improving irrigation efficiencies, using IDWR	Sawtooth Valley	IDFG, IDWR, NMFS, USFS, Custer/Blaine Counties		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	water bank and other conservation tools.								
Recovery Strategy 7.2.4: Reestablish a self-sustaining anadromous Sockeye Salmon population in Redfish Lake									
7.2.4-1	1. Manage Springfield Hatchery to meet Sockeye Salmon recovery goals.	Redfish Lake	IDFG	Springfield Hatchery opened in 2013	See costs in Action 7.2.2-1				
7.2.4-2	2. Replace Redfish Lake weir and trap to allow handling and holding of larger adult returns.	Redfish Lake	IDFG		To be determined				
7.2.4-3	3. Once adequate and consistent returns of anadromous adults are achieved, phase out the use of Redfish lake captive broodstock.	Redfish Lake	IDFG, NMFS		To be determined				
Recovery Strategy 7.2.5:Investigate and develop strategies for future actions to support Sawtooth Valley Sockeye Salmon reintroduction and adaptation for Pettit Lake									
7.2.5-1	1. Release adults produced through the captive broodstock program into Pettit Lake for a defined period.	Pettit Lake	IDFG, NMFS						
7.2.5.2	2. Refine program as needed to reestablish a locally adapted population in Pettit Lake.	Pettit Lake	IDFG, NMFS						

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
Recovery Strategy 7.2.6: Investigate and evaluate the potential for restoring natural production of anadromous Sockeye Salmon from returning residual outplants from Alturas Lake									
7.2.6-1	1. Determine appropriate strategies and actions for restoring natural production in Alturas Lake. Options may include trap and transport or establishing a new hatchery program.	Alturas Lake	SBSTOC	This is a key information need that will also be included in Section 11 RM&E. Same as # 14 above.	Not applicable				
7.2.6-2	2.Determine whether Alturas Lake still contains anadromous or residual genetic resources.	Alturas Lake	NMFS, IDFG, SBSTOC		Not applicable				
Recovery Strategy 7.2.7: As sufficient number of natural-origin adults return, develop integrated approach to manage natural- and hatchery-origin adults in the hatchery program and the wild									
7.2.7-1	1. Examine the benefits and/or risks of alternative strategies for recovering extant and/or historical life-history patterns in the natal lakes.	Sawtooth Valley	SBT, IDFG	Technical staff and policy issue	Not applicable				
7.2.7-2	2. Develop long-term guidelines to support and maintain localized adaptations within and among populations.	Sawtooth Valley	NMFS	Technical staff and policy issue	Not applicable				
7.2.7-3	3. Manage Springfield	Redfish	IDFG	Springfield Hatchery	See costs in				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	Hatchery to meet Sockeye Salmon recovery goals.	Lake		opened in 2013.	Action 7.2.2-a				
7.2.7-4	4. Once adequate and consistent returns of anadromous adults are achieved, phase out the use of Redfish lake captive broodstock.	Redfish Lake	IDFG, NMFS, SBSTOC		To be determined				
Recovery Strategy 7.2.8: As sufficient numbers of hatchery-origin anadromous adults return to the basin, identify options for future harvest									
7.2.8-1	1. Develop a new abundance-based harvest management framework for Snake River Sockeye Salmon.	Sawtooth Valley Salmon River	NMFS, IDFG, SBT and other appropriate co-managers						
Recovery Strategy 7.2.9: Continue research and actions to reestablish natural populations in other natal lakes									
7.2.9-1	1. Develop plan describing objectives for Pettit Lake, e.g., whether or not the program would use Redfish Lake fish in Pettit Lake, and what life stage(s) to release into Pettit Lake.	Pettit Lake	IDFG, Shoshone-Bannock Tribes	Technical staff and policy issue	Not applicable				
7.2.9-2	2. Mark sufficient numbers of outmigrants from Pettit Lake to	Pettit Lake	Shoshone-Bannock Tribes; IDFG	Same as No. 1 above.	To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	enable collection of returning spawners specific to this lake.								
7.2.9-3	3. Construct juvenile/adult trapping structure in Alturas Lake Creek.	Alturas Lake Creek	BPA Shoshone-Bannock Tribes		To be determined				
7.2.9-4	4.Improve/replace juvenile trapping structure in Pettit Lake Creek.	Pettit Lake Creek	BPA Shoshone-Bannock Tribes		To be determined				
7.2.9-5	5. Identify lake of origin from adults returning to basin collection facilities.	Sawtooth Valley	IDFG		To be determined				
7.2.9-6	6.Continue to sort returning adults at Sawtooth weir, based on marks identifying source of outmigrant.	Sawtooth Valley	IDFG		To be determined				
7.2.9-7	7.For returning spawners that are to spawn in upper basin lakes, pass for volitional migration or transport to appropriate lake.	Sawtooth Valley	IDFG, Shoshone-Bannock Tribes		To be determined				
7.2.9-8	8. Investigate strategies to enhance and support	Alturas Lake	IDFG; SBSTOC	Technical staff and policy issue	Not applicable				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	anadromy in extant Alturas Lake early stream spawning Sockeye Salmon.								
7.2.9-9	9. Continue limnological and ecological research and evaluations of the lakes.	Sawtooth Valley lakes	Shoshone-Bannock Tribes		467	467	467	467	467
7.2.9-10	10. Address nutrients as limiting factors in all lakes used for Sockeye Salmon recovery and study relationship to prey base in natal lakes.	Sawtooth Valley lakes	Shoshone-Bannock Tribes		To be determined				
7.2.9-11	11. Investigate and manage risks to native kokanee in Stanley Lake: i.e., outlet barrier, lake trout and non-native kokanee	Stanley Lake	IDFG, NMFS		To be determined				
7.2.9-12	12. Research possible competition for food resources or spawning areas in natal lakes.	Sawtooth Valley lakes	Shoshone-Bannock Tribes		To be determined				
7.2.9-13	13. Determine appropriate broodstock and strategies for	Stanley Lake	NOAA, SBSTOC	This is a key information need that will also be included in Section 11	To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	recovery of Sockeye Salmon in Stanley Lake .			RM&E					
7.2.9-14	14. Identify actions to improve fish passage at Sawtooth Hatchery weir to allow fish to enter natal lakes.	Sawtooth Valley	IDFG, USFWS, Shoshone-Bannock Tribes	Also a viability and predation issue	Not applicable				
7.2.9-15	15. Reconciling lake trout management in Stanley Lake and remove barrier to volitional Sockeye Salmon passage.	Stanley Lake	IDFG, USFS, NMFS		Not applicable				
7.2.9-16	16.Based on resolution of lake trout management , develop a program for Stanley Lake to support Sockeye Salmon recovery.	Stanley Lake	SBSTOC, , NMFS		To be determined				
7.2.9-17	17. Reestablish adult passage at Stanley Lake.	Stanley Lake	IDFG, BPA, USFS		To be determined				
Recovery Strategy 7.2.10: Continue research on natal lakes' carrying capacity, nutrients and ecology									
7.2.10-1	1. Conduct limnological studies to evaluate nursery lake habitat conditions encountered by adult and juvenile Sockeye Salmon during	Sawtooth Valley	Shoshone-Bannock Tribes		See Action 7.2.9-10				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	freshwater phase.								
7.2.10-2	2. Determine if lake fertilization is necessary for each lake used for Sockeye Salmon recovery, and, if warranted, develop and implement a plan to fertilize lakes to increase rearing habitat productivity.	Sawtooth Valley	SBSTOC, Shoshone-Bannock Tribes	The selection of lakes to fertilize should align with the IDFG Master Plan and its implementation.	To be determined				
7.2.10-3	3. Develop and implement a study in Yellowbelly Lake to evaluate lake carrying capacity of Sockeye Salmon in the absence of resident kokanee.	Yellowbelly Lake	Shoshone-Bannock Tribes		To be determined				
7.2.10-4	4. Continue limnological and ecological research and evaluations of the lakes reduced population structure, distribution, abundance, diversity.	Stanley and Yellowbelly Lakes	Shoshone-Bannock Tribes		See Action 7.2.9-10				
Recovery Strategy 7.2.11: Protect and conserve natural ecological processes at the watershed scale that support population viability									
7.2.11-1	1. Construct and maintain NMFS-	upper Salmon	NMFS, IDFG, SWCDs,	Identify costs based on each fish screen design	To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	approved fish screens.	River	Irrigation Districts	and specifications.					
7.2.11-2	2. Maintain current wilderness protection for the ESU in the Sawtooth Wilderness area and protect the currently pristine watershed habitat.	Sawtooth Wilderness area	USFS		To be determined				
7.2.11-3	3. Continue to implement the Sawtooth National Recreation Area's Management Plan and restoration actions.	Sawtooth National Recreation Area	USFS		To be determined				
7.2.11-4	4. Implement BMPs to protect and conserve ecological processes.	Sawtooth Valley	USFS, SWCDs, Counties, landowners		To be determined				
Strategy 7.2.12: Protect, restore and manage spawning and rearing habitat									
7.2.12-1	1. Maintain appropriate protections to manage lakeshore recreation to minimize any potential disturbance in areas where Sockeye Salmon spawn.	Sawtooth Valley	U.S. Forest Service, IDFG		To be determined				
7.2.12-2	2. Maintain appropriate	Sawtooth	U.S. Forest		To be				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	protections to continue to protect, restore and maintain spawning and rearing habitat.	Valley	Service, county		determined				
7.2.12-3	3. Maintain current wilderness protection in Sawtooth Wilderness Area.	Sawtooth Valley	U.S. Forest Service		To be determined				
7.2.12-4	4. Continue appropriate protections to manage other human development to restore or maintain native vegetation that provides naturally resilient and productive shoreline habitat.	Sawtooth Valley	U.S. Forest Service, IDFG		To be determined				
7.2.12-5	5. Identify ways to maintain current protections for Sockeye Salmon critical habitat in the future, if ESU is delisted.	Sawtooth Valley	U.S. Forest Service, IDFG, County	This is important because critical habitat protection will no longer be designated when ESU is not listed.	To be determined				
Recovery Strategy 7.2.13: Maintain unimpaired water quality and improve water quality as needed									
7.2.13-1	1. Continue to manage recreational use and motorized boat activity to	Sawtooth Valley	U.S. Forest Service, IDFG		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	minimize the risk of fuel spill and introduction of wastewater contaminants into lakes.								
7.2.13-2	2. Implement TMDLs for impaired water bodies in Salmon River watershed.	Salmon River watershed	IDEQ		To be determined				
7.2.13-3	3. Monitor contaminants to determine whether there is residual contamination with Toxaphene in three lakes or arsenic contamination in Alturas Lake.	Sawtooth Valley	IDEQ		To be determined				
7.2.13-4	4. Improve water quality (sediment) to maintain, enhance and restore fish habitat and passage.	Salmon River basin	SWCDs, USFS		To be determined				
7.2.13-5	5. Improve water quality (sed., temp.) between Redfish Lake Creek and East Fork Salmon River.	Salmon River	SWCDs, IDFG, Shoshone-Bannock Tribes		To be determined				
7.2.13-6	6. Increase stream flow to improve hydrology by implementing water conservation measures,	Salmon River (between East Fork	IDFG, SWCDs, Irrigation Districts,		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	improved water delivery, and improving water storage function of riparian areas and wetlands.	confluence and the headwaters)	landowners						
Recovery Strategy 7.2.14: Investigate and improve conditions in Salmon River and tributaries to support increased survival of migrating Snake River Sockeye Salmon									
7.2.14-1	1. Protect and enhance stream tributary habitat leading from natal lakes to the Salmon River in the Sawtooth Valley.	Upper Salmon River and tributaries	USFS		To be determined				
7.2.14-2	2. Protect and enhance watershed habitat to promote natural processes and watershed function.	Salmon and Lower Snake Rivers	USFS		To be determined				
7.2.14-3	3. Implement existing agreements on Federal lands in the Sawtooth Valley and Salmon River watersheds.	Upper Salmon River and tributaries; Sawtooth Valley	USFS		Baseline				
7.2.14-4	4. Identify specific actions and responsible parties/entities to improve water quantity and the quality of	Especially in upper reaches of the mainstem	USFS		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	juvenile and adult migration corridor habitats and monitor the actions.	Salmon River and mainstem lower Snake River							
7.2.14-5	5. Investigate the relatively high losses of juvenile and adult Sockeye Salmon in the Salmon River and identify actions that could reduce these losses.	Salmon River	NMFS, IDEQ		To be determined				
7.2.14-6	6. Continue to implement monitoring efforts to understand juvenile and adult survival in the Salmon River.	Salmon River	IDEQ, NMFS		949	To be determined			
7.2.14-7	7. Implement TMDLs for impaired water bodies in Salmon River watershed	Salmon River watershed	IDEQ		To be determined				
Recovery Strategy 7.2.15: Monitor and control predation, disease, invasive species and competition and develop actions as needed									
7.2.15-1	1. Implement plan for collection of returning spawners at Lower Granite Dam to reduce exposure to elevated temperatures in the	Snake River	IDFG, BPA? Other?		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	mainstem Salmon River during late July and August.								
7.2.15-2	2. Implement Idaho Department of Agriculture, U.S. Forest Service and IDFG whirling disease monitoring and control program.	Sawtooth Valley, upper Salmon River	IDA, USFWS, IDFG	Whirling Disease has been detected ….	$29,000 per year	29	29	29	29
7.2.15-3	3. Implement Idaho Department of Agriculture, U.S. Forest Service and IDFG invasive species monitoring and control programs.	Sawtooth Valley, upper Salmon River	Idaho Dept. of Agriculture, IDFG, USFS	New Zealand mud snails have been detected in Salmon River mainstem.	Same as 7.2.15-2 above				
7.2.15-4	4. Reduce non-native kokanee in lakes used for Sockeye Salmon recovery.	Redfish Lake, Pettit Lake, Alturas Lake	SBT; IDFG	Only feasible in Alturas Lake if genetic structure indicates a need	To be determined				
7.2.15-5	5. Evaluate the effects of lake trout on Sockeye Salmon, develop an eradication strategy, if appropriate, and implement strategy as	Stanley Lake	IDFG		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	necessary.								
7.2.15-6	6. Develop strategy (ies) to prevent lake trout movement and colonization of additional Sockeye Salmon lakes.	Sawtooth Valley	IDFG		To be determined				
7.2.15-7	7. Evaluate the effects of cutthroat trout on Sockeye Salmon.	Yellowbelly Lake	IDFG		To be determined				
7.2.15-8	8. Develop and implement a study in Yellowbelly Lake to evaluate lake carrying capacity of Sockeye Salmon limiting factor in the absence of resident kokanee.	Yellowbelly Lake	SBT		To be determined				
7.2.15-9	9. Identify criteria for transitioning to passing selected adults above weirs to migrate naturally, and for opening weirs to allow returns to distribute themselves naturally.	Sawtooth Valley	SBSTOC	Technical staff or policy issue	Not applicable				
7.2.15-10	10. Identify ways to address predation at	Sawtooth Valley	IDFG, USFWS		To be determined				

Action No.	Recovery Actions	Subbasin/ Lake/ Watershed	Potential Implementing Entity	Comments	FY 2014 ($K/year)	FY 15	FY 16	FY 17	FY 18
	Sawtooth Hatchery weir.								
Recovery Strategy 7.2.16: Create an adaptive management feedback loop to track progress toward achieving recovery goals, monitor and evaluate key information needs, assess information and refine strategies and actions									
7.2.16-1	1. Implement Research, Monitoring and Adaptive Management Program	Sawtooth Valley	IDFG, NMFS, BPA, Shoshone-Bannock Tribes	Key implementation action	To be determined				
TOTAL FY 14 - FY 19					$20,293,955				

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Appendix B: Module for Ocean Environment

This appendix can be found at:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/ocean_module.pdf

Appendix C: Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead

This appendix can be found at:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/estuary-mod.pdf

Appendix D: Snake River Harvest Module

This appendix can be found at:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/harvest_module_062514.pdf

Appendix E: Supplemental Recovery Plan Module for Snake River Salmon and Steelhead Mainstem Columbia River Hydro System

This appendix can be found at:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/hydro_supplemental_recovery_plan_module_063014.pdf