Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions

NOAA Fisheries

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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.
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.
Beverton-Holt Function	This function predicts the number of progeny that will return to spawn from a given number of parental spawners.
Biogeographical Region	An area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms 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 delisting, to address, for example, other legislative mandates or social, economic, and ecological values.
Compensatory Mortality	Refers to mortality that would have occurred for another reason.
Compliance Monitoring	Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.
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.
Demand	The amount of power being used at any given time. Demand in the Northwest is seasonal; with the highest use in the winter for heating and the lowest in the summer.
Density-Independent Survival	A change in survival that is not influenced by the number of fish in the population. Generally speaking, most factors influencing survival after the smolt stage are assumed to be density independent. During the egg-to-smolt stage, the density of adults

	and juveniles can influence survival as a result of competition for limited habitat or other factors. For evaluation of survival gaps, estimates of survival changes resulting from actions affecting early life stages of salmon and steelhead are made under the assumption of low density.
Dissolved Gas Level	As falling water hits the river surface, it drags in air as it plunges. With increasing water pressure, the air dissolves into the water and increases the levels of pre-existing dissolved gases.
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 vs. 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.
Draft Limit	The lowest level to which a reservoir can be drawn down. The limit is based on rule curves that are calculated on both historic and current streamflow data.
Drafting	The process of releasing water from storage in a reservoir. Operators begin drafting reservoirs—through turbines or over the spillway of a dam—to lower the level for a number of resasons, including flood control or downstream flows for fish or power generation.
Dredging	The act of removing sediment from the river bottom to keep the channel at the proper depth for navigation. The continual moving and shifting of sediment makes dredging an ongoing activity.
Effectiveness Monitoring	Monitoring set up to test cause-and-effect hypotheses about recovery actions: 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?
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 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.
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 manmade factors affecting its continued existence.
Fall Chinook Salmon	This salmon stock returns from the ocean in late summer and early fall to head upriver to its spawning grounds, distinguishing it from other stocks which migrate in different seasons.
Fish Guidance Efficiency	Number of fish guided into the bypass system divided by total number passing via the powerhouse (i.e., the combined total for bypass system and turbine passage).
Fish Ladder	A series of stair-step pools that enables salmon to get past the dams. Swimming from pool to pool, salmon work their way up the ladder to the top where they continue upriver.
Fish Passage Efficiency	Number of fish passing the dam via non-turbine routes divided by total number passing the dam by all routes.
Flip Lips	A structural device that redirects water as it comes over the spillway of a dam. Flip lips reduce deep plunging of water into the pool below; keeping the water from becoming supersaturated with nitrogen. Fish are naturally attracted to the rapidly moving water at the base of the dam but can suffer from gas bubble disease when the water is supersaturated with gas.
Flood Control	Streamflows in the Columbia River Basin can be managed to keep water below damaging flood levels in most years. This level of flood control is possible because storage reservoirs on the river can capture and store heavy runoff as it occurs.
Flood Control Rule Curve	The curve is also called the upper rule curve. It establishes the amount of storage space that must be maintained in a reservoir to reduce damaging flood conditions downriver.
Flood Control Storage Space	The space that is provided in a storage reservoir to allow for the capture of runoff that could otherwise cause flood damage.

Flow Augmentation	Water released from system storage at targeted times and places to increase streamflows to benefit migrating 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, they are not thought to constitute a population.
Hyporheic Zone	Area of saturated sediment and gravel beneath and beside streams and rivers where groundwater and surface water mix.
Implementation monitoring	Monitoring to determine whether an activity was performed and/or completed as planned.
Independent population	Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.
Indicator	A variable used to forecast the value or change in the value of another variable.
Interim regional Recovery plan	A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.
International Joint Commission	Six-person Canada-U.S. board created by the 1909 Boundary Water Treaty to resolve disputes on waters shared by the two nations.
Intrinsic Productivity	The average of adjusted recruits per spawner estimates for only those brood years with the lowest spawner abundance levels.
Kelts	Steelhead that have spawned but may survive to spawn again, unlike most other anadromous fish.
Lambda	Also known as Population growth rate, or the rate at which the number of fish in a population increases or decreases.
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.

Levees, Flood Walls, & Bank Protection	A levee is a raised embankment built to keep out flood waters. Flood walls, such as the concrete seawall along the Willamette River in downtown Portland, are barriers constructed to hold out high water. The soil on river banks is protected from erosion in a variety of ways. River grasses and trees are cultivated in some areas, and fine mesh screens are laid on banks in other areas to keep soil in place. Rip-rap is also used to protect against fast moving streams or vigorous wave action.
Limiting Factor	Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish at the population, intermediate (e.g., stratum or major population grouping), or ESU levels 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 ability to reach its desired status.
Locally developed recovery plan	A plan developed by state, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as state, tribal, and local mandates and recovery needs.
Locks	The key to inland navigation on the Columbia-Snake River Waterway, locks raise and lower ships between pools on the river, i.e., from below a dam to the pool above it. On the trip from the ocean to Lewiston, Idaho, vessels travel from sea level through eight locks to an elevation of over 700 feet.
Major dams	Large hydro-electric projects developed by Federal agencies within the Pacific Northwest. Twenty-nine major dams are in the Columbia River Basin. Two dams are in the Rogue River Basin. A total of 31 dams comprise the Federal Power System.
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.
Major population group (MPG)	A group of salmonid populations that are geographically and genetically cohesive. The MPG is a level of organization between demographically independent populations and the ESU.
Megawatts	A measure of electrical power equal to one million watts. Megawatts delivered over an hour are measured in megawatt-hours.
Morphology	The form and structure of an organism, with special emphasis on external features.

Multipurpose Facilities	The Columbia River and the reservoir system are used for many purposes or uses. Projects that were authorized to serve a variety of purposes are referred to as "multipurpose."
Northern Pikeminnow	A giant 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.
Quasi-Extinction Threshold (QET)	This is the point at which a population has become too small to reliably reproduce itself, even though there may be a few fish remaining. Since there is debate about the exact population level at which this condition occurs, several possible levels (50, 30, 10, 1) are considered. Results from short-term quasi-extinction probability modeling are used to help assess near-term (24-year) extinction risk.
Operating Requirements	These are the limits within which a reservoir or dam must be operated. Some requirements are established by Congress when a project is authorized; others evolve with operating experience.
Operating Year	Detailed operations planned over a 12-month period. The operating year begins on August 1 and ends on July 31.
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.
Phenotype	The external appearance of an organism resulting from the interaction of its genetic makeup and the environment.
Piscivorous	Describes fish that prey on other fish for food.
Population bottlenecks	The most significant limiting factors currently impeding a population from reaching its desired status. Bottlenecks result in the greatest relative reductions in abundance, productivity, spatial distribution, or diversity and are defined by considering viability impairment across limiting life stages and limiting factors.
Productivity	A measure 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.
Proposed Action	A proposed action or set of actions
Prospective Actions	Actions from both the FCRPS Biological Assessment and Upper Snake Biological Assessment, August 2007

Reasonable and Prudent Alternative (RPA)	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 believes 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 NOAA Fisheries 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 plan supplement	A NOAA Fisheries supplement to a locally developed recovery plan that describes how the plan addresses ESA requirements for recovery plans. The supplement also proposes ESA de-listing criteria for the ESUs addressed by the plan, since a determination of these criteria is a NOAA Fisheries' decision.
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.
Recruits per spawner	Generally, a population would be deemed to be "trending toward recovery" if average population growth rates (or productivities) are expected to be greater than 1.0.
Redd	A nest constructed by female salmonids in streambed gravels where eggs are deposited and fertilization occurs.
Reservoir Drawdown	The water levels in a reservoir can be lowered, or drawn down, by releases from the dam. These drawdowns have the effect of speeding up the water through a reservoir by decreasing its cross-sectional area.
Resident Fish	Fish that are permanent inhabitants of a water body. Resident fish include trout, bass, and perch.
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.

Rule Curve	Water levels, represented graphically as curves, that guide reservoir operations.
Runoff	Precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water.
Salmonid	Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.
Smolt	A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt from freshwater to a saltwater environment.
Snowpack	The accumulation of snow in the mountains that occurs during the late fall and winter.
Sound	In order to pass via the spillway of a dam, smolts must dive to locate spillway entrances.
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.
Spill Effectiveness	The proportion of fish passing the spillway divided by the proportion of water spilled.
Spill Efficiency	The total number of fish passing the spillway divided by the total number passing the dam.
Stakeholders	Agencies, groups, or private citizens with an interest in recovery planning, or who will be affected by recovery planning and actions
Stratum/major population group	An aggregate of independent populations within an ESU that share similar genetic and spatial characteristics.
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.
Streamflow Records	For over 100 years, water resource managers in the Northwest have maintained records on the seasonal volume and rate of flow in the Columbia River. These historical records are of profound importance to planning system operations each year.
Technical Recovery Team (TRT)	Teams convened by NOAA Fisheries to develop technical products related to recovery planning. TRTs 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.
Temperature Control	By drawing water from different elevations within a reservoir, water temperature can be regulated. This temperature regulation

	results in the ability to control the water temperature released from the reservoirs, and the subsequent water temperature downstream.
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.
Transmission Grid	The network of high-voltage transmission lines serving the region, carrying power from generating plant to cities.
Turbine	An enclosed rotary type of prime mover that drives an electric generator to produce power.
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.
Viable salmonid population (VSP)	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity.
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., June 2000.

Acronyms and Abbreviations

Action Agencies	U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and the Bonneville Power Administration
AFF	anadromous fish evaluation program
amsl	above mean sea level
B.C.	British Columbia
BIA	Bureau of Indian Affairs
BiOp	Biological Opinion
BLM	Bureau of Land Management
BMPs	Best Management Practices
BON	Bonneville Dam
BPA	Bonneville Power Administration
BRT	Biological Review Team (NOAA Fisheries)
BY	brood years
CBFWA	Columbia Basin Fish and Wildlife Authority
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHARTs	critical habitat analytical review teams
CI	confidence interval
Comanagers	States and Tribes of the Columbia River Basin
COMPASS	Comprehensive Fish Passage
Corps	U.S. Army Corps of Engineers
CR	Columbia River
CRB	Columbia River Basin
CREP	Conservation Reserve Enhancement Program
CRFMP	Columbia River Fishery Management Plan
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWSRO	Confederated Tribes of the Warm Springs Reservation of Oregon
CTWS	Confederated Tribes of the Warm Springs
CWA	Clean Water Act
CWMS	Corps Water Management System (database)
CWT	coded-wire tag
D	differential delayed survival of transported fish

DART	Data Access in Real Time (University of Washington Program)
DDT	dichlorodiphenyltrichloroethane
DIP	demographically independent population
DNR	see WA DNR
DPS	Distinct Population Segment
EDT	ecosystem diagnosis and treatment
EEZ	Exclusive Economic Zone
EF	east fork
EFH	essential fish habitat
EIP	Ecological Improvement Potential
EIS	environmental impact statement
ENSO	El Niño Southern Oscillation
ESA	Endangered Species Act
ESBS	extended-length submersible bar screen
EST	Columbia River estuary
ESU	evolutionary significant unit
FCRPS	Federal Columbia River Power System
FFDRWG	Fish Facility Design Review Work Group
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FGE	fish guidance efficiency
FMEP	Fisheries Management and Evaluation Plan
FPE	fish passage efficiency
FPOM	Fish Passage Operations and Maintenance Coordination Team
FR	Federal Regulation
FRN	Federal Regulation Notice
FS	Forest Service
GBT	gas bubble trauma
GDU	genetic diversity unit
H	High
HCD	Habitat Conservation Diversion
HCP	Habitat Conservation Plan
HCY	Hell’s Canyon
HGMP	hatchery and genetic management plan

HIP	Habitat Improvement Program
HOF	hatchery-origin fish
HSRG	Hatchery Scientific Review Group
HUC	Hydrological Unit Code
HYDROSIM	Hydro Simulation Program
I-205	Interstate Highway 205
I-5	Interstate Highway 5
ICB-TRT	Interior Columbia Basin Technical Recovery Team
ICTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IDL	Idaho Department of Lands
IHR	Ice Harbor Dam
IPER	Implementation Plan Evaluation Report
ISAB	Independent Scientific Advisory Board
ISRP	Independent Scientific Review Panel
ISS	Idaho Supplementation Studies
JDA	John Day Dam
kcfs	thousand cubic feet per second
km^2	square kilometers
ksfd	Thousand cubic feet per second days
L	Low
LCFRB	Lower Columbia Fish Recovery Board of the NWPCC
LCR	Lower Columbia River
LGO	Little Goose Dam
LGR	Lower Granite Dam
L-M	Low to Medium
LMN	Lower Monumental Dam
LSRCP	Lower Snake River Compensation Plan
LWD	large woody debris
MAF	million acre-feet
MaSA	major spawning areas
MCN	McNary Dam
MCR	Mid-Columbia River
MFJD	Middle Fork John Day
MHHW	mean higher high water level

mi/mi^2	miles per square mile
MIP	minimum irrigation pool
MiSA	minor spawning areas
MMPA	Marine Mammal Protection Act
MOP	minimum operating pool
MPG	major population group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NF	north fork
NFH	National Fish Hatcheries
NFJDR	North Fork John Day River
ng/g	nanograms per gram
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOF	natural-origin fish
NPMP	Northern Pikeminnow Management Program
NRC	National Research Council
NWF	National Wildlife Federation
NWPCC	Northwest Power and Conservation Council
NWPPC	Northwest Power Planning Council
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PA	Proposed Action
PAH	polyaromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	primary constituent element
PCSRF	Pacific Coast Salmon Recovery Fund
PCTS	Public Consultation Tracking System (database)
PDO	Pacific Decadal Oscillation
PECE	"Policy for Evaluation of Conservation Efforts When Making Listing Decisions"
PFMC	Pacific Fishery Management Council
PGE	Portland General Electric

PIT	passive integrated transponder
POD	point of diversion
ppt	Parts per thousand
PUD	Public Utility District
QET	quasi-extinction threshold
R/S	returns-per-spawner
RFT	reproductive failure threshold
RHCA	riparian habitat conservation area
Rkm	river kilometer
RM	river mile
RM&E	Research, Monitoring, and Evaluation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPMs	reasonable and prudent measures
R/S	recruits per spawner
RSW	removable spillway weir
SAR	smolt-to-adult return rate
SASSI	Salmon and Steelhead Stock Inventory
SbyC	separated-by-code
SCA	Supplemental Comprehensive Analysis
SCT	System Configuration Team
SEF	East Fork Salmon River
SF	south fork
SFJD	South Fork John Day
SIMPAS	simulated passage (model)
SR	Snake River
SRPAH	Pahsimeroi River
SRS	sediment retention structure
SRUMA	Salmon River-Upper Mainstem
SRWG	Studies Review Workgroup
SRYFS	Salmon River-Yankee Fork
STS	submersible traveling screen
SWHA	shallow water habitat area
SWCD	Soil and Water Conservation District
SYSTDG	System Total Dissolved Gas (TDG) Model

T&C	terms and conditions
TDA	The Dalles Dam
TDG	total dissolved gas
TERP	Tower Ecosystem Restoration Projects
TMDL	total maximum daily load
TMT	Technical Management Team
TRT	Technical Recovery Team
TSW	temporary spillway weir
UCM	Unit Characteristic Method
UCR	Upper Columbia River
UCUT	Upper Columbia United Tribes
UNF	Umatilla National Forest
UPA	Updated Proposed Action
URC	upper rule curve
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USRC	Upper Salmon River at Challis Project
USRITAT	Upper Salmon River Interagency Technical Advisory Team
UWR	Upper Willamette River
VARQ	variable (VAR) outflow (Q)
VH	Very High
VL	Very Low
VSP	viable salmonid population
W/LC TRT	Willamette/Lower Columbia TRT
WA DNR	Washington Department of Natural Resources
WCS BRT	West Coast Salmon Biological Review Team
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WF	west fork
WNFH	Winthrop National Fish Hatchery
WQT	Water Quality Team

WRIA	water resource inventory area
YN	Yakima Nation

Chapter 1

Supplemental Comprehensive Analysis Purpose & Use

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Chapter 1
Supplemental Comprehensive Analysis - Purpose & Use

NOAA Fisheries is conducting multiple ESA consultations for several Federal actions that are occurring simultaneously affecting the same listed species of Columbia River Salmon and Steelhead. The actions are listed in Chapter 2, Prospective Actions; they concern the operation of the Federal Columbia River Power System (FCRPS), various Bureau of Reclamation irrigation storage projects and certain fisheries in the Columbia and Snake River Basins. Litigation concerning consultations for these activities creates a situation that justifies simultaneous ESA conclusions about the effects of these projects.

NOAA Fisheries issued its previous Biological Opinion for the FCRPS and associated Reclamation irrigation projects on November 30, 2004. In *NWF v. NMFS*, CV01-640-RE, Judge James A. Redden, Federal District Court of Oregon, invalidated this Opinion by his decision of May 26, 2005. NOAA Fisheries issued its previous biological opinion for Reclamation's Upper Snake River projects on March 31, 2005. In *American Rivers v. NOAA Fisheries*, CV-04-0061-RE, Judge Redden also invalidated NOAA Fisheries' Biological Opinion for the Upper Snake projects on May 23, 2006. The Court remanded both Biological Opinions to NOAA Fisheries and the FCRPS Action Agencies to comply with the ESA, as interpreted by the Court. Although these are separate ESA consultations and court cases, they are on the same court-ordered schedule for completion.

NOAA Fisheries is also one of the federal agencies involved in the Indian treaty fishing rights case of *United States v. Oregon*, CV68-513-KI (D. Oregon). Columbia River treaty and non-treaty fisheries have most recently occurred pursuant to a settlement agreement approved by the *U.S. v. Oregon* court in 2005. That agreement will expire in May, 2008. The parties to *US v. Oregon* have negotiated a new ten year agreement which they must submit to the court for approval. The court requires that NOAA Fisheries first issue a biological opinion detailing whether the effects of this agreement on the same listed salmon and steelhead species that are affected by the FCRPS and various USBR projects are consistent with the ESA standards of Section 7(a)(2). The parties to *U.S. v. Oregon* are all also participants in the litigation and remand for the FCRPS. Several are also participants in the litigation and remand for the USBR Upper Snake projects. The fishing activities of the *U.S. v. Oregon* agreement have been integrated by the parties into the actions considered for the FCRPS and USBR projects.

The FCRPS Action Agencies and Reclamation for its Upper Snake projects founded their two biological assessments for their actions on a common comprehensive analysis entitled Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions (Corps et al. 2007a). NOAA Fisheries received these biological assessments and the supporting Comprehensive Analysis (CA) on August 29, 2007. NOAA Fisheries' development of biological opinions for these actions began with consideration of the FCRPS Action

Agencies' Comprehensive Analysis. NOAA Fisheries has prepared this Supplemental Comprehensive Analysis to capture the best available data and analysis contemporaneous with its issuance of these biological opinions.

NOAA Fisheries' Supplemental Comprehensive Analysis builds on the FCRPS Action Agencies' Comprehensive Analysis, incorporating by reference the information relevant to NOAA Fisheries' analysis. NOAA Fisheries augments or substitutes that information with additional or alternative data and analysis about the effects of these actions on the listed species. Where there are explicit or implicit differences between NOAA Fisheries' SCA and the FCRPS Action Agencies' Comprehensive Analysis, NOAA Fisheries determines that the information in the SCA represents the best science and data available. Further, NOAA Fisheries has integrated its consideration of the activities called for by the *U.S. v. Oregon* settlement agreement into this SCA, considering those activities to be part of the Prospective Actions for that analysis.

The SCA is a reference document. The Biological Opinion for the FCRPS and Reclamation Projects, the Biological Opinion for Reclamation's Upper Snake Projects and the Biological Opinion for the 2008-2017 *U.S. v. Oregon* Management Agreement are decision documents. NOAA Fisheries' ultimate determinations about jeopardy and destruction or adverse modification of critical habitat, pursuant to ESA § 7(a)(2), are found in the biological opinions. Incidental take statements for these actions, pursuant to ESA § 7(b)(4), are also in the respective biological opinions. NOAA Fisheries' consideration and evaluation of the relevant data and analysis on which these decisions are based, are found in the SCA. The biological opinions each explicitly incorporate information from the SCA necessary to support their respective determinations. In this way, the multiple biological opinions are tiered off of the common SCA.

At the same time, to ensure the relevance of its information, the SCA is based on the actions as detailed in their originating documents. The SCA incorporates for its analysis the Reasonable and Prudent Alternative (RPA) as described in the biological opinion for the FCRPS and associated Reclamation projects. Also, the SCA looks to the FCRPS Biological Opinion for the description of NOAA Fisheries' issuance of a research and enhancement permit, pursuant to ESA § 10(a)(1)(A), for the Corps' Juvenile Transport Program. Similarly, the SCA incorporates for its analysis the Proposed Action for Reclamation's Upper Snake Projects, from the Reclamation's biological assessment for those projects. Finally, the SCA looks to the 2008-2017 *U.S. v. Oregon* Management Agreement Biological Opinion for a full description of those activities for consultation. In this way the SCA is contemporaneous with NOAA Fisheries' Biological opinions for all of these actions.

Chapter 2

Prospective Actions

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Chapter 2
Prospective Actions

The following Federal actions are aggregated in this Supplemental Comprehensive Analysis and are referenced hereinafter as the Prospective Actions:

- Operation and configuration of the FCRPS as described in the 2007 FCRPS Biological Assessment (Corps et al. 2007b) and the mainstem effects of 11 Reclamation irrigation projects (Corps et al. 2007b, Appendix B-1-7), as modified by;

    - NOAA Fisheries' RPA for the FCRPS (described in Chapter 4 of the FCRPS Biological Opinion (NMFS 2008a),

- NOAA Fisheries' § 10(a)(1)(A) Transportation Permit (described in Chapter 2 of the FCRPS Biological Opinion [NMFS 2008a]), and

- Reclamation's Upper Snake proposed action (described in Reclamation's 2007 Upper Snake Biological Assessment [USBR 2007]).

- NOAA Fisheries' participation in the 2008-2017 *United States v. Oregon* Management Agreement (hereafter, "2008 *U.S. v. Oregon* Agreement") concerning particular Columbia River fisheries related activities as described in Chapter 2 of NOAA Fisheries' Biological Opinion for that Agreement

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Chapter 3

Comprehensive Action Area

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Chapter 3
Comprehensive Action Area

The action area for this Comprehensive Analysis is the composite of the relevant action areas described in Chapters 4 of the FCRPS and USBR Upper Snake Biological Opinions and in Chapter 3 of the 2008-2017 *United States v. Oregon* Agreement Biological Opinion.

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Chapter 4

Species & Critical Habitat Affected

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Chapter 4
Species & Critical Habitat Affected

4.1 Species Affected by the Prospective Actions

The following 13 species (and for 12, their designated critical habitat) are the subject of the FCRPS and Upper Snake consultations on remand.

Chinook Salmon (*Oncorhynchus tshawytscha*)

ESU	ESA Listing Status	ESA Critical Habitat
Snake River (SR) spring/summer Chinook salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Critical habitat designated on October 25, 1999 [NMFS 1999a]
Snake River (SR) fall Chinook salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Critical habitat designated on December 28, 1993 [NMFS 1993]
Upper Columbia River (UCR) spring Chinook salmon	Listed as endangered on June 28, 2005 [NMFS 2005a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]
Upper Willamette River (UWR) Chinook salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]
Lower Columbia River (LCR) Chinook salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]

Steelhead (*Oncorhynchus mykiss*)

ESU	ESA Listing Status	ESA Critical Habitat
Snake River (SR) steelhead	Listed as threatened on January 5, 2006 [NMFS 2006a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]
Upper Columbia River (UCR) steelhead	Listed as endangered on June 13, 2007 [Court decision]	Critical habitat designated on September 2, 2005 [NMFS 2005b]
Middle Columbia River (MCR) steelhead	Listed as threatened on January 5, 2006 [NMFS 2006a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]

Steelhead (*Oncorhynchus mykiss*) Continued

ESU	ESA Listing Status	ESA Critical Habitat
Upper Willamette River (UWR) steelhead	Listed as threatened on January 5, 2006 [NMFS 2006 a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]
Lower Columbia River (LCR) steelhead	Listed as threatened on January 5, 2006 [NMFS 2006 a]	Critical habitat designated on September 2, 2005 [NMFS 2005b]

Chum Salmon (*Oncorhynchus keta*)

ESU	ESA Listing Status	ESA Critical Habitat
Columbia River (CR) chum salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Habitat designated on September 2, 2005 [NMFS 2005b]

Sockeye Salmon (*Oncorhynchus nerka*)

ESU	ESA Listing Status	ESA Critical Habitat
Snake River (SR) sockeye salmon	Listed as endangered on June 28, 2005 [NMFS 2005a]	Critical habitat designated on December 28, 1993 [NMFS 1993]

Coho Salmon (*Oncorhynchus kisutch*)

ESU	ESA Listing Status	ESA Critical Habitat
Lower Columbia River coho salmon	Listed as threatened on June 28, 2005 [NMFS 2005a]	Critical habitat designation under development

Killer Whales (*Orcinus orca*)

ESU	ESA Listing Status	ESA Critical Habitat
Southern Resident DPS Killer Whales	Listed as endangered on November 18, 2005 [NMFS 2005d]	Critical habitat designation on November 29, 2006 [NMFS 2006c]

Green Sturgeon (*A. medirostris*)

ESU	ESA Listing Status	ESA Critical Habitat
Southern DPS of Green Sturgeon	Listed as endangered on April 7, 2006 [NMFS 2006d]	Critical habitat designation under development

4.2 Designated Critical Habitat Affected by the Prospective Actions

4.2.1 Designated Critical Habitat for Columbia Basin Salmon and Steelhead

NOAA Fisheries has designated critical habitat for 12 of the 13 salmon and steelhead species that would be affected by the FCRPS and Upper Snake prospective actions.[1] Critical habitat includes the stream channel within each designated stream reach with the lateral extent defined by the ordinary high-water line. Within these areas, the primary constituent elements (PCEs) essential for the conservation of the listed species are those sites and habitat components that support one or more life stages. The PCEs for three species of SR salmon are shown in Table 4.2.1-1, below. The PCEs for nine other species of Columbia basin salmon and steelhead are described in the paragraphs following Table 4.2.1-1.

Table 4.2.1-1. PCEs identified for SR Sockeye, spring/summer Chinook, and fall Chinook Salmon (NMFS 1993)

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

[1] NOAA has not yet developed a critical habitat designation for LCR coho salmon.

Habitat Component	Sockeye	Spring/Summer Chinook	Fall Chinook
	8) space 9) safe passage		

NOAA Fisheries (NMFS 2005b) has identified the following PCEs for the nine other species of Columbia basin salmonids.[2]

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

2. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.

3. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

4. Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed

[2] A fifth category in NOAA Fisheries (NMFS 2005b), "nearshore marine areas," refers to areas designated in Puget Sound (i.e., is not applicable to Columbia basin salmonids).

to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

At the time of the critical habitat designations that became final in September of 2005, NOAA Fisheries' Critical Habitat Analytical Review Teams (CHARTs) rated 525 occupied watersheds in the Columbia River basin. The CHARTs gave each of these occupied watersheds a high, medium, or low rating. High-value watersheds are those with a high likelihood of promoting conservation, while low value watersheds are expected to contribute relatively little. Conservation value was determined by considering the factors listed in Table 4.2-2 below.

Table 4.2-2. Factors considered by Columbia Basin CHARTs to determine the conservation value of occupied HUC-5s.[3]

Factors	Considerations
PCE quantity	Total stream area or number of reaches in the HUC-5 where PCEs are found; compares to both distribution in other HUC-5s and to probable historical quantity within the HUC-5
PCE quality – current condition	Existing condition of the quality of PCEs in the HUC-5
PCE quality - potential condition	Likelihood of achieving PCE potential in the HUC-5, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility
PCE quality - support of rarity/importance	Support of rare genetic or life history characteristics or rare/important types in the HUC-5
PCE quantity - support of abundant populations	Support of variable-sized populations relative to other HUC-5s and the probably historical levels in the HUC-5
PCE quality - support of spawning/rearing	Support of spawning or rearing of varying numbers of populations (i.e., different run-timing or life history types within a single ESU and or different ESUs)

Of the 525 watersheds evaluated, 382 were assigned a high rating, 93 a medium rating, and 50 a low rating. The CHART ratings do not address SR spring/summer Chinook salmon, SR fall Chinook salmon, or SR sockeye salmon because critical habitat was designated for these ESUs in 1993. Ratings for the LCR coho salmon ESU are under development.

Many factors, both human-caused and natural, have contributed to the decline of salmon over the past century. Salmon habitat has been altered through activities such as urban development, logging, grazing, power generation, and agriculture. These habitat alterations have resulted in the

[3] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC-5 is a five unit (ten two-digit numbers) code. Examples of HUC-5s are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the upper Willamette basin, Oregon.

loss of important spawning and rearing habitat and the loss or degradation of migration corridors. Thus, critical habitat is not able to serve its conservation role in its current condition in many of the designated watersheds. Factors limiting the functioning of PCEs and thus the conservation value of critical habitat are discussed for each species in Chapter 8 of this document.

4.2.2 Designated Critical Habitat for Southern Resident Killer Whales

NOAA Fisheries published the final designation of critical habitat was published November 29, 2006 (NMFS 2006c). Critical habitat consists of three specific areas (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca, which comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NOAA Fisheries identified the following physical or biological features (i.e., PCEs) essential to conservation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Factors limiting the functioning of PCEs and thus the conservation value of critical habitat are water quality (Puget Sound); prey quantity, quality, and availability (throughout portions of the designated area used for foraging); and impediments to passage between areas used for foraging and other activities (e.g., the presence of vessels).

There is no designated critical habitat for Southern Resident Killer Whales in the action area for the Prospective Actions.

4.2.3 Designated Critical Habitat for Green Sturgeon

NOAA Fisheries has not yet designated critical habitat for this species.

4.3 Endangered Species Act Recovery Planning

This section describes current recovery planning activities for the listed salmonid species affected by the FCRPS.

The ESA requires NOAA Fisheries to develop and implement recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed “for the conservation and survival” [ESA Section 4(f)(1)] of threatened and endangered species to the point that they no longer need the Act’s protection. ESA recovery plans organize, coordinate, and prioritize possible recovery actions to provide a road map for species’ recovery. NOAA Fisheries’ recovery plans articulate the goals and scientifically supported strategies needed to recover a listed species (NMFS 2007a).

The ESA mandates that a recovery plan must provide:

- 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 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. See ESA Section 4(f)(1)(B).

ESA Section 4(a)(1) lists factors for listing, re-classification or delisting, and these are addressed in recovery plans:

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

ESA Recovery Planning: Overview

NOAA Fisheries is basing ESA recovery plans for Pacific salmon on the state, regional, Tribal, local, and private conservation efforts already underway throughout the region. To support recovery planning process in the Columbia Basin, NOAA Fisheries convened two Technical Recovery Teams (TRT) to develop recommendations on biological viability criteria for ESUs and their component populations, to provide scientific support to local and regional recovery planning efforts, and to provide scientific evaluations of recovery plans. These are the Willamette /Lower Columbia and the Interior Columbia TRTs.

Nominations for each TRT were solicited from the scientific community and candidates were evaluated by an independent panel before being appointed. These TRTs are scientific advisory committees. Although they are coordinated and chaired by NOAA Fisheries' Northwest Fisheries Science Center staff and their work includes significant contributions from NOAA Fisheries science staff, most of the members are not NOAA Fisheries scientists. TRT members include scientists from other federal agencies, state agencies, Tribes, states, universities, and consultants.

All TRTs used the same biological principles for developing their ESU and population viability criteria. These principles are described in a NOAA Fisheries technical memorandum, *Viable Salmonid*

Populations and the Recovery of Evolutionarily Significant Units (McElhany et al. 2000). A viable salmonid population (VSP) is defined as one that has a negligible extinction risk over a 100-year time frame. Viable salmonid populations are defined in terms of four parameters: abundance, productivity or growth rate, spatial structure, and diversity. Viable ESUs are defined by some combination of populations, at least some of which meet or exceed "viable" thresholds for abundance and productivity, and that have appropriate geographic distribution, protection from catastrophic events, and diversity of life histories and other genetic expression.

The TRTs identified the historical population structure of each ESU/DPS including independent populations and major population groups (MPGs), based on shared geography or ecosystems, genetic similarity, and other considerations, within each ESU/DPS (The Interior Columbia TRT called these groupings major population groups (MPGs); the Willamette/Lower Columbia TRT called them strata—in this discussion we use the term major population group to refer to both.).

Both TRTs then developed viability criteria at the population, MPG, and ESU/DPS scales (WLCTRT and ODFW 2006; ICTRT 2007a). Both TRTs concluded that for an ESU/DPS to be considered viable, all MPGs within that ESU/DPS should be at low risk. A low risk MPG was defined as one with some minimum number of viable populations and with other populations improved to or maintained at some other (generally higher) risk status so that they are nevertheless contributing to overall MPG or ESU/DPS viability.[4]

Given the hierarchical structure of salmonid biology, an overall assessment of extinction risk for an ESU or DPS begins at the population level and builds up to the MPG and ESU/DPS levels (See Figure 4.3-1). Moreover, the status of individual populations is evaluated to assess MPG risk status, and then the status of each MPG within an ESU/DPS is considered when evaluating overall ESU/DPS status. Both TRTs developed reports assessing the current status and extinction risk of individual populations, MPGs, and ESUs/DPSs based on their criteria.

[4] Technical Recovery Team "viability" recommendations are associated with recovery and delisting in recovery plans for salmon and steelhead. It therefore goes beyond the "potential for recovery" prong of the jeopardy standard as described in Section 7.1.

Hierarchy in Salmonid Population Structure

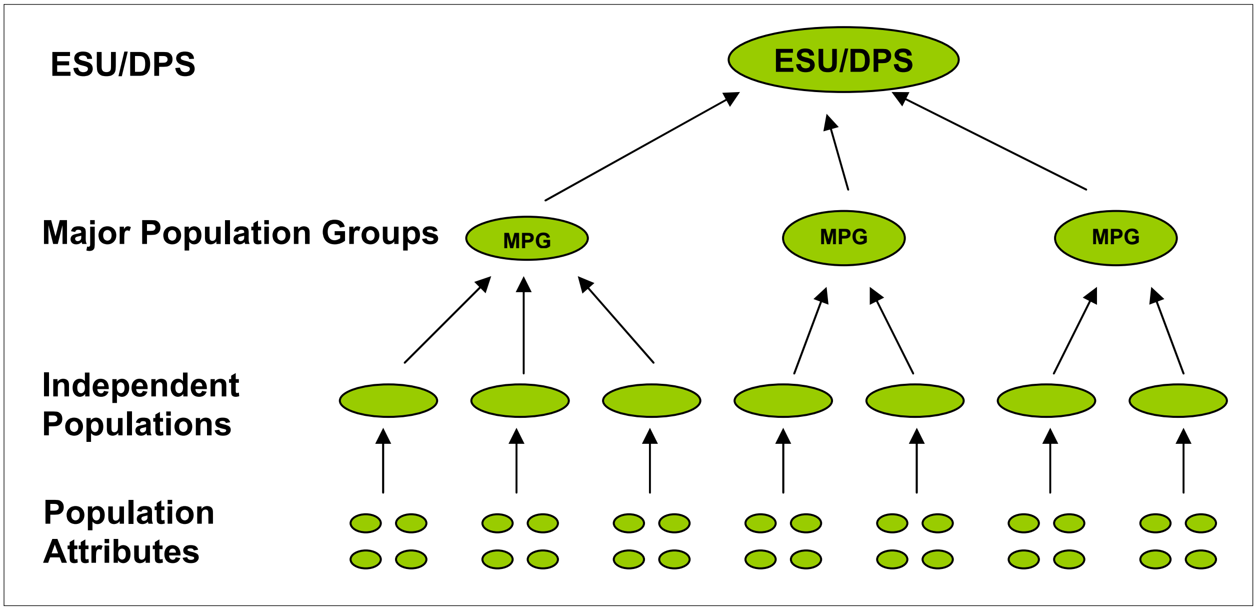

Figure 4.3-1 Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning.

Adopting Plans as NOAA Fisheries' Recovery Plans

In some cases, NOAA Fisheries will adopt a local plan directly as the ESA recovery plan. In other cases, NOAA Fisheries may write a "supplement" summarizing a locally developed plan and noting any necessary additions or qualifications to make it adequate for ESA recovery. The supplement then becomes part of the ESA recovery plan for the ESU. To finalize and formally adopt a plan under the ESA, NOAA Fisheries issues a notice of availability of the proposed recovery plan in the Federal Register and requests public comment for at least 60 days. During this time, NOAA Fisheries also requests technical review of the certain aspects of the plan. NOAA Fisheries then considers all comments received and may amend the proposed plan in response. The record for the final plan includes NOAA Fisheries' written response to comments. NOAA Fisheries also publishes a notice in the Federal Register when the plan is final. The status of recovery plans in the domains, sub-domains, and management units are summarized in table 4.3-2.

Major Recovery Plan Elements

All recovery plans contain several common elements, described below.

Recovery goals, broad sense recovery goals and delisting criteria

The primary goal of ESA recovery plans is for the species to reach the point where they no longer need the protection of the Act – i.e., to be delisted. All locally developed recovery plans incorporate this primary goal. Some of the locally developed recovery plans in the Columbia Basin also contain "broad-sense recovery goals" that go beyond ESA requirements for delisting, to address other legislative mandates or social, economic, and ecological values. Recovery plans may, for instance, address the impacts of regional human population growth on listed salmonids in the Columbia River basin.[5]

Delisting criteria define conditions that, when met, would result in a determination by NOAA Fisheries that the species are not likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Where species are endangered, the recovery plans also provide criteria for determining that the species is no longer in danger of extinction throughout all, or a significant portion, of its range.

ESA delisting criteria are of two kinds: biological criteria – the population or demographic parameters for viability, and threats criteria - the conditions under which the listing factors, or threats detailed in the ESA Section 4(a)(1) can be considered to be addressed or mitigated. All of the Columbia basin recovery plans either have based or will base their biological recovery criteria on viability criteria from Interior Columbia and Willamette/Lower Columbia TRT reports. All of the plans' threats criteria have been or will be developed to address the specific conditions related to habitat, hydropower, harvest, hatcheries, and other limiting factors (such as predation, competition, and invasive species) as they affect the ESUs or DPSs in a particular domain. Together, the biological criteria and threats criteria make up the "objective, measurable criteria" required under Section 4(f)(1)(B).

Delisting criteria are a NOAA Fisheries' determination and may include both technical and policy considerations. The criteria that are in recovery plans could exceed the minimum necessary to delist the species. Delisting decisions will be made at some future time and will take into account information and conditions at that time.

In accordance with ESA Section 4(c)(2), NOAA Fisheries will conduct status reviews of the 13 listed Columbia Basin salmon and steelhead ESUs or DPSs every five years to evaluate their status and determine whether they should be proposed for de-listing or a change in status. Such evaluations will take into account the following:

- The biological recovery criteria (ICTRT 2007a; WLCTRT and ODFW 2006) and listing factor (threats) criteria (which attempt to provide measurable criteria for the Section 4(a)(1) listing factors).
- The management programs in place to address the threats.
- Principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000).

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[5] Regional population growth is projected to continue through 2030 in the Pacific Northwest (ISAB 2007a). The implications of this growth include increased demand for land, water, and hydroelectricity, all of which have the potential to limit listed salmonid viability. Recovery plans, under the premise of "broad-sense recovery goals," may account for the impacts of human population growth in local recovery efforts. In doing so, recovery planning would not only go beyond the ESA requirements for delisting, but would address, and potentially mitigate for, the impacts of regional growth on listed species.

- Best available information on population and ESU/DPS 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.

- Hatchery fish considerations and progress on hatchery reform.

- Conservation efforts evaluated according to NOAA Fisheries' Policy for Evaluating Conservation Efforts (NMFS 2003a).

Recovery Scenarios

Both the Willamette/Lower Columbia and Interior Columbia TRT recommended that for an ESU/DPS to be considered at low risk of extinction (and therefore viable), all MPGs in that ESU/DPS should be at low risk. A low risk MPG was defined as one with some minimum number of viable populations and with other populations improved to or maintained at some other (possibly higher) risk status so that they are contributing to overall MPG or ESU/DPS viability. Thus, the status of individual populations is evaluated to assess MPG risk status, and then the status of each MPG within an ESU/DPS is considered when evaluating overall ESU/MPG status (see Sections 7.1.1.1 and 7.3).

For Columbia Basin ESUs/DPS that are comprised of multiple populations and MPGs, it may not be necessary for all of the populations to attain low risk in order to provide sufficient viability for the ESU/DPS as a whole; the ESU/DPS-level viability criteria allow for some combination of risk status among the component populations. Furthermore, there is more than one combination of populations at various risk levels that constitute a viable ESU/DPS. NOAA Fisheries refers to the possible combinations of low-risk status populations in each MPG that would allow the ESU/DPS to meet the viability criteria as "recovery scenarios."

Status reviews conducted by the Biological Review Team (BRT)[6] provide precedence for determinations that not all populations that were historically present must be present in an ESU for the ESU to be viable (need status review cites for non-listed ESUs). The BRT reviewed ESUs and determined that they were not threatened or endangered, even though the ESUs contained some populations that clearly would not meet VSP criteria.[7]

In the analyses described in Sections 7.1 through 7.3, NOAA Fisheries applied two general considerations apply to determining the minimum number of populations that needed to be viable within an MPG for it to be sufficiently low risk for viability of the ESU/DPS. First, having multiple viable populations can provide a spatial distribution that maintains within MPG diversity while

[6] The BRT's findings are not recommendations regarding listing because they did not include consideration of the potential contribution of hatchery stocks to the viability of ESUs, or evaluate efforts being made to protect the species (NMFS 2005a).
[7] NMFS (2005a).

providing for dispersal at normative rates and second, having multiple viable populations reduces extinction risk due to local catastrophic events (VSP paper, WLCTRT and ODFW 2006). Also, a general objective for the combinations of viable and less than viable populations provided by the ICTRT (2007 a) is that the composite MPG productivity be at or above replacement, thus ensuring long-term persistence of the ESU/DPS. The ICTRT and WLCTRT also concluded that achieving viability goals for the minimum number of populations will likely require attempting to meet those targets in more than just those populations because the efficacy of recovery efforts is uncertain. Finally, both TRTs stated the importance of maintaining the status of the additional populations not meeting viability criteria within a particular recovery scenario at levels that contribute to the ecological and evolutionary function of the ESU as a whole. At the time of a status review and listing classification decision, all of these considerations will be applied in the context of the status and risks facing the populations.

Limiting Factors Analyses & Threats Assessments

Recovery plans describe the limiting factors and threats that are the reasons for the species' decline. The recovery plans define "limiting factors" as the biological and physical conditions limiting ESU/DPS and population status (e.g. elevated water temperature), and define "threats" as those human activities or naturally induced conditions that cause the limiting factors (e.g. removal of riparian vegetation, which causes loss of shade and, consequently, elevated water temperature). The limiting factors are evaluated based on their impacts on population viability parameters and risk status.

Most Columbia Basin salmon ESUs and steelhead DPSs contain multiple populations distributed across a wide region of varying ecology and multiple political and jurisdictional boundaries. Because populations are the building blocks for evaluating the status of ESUs/DPSs, limiting factors and threats analyses in recovery plans are based on assessments of population-level limiting factors and then rolled up to the MPG and ESU/DPS level. These limiting factors/threats analyses are based on available scientific information, including subbasin assessments and plans, watershed assessments, expert panels, published research, ongoing field studies, and the expert opinion of regional biologists.

Recovery Strategies and Actions

Recovery plans include, "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" (ESA (f)(1)(B)(i). NOAA Fisheries has required Columbia Basin recovery actions to be derived from the limiting factors and threats assessments. Columbia Basin recovery plans generally describe strategies and actions for each population in an ESU/DPS.

Estimates of Time & Cost

All of the locally-developed recovery plans contain extensive lists of actions needed to recover the ESUs/DPSs. The estimate of total time for recovery may end up ranging from 5 to 50 years; however, 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. Most of the recovery plans are focusing on immediate needs and NOAA Fisheries has supported an initial focus on the first 10 to 15 years of implementation, provided that, before the end of this first implementation period, specific 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.

Research, Monitoring & Evaluation

Recovery plans need monitoring and evaluation programs that answer these basic questions: How will we know we are making progress? How will we get the information we need? And how will we use the information in decision making? All of the recovery plans will have actions for research, monitoring and evaluation. The Upper Columbia Recovery Plan for salmon and steelhead contains the Columbia Basin's first such monitoring plan. It is designed and will be incorporated into an adaptive management framework based on the principles and concepts laid out in the NOAA Fisheries draft guidance document, Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance (NMFS 2007b) NOAA Fisheries will work with local planners to ensure that, taken together, the monitoring and evaluation programs for each management unit, combined with monitoring components of the modules incorporated into the plans, address the needs of the entire ESUs/DPSs.

Relationship between Recovery Planning and Section 7

Recovery plans provide important context for making section 7 determinations. When NOAA Fisheries conducts a consultation pursuant to section 7(a)(2), it assists Federal agencies in ensuring that their actions are not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The ESA regulations, define "jeopardize the continued existence of" as "engag[ing] in an action that would reasonably be expected, directly or indirectly to reduce appreciably the likelihood of both the survival and recovery of listed species in the wild by reducing the reproduction, numbers or distribution of that species." Recovery plans provide criteria that describe what "recovery" looks like. Recovery plans provide biological criteria for the abundance, productivity, spatial structure and diversity of a recovered species and also criteria for evaluating whether threats to the species have been addressed. The criteria describing the characteristics of recovered species also provide metrics that are useful for evaluating the effects of human actions on listed species. NOAA Fisheries' critical habitat analysis determines whether the proposed action will destroy or adversely modify designated or proposed critical habitat for ESA-listed species by examining any expected changes in the conservation value of the essential features of that critical habitat.

Table 4.3-2. Status of Columbia Basin Recovery Plans[8]

Domain Sub domain *Management Unit*	**Species Addressed**	**Final Recovery Plan**	**Interim Regional Recovery Plan Complete**[9]	**Target Draft Completion**	**Entity**
			Interior Columbia		
Upper Columbia	Upper Col steelhead Upper Col. Chinook	X			U. Col Salmon Recovery Board
Snake *Idaho*	Snake River sockeye Snake River fall Chinook Snake River steelhead Snake River sp/su Chinook			January 2008	NOAA Fisheries in coordination with State of Idaho
Oregon	Snake River fall Chinook Snake River steelhead Snake River sp/su Chinook			January 2008	OR Snake Sounding Board
SE.Washington	Snake River fall Chinook Snake River steelhead Snake River sp/su Chinook		X		SE Wash. Salmon Recovery Board
Mid Columbia DPS	Mid Columbia steelhead			January, 2008	NOAA Fisheries in coordination with all Management Units
Oregon	Mid Columbia steelhead			October 2007	OR Snake Sounding Board
Yakima	Mid Columbia steelhead		X	Revision Oct. 2007	Yakima Salmon Recovery Board
SE.Washington	Mid Columbia steelhead		X		SE Wash. Salmon Recovery Board
Gorge	Mid Columbia Steelhead Lower Columbia steelhead			October 2007	NOAA Fisheries; Yakama Nation, with others

[8] Links to each individual plan are provided at: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Draft-Plans.cfm
[9] These plans have been noticed in the Federal Register, received public comment and NOAA Fisheries has approved them as Interim Regional Recovery Plans until full ESU/DPS plans are complete.

Domain Sub domain *Management Unit*	**Species Addressed**	**Final Recovery Plan**	**Interim Regional Recovery Plan Complete**[9]	**Target Draft Completion**	**Entity**
Willamette/Lower Columbia					
Lower Columbia *Washington*	Columbia chum, Lower Columbia steelhead, L.Columbia Chinook L. Columbia coho		X		
Oregon	Columbia chum, Lower Columbia steelhead, L.Columbia Chinook L.Columbia coho				ODFW, NOAA Fisheries, L. Col. Sounding Board
U. Willamette	U.Willamette steelhead U.Willamette Chinook				ODFW, NOAA Fisheries, Willamette Sounding Board

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Chapter 5

Environmental Baseline

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Chapter 5
Environmental Baseline

This chapter describes the effects of past and ongoing human and natural factors within the combined action area (Chapter 3), on the current status of the species, their habitats and ecosystems. The environmental baseline includes,

> "the past and present impacts of all Federal, state, or private actions and other human activities in the action area, including the anticipated impacts of all proposed Federal projects in the action area that have undergone Section 7 consultation and the impacts of state and private actions that are contemporaneous with the consultation in progress" (50 CFR 402.02, 'effects of the action').

To facilitate our analytical approach (see Section 7 of this document), this section is organized into hydro effects, tributary habitat effects, estuary and plume habitat effects, predation and disease effects, hatchery effects, harvest effects, and large-scale environmental factors. These are over-view discussions of environmental conditions affecting one or more ESUs in the action area and focused on past and ongoing effects related to the FCRPS, Upper Snake projects, and in-river harvest activities. In general, Columbia River salmon have been adversely affected by a broad number of human activities including habitat losses from all causes (population growth, urbanization, roads, etc.), fishing pressure, flood control, irrigation dams, pollution, municipal and industrial water use, introduced species, and hatchery production (NRC 1996). In addition, salmon populations have been strongly affected by ocean and climate conditions. Species-specific information that continues this discussion of the environmental baseline, including the current status of designated critical habitats, is presented in Chapter 8 of this document.

Killer whale (*Orcinus orca*) and green sturgeon (*Acipenser medirostris*) are included in this consultation. However, the Action Agencies have determined that while the Prospective Action may affect these species, they are not likely to be adversely affected and have requested NOAA Fisheries concurrence (Corps et al. 2008). For this reason, green sturgeon and killer whale are treated separately in Chapters 9 and 10. For details on the environmental baseline conditions for these species, please refer to Chapters 9 and 10.

The aggregated factors described below, taken together, have contributed to the current status of the species as quantified, to the best of NOAA Fisheries' abilities, in the environmental baseline section of Chapter 8, as well as in the Aggregate Analysis Appendix—including the mortality estimates for juvenile and adults migrating through the FCRPS mainstem projects (see SCA, Adult Survival Estimates and Hydro Modeling Appendices).

5.1 Hydro System Effects

This section identifies the past and continuing effects of dams and reservoirs located in the mainstem Columbia and Snake Rivers' migratory corridor on listed species of salmon and steelhead and their designated critical habitat. The mainstem migratory corridor extends from the base of Hells Canyon Dam, on the Snake River, and from Chief Joseph Dam, on the Columbia River, to the mouth of the Columbia River.

Columbia River Basin anadromous salmonids have been affected by the development and operation of dams. Dams, without adequate fish passage systems, have extirpated anadromous fish from their pre-development spawning and rearing habitats. Dams and reservoirs, within the currently accessible migratory corridor, have greatly altered the river environment and have affected fish passage. The operation of water storage projects has altered the natural hydrograph of the Snake and Columbia Rivers. Water impoundment and dam operations also affect downstream water quality characteristics, vital components to anadromous fish survival. Detailed descriptions of these effects are provided in Williams et al. 2005 and Ferguson et al. 2005 (NOAA Technical Memoranda NMFS-NWFSC-63 and 64). This information is summarized generally below. If any discrepancies are created as a result of this effort to summarize the more complex body of information into a more readable form, the information in the Technical Memoranda should be relied upon.

The effects of the operation, maintenance and structural modification of the FCRPS dams and reservoirs are one of the subjects of this SCA in support of multiple ESA consultations. The basic existence of the FCRPS dams is not the proposed action for ESA consultation, but is analyzed as part of the consultation consistent with the court decision in *NWF v. NMFS*, 481 F.3d 1224 (9th Cir. 2007). Rather that using a "reference operation," as in its 2004 FCRPS Biological Opinion (NMFS 2004a), NOAA Fisheries attempts to identify, and to the extent possible, quantify effects in the environmental baseline. However, because much of the effects in the environmental baseline would persist under the Prospective Action, NOAA Fisheries cannot draw a bright line for this consultation between hydro effects of the environmental baseline and those of the action for consultation. This section presents NOAA Fisheries' assessment of current dam effects on the listed species and critical habitat. This is the starting point for the species-specific analysis that continues in Chapter 8.

5.1.1 Blocked and Inundated Habitat

The construction of the FCRPS projects, Canadian flood control and hydropower projects, the Mid-Columbia Public Utility District dams, and (downstream of Shoshone Falls on the Snake River) Reclamation's Upper Snake projects and Idaho Power Company's mainstem dams have blocked access to salmon and steelhead from thousands of miles of habitat in the Columbia River basin, and inundated hundreds of miles more. Many smaller dams – even temporary dams - have had the same effects, though on much smaller scales.

Construction of Grand Coulee Dam in 1939 blocked access to historical production areas for upper Columbia River spring Chinook salmon and steelhead (NRC 1996; ICTRT 2003). Chief Joseph Dam, located downstream of Grand Coulee Dam, is also impassable. The Sanpoil, Spokane, Colville, Kettle, Pend Oreille, and Kootenai rivers each supported one or more populations of Chinook salmon and/or steelhead.

Before European contact, Snake River fall Chinook salmon occupied the mainstem Snake River up to Shoshone Falls (Gilbert and Evermann 1894; ICTRT 2003). In particular, the area downstream of Upper Salmon Falls, at river mile (RM) 578, was identified by Evermann (1895) as the "largest and most important salmon spawning ground of which we know in the Snake River." After loss of these upstream reaches with construction of Swan Falls Dam in 1901, the reach between Marsing, Idaho, and Swan Falls Dam (RM 349 to 424) was the primary spawning and rearing area for Snake River fall Chinook salmon (Irving and Bjornn 1981; Haas 1965, cited in ICTRT 2003). However, construction of the Hells Canyon Dam complex (1958–1967) cut off access to historical habitat upstream of RM 248. Additional fall Chinook habitat was lost through inundation as a result of the construction of the lower mainstem Snake River dams (Groves and Chandler 1999). In addition to the loss of fall Chinook salmon habitat on the mainstem Snake River, the Hells Canyon Dam complex cut off access to historical habitat in seven large tributaries for spring/summer Chinook salmon and steelhead. The seven tributaries are the Boise, Burnt, Malheur, Owyhee, Payette, Powder, and Weiser rivers (USBR 1997).[1] Each of these tributaries provided hundreds of miles of spawning and rearing habitat for spring/summer Chinook salmon and steelhead (and several lakes for sockeye salmon in the Payette River basin) (Fulton 1968; Fulton 1970; Gustafson 1997).

Similarly, dams constructed in tributary streams often were constructed without fish passage facilities, or fish passage that was provided functioned poorly. For example, Sunbeam Dam, built in 1910 about 20 miles downstream from Redfish Lake on the main Salmon River, was too high for salmon to surmount by leaping and was originally constructed without fish passage facilities. Though a poorly functioning concrete fish ladder was completed in 1920 and the dam was breached by blasting in 1934, the relatively short life of Sunbeam Dam is considered to be a major contributor to the decline of Snake River sockeye. In similar ways, many tributaries have been blocked by dams lacking adequate fish passage facilities.

In recent years, high quality fish passage is being restored where it did not previously exist, either through improvements to existing fish passage facilities or through dam removal (e.g., Marmot Dam on the Sandy River, Powerdale Dam on the Hood River, and Condit Dam on the White Salmon River). The anticipated effects of these actions on individual species are discussed in Sections 8.2 through 8.13 of this document.

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[1] Many major projects were constructed between 1901 and 1958 in the tributaries upstream of the Hells Canyon Complex which prevented salmon and steelhead from reaching historical habitat. These include Barber (1906), Arrowrock (1915), Lucky Peak (1957) dams on the Boise River; Black Canyon Dam (1924) on the Payette River; Owyhee Dam (1932) on the Owyhee River; Thief Valley Dam (1931) on the Powder River; and Unity Dam (1940) on the Burnt River (USBR 1997).

Within the habitat currently accessible by salmon and steelhead, dams have negatively affected spawning and rearing habitat. Within the Columbia and Snake rivers where fish currently have access, short, relatively shallow and high velocity tailwater segments immediately downstream from each mainstem project provide small amounts of riverine habitat, some of which are used by spawning salmon. In addition, except for the Hanford and Hells Canyon Reaches (noted below) mainstem habitats in the Columbia and Snake Rivers have been reduced primarily to a single channel. Floodplains have been reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large woody debris in the mainstem has been greatly reduced. Remaining habitats often are affected by flow fluctuations associated with reservoir water management for power peaking, flood control, and other operations.

Upstream from Bonneville Dam, the 41-mile stretch (66 km) of the Columbia River known as the Hanford Reach between the head of Lake Wallula (McNary Dam pool) and the tailrace of Priest Rapids Dam, and the approximately 101-mile stretch (162 km) of the Snake River often referred to as the Hells Canyon Reach provide the longest remaining riverine ecosystems between Bonneville Dam and Chief Joseph dam on the Columbia River and Hells Canyon Dam on the Snake River (647 –miles or 1,042 km).

5.1.2 Mainstem Habitats & the Migratory Corridor

The Columbia and Snake Rivers (mainstem habitat) serve as migration corridors for migrating salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Features of migration habitat important to these fish generally include: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (prey), riparian vegetation, space, and safe passage. For fall Chinook salmon and, to a lesser extent chum salmon, mainstem habitat also serves as important spawning and rearing habitat. Features of spawning and rearing habitat that are important to these fish generally include: spawning gravel, water quality, water quantity, water temperature, food, riparian vegetation, and access (to spawning and rearing areas).

Current conditions within much of the mainstem Columbia and Snake Rivers are altered compared to historic conditions. The development of hydropower and water storage projects within the Columbia River basin have resulted in the inundation of many mainstem spawning and shallow-water rearing areas (loss of spawning gravels and access to spawning and rearing areas); altered water quality (reduced spring turbidity levels), water quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperature (including generally warmer minimum winter temperatures and cooler maximum summer temperatures), water velocity (reduced spring flows and increased cross-sectional areas of the river channel), food (alteration of food webs, including the type and availability of prey species), and safe passage (increased mortality rates of migrating juveniles) (Williams et. al 2005; Ferguson et. al 2005).

Table 5.1.2-1. Migration rates (km/day) of juvenile SR spring-summer Chinook salmon and steelhead through free flowing and impounded sections of the Snake and Columbia Rivers under low, medium, and high flow conditions. (Taken from Raymond 1979)

River Condition	Magnitude of Flow		
	Low[a]	Medium[b]	High[c]
Free-flowing	24	40	54
Impounded	8	13	24

a. Snake, 1,000 to 1,500 m^3/second; Columbia 4,000 to 5,000 m^3/second.
b. Snake, 2,000 to 3,000 m^3/second; Columbia 6,000 to 9,000 m^3/second.
c. Snake, 3,000 to 5,000 m^3/second; Columbia 10,000 to 14,000 m^3/second.

Within the migratory corridor, both dams and their associated reservoirs influence the current status of Columbia Basin salmon. To a greater or lesser extent specific to each dam, the dam present fish-passage hazards, causing passage delays and varying rates of injury and mortality. The altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow (*Ptychocheilus oregonensis*), nonnative walleye (*Sander vitreus*), and smallmouth bass (*Micropterus dolomieu*).

5.1.2.1 Smolt Passage

Delay

Prior to the development of mainstem dams (c. 1938–1978), the mainstem migratory corridor was free-flowing with high velocities and a broad complex of habitats including rapids, short chutes, falls, riffles, and pools. It is not known how long it took juvenile salmon and steelhead to traverse the free-flowing river, but in 1966, when Snake River salmon encountered only four mainstem dams (Ice Harbor Dam on the Snake River and McNary, The Dalles, and Bonneville dams on the Columbia River), Raymond (1968; Raymond 1979), by comparing fish captured and marked in the Salmon River and recaptured at the four dams, estimated that migrating smolts traveled about one-third (in lower flow conditions) to one-half (in higher flow conditions) as fast through the impounded reaches as through the free-flowing reaches.

Dams within the migratory corridor converted much of the once free-flowing river into a stair-step series of slow pools. Today, median travel times for yearling Chinook from the Snake River to Bonneville Dam range from 14 days to 31 days depending on flow conditions, an increase of 40 to 50% over travel times measured in 1966 (see discussion above) when fish encountered only the four mainstem dams (Williams et al. 2005).

This increased travel time (migration delay) presents an array of potential survival hazards to migrating juvenile salmon and steelhead: increasing their exposure to potential mortality vectors in the reservoirs (e.g. predation, disease, thermals stress), disrupting arrival timing to the estuary (which likely affects predator/prey relationships),[2] depleting energy reserves, potentially causing metabolic problems associated with smoltification (smoltification is the process of metabolic changes required to allow juvenile fish to convert from freshwater to saltwater environments), and for some steelhead and all Chinook salmon, contributing to residualism (a loss of migratory behavior).

A substantial fraction of the mortality experienced by juvenile outmigrants through the portion of the migratory corridor affected by the FCRPS occurs in the reservoirs (e.g., about half of the mortality of in-river migrating juvenile spring Chinook and steelhead) and reducing migration delays have therefore been a focus of recent actions to improve juvenile outmigrant survival through the FCRPS. For example, Federal storage reservoirs have, compared to historical operations, been operated to increase spring and summer flows to accelerate smolt migrations, voluntary spill (and most recently, the addition of surface passage routes) has been implemented to reduce forebay delay, and a large fraction of the annual outmigration has been collected and transported through the system, greatly accelerating passage.

Dam Passage

A substantial proportion of juvenile salmon and steelhead can be killed while migrating through 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. Some juvenile mortality and injury is associated with all routes of dam passage, but turbines generally cause the highest direct mortality rates—generally ranging between 8 and 19 percent. Juveniles passing through project spillways, sluiceways and other surface routes generally suffer the lowest direct mortality rates, typically losses are 2% or less. However, substantially higher spillway mortalities have been measured through spillways at several mainstem projects (Ferguson et al. 2005, NOAA Technical Memoranda NMFS-NWFSC-64).[3] A significant rate of juvenile mortality (approximately 3-5%) can occur in project forebays, just upstream of the dams (Axel et al. 2003; Ferguson et al. 2005; Hockersmith 2007), where fish can be substantially delayed (median of 15-20 hours) before passing through the dam (Perry et al. 2007).[4] Forebay delay increases juvenile fish exposure to fish and avian predators, and increases their exposure time to adverse water quality conditions (e.g. elevated total dissolved gas levels and high water temperatures) (See discussion below regarding newly developed surface passage routes that are proving effective at reducing forebay delay).

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[2] During the spring and summer a series of changes occur in the estuary and near-shore ocean environment. The assemblages of species change through time and disrupting arrival timing may increase the exposure of juvenile salmon to predators and/or diminish the availability of prey species.

[3] The route-specific mortality rate values given here are the averages of several investigations. Higher and lower moralities have been observed and measured route-specific mortality is influenced by an array of factors ranging from the health and species of the test fish, to the performance characteristics and working condition of the system being studied and environmental conditions.

[4] This study was conducted at McNary Dam; estimates of delay for individual fish ranged from 0 to 172 hours in this study.

In the 1980s and 1990s, seven of the eight FCRPS dams lying in the migratory path of Snake River juvenile salmon and steelhead were equipped with turbine intake screen systems that divert, depending on the species, 45-90% of the fish away from turbine entry and into bypass system channels. These bypass systems allow migrants to be collected for transport downstream to below Bonneville Dam or released back to the river. Contemporary mechanical screen bypass systems are vastly improved compared to the original systems that operated during the 1970s and early 1980s, based on recent low rates of descaling, injury, and system mortality. At present, estimates of mortality through these passage routes are usually low, typically less than 2 percent (Ferguson et al. 2005). As an example, Ferguson et al. (2007) summarized the impacts of the old juvenile bypass system in powerhouse two at Bonneville Dam (significant mortality, injury, and descaling as well as elevated stress indicators), and found that the new bypass system had high survival rates, virtually no injuries, little delay (compared to water particle travel times), and only mild indications of stress. However, outfall locations and dam configuration and operations remain important considerations for maximizing the survival of juvenile salmonids that are bypassed back to the river below dams. For instance, Perry et al. (2007) found that at McNary Dam in 2005, juvenile mortality associated with the bypass system occurred through predation downstream of the tailrace release outfall (where conditions allowed predators to exploit a point-source stream of bypassed migrants).

Sandford and Smith (2002) found that comparisons of SARs from in-river migrants with different juvenile migration histories showed that, for some stocks in some years, multiply bypassed fish returned at significantly lower rates than fish that were never detected in a bypass system. Most data from the 1995 through 1998 outmigrations indicated that multiple bypassed spring-summer Chinook salmon and hatchery steelhead had lower SAR than those not detected at collector dams. Budy et al. (2002) interpreted this as direct evidence that fish passing through bypass systems suffered "delayed" mortality. However, in more recent data, SARs did not differ for wild steelhead (2000 outmigration) or wild Chinook salmon (1999 and 2000 outmigrations) (Williams et al. 2005). Thus, "delayed" mortality resulting from juveniles passing through one or more bypass systems may occur in some, but not in all years (Williams et al. 2005). Although little empirical evidence exists at present to support or refute any mechanistic hypotheses that might explain these results, Williams et al. (2005) posited that differential size selection, possible inherent differences in the "quality" of fish using the bypass systems, and delayed passage (in each case, compared to fish using other passage routes) provided a mechanistic foundation for explaining the differences in return rates of fish multiply bypassed versus those that were not.

In recent years, operational improvements and passage route configuration changes at several of the dams have reduced juvenile mortality and injury rates. The proportion of water released through spillways has increased at most of the dams, resulting in a higher proportion of the migrants passing through these routes. Spilling water for fish (also termed voluntary spill) has been increasingly provided on a 24-hour basis during the juvenile migration at most FCRPS dams in the migratory corridor. (Water is also spilled when flows are higher than needed for turbine operation; an operation termed involuntary spill.)

All dams in the mainstem migratory corridor have multi-gated spillways that use either vertical lift or radial gates that open 15 to 18 meters below the usual reservoir surface. To pass via the spillway, smolts, which have a tendency to migrate within several meters of the water surface, must sound (dive) to locate spillway entrances. A reluctance to sound during daylight hours tends to increase juvenile delay in the forebays.

Surface passage routes increase spill effectiveness (spill effectiveness is the proportion of fish passing a project via spillways divided by the proportion of total project flow that is spilled). Surface bypass structures are currently used at five of the eight Corps dams on the lower Columbia and Snake Rivers. Three types of surface bypass structures are installed – removable spillway weirs (RSWs), temporary spillway weirs (TSWs), and surface bypass channels, including existing ice and trash sluiceways.

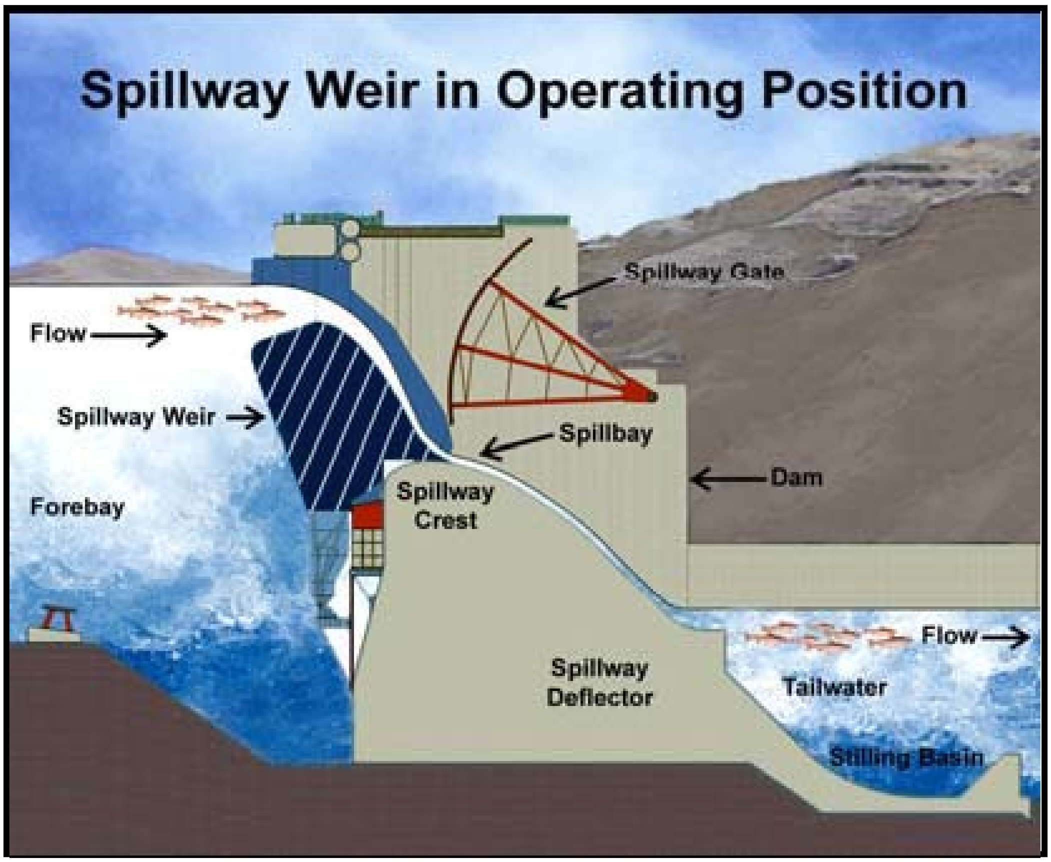


Figure 5.1-1. Cross-section view of a removable spillway weir in its operating position.

One spillway bay at both Lower Granite and Ice Harbor dams has been fitted with an RSW which converts the spill bay into an overflow weir. At McNary Dam two spill bays have been fitted with temporary spillway weirs. At The Dalles Dam, a trash sluiceway system at the powerhouse is operated throughout the migration season to attract fish away from the powerhouse via surface flow. At Bonneville Dam, the powerhouse 2 trash sluiceway was modified to serve as a corner collector to pass juvenile salmon. Corner collectors, providing similar benefits have been installed at Rocky Reach Dam (owned by Douglas County Public Utility District). When properly configured, these surface passage routes are proving to be the safest and quickest passage routes for juveniles through the forebays and dams (Plumb et al. 2003 and 2004; Ferguson et al. 2005; Axel et al. 2007; Ogden et al. 2007).

Restoring and improving fish passage is one of NOAA Fisheries' primary recovery strategies and through hydropower licensing proceedings, NOAA Fisheries recently obtained new and improved passage at several facilities in Columbia Basin tributaries (e.g., Lewis River Project on the Lewis River, Cowlitz, Pelton Round Butte on the Deschutes, and others). Where appropriate, the effects of these new passage facilities are included in the analysis of anticipated effects of the environmental baseline (Chapter 8 of this document).

Transportation Program

Following a decade of research that led to the conclusion that in most cases, the average adult return rates of predominantly stream-type salmonids (spring/summer Chinook and steelhead) that were transported as juveniles exceeded the return rates of fish that migrated in-river, the Corps began large-scale juvenile transportation as a management measure in 1975 (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Currently, fish collection and transportation systems are operated seasonally at Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, and McNary Dam. Most transported fish are barged to release points downstream from Bonneville Dam. When collection numbers become too small for barging to be cost-effective, collected fish are transported via truck. Approximately 60-90% of spring migrating smolts (spring/summer Chinook and steelhead) in the Snake River basin are transported annually (Table 5.1-1), although almost all fish (99%) were transported during the low water year conditions of 2001 (Williams et al. 2005). In 2007 transport rates were estimated to be much lower (about 25% for wild and hatchery yearling Chinook salmon and about 41% for wild and hatchery steelhead) (Smith 2008).

Recent data show that the effectiveness of transportation, in terms of the ratio of returning adults to transported juveniles (termed smolt-to-adult return ratio or SAR) from the Snake River, varies among species, season, and collection location (Williams et al. 2005; Scheuerell and Zabel 2007). In general, the SARs of both transported and in-river migrating Snake River spring Chinook and steelhead tend to decrease after early May (day of arrival below Bonneville Dam). For steelhead, SARs of transported fish are typically equal to or higher than those of the surviving in-river migrants arriving downstream of Bonneville Dam (transport-to-in-river SAR ratios > 1.0). For spring Chinook salmon, SARs of surviving inriver migrating fish are often substantially higher in early to mid May than those of transported migrants arriving downstream of Bonneville Dam (transport-to-in-river SAR ratios < 1.0). However, in late May and June, the differences are generally diminished such that SARs are nearly equal (transport-to-in-river ratios ≈1.0).

Table 5.1-1. Estimated combined annual percentage of the non-tagged yearling Chinook salmon and steelhead populations transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams. (Williams et al. 2005)

	Chinook		Steelhead	
Year	**Wild**	**Hatchery**	**Wild**	**Hatchery**
1993	88.5	88.1	93.2	94.7
1994	87.7	84.0	91.3	82.2
1995	86.4	79.6	91.8	94.3
1996	71.0	68.7	79.8	82.9
1997	71.1	71.5	87.5	84.5
1998	82.5	81.4	88.2	87.3
1999	85.9	77.3	87.6	88.5
2000	70.4	61.9	83.9	81.5
2001	99.0	97.3	99.3	96.7
2002	72.1	64.2	75.2	70.4
2003	70.4	61.5	72.9	68.4

5.1.2.2 Adult Dam Passage

Unlike downstream migrating juveniles, there is no indication that reservoirs substantially delay adult upstream migration (Ferguson et al. 2005).

Adult fish passage, in the form of fish ladders, is provided at the eight mainstem FCRPS projects in the lower Snake and lower Columbia rivers and the five mainstem Federal Energy Regulatory Commission (FERC)-licensed projects in the mid-Columbia reach. In general, adult passage facilities are highly effective. Nonetheless, salmon may have difficulty finding ladder entrances, and fish also may fall back over the dam, either voluntarily (e.g., adults that "overshoot" their natal stream and migrate downstream through a dam of their own volition), or involuntarily, being entrained in spillways after exiting a fish ladder. Some adults that fall back or migrate downstream, pass through project turbines and juvenile bypass systems. Adult mortality rates have been estimates (or calculated using engineering principles) at between 22% and 59%, depending on the species and size of the individual fish (larger fish are more likely to contact a turbine blade, etc.) (Ferguson et al. 2005). The survival of adults through juvenile bypass systems is even less well known. It is logical to assume that survival rates would be much higher through these systems than through turbine units, and indeed, with the possible exception of passage through the 14" to 16" gatewell orifices, conditions within these systems should be easily navigable by adults.

Kelts

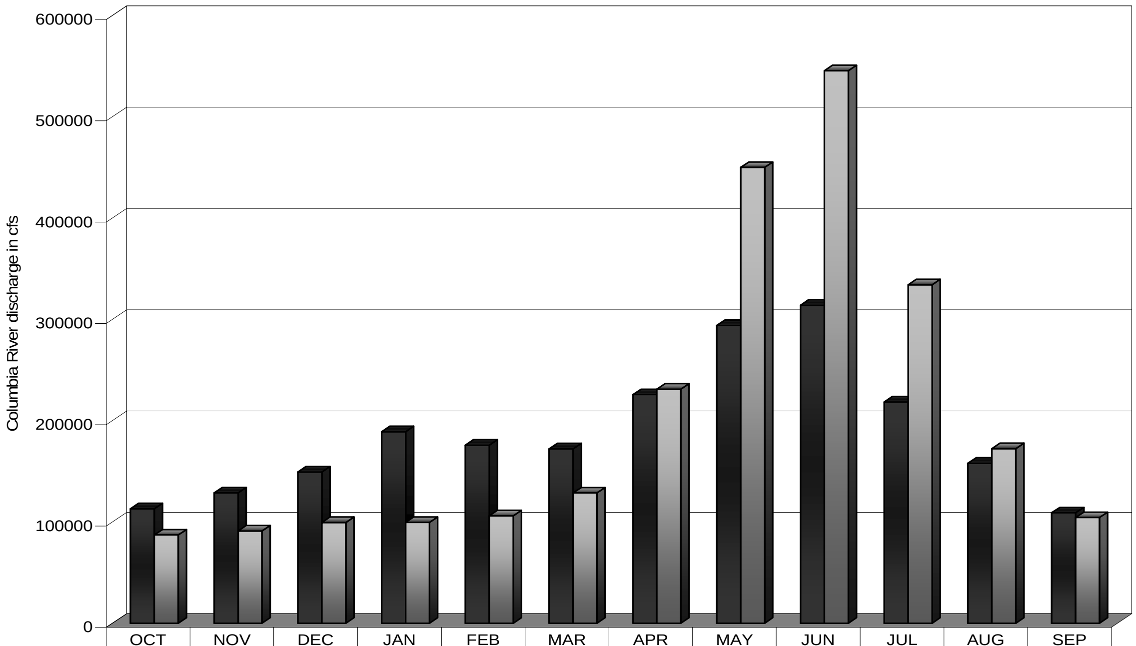
Unlike other Pacific salmonids, a large fraction of the adult steelhead do not die after spawning and instead attempts to migrate back to the Pacific Ocean. Termed kelts, very few of these post-spawn adult steelhead survive downstream passage through the hydrosystem to return and spawn again. Estimates of FCRPS passage survival ranged from 4.1-6.0% in the low flow year 2001 to 15.6% in 2002, and 34% in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). Median forebay residence times for steelhead kelts at The Dalles and Bonneville dams during no spill were 9.6 and 8.0 hours, respectively. During spill, their times in the forebay at the same dams were 1.3 and 3.0 hours, respectively (Wertheimer and Evans 2005). Steelhead also reacted strongly to spill at John Day, and The Dalles with more than 90% of kelts passing via non-turbine routes during periods when spill was at or above 30% of total project discharge. Maximizing non-turbine passage of kelts is important because the survival of kelts passing via turbines, while not well known, is considered to be low because turbine passage survival tends to be lower for large fish than small fish (see discussion above). At present, juvenile collection and bypass systems are not designed to safely pass adult fish.

The importance of repeat spawning kelts to steelhead populations varies widely, with the fraction of repeat spawners in spawning steelhead populations ranging from 1 to 51% (Wertheimer and Evans 2005). Boggs and Peery (2004) cite an estimated 2% kelt rate for the Clearwater River in 1954. It is estimated that 17-25% of the steelhead run that pass Lower Granite Dam, return downstream as kelts (Boggs and Peery 2004; Wertheimer and Evans 2005). Thus, while there is a relatively large number of kelts present, their relatively poor survival through the FCRPS may limit the contribution that they can make to steelhead populations.

5.1.3 Mainstem Hydrologic Conditions

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow, altered its seasonality, and reduced sediment discharge and turbidity (NRC 1996; Sherwood et al. 1990; Simenstad et al. 1982 and 1990; Weitkamp 1994). Annual spring freshet flows through the Columbia River estuary are about one-half of the pre-development levels that flushed the estuary and carried smolts to sea (Figure 5.1-2). Total sediment discharge is about one-third of nineteenth-century levels. For example, large-scale U.S. and Canadian reservoir storage and flow regulation that began in the 1970s reduced the 2-year flood peak discharge, as measured at The Dalles, Oregon, from 580,000 cfs to 360,000 cfs (Corps 1999).

Figure 5.1-2. Simulated mean monthly Columbia River flows at Bonneville Dam under current conditions and flows that would have occurred without water development (water years 1929 – 1978. Source: Current Condition Flows – Bonneville Power Administration, HYDSIM model run FRIII_07rerun2004biop.xls; Pre-Development Flows – USBR (1999) Cumulative Hydrologic Effects of Water Use: An Estimate of the Hydrologic Impacts of Water Resource Development in the Columbia River Basin.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Flow affects juvenile migrant travel time and the distribution of fish among the various routes of dam passage. In general, the lower the flow through the series of FCRPS reservoirs, the longer the travel time of outmigrating juveniles that migrate in-river.[5] The longer juveniles remain in project reservoirs, the greater their exposure to predation, elevated temperatures, disease, and other sources of mortality and injury.

Recognizing that the flow versus survival relationships for some ESUs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b), NOAA Fisheries and the FCRPS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above those objectives (Table 5.1-2). This has been accomplished by avoiding excessive drafts going into the spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during the summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow

[5] At lower river flows a higher proportion of some ESUs is collected and transported thereby avoiding the delay associated with in-river hydrosystem passage.

management with the understanding that their achievement depends on the water resources available in a given year.

Table 5.1-2. Snake and Columbia River flow objectives for operating the FCRPS since 1995. (Source: NMFS 1995a)

Location	Spring (in kcfs)	Summer (in kcfs)
Lower Granite	85-100 a	50-55 a
McNary	220-260 a	200
Priest Rapids	135	
a. flow objective varies with anticipated runoff volume		

The longer juveniles remain in the project reservoirs, the greater the potential that they will stop migrating.[6] Dam operating protocols designed to improve fish passage survival are often defined in terms of streamflow criteria. For example, under current operations, at spring flows of less than 85,000 cfs at Lower Granite Dam, the spill rate and duration are reduced. Spillways are usually the safest route of juvenile dam passage (Ferguson et al. 2005) and at lower total river flows, fewer migrants pass via project spillways.

Decreased spring flows and sediment discharges have also reduced the size, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Cudaback and Jay 1996; Hickey et al. 1997). Changes in estuarine bathymetry and flow have altered the extent and pattern of salinity intrusion up the Columbia River and have increased stratification and reduced mixing (Sherwood et al. 1990).

In summary, combined with the influence of reservoirs behind the dams within the migratory corridor, reductions in spring and early summer flows slow juvenile fish emigration, increases their exposure to injury and mortality factors within the reservoirs (e.g. predation, temperature stress, disease, and others), and changes ocean-entry timing (see Section 5.1.3.1 for further detail). These flow reductions also reduce turbidity, which has also been shown to reduce juvenile survival (see Section 5.1.4.2). Flow-related changes in estuary bathymetry likely reduce juvenile rearing habitat, significant primarily to lower river populations and ESUs (e.g., LCR Chinook).

5.1.3.1 Mainstem Effects of Reclamation's Irrigation Projects in the Columbia Basin

In total, Reclamation's 23 irrigation projects in the Columbia basin reduce the annual runoff volume at Bonneville Dam by about 5.5 Maf (Table 5.1-3).[7] These depletions occur primarily during the spring and summer as the reservoirs are refilled and as water is diverted for irrigation and are incorporated

[6] The propensity to residualize varies between species. Steelhead are generally the most likely to residualize, followed by fall Chinook. Spring and summer Chinook seldom residualize. Residual sockeye are known in Sawtooth Valley lakes, but not the mechanisms (genetic and environmental) that lead to this form. In recent years some returning adult SR fall Chinook have displayed evidence of over-wintering in fresh water, indicating that some SR fall Chinook stop migrating during the summer and do not die or residualize, but complete their migrations the following spring (Section 5.1.4.1).

[7] Table 5.1-3 does not include the effects of all Reclamation reservoir operations. The hydrologic effects of Reclamation's multi-purpose FCRPS reservoir operations are not included.

into the juvenile passage modeling for the interior species. These hydrologic effects are included in the hydrologic analysis conducted for this consultation.

Spring flow reductions have both beneficial and adverse effects on fish survival. During above average water years, flow reduction during reservoir refill reduces involuntary spills. High rates of involuntary spill are known to cause undesirable TDG conditions in the migratory corridor. This beneficial effect is small as the amount of flow attenuation provided by Reclamation project operations is generally too small to greatly affect the magnitude and duration of involuntary spill events below Hells Canyon in Chief Joseph dams.

Flow depletions associated with Reclamation's projects contribute to juvenile migration delay and decrease juvenile migrant survival. These mainstem survival effects are captured in the juvenile migrant survival modeling (i.e., COMPASS modeling).

In addition to these mainstem flow effects, several of these projects below Hells Canyon and Chief Joseph dams may affect listed salmonids in the tributary streams where the project is located or where Reclamation's irrigation return flows occur. Supplemental consultations have been completed, are now underway, or are scheduled to begin for each of Reclamation's projects with tributary effects. For example, NOAA Fisheries completed a supplemental biological opinion for the Umatilla Irrigation Project dated April 23, 2004, in which these tributary effects are analyzed.

Table 5.1-3. Average flow reduction effects of Reclamation's irrigation projects in the Columbia basin (in cfs) [1/]

Project [2/]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Columbia Basin Project (CBP)	-2,779	-293	-548	48	201	-1,404	-6,058	-6,971	-7,061	-7,464	-6,039	-6,129
Return Flows at Wanapum	64	53	47	41	38	33	48	43	45	51	60	70
Return Flows at Priest Rapids	278	126	108	94	73	122	244	202	231	245	269	307
Columbia Basin Project effects at Priest Rapids	-2,437	-114	-393	183	312	-1,249	-5,766	-6,726	-6,785	-7,168	-5,710	-5,752
Chief Joseph Dam Project	-2	0	0	0	0	0	-10	-64	-138	-190	-112	-22
Okanogan Project	-4	-6	-8	-7	-8	-11	-43	-87	-65	-15	10	10
Sum of effects at Priest Rapids	-2,443	-120	-401	176	304	-1,260	-5,819	-6,877	-6,988	-7,373	-5,812	-5,764
Yakima Project	-300	-800	-750	-650	-700	-1,100	-2,900	-4,300	-2,600	-200	1,550	1,600
Umatilla Phase II Pump Exchange	-62	0	0	0	0	0	-2	-8	-47	-137	-146	-96
Snake River												
Upper Snake River above Brownlee Reservoir	-329	-4,805	-5,174	-2,031	-2,910	-4,793	-5,794	-11,972	-9,523	1,922	3,822	3,352
Sum of effects at Lower Granite	-329	-4,805	-5,174	-2,031	-2,910	-4,793	-5,794	-11,972	-9,523	1,922	3,822	3,352
Lower Columbia River												
CBP Return Flows at McNary	534	386	312	236	228	309	432	432	475	470	512	550
CBP Blocks 2 and 3	-25	0	0	0	0	-9	-38	-50	-62	-70	-63	-25
Sum of effects at McNary	-2,625	-5,339	-6,013	-2,269	-3,078	-6,853	-14,121	-22,775	-18,745	-5,388	-137	-383
Percent of Columbia River Flows	<1	4.7	4.4	1.6	2.3	3.9	4.4	6	4	<1	3.3	4.7
Umatilla Phase I Pump Exchange	-32	0	0	0	0	5	10	2	-52	-19	-138	-50
Umatilla Project	196	-5	-186	-244	-314	91	-27	51	129	-26	36	135
Deschutes, Crooked River, and	-413	-450	-434	-410	-212	-757	-514	-166	-57	31	144	-53

Project [2/]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wapinitia Projects												
The Dalles Project	-4	0	0	0	0	0	-7	-27	-37	-47	-38	-22
Sum of effects at Bonneville	-2,878	-5,794	-6,633	-2,923	-3,604	-7,514	-14,659	-22,915	-18,762	-5,449	-133	-373
Tualatin Project	-24	-103	-58	-170	-178	-75	-40	-13	14	68	94	97
Sum of effects at Columbia River mouth	-2,902	-5,897	-6,691	-3,093	-3,782	-7,589	-14,699	-22,928	-18,748	-5,381	-39	-276

[1/] Negative values imply a flow reduction due to Reclamation activities. Natural flow diversions would still occur without Reclamation.
[2/] Sources: Corps et al. 2007a (Comprehensive Analysis, Appendix B, Tables B-5 and B-10),

5.1.4 Mainstem Water Quality

Water quality characteristics of the mainstem Snake and Columbia Rivers are affected by an array of land and water use developments. Water quality characteristics of particular concern are: water temperature, turbidity, total dissolved gas, and chemical pollutants.

5.1.4.1 Water Temperature

Water development influences water temperatures through storage, diversion, and irrigation return flows. Changes in water temperatures can have significant implications for anadromous fish survival.

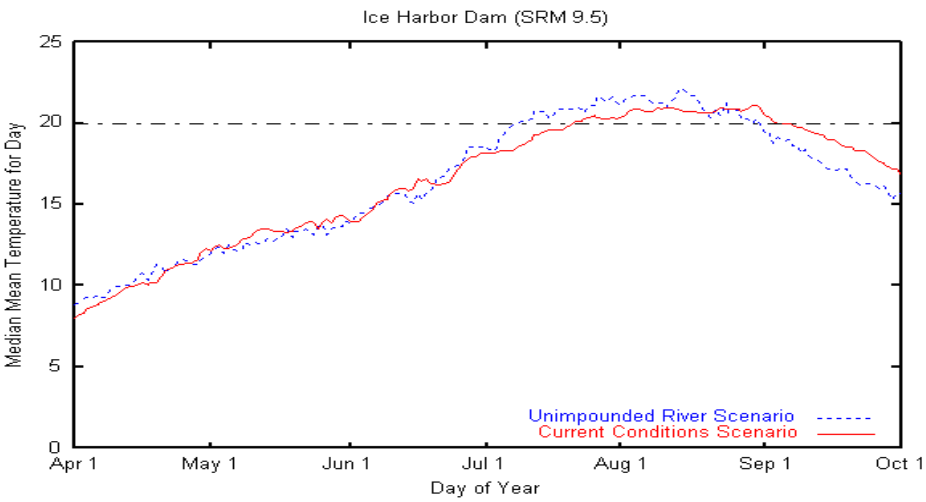
Comparisons of long term temperature monitoring in the migration corridor before and after impoundment reveal a fundamental change in the thermal regime of the Snake and Columbia rivers. Using historical flows and environmental records for the 35 years period from 1960 to 1995, one recent study compared water temperature records in the Lower Snake River with and without the lower Snake River dams (Perkins and Richmond 2001).[8] As shown in Figure 5.1-3, there are three notable differences between the current and the unimpounded river:

- the maximum summer water temperature has been slightly reduced,
- water temperature variability has decreased, and
- post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall. The latter phenomenon is termed thermal inertia.

Thermal inertia is of particular biological significance as it may, depending upon the specific species in question, affect adult migrations, spawn timing and juvenile emergence, rearing, and outmigration timing, as described below.

[8] NOTE: Significant land use practices, including the development of a large number of water storage and diversion projects had already occurred by the 1960s. This graphic does not attempt to imply that the unimpounded river scenario can be equated to pre-development.

Figure 5.1-3. Median daily Snake River water temperatures (°C) at Ice Harbor Dam before and after development of the four lower Snake River projects (20°C denotes Washington Department of Ecology standard).



Biological Effects

High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmon to stop or delay their migrations. Warm water temperatures also increase the foraging rate of predatory fish thereby increasing the consumption of smolts. Though the duration and magnitude of high water temperatures in the migratory corridor is generally less under current, developed conditions than prior to water development, some juvenile fish are exposed to these conditions for a longer period of time due to the substantial increase in travel time.

In 2003, EPA collaborated with NOAA Fisheries and other regional resource managers in the preparation of guidance for developing water quality standards. With regard to water temperature, the EPA reviewed the scientific literature and established recommended thresholds for a variety of salmonid life stage reactions (Table 5.1-4). Comparison of the EPA guidelines (Table 5.1-5) with Tables 5.1-4 helps to identify the salmonid species, life stages and seasons for concern for listed stocks migrating and reproducing in the FCRPS affected segments of the Columbia River Basin (see Potential for Thermal Effects in Table 5.1-4).

To improve juvenile SR fall Chinook survival, Dworshak Dam on the North Fork Clearwater River has most recently been operated to cool the lower Snake River during July and August. Aimed at avoiding temperatures in the Lower Granite Dam tailrace in excess of 20 degrees C, this action reduces water temperatures in Lower Granite Reservoir by 2 to 5 degrees C. This beneficial effect gradually diminishes downstream.

The effects of thermal inertia on salmon depend on the coincidence of sensitive life stages with the time shifts in water temperature. Snake River fall Chinook may be the most vulnerable ESU as they spawn, incubate, and rear in mainstem habitats. In some years, adult arrival at spawning sites in the Snake system is delayed by high water temperatures (Bennett and Peery 2003). The migration is slowed or stopped when the fish take refuge in cooler areas (e.g. tributary mouths) and resumes when the general river temperature declines. Delayed adult migration, combined with delayed onset of water temperatures conducive to spawning, delays the onset of spawning. By reducing maximum late summer water temperatures, the FCRPS may have allowed the expression of the SR fall Chinook yearling outmigration strategy (see Section 8.2).

In turn incubation, hatching, and rearing may occur under less than ideal thermal conditions, resulting in delayed juvenile emigration. Delayed downstream migration places juveniles in the migration corridor later in the spring, when water temperatures are rising, which in turn decreases the likelihood of survival.

The impacts of high summer water temperatures on juvenile salmon health may also be reduced by the availability of thermal refugia, areas where localized shade, springs or tributary inflows provide lower water temperatures. Researchers collecting juvenile fall Chinook in lower Granite Reservoir have noted higher concentrations of juveniles in such areas, suggesting that fish may be exploiting such opportunities (Kock et al. 2007).

Coincident and possible due to climate change, average annual Columbia Basin air temperatures have increased by about 1 degree C over the past century and water temperatures in the mainstem Snake and Columbia rivers have been affected similarly (ISAB 2007b). The influence of this and other large-scale environmental variations are discussed in Section 5.7 of this document.

Table 5.1-4. Summary of Potential Thermal Effects to Salmonids in the Columbia Basin. (Source: EPA 2003)

Species	Life Stage	Timing	Potential for Thermal Effects
Spring Chinook	Adult Migration	April – June	
	Spawning	August – October	X
	Egg Incubation/Alevin	Throughout Winter Season	
	Emergence	March – May	
	Juvenile Rearing	One Year in River	X
	Juvenile Outmigration	Spring	
Fall Chinook	Adult Migration	July – September	X
	Holding Period and Spawning	July – October	X
	Emergence	March – April	
	Juvenile Outmigration	March – April (season may extend through May - August)	Possible
Coho	Adult Migration	October	
	Spawning	November – January	
	Incubation	May – July	X
	Rearing	1-2 years	X
	Juvenile Outmigration	Spring	
Steelhead	Adult Migration	May – October	X
	Spawning	November – March	
	Incubation	May – July	X
	Emergence	May –July	X
	Rearing	1-2 Years in Freshwater	X
	Juvenile Outmigration	Spring	

Table 5.1-5. Summary of the EPA Water Temperature Guidelines and Potential Effects to Salmon. (Source: EPA 2003)

Life Stage	Life Stage Reaction		Threshold (˚C)
Adult	Lethal (1 week exposure)		21-22
	Migration Blockage		21-22
	Disease Risk	High	18-20
		Elevated	14-17
		Minimized	12-13
	Swim Performance	Reduced	>20
		Optimal	15-19
	Overall Reduction in Migration Fitness		>17-18
Spawning	Spawning Behavior Observed in the Field		4-14
Eggs & Incubation	Good Survival		4-12
	Optimal Incubation		6-10
	Reduced Viability of Gametes		>13
Emergence & Juvenile Rearing	Lethal (1 week exposure)		23-26
	Optimal Growth	Unlimited Food	13-20
		Limited Food	10-16
	Rearing Preference Temperature		10-17
	Impaired Smoltification		12-15
	Disease Risk	High	>18-20
		Elevated	14-17
		Minimized	12-13

5.1.4.2 Turbidity

Flow regulation and reservoir existence reduces turbidity in the Columbia and Snake Rivers. Reduced turbidity can increase predator success through improved prey detection, increasing the susceptibility smolts to predation. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia River and Snake River migratory corridors.

5.1.4.3 Total Dissolved Gas

Spill at mainstem dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated total dissolved gas (TDG) conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1-2% when TDG concentrations in the upper water column do not exceed 120% of saturation in FCRPS project tailraces and 115% in project forebays. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms.

Depth Compensation

The effects of total dissolved gas (TDG) supersaturation on aquatic organisms are moderated by depth due to hydrostatic pressure. Each meter of depth compensates for 10% of gas supersaturation as measured at the water surface. As illustrated by Figure 5.1-4, if the dissolved gas is recorded as 120% of supersaturation at the surface, then the saturation state at 0.5 m is reduced to 115%. A fish or an aquatic invertebrate at a depth of 0.5 m at equilibrium with the gas level of the surrounding water will benefit from depth compensation. That is, the organism's tissue will also be at 115% of saturation. If the fish is 2.0 m deep, its tissues will not be supersaturated. That is, a fish at 2.0 m of depth with the gas in its tissues in equilibrium with the surrounding water cannot develop gas bubble disease or trauma. In short, gas bubble trauma is the result of uncompensated hyperbaric pressure of TDG. Moreover, it is the same for all fish species, salmonid or resident, as well as for invertebrates (Weitkamp 2003).

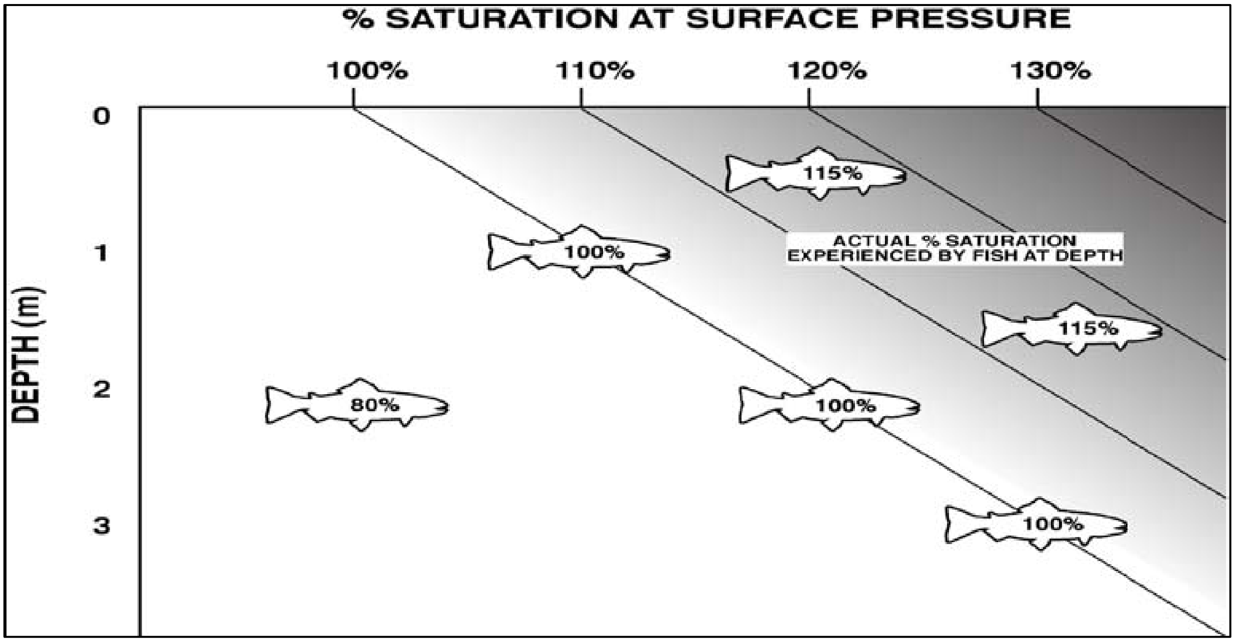
TDG Control Efforts

Current reservoir operations typically limit gas-generating, high-spill events to a few days or weeks during high-flow years. Historically, TDG supersaturation was a major contributor to juvenile salmon mortality, and TDG abatement is a focus of efforts to improve salmon survival. The 115-120% guideline is generally exceeded only with high rates of involuntary spill during the peak of the annual runoff hydrograph. The Corps has invested heavily in controlling TDG generation at its projects in the migratory corridor by:

- installing spillway improvements, typically flip-lips, at each mainstem dam (currently in progress at Chief Joseph Dam),
- managing spill operations to reduce gas entrainment, and

- TDG and GBT abatement monitoring and evaluation.

Figure 5.1-4. Compensatory effects of depth (hyperbaric pressure) on fish exposed to supersaturated water.



5.1.4.4 Pollutants

Background or ambient levels of pollutants in inflows carry cumulative loads from upstream areas in variable and generally unknown amounts. Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the rivers. Industrial and municipal wastes from the Portland-Vancouver metro areas affect the lower river and estuary. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids including DDT, PCBs, and polyaromatic hydrocarbons (PAH) (NMFS 2001a). This data also indicates that juvenile salmonids in the Columbia River estuary have contaminant body burdens in the range where sublethal effects may occur. The sources of exposure are not clear but may be widespread. Several pesticides and heavy metal contaminants have been sampled in Columbia River sediments (ODEQ 2007). In field studies, juvenile salmon from sites in the Pacific Northwest have demonstrated immunosuppression, reduced disease resistance, and reduced growth rates due to contaminant exposure during their period of estuarine residence (Arkoosh et al. 1991, 1994, 1998; Varanasi et al. 1993; Casillas et al. 1995 a, 1995b, and 1998 a). Thus, some, currently unknown, level of impact in the Columbia River estuary is likely.

5.2 Tributary Habitat Effects

With the exception of fall Chinook, which generally spawn and rear in the mainstem, salmon and steelhead spawning and rearing habitat is found in tributaries to the Columbia and Snake Rivers. The quality and quantity of habitat in many Columbia River Basin watersheds have declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydrosystem development, mining, and urbanization have changed the historical habitat conditions. Anadromous fish typically spend a few months to 3 years rearing in freshwater tributaries. Depending on the species, they spend from a few days to 1 or 2 years in the Columbia River estuary before migrating out to the ocean and another 1 to 4 years in the ocean before returning as adults to spawn in their natal streams. Thirty-two subbasins provide spawning and rearing habitat.

Many tributaries have been significantly depleted by water diversions. In 1993, Fish and Wildlife agency, Tribal, and conservation group experts estimated that 80% of 153 Oregon tributaries had low-flow problems (two-thirds caused at least in part by irrigation withdrawals) (OWRD 1993). The Northwest Power and Conservation Council showed similar problems in many Idaho, Oregon, and Washington tributaries (NPPC 1992). Depleted tributary streamflows have been identified a major limiting factors for most species in the Interior Columbia basin (PCSRF 2007).

In many watersheds, access to historical habitat areas is lost to land development, primarily due to road culverts that are not designed or installed to permit fish passage.

Water quality in many Columbia River Basin streams has been degraded to varying degrees by human activities such as dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities, and urbanization. Over 2,500 streams and river segments and lakes do not meet Federally-approved, state and Tribal water quality standards and are now listed as water-quality-limited under Section 303(d) of the Clean Water Act. Water quality problems in the upper tributaries contribute to poor water quality in mainstem reaches and the estuary where sediment and contaminants from the tributaries settle.

Most of the water bodies in Oregon, Washington, and Idaho that are on the 303(d) list do not meet water quality standards for temperature. Temperature alterations affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification. Many factors can cause high stream temperatures, but they are primarily related to land-use practices rather than point-source discharges. Some common actions that result in high stream temperatures are the removal of trees or shrubs that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have contributed to lower base-stream flows, which in turn contribute to water temperature increases. Channel widening and land uses that create shallower streams also increase water temperatures.

Pollutants also degrade tributary water quality. Salmon require clean gravel for successful spawning, egg incubation, and emergence of fry. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. Excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH also directly affect water quality for salmon and steelhead.

5.2.1 Indirect Effects of Hydrosystem Mortality on Nutrients in Tributaries

Mortality in the hydrosystem reduces the transport of marine-derived nutrients (MDN) to freshwater spawning and rearing areas. Gresh et al. (2000) estimated that only 6 to 7% of the marine-derived nitrogen and phosphorus that was delivered to the rivers of the Pacific Northwest by spawning salmon 140 years ago is currently returning to those streams. He attributed the loss to habitat changes due to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. Marine-derived nutrients (MDN) have been shown to support the growth of coastal populations of coho salmon, which feed on salmon eggs and spawned-out carcasses. Bilby et al. (2001) observed an increase in the amount of marine-derived nitrogen in the muscle of coho parr with increasing abundance of carcass tissue up to about 0.01 kg/m^2 and 0.15 kg/m^2-wet weight. Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading. Helfield and Naiman (2001) hypothesized that there were several pathways for the transfer of MDN from streams to riparian vegetation, including the transfer of dissolved nutrients from decomposing carcasses into shallow subsurface flow paths and the dissemination in feces, urine, and partially-eaten carcasses by bears and other salmon-eating fauna. In studies with juvenile coho salmon, Quinn and Peterson (1996) correlated increased body size with higher rates of overwinter survival, although this study was not designed to determine whether the effect was related to carcass density. Bilby et al. (2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material at sites in the Salmon and John Day rivers, suggesting that spawning salmon may be influencing aquatic productivity and the availability of food for rearing fishes, but mechanisms were not postulated. In summary, there is an increasing body of work suggesting that the biomass of carcasses affects the productivity of salmonid rearing habitat, but functional and quantitative relationships are poorly understood and difficult to generalize from the specific conditions studied. Limiting factors, and thus the ecological importance of marine-derived nutrients, differ among streams.

In summary, the best available scientific information indicates that reduced adult returns are likely to limit biogeochemical processes important to salmonid productivity in some watersheds by depriving rearing areas of some nutrient inputs. These nutrient limitations also result from habitat degradation, harvest, and adverse ocean conditions, all of which have reduced salmon survival and adult returns over time (Scheuerell and Williams 2005).

5.3 Estuary & Plume Habitat Effects

5.3.1 Columbia River Estuary

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to 2 miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet. Sand deposition at river mouths has extended the Oregon coastline approximately 4 miles seaward and the Washington coastline approximately 2 miles seaward (Thomas 1981).

More than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948 (Lower Columbia River Estuary Program [LCREP] 1999). Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased.

In addition, model studies indicate that the hydrosystem and reduced river flows caused by climate change together have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more (Bottom et al. 2000). Overbank flow events, important to habitat diversity, have become rare, in part because flow management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the "bankfull" flow level (from about 18,000 to 24,000 m^3/s). The dynamics of estuarine habitat have changed in other ways relative to flow. The availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the absorption capacity of the estuary appears to have declined.

The significance of these changes for salmonids is unclear, although estuarine habitat is likely to provide services (food and refuge from predators) to subyearling migrants that reside in estuaries for up to two months or more (Fresh et al. 2005; Casillas 1999). Fresh et al. (2005) found that: "Estuarine habitats clearly contribute to the viability and persistence of salmon populations in a number of ways. The amount of estuarine habitat that is accessible affects the abundance and productivity of a population. The distribution, connectivity, number, sizes, and shapes of estuarine habitats affect both the life history diversity and the spatial structure of a population." Historical data from Rich (1920) indicate that small juvenile salmon (< 50 mm), that entered the Columbia River estuary during May, grew 50 to 100 mm during June, July, and August. Contemporary data (Dawley et al.1986; CREDDP 1980) show little use of the Columbia River estuary by rearing salmon or steelhead.

5.3.2 Columbia River Plume

The Columbia River plume is that portion of the near-shore ocean environment sufficiently influenced by Columbia River energy, water quality, and biotic constituents to affect the local ecosystem. The plume is important juvenile salmonid habitat, particularly during the first month or two of ocean residence. The plume may represent an extension of the estuarine habitat, but more likely, it is a unique habitat created by interaction of the Columbia River freshwater flow with the California Current and local oceanographic conditions. Ongoing studies show that nutrient concentrations in the plume are similar to nutrient concentrations associated with upwelled waters. Upwelling is an oceanographic process that produces highly productive areas for marine species. Primary productivity, and more importantly, the abundance of zooplankton prey, is higher in the plume compared with adjacent non-plume waters. Further, salmon appear to prefer low surface salinity, as the abundance and distribution of juvenile salmon are higher and more concentrated in the Columbia River plume than in adjacent, more saline waters. These findings support the hypothesis that the plume is an important habitat for juvenile salmonids. What is not known is how Columbia River flows affect the structure of the plume during outmigration periods and whether critical threshold flows are needed. Research is ongoing to document important relationships between juvenile salmon growth and survival during this stage of their life history.

5.4 Predation & Disease Effects

5.4.1 Predation

Salmon and steelhead are exposed to high rates of natural predation during all life stages. Fish, birds, and marine mammals, including harbor seals, sea lions, and killer whales all prey on juvenile and adult salmon.

Dams and reservoirs are generally believed to have increased the incidence of predation over historical levels (Poe et al.1994). Impoundments in the Columbia River Basin:

- increase the availability of microhabitats in the range preferred by piscivorous fish (Faler et al. 1988; Beamesderfer 1992; Mesa and Olson 1993; Poe et al.1994);
- increase local water temperatures which increases piscivorous fish digestion and consumption rates (Falter 1969; Steigenberger and Larkin 1974; Beyer et al. 1988; Vigg and Burley1991; Vigg et al.1991);

- decrease turbidity, which increases predator capture efficiency (Gray and Rondorf 1986); and
- increase stress and subclinical disease of juvenile salmonids, which could increase susceptibility to predation (Rieman et al.1991; Gadomski et al.1994; Mesa 1994).

In addition, dam-related passage delay can affect the availability, distribution, timing, and aggregation of migrating salmonids, thereby increasing exposure time to predation (Raymond 1968, 1969, 1979, 1988; Park 1969; Van Hyning 1973; Bentley and Raymond 1976). In particular, passage delay increases exposure time later in the season, when predator consumption rates are higher (Beamesderfer et al. 1990; Rieman et al. 1991).

5.4.1.1 Piscivorous Predation

The Columbia River Basin has a diverse assemblage of native and introduced fish species, some of which prey on salmon and steelhead. The primary resident fish predators of salmonids in the reaches of the Columbia and Snake Rivers inhabited by anadromous salmon are northern pikeminnow (native), smallmouth bass (introduced), and walleye (introduced) (NMFS 2000a). Other predatory resident fish include channel catfish (introduced), Pacific lamprey (native), yellow perch (introduced), largemouth bass (introduced), and bull trout (native).

Northern Pikeminnow

Although northern pikeminnow (*Ptychocheilus oregonensis*) is a native species that always has preyed on juvenile salmonids, as noted above, development of the Columbia River hydropower system has likely increased the level of predation. Northern pikeminnow predation throughout the Columbia and Snake Rivers was indexed in 1990-1993 based on electrofishing catch rates of predators and the occurrence of salmonids in predator stomachs relative to estimates in John Day Reservoir (Ward et al. 1995). Northern pikeminnow abundance was estimated to total 1.8 million, and daily consumption rates averaged 0.06 salmonids per predator (Beamesderfer et al. 1996).

Beamesderfer et al. (1996) estimates that over 16 million total salmonids were consumed annually in the mainstem Columbia and Snake Rivers prior to initiation of the Northern Pikeminnow Management Program (NPMP see below). However, total system-wide impacts are not evenly distributed throughout the Columbia and Snake Rivers but are concentrated in the lower Columbia River from The Dalles Reservoir downstream, where approximately 13 million of the 16.4 million total salmonids are estimated to have been consumed by northern pikeminnow. This estimated predation loss is 8% of the approximately 200 million hatchery and wild juvenile salmonid migrants in the system.

Northern Pikeminnow Management Program (NPMP)

Predator control fisheries have been implemented in the Columbia Basin since 1990 to harvest northern pikeminnow with an annual exploitation rate goal of 10-20%, needed to obtain up to a 50% reduction in smolts consumed by pikeminnow (Rieman et al. 1991). The NPMP is a multi-year, ongoing effort funded by BPA to reduce piscivorous predation on juvenile salmon, primarily through public, angler-driven, system-wide removals of predator-sized northern pikeminnow. From 1991 to 1996, three fisheries (sport-reward, dam angling, and gill net) harvested approximately 1.1 million northern pikeminnows greater than or equal to 250 mm fork length. Total exploitation averaged 12.0% (range, 8.1 to 15.5%) for 1991 to 1996 (Section 6.2.7.1 in NMFS 2000b).

Since the program's inception in 1990, the NPMP's monetary incentive to harvest northern pikeminnow has motivated sports fishermen to remove over two million northern pikeminnow throughout the system. This has reduced predation mortality by an estimated 25% (Friesen and Ward 1999), which is estimated to equate to approximately 4 million fewer juvenile salmonids consumed by pikeminnow each year. Currently, the annual harvest rate ranges approximately between 8 and 16% of the northern pikeminnow that qualify in size but has averaged approximately 12% in the last number of years. In 2001 and again in 2004, BPA increased the reward, which led to increases in both catch and exploitation.

Smallmouth Bass

Found in lakes, rivers, and streams, smallmouth bass (*Micropterus dolomieu*) have relatively large mouths that enable them to consume juvenile fish, including salmonids. According to Bennett and Naughton (1999), smallmouth bass and salmonid use many of the same habitat types. Smallmouth bass are the dominant predators in reservoirs of the lower Snake River and are co-dominant with northern pikeminnow and percids in certain reaches of the Snake River (NMFS 2000a). The highest densities of smallmouth bass in the Columbia and Snake Rivers occur in the Lower Granite forebay, tailrace, and reservoir, followed by the John Day Reservoir (NMFS 2000a). Throughout the John Day Reservoir study area, smallmouth bass consumed far fewer juvenile salmonids than did northern pikeminnow (Zimmerman 1999).

Zimmerman (1999) also found that smallmouth bass consumed smaller Chinook salmon in the spring than did northern pikeminnow, and they consumed far more subyearling Chinook salmon in the summer than yearling Chinook in the spring. Predator-prey size relationships may reflect the degree and timing of habitat overlap, as suggested by Tabor et al. (1993), who attributed high levels of smallmouth bass predation on subyearling Chinook salmon to overlap of rearing habitat for subyearling Chinook with the preferred habitats of smallmouth bass in summer.

There is also information to suggest that growth of smallmouth bass due to the availability of American shad prey in the late summer and fall could potentially result in a large increase in the number of juvenile salmonids consumed by this predator (Sauter et al. 2004).

Walleye

As the largest member of the perch family, walleye (*Sander vitreus*) can grow up to 20 pounds, are extremely piscivorous, and in the Columbia Basin are most abundant in dam tailraces, where the potential for impacts on juvenile salmonids is high (NMFS 2000a).

In the 1983-1986 John Day Reservoir study that forms the basis for the current predator management program, Rieman et al. (1991) found that walleye consumed 13% of the estimated annual 2.7 million juvenile salmonids consumed by predatory fish. Northern pikeminnow accounted for 78% and smallmouth bass took 9%. Poe et al. (1991) stated that walleye are much less important predators than other fish species, and their salmon consumption appeared to consist mostly of subyearling Chinook during late summer in the John Day Reservoir. While the John Day Reservoir study found that smallmouth bass were the third most important predator of salmonids, more recent studies have indicated that there are smallmouth bass hotspots (e.g., The Dalles Dam tailrace) that may be worth further investigation for predator management options.

5.4.1.2 Avian Predation

Avian predation is another factor limiting salmonid recovery in the Columbia River Basin. Throughout the basin, piscivorous birds congregate near hydroelectric dams and in the estuary near man-made islands and structures and eat large numbers of migrating juvenile salmonids (Ruggerone 1986; Roby et al. 2003; Collis et al. 2002). Diet analyses indicate that juvenile salmonids are a major food source for avian predators in the Columbia River and its estuary and that basin-wide losses to avian predators are high enough that they constitute a substantial portion of several runs of salmon and steelhead (Roby et al. 2003).

Avian predation has been exacerbated by environmental changes associated with river developments. Water clarity caused by suspended sediments setting in impoundments increases the vulnerability of migrating smolts. Delay in project reservoirs, particularly immediately upstream from the dams increases smolt exposure to avian predators, and juvenile bypass systems concentrate smolts, creating potential feeding stations for birds. Dredge spoil islands, associated with maintaining the navigation channel, provide habitat for nesting Caspian terns and other piscivorous birds.

Caspian terns, double-crested cormorants, glaucous-winged/western gull hybrids, California gulls, and ring-billed gulls are the principal avian predators in the basin (NMFS 2000a). Populations of these birds have increased throughout the basin as a result of nesting and feeding habitats created by human activities, such as dredge spoil deposition in or near the estuary (creating nesting habitat) and reservoir impoundments and tailrace bypass outfalls associated with hydro projects (Roby et al. 2003). The breeding season for these birds coincides with the outmigration of yearling salmonids, which provides a ready prey source in the vicinity of large avian nesting colonies (Roby et al. 2003).

For many of the listed salmon species migrating through the Columbia River estuary, avian predation is considered one of the primary limiting factors affecting juvenile survival (Fresh et al. 2005. Since 1997, researchers have been studying the effect of piscivorous waterbirds on juvenile salmonid survival in the Lower Columbia River. In 1998, Collis et al. (2003) estimated that Caspian terns nesting on Rice Island consumed about 12.4 million juvenile salmonids, or approximately 13% of the estimated 97 million out-migrating smolts that reached the estuary during the 1998 migration year. This research prompted managers to relocate the tern colony to East Sand Island, approximately 15 miles downstream and near the ocean and a wider prey base, which resulted in a successful reduction in predation of juvenile salmonids by approximately five to six million fish annually. However, annual predation rates of terns nesting on East Sand Island are still substantial. On average, terns consumed 5.9 million smolts annually from 2000 to 2003 (Collis et al. 2003).

The double-crested cormorant colony on East Sand Island in the Columbia River estuary is the largest along the Pacific coast (Collis et al. 2002). In 2003, approximately 10,646 breeding pairs were nesting on East Sand Island. Given the birds' feeding habits, it is difficult to determine the number of juvenile salmonids they consume. However, based on preliminary bioenergetics modeling, it appears that cormorants nesting on East Sand Island consumed about the same numbers of juvenile salmonids as Caspian terns in 2003.

Inland populations of avian predators also consume substantial numbers of juvenile salmon and steelhead. The primary avian predator colonies present on islands in the Columbia Plateau region include Caspian terns, double-crested cormorants, ring-billed and California gulls, and American white pelicans. The most significant populations of avian predators occur on Crescent Island (Caspian terns) and Foundation Island (cormorants) which are located in the Columbia River near the mouth of the Snake River. In 2000 and 2001, bioenergetics modeling was used to estimate the smolt consumption rate of the Crescent Island tern colony at 465,000 and 679,000 smolts, respectively (Antolos et al. 2005). Approximately 25% of this consumption consisted of steelhead from the Snake and upper Columbia rivers. Steelhead appear to be particularly vulnerable to avian predators. In 2001, the consumption rate of in-river migrating PIT tagged Snake River steelhead by the Crescent Island tern colony was estimated at 12.4%, much higher than the estimated yearling Chinook consumption rate of 3.9% (Antolos et al. 2005). From 2003 to 2005, the minimum combined avian consumption rates (Crescent and Foundation Island) of in-river migrating PIT tagged juvenile Snake River steelhead ranged from 4.1 to 18.3% (Ryan et al. 2006). The majority of these tag detections were from the tern colony on Crescent Island. While the population of Crescent Island tern colony has decreased in recent years (-6% between 2005 and 2006) the overall tern population in the Columbia Plateau region has remained about the same since 1997, at approximately 1000 pairs (Collis et al. 2007). In contrast, double-crested cormorant populations are increasing in the Columba Plateau region with a 14% increase in the breeding colony on Foundation Island between 2005 and 2006 (Collis et al. 2007). In 2006, salmonids comprised approximately 4% of the diet of the Foundation Island cormorant colony, which included 0.89% of the in-river PIT tagged Snake River smolts, suggesting that juvenile salmonids are not a primary cormorant food source during the breeding season (Collis et al. 2007). However, this 2006 study also indicates that a minimum of 2.8% and 1.4% of the hatchery and wild in-river migrating Snake River steelhead were consumed by this colony. Other piscivorous bird predator populations (primarily gulls and pelicans) are having little impact on the survival of juvenile salmonids from the Snake and upper Columbia rivers (Collis et al. 2007).

5.4.1.3 Pinniped Predation

Marine mammal predation has increased in recent years in the tailrace below Bonneville Dam. Aggregations of over 100 individual pinnipeds, primarily California sea lions with a few Stellar sea lions and Pacific harbor seals, have been observed feeding immediately below the dam, often near the powerhouse fishway entrances. Based on visual observations of adult fish consumption downstream from Bonneville Dam and adult fish ladder counts, researchers have estimated that pinnipeds consumed 0.4, 1.2, and 2.0, 3.8, 2.7, and 5.1% of the total annual spring Chinook salmon runs during 2002, 2003, 2004, 2005, 2006, and 2007 respectively. Thus, based on actual observations, the average estimated predation rate (2004-2007) to spring-run Chinook salmon and winter-run steelhead is about 3.0% and 7.8%, respectively. However, these estimates are likely far less than actually occurs based on the limited amount of time and coverage of the observation period. Better estimates are likely provided by recent evaluations of radio telemetry study results, which suggest that the predation rate of California sea lions since 2004 is likely about 8.5% for spring-run Chinook and 21.8% for winter-run steelhead migrating past Bonneville Dam (Marine Mammal Appendix).

Recent attempts to reduce pinniped predation by hazing and by installing excluder devices at fishway entrances have met with limited success. However, NOAA Fisheries has completed Section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protections Act, for the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook and winter-run steelhead in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the absolute survival of migrating adult spring-run Chinook by 5.5% and of winter-run steelhead by 14.2%.

5.4.2 Disease

Columbia Basin salmonids co-exist with a range of viruses, bacteria, fungi, and parasites, collectively known as pathogens, that have significant effects on salmon populations through mortality or reduced fitness (morbidity). For salmonid and pathogen populations to persist, interactions between host and pathogen, like interactions between predator and prey, must maintain a dynamic balance where neither is wholly eliminated. Three major factors in this balance have been identified as host, environment, and pathogen. A change in one or more of these three factors will result in a change in the equilibrium, often resulting in large outbreaks of disease (epizootics) which may decimate salmonid populations.

Development of the Columbia Basin has created a number of factors that have the potential to cause shifts in the host-pathogen equilibria, increasing risks of epizootics. Impoundments increase summer water temperatures, creating conditions where some of the infectivity rates (rate of spread) and virulence (severity of effects on the host organism) of some pathogens are increased. Passage through the hydrosystem also delays and stresses salmonids, increasing their exposure and reducing their resistance to disease. Introduction of exotic species and between-basin transfer of native fishes create opportunities for the introduction of new pathogens, or for endemic pathogens to increase their range. Large-scale intensive hatchery culture provides conditions where pathogens could spread rapidly within the hatchery, and increases the risk of transfer of disease out of the hatchery through hatchery effluents and the release of infected fish. Changing environmental conditions altered relationships between parasites and their hosts, potentially increasing the severity of parasitic infection. Handling and transport of fish at dams has led to fish being held at much higher densities than observed in the wild, increasing chances of disease transmission. Thus, with changes in host, pathogen, and environment, a shift in host-pathogen relationships from pre-development conditions has occurred.

The effects of disease on wild salmonid populations are notoriously hard to enumerate, and the significance of a particular pathogen may also widely vary among different salmonid populations. Diseases which have been observed to cause significant losses to migrating fish (both hatchery and wild) in the Columbia River system are Columnaris (*Flexibacter columnaris*), bacterial kidney disease (*Renibacterium salmoninarum*), and ceratomyxosis (*Ceratomyxa shasta*). With the interruptions of natural disease control mechanisms through shifts in environmental conditions, introductions of new pathogens (or changes in distribution of endemic ones), or introduction of new potential sources of pathogens, such as hatcheries, this equilibrium has been substantially altered and the potential for large epizootics and high losses to salmonid populations has increased.

5.4.2.1 Effects of Temperature on Disease

In addition to the stress and direct physiological damage suffered by salmonids when exposed to elevated water temperatures, risks of mortality due to disease also increases. There appear to be two primary reasons for this increase. Temperature-related stress reduces the capacity of the fish to resist infection and eliminate pathogens. Pathogens also respond to changes in temperature. There is a particular range of optimum temperatures for each pathogen and in this range the reproduction, infectivity, and virulence of a pathogen are maximized. The combination of reduced resistance of fish and increased virulence and infectivity of a particular pathogen can result in epizootics and high rates of mortality due to disease. In a summary of issues related to temperature criteria for salmon, the EPA (2001) summarized the effects of water temperature on disease risk as follows:

Risk	Temperature range (˚C)
Minimized	<12-13
Elevated	14-17
Severe	18-20

There are a number of pathogens known in the Columbia Basin which show a direct increase in infectivity and virulence with increased water temperature. A brief summary of Columbia Basin pathogens with the potential for causing increased mortality among salmonids under elevated water temperature conditions is described in Table 5.4-1 below.

Table 5.4-1. Fish diseases known from the Columbia Basin showing increases in infectivity and virulence with increasing water temperature. (Source: WDOE 2002; EPA 1999; EPA 2001)

Organism	Disease	Temperature effects	Susceptible species	Severity of effects
		Bacteria		
Flexibacter columnaris	Columnaris	Epizootics strongly related to high water temperature (>15)	All species	Has been observed to cause high levels of mortality among wild and hatchery populations, ^{o}C)
Renibacterium salmoninarum	Bacterial Kidney Disease (BKD)	Increased temperatures reduce	All salmonids, especially	Often causes high levels of mortality in

Organism	Disease	Temperature effects	Susceptible species	Severity of effects
		infectivity, but increase the severity of infections (time until death) in laboratory trials.	chinook and sockeye	hatcheries. High prevalence in some wild fish populations.
Aeromonas salmonicida	Furunculosis	Epizootics strongly correlated with temperature	All fishes	Has been observed to cause high levels of mortality in the wild and hatcheries
Myxobacter sp.	Bacterial Gill Disease (BGD)	Epizootics strongly correlated with water temperature and poor water quality	All fishes	
		Parasites		
Ceratomyxa shasta	Ceratomyxosis	Increased temperatures reduced time from exposure to death in laboratory studies.	Salmonids, especially chinook	Has been observed to cause high levels of mortality in the wild and in hatcheries.
Icthyopthirius multifilis	Ich	Epizootics strongly associated with temps >15 ^{o} C	All fishes	Has been observed to cause high levels of mortality in the wild and in hatcheries

Juvenile salmon and steelhead mortalities from an array of disease have been observed at many fish collection and handling systems in the migratory corridor. Columnaris and BKD are two common diseases observed at FCRPS juvenile collection systems. In many cases, the proximate causes of fish mortality in the action area are largely unknown. While it is known that juvenile passage survival is lower under low-flow, high-temperature conditions, it is seldom known whether the direct cause of death is thermal stress, increased predation, increased susceptibility to disease, or a combination of these factors.

5.5 Hatchery Effects

The hatchery programs in the Proposed Action are funded by the Action Agencies to compensate for impacts to salmon and steelhead attributable to the FCRPS and continued funding is proposed. Benefits and risks from past and present hatchery operations are imbedded in the environmental baseline. For an overview of past and present hatchery programs see NMFS 2004b and NMFS 2006b.

Today, because nearly 90 percent of the Chinook salmon and steelhead habitat originally available in the Columbia Basin has been lost or degraded (Brannon et al. 2002), fish produced by hatcheries comprise the vast majority of the annual returns to the basin (CBFWA 1990). Annual returns of salmon and steelhead would be reduced by up to ninety percent and there would be little or no tribal, recreational, or commercial fishing opportunity without hatcheries.

Hatchery programs support tribal, recreational and commercial fisheries. The primary purpose of the nearly two hundred hatchery programs that operate in the Columbia Basin is to compensate for Federal and public and private utilities projects. Other hatchery programs are designed to conserve genetic resources, and in some cases, are used to help improve viability after the factors limiting viability are addressed.

As an unintended consequence of providing these benefits, there is the potential for hatchery programs to increase the extinction risk and threaten the long-term viability of natural populations. For example, because the progeny of hatchery fish that spawn in the wild are known to be less likely to survive and return as adults than the progeny of natural-origin spawners (Berejikian and Ford.2004), the fitness of a spawning aggregate or natural population is likely to decline (termed, outbreeding depression) if hatchery and natural-origin fish interbreed. For steelhead, outbreeding depression has been found to occur in the progeny of matings of hatchery and wild fish, even when the hatchery fish are the progeny of wild fish that were raised in a hatchery. Other potential risks posed by hatchery programs include disease transmission, competition with natural-origin fish, and increased predator and fishing pressure based mortality. The risks of several basin hatchery programs have been reduced through careful hatchery management and the implementation of hatchery reforms. When conducting ESA consultations on hatchery actions, NOAA Fisheries requires the submission of new Hatchery Genetic Management Plans and evaluates those plans to ensure such risks are minimized.

NMFS (2004b) evaluated the benefits and risks of hatchery programs at the population level and at the ESU or DPS level. For programs in the Interior Columbia (upstream from Bonneville Dam), NMFS (2006b), with input provided by members of the Hatchery and Harvest Workgroup of the FCRPS remand collaboration; (1) summarized the major factors limiting salmon and steelhead recovery at the population scale, (2) provided an inventory of existing hatchery programs including their funding source(s) and the status of their regulatory compliance under the ESA and under the National Environmental Policy Act, (3) summarized the effects on salmon and steelhead viability from current hatchery operations, and (4) identified new opportunities or changes in hatchery programs likely to benefit population viability. As a follow-up to this report, NOAA Fisheries developed guidance for determining hatchery effects, including a general assessment of hatchery programs in the upper Columbia and Snake River Basin, and presented this paper to the Hatchery and Harvest Workgroup and to the Policy Workgroup in August of 2006. NOAA Fisheries received comments and made edits to this paper to provide updated guidance for assessing benefits and risks and operating hatchery programs (see Artificial Propagation for Pacific Salmon Appendix).

The history or evolution of hatcheries is an important factor in analyzing their past and present effects. From their origin more than one hundred years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability. The first hatcheries, beginning in the late 19th century, provided additional fish for harvest purposes on top of large relatively healthy salmon and steelhead populations. As development of the Columbia Basin proceeded (e.g., construction of the FCRPS between 1939 and 1975), the role of hatcheries shifted to replacing losses in fish production attributable to habitat degradation and reduced salmon and steelhead survival. Since that time, most hatchery programs have been tasked to maintain fishable returns of adult salmon, usually for cultural, social, recreational, or economic purposes as the capacity of natural habitat to produce salmon and steelhead has been reduced. National Fish Hatcheries in the upper Columbia, for example, produce salmon and steelhead for areas blocked by federal dams (about 50 percent of the production area for upper Columbia spring Chinook salmon and steelhead is blocked by dams and remains inaccessible) while federally funded hatchery programs in the Snake River are expected to replace losses of fall Chinook salmon from inundation of their spawning habitat and from reduced survival during their migration to and from the ocean because of the eight Lower Snake and Columbia River Federal projects. The scope and level of hatchery production increased greatly during this period as impacts from development and the requirement to compensate for those impacts increased.

A new role for hatcheries emerged during the 1980s and 1990s after populations declined to unprecedented low levels. Because tools were needed to help conserve salmon and steelhead genetic resources and reduce short-term extinction risk, some hatchery programs changed their goals and practices and whole new programs were implemented, including substantial new research to assess the efficacy of artificial propagation as a tool to promote conservation.

Genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery as well as in fish spawned in the wild (NMFS 1991b; Hard et al. 1992). For a list of hatchery fish included in salmon ESUs and steelhead DPSs, see NMFS (2004b). Hatchery programs have also been used as a tool to conserve the genetic resources of depressed natural populations and to reduce extinction risk, at least in the short-term (e.g. Snake River Sockeye). Such programs are designed to preserve the genetic resources that salmon and steelhead conservation depends on and buy time until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs reduce the risk of extinction (NMFS 2005b). Hatchery programs that only conserve genetic resources, however, "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or long-term (NMFS 2005b). Furthermore, hatchery programs that conserve vital genetic resources are not without risk because the manner in which these programs are implemented can affect the genetic structure and evolutionary trajectory of the target population by reducing genetic and phenotypic variability and patterns of local adaptation (ICTRT 2007b).

Population viability and reductions in threats are key measures of salmon and steelhead status relative to recovery. Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., hatchery supplementation). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish (i.e., F1 hatchery-origin fish). They are not, however, a proven technology for achieving sustained increases in adult production (NRC 1995), and the long-term benefits and risks of hatchery supplementation remain untested (Araki et al. 2007a). For an overview of the benefits and adverse implications from existing hatchery operations see NMFS (2004b and 2006b).

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. Hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival or when access to spawning and rearing habitat is blocked. Under circumstances like these and in the short-term, the demographic risks of extinction of such populations likely exceed genetic and ecological risks to natural-origin fish that would result from hatchery supplementation. Benefits like this should be considered *transitory* or short-term and do not contribute to survival rate changes necessary to meet ICTRT abundance and productivity viability criteria. For example, in Puget Sound, eight Chinook salmon hatchery programs have been specifically implemented to preserve native populations in their natal watersheds “where habitat needed to sustain the populations naturally at viable levels has been lost or degraded” (NMFS 2005b). These hatchery programs help “to preserve remaining genetic diversity, and likely have prevented the loss of several populations” (NMFS 2005b). Until, however, the factors limiting Chinook salmon productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon viability may not be realized. Fixing the factors limiting viability is the key to long-term viability. “The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery” (HSRG 2004). Salmon and steelhead populations that rely on hatchery production are not viable (McElhany et al. 2000), and increased dependence on hatchery intervention results in decreasing benefits and increasing risk (ICTRT 2007a).

Increasing knowledge and experience is another important factor in the application of hatchery supplementation. Hatchery supplementation is an “experimental” technology. It is relatively new and there is little data on long-term benefits and risks – study results for a single generation of Pacific salmon take a minimum of three to five years. New information is emerging, however, from ongoing research and important new research will be implemented as a result of this Biological Opinion (see Chapter 2). The reproductive fitness of hatchery fish and the effects of hatchery supplementation on population viability will be investigated for steelhead in the Methow River and for fall Chinook salmon in the Snake River. NOAA Fisheries intends that the information emerging from ongoing and new studies will shape future decisions over hatchery supplementation throughout the Interior Columbia Basin.

This Supplemental Comprehensive Analysis includes in the baseline the past effects of hatchery operations in the Columbia River Basin. As is acknowledged in Section 8.1.3, the past effects, and in some instances, continuing effects, of hatchery practices constitute significant factors which may increase risk to the recovery of the ESU. Such effects include those which result from the operation of hatcheries prior to this consultation, as well as the continued operation of hatcheries following this consultation to the extent hatcheries have undergone ESA section 7 consultation. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 7 consultation, the effects of future operations cannot be included in the baseline. In some instances, effects are ongoing (e.g., returning adults from past hatchery practices) and included in this analysis despite the fact that future operations are excluded from the baseline. See Hatchery Effects Appendix for the status of hatchery operations in the Columbia River Basin.

While hatchery effects are included in the baseline as described above, nevertheless the proposed action does not encompass hatchery operations per se, and therefore no incidental take coverage is offered through this biological opinion to hatcheries operating in the region. Instead, we expect the operators of each hatchery to address its obligations under the ESA in separate consultations, as required.

5.6 Harvest Effects

For thousands of years Native Americans have fished for salmon and steelhead, as well as other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls; to spears, weirs, and traps (usually in smaller streams and headwater areas). Commercial fishing developed rapidly with the arrival of European settlers and the advent of canning technologies in the late 1800s. The development of non-Indian fisheries began circa 1830, and by 1861 commercial fishing was an important economic activity. Fishing pressure, especially in the late nineteenth and early twentieth centuries, has long been recognized as a significant factor in the decline of Columbia River salmon runs (NRC 1996).

Treaty Indian 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 of *United States v. Oregon*, No. 68-513 (D. Oregon, continuing jurisdiction case filed in 1968). In U.S. v. Oregon, the court affirmed that the treaties reserved to the Tribes 50% of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas. In at least a half-dozen published opinions and several unpublished opinions in *U.S. v. Oregon*, as well as dozens of rulings in the parallel case in *U.S. v. Washington* (interpreting the same treaty language for Tribes in the Puget Sound area), the courts have established a large body of case law setting forth the fundamental principles of treaty rights and the permissible limits of conservation regulation of treaty fisheries. The parties to *U.S. v. Oregon* are the

United States acting through the Department of the Interior (U.S. Fish and Wildlife Service and Bureau of Indian Affairs) and the Department of Commerce (NOAA Fisheries), the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Confederated Tribes and Bands of the Yakama Nation, and the Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho.

Treaty Indian and non-Indian commercial and recreational fisheries in the Columbia River basin were managed subject to provisions of the Columbia River Fish Management Plan (CRFMP) from 1988 through 1998. The CRFMP was a stipulated agreement adopted by the Federal Court under the continuing jurisdiction of *U.S. v. Oregon*. NOAA Fisheries has consulted under section 7 of the ESA on proposed *U.S. v. Oregon* fisheries in the Columbia basin since 1992 when affected salmonids were fist listed. Table 5.6-1 displays the incidental take limits and expected incidental take (as a proportion of total run size) of listed salmonids for treaty Indian and non-Indian fisheries under the 2005-2007 Interim Management Agreement, which was scheduled to expire on December 31, 2007. The 2005 Interim Management Agreement was subsequently extended by the parties through May 8, 2008.

Table 5.6-1. Incidental take limits and expected incidental take (as proportion of total run size) of listed salmonids for non-Indian and treaty Indian fisheries under the 2005-07 Interim Management Agreement (table and associated footnotes taken from the Biological Opinion on the Interim Agreement (U.S. District Court 2005)).

ESU		Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Snake River Fall Chinook		31.29	11.6 – 23.04	5.9 – 8.25
Snake River Spring/Summer Chinook		5.5 – 17.07	5.0 – 15.0	0.5 – 2.0
Lower Columbia River Chinook	Spring Component	managed for escapement goal	0	0.2 – 2.0
	Tule Component (LRH stock)	49% exploitation rate	0	7.3 – 12.0 (49% exploitation rate
	Bright Component (LRW stock)	managed for escapement goal	0	9.5 – 18.8 (5.700 goal)
Upper Willamette River Chinook		15.0	0	5.0 – 11.0
Snake River Basin Steelhead	A-Run Component	4.03	3.5 – 8.2	1.0 – 1.8
	B-Run Component	17.04	3.4 – 15.04	1.5 – 2.0
Lower Columbia River Steelhead	Winter Component	6.05	0.6 – 10.76	0.8 – 6.0
	Sumer Component	4.03	3.5 – 8.27	0.6-1.6
Upper Willamette River Steelhead		6.04	0	0.8 – 6.02
Middle Columbia River Steelhead	Winter Component	6.05	0.6 – 10.7	0.8 – 6.0
	Summer Component	4.03	3.5 – 8.2	1.0 – 1.8

ESU		Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Upper Columbia River Spring Chinook		5.5 – 17.01	5.0 – 15.0	0.5 – 2.0
Columbia River Chum		5.0	0	1.6
Upper Columbia River Steelhead	Natural-origin Component	4.04	3.5 – 8.2	1.0 – 1.8
	Hatchery Component		3.5 – 8.2	8.6 – 15.0
Snake River Sockeye		6.0 – 8.08	2.8 – 7.0	0.0 – 1.0
Lower Columbia Coho		6.59	0	0 – 6.59

While the general principles for quantifying treaty Indian fishing rights are well established, their application to individual runs during the annual spring and fall fishing seasons is complicated. Annual calculations of allowable harvest rates depend (among other things) on estimated run sizes for the particular year, on the mix of stocks that is present, on application of the ESA to mixed-stock fisheries, on application of the tenets of the "conservation necessity principle" to regulation of treaty Indian fisheries, and on the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty Indian fishing rights during a particular fishing season often cannot be established by a rigid formula, the treaty fishing right itself continues to exist and must be accounted for in the environmental baseline.

The sections that follow evaluate harvest mortality, under the environmental baseline, for individual ESUs and DPSs, as well as the estimated effects of all forms of harvest on those ESUs and/or DPSs that are subject to substantial harvest outside of the action area.

5.6.1 Species Effects of Harvest under the Environmental Baseline

Snake River Fall Chinook

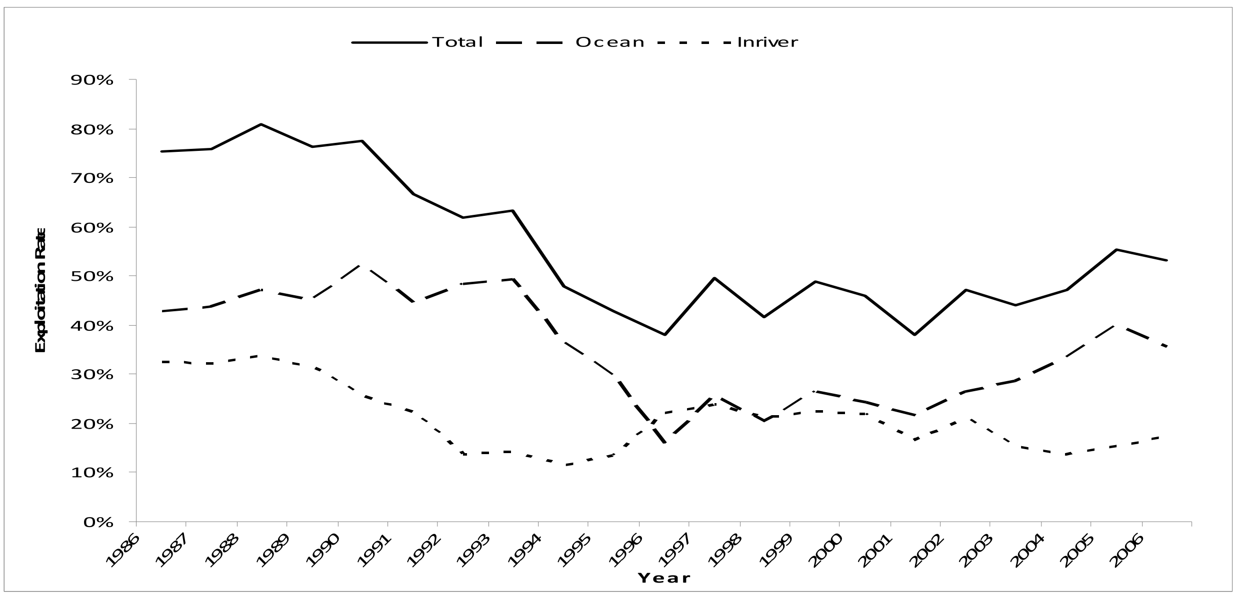
Snake River (SR) fall Chinook are caught in ocean and in-river fisheries. Ocean fisheries occur outside the action area, but are nonetheless reviewed here to provide a more comprehensive overview of harvest affecting the status of this species.

SR fall Chinook are broadly distributed and caught in fisheries from Alaska to California, but the center of their distribution and the majority of impacts occur in fisheries from the west Coast of Vancouver Island to central Oregon. The total ocean fishery exploitation rate averaged 46% from 1986 to 1991, and 31% from 1992 to 2006 (NMFS 2008e). Ocean fisheries have been required since 1996, through ESA consultation, to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 base period (NMFS 2008e).

SR fall Chinook area also caught in fall season fisheries in the Columbia River with most impacts occurring in Non-Indian and treaty Indian fisheries from the river mouth to McNary Dam. Fisheries affecting SR fall Chinook have been subject to ESA constraints since 1992. Since 1996, fisheries have been subject to a total harvest rate limit of 31.29%. This represents a 30% reduction in the 1988 to 1993 base period harvest rate. Columbia River fisheries have a similar 30% base period reduction standard. But the ocean and inriver standards are separate, and the fisheries are managed independently subject to their respective own standard.

Total harvest mortality for the combined ocean and inriver fisheries can be expressed in terms of exploitation rates which provide a common currency for comparing ocean and inriver fishery impacts (Fisheries in the Columbia River are generally managed subject to harvest rate limits. Harvest rates are expressed as a proportion of the run returning to the river that is killed in river fisheries). The total exploitation rate has declined significantly since the ESA listing. Total exploitation rate averaged 75% from 1986 to 1991, and 45% from 1992 to 2006 (Figure 5.6.1-1).

Figure 5.6.1-1. Ocean and In-river Exploitation Rates for Snake River fall Chinook

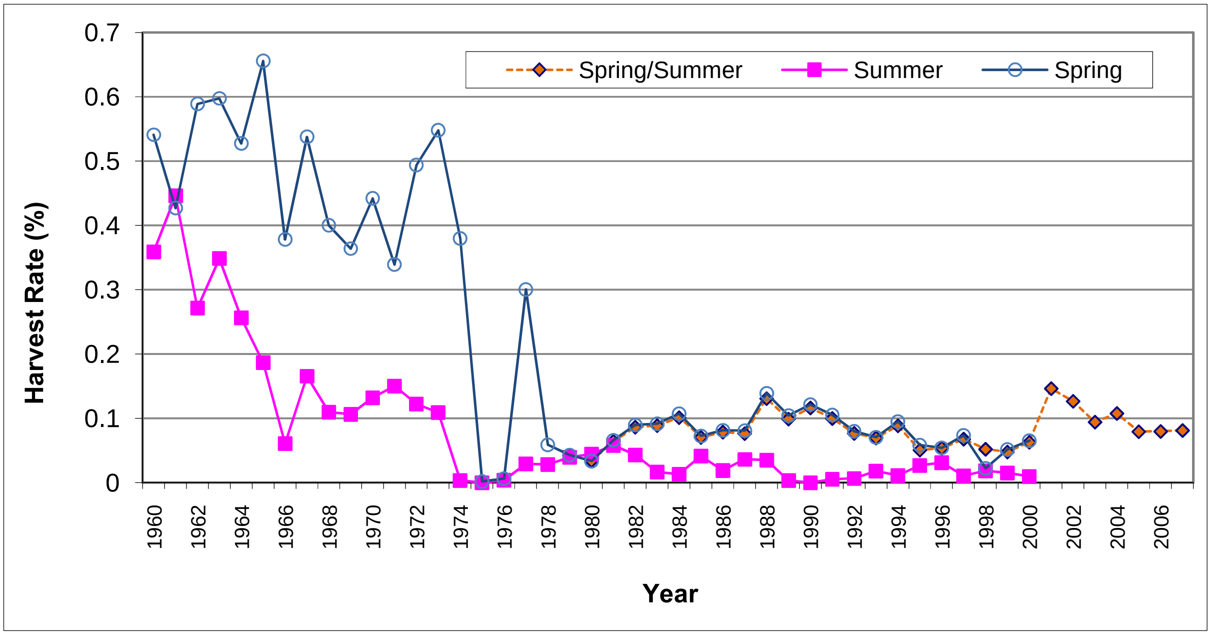


Upper Columbia River Spring Chinook & Snake River Spring/Summer Chinook

"Upriver" spring Chinook is a "management unit" and includes Upper Columbia River (UCR) Chinook ESU and Snake River (SR) spring and Summer Chinook ESUs. Recent analysis of PIT-tag information indicates that the timing of the SR summer Chinook populations is intermediate, and more similar to that of the SR spring Chinook populations than other summer Chinook populations that return to the Upper Columbia (that are not ESA listed). Until 2005, SR spring and summer Chinook were treated as different stocks and managed separately. Beginning in 2005, the end of the spring management period was shifted later by two weeks, to June 15, so that SR spring and summer Chinook populations could be managed, for harvest purposes, as a single stock, and separately from upper Columbia River summer populations. The harvest rate on the aggregate run of SR spring/summer Chinook has been recalculated back to 1979 (Figure 5.6.1-2). "Upriver" spring Chinook are caught in spring season fisheries in the mainstem Columbia River. Harvest mortality in ocean fisheries is assumed to be zero.

A review of the record of sequential harvest reductions over past years provides a pertinent perspective about harvest-related management actions that have been taken to protect upriver, natural-origin spring Chinook stocks, including SR spring/summer Chinook. A more detailed discussion of this record is provided in a biological opinion related to the 2001 harvest management agreement (NMFS 2001b).

Figure 5.6.1-2. Harvest rates for all commercial, recreational, and C&S fisheries in the mainstem (TAC 2008).



Upriver spring Chinook stocks were subject to substantial harvest through the early seventies. The average harvest rate on upriver spring Chinook from 1938-1973 was 55%. As the stocks declined it became apparent that these harvest rates were not sustainable. By the mid-1970s, the spring season fisheries that targeted upriver stocks were largely eliminated by the state and tribal managers. Harvest rates in all mainstem commercial, recreational, and ceremonial and subsistence (C&S) fisheries have averaged just over 8% since then (Figure 5.6.1-2).

The last mainstem fisheries targeting upriver summer Chinook stocks, including the summer component of the SR ESU, occurred in 1964. Harvest rates have not exceeded 10% since 1973 and have averaged less than 3% since 1974. As discussed above, in 2005 the management period separating upriver spring and summer Chinook stocks was adjusted. Snake River spring and summer Chinook are now managed as a unit and subject to similar harvest rates.

Beginning in 1988, the Columbia River Fish Management Plan (CRFMP or Plan), developed under the jurisdiction of *U.S. v. Oregon*, provided a framework for managing the mainstem fisheries that impact upriver spring and summer Chinook stocks. The purpose of the Plan was to define harvest limits that would be sufficiently protective, in order to allow for the rebuilding of stocks of concern. The Plan was formally approved in 1988, but fisheries were managed subject to its provisions beginning in 1986. The Plan allowed for harvest rates of up to 4.1% on upriver spring stocks in non-Indian fisheries and 5% or 7% in treaty Indian C&S fisheries, depending on run size. There were provisions that allowed for higher harvest rates if run sizes increased, but such runs had not been seen for many years.

Despite the Plan's provisions, further constraints were implemented in 1992, through the Section 7 consultation process, when SR spring/summer Chinook were first listed. Management constraints were refined through a series of annual consultations that led to the development in 1996 of a three year Management Agreement that modified the Plan's original management framework. The Plan's provisions were modified by reducing allowable impacts in the non-Indian fisheries to 1-3%, depending on run size. The alternative target harvest rates in the treaty Indian fisheries (5-7%) were not changed as a result of the Agreement, largely in deference to treaty right considerations. However, the Agreement for the first time required that fisheries be managed in response to the status of listed natural-origin fish, rather than an aggregate runsize that was now composed primarily of hatchery-origin fish.

The CRFMP also limited harvest rates on upriver summer Chinook stocks in the non-Indian and treaty-Indian fisheries, which at that time included the SR summer Chinook populations, to 5% each. The three year Agreement reduced the harvest rate limit for upriver summer Chinook in the non-Indian fishery from 5-1% and clarified that all treaty Indian fisheries were subject to the 5% harvest rate limit.

The parties used provisions of the 1996 Agreement to direct fisheries through 1999. In 2000, and particularly 2001, the parties began to anticipate, as a result of preseason forecasts, the increased returns that occurred in the early part of the decade (NMFS 2001b). This lead to more detailed discussion among the *U.S. v. Oregon* parties regarding an abundance-based management system that would be responsive to the status of natural-origin spring Chinook stocks. In 2001, the parties concluded an agreement that allowed the harvest rates to vary between 5.5% and 17%, depending on the status of spring Chinook stocks (NMFS 2001b). That agreement was modified in 2005 to account for new information on the run timing of Snake River spring and summer Chinook populations (NMFS 2005c). The harvest rate schedule was adjusted so that it now accounted for the abundance of SR spring and summer Chinook populations, but the range of allowable harvest rates remained the same, – 5.5 to 17%. But for this technical adjustment made in 2005, the current abundance based harvest rate schedule has been in place since 2001.

Snake River, Upper Columbia, Middle Columbia & Lower Columbia River Steelhead

Steelhead returning to the Columbia Basin have both winter and summer-run return timing. Winter steelhead generally enter freshwater from November through May and spawn from March through June. The returns of wild winter steelhead generally peak in March and April, while hatchery fish dominate during the earlier portion of the run. Winter steelhead primarily return to rivers below Bonneville Dam, but there are a few winter-run populations that return to rivers in the Bonneville pool. Most of the Lower Columbia River (LCR) steelhead populations have winter timing. Summer run steelhead returning to the Kalama, Lewis, and Washougal rivers from the Cascade Summer MPG, and Wind and Hood Rivers form the George summer MPG are part of the LCR steelhead DPS. Winter-run populations returning to the Klickitat and Fifteenmile Creek watersheds (Cascades Eastern Slope MPG) are part of the Middle Columbia River (MCR) steelhead DPS.

Summer steelhead enter the Columbia Basin from April through October and return to tributaries from the area below Bonneville Dam to the upper reaches of the SR and upper Columbia River. There are three identifiable stocks of summer steelhead that are used for management purposes. They include: Skamania, A-run, and B-run stocks. Skamania steelhead are a “lower river” summer stock.[9] A-run and B-run steelhead are “upriver” summer stocks, meaning they return to areas in the Upper Columbia River, Snake River, and Middle Columbia between Bonneville and McNary Dams. Most populations from MCR DPSs have summer timing. All SR and UCR populations are summer-run steelhead. Skamania steelhead have an earlier return timing than upriver steelhead with peak returns in May and June.

Hatchery fish of the Skamania stock return to tributaries in the Bonneville pool including the Big White Salmon, Hood River, and Klickitat. Summer steelhead caught in the lower Columbia River below Bonneville Dam from March through June are classified as Skamania steelhead. Summer steelhead that cross Bonneville Dam from April 1 through June 31 are also classified as Skamania stock. Steelhead crossing Bonneville Dam beginning July 1 are considered upriver summer steelhead.

Upriver steelhead are separated into A-run and B-run stocks. A-run steelhead typically return earlier than B-run steelhead, are smaller, and return primarily after one year in the ocean. Conversely, B-run steelhead return later, are larger, and return primarily after 2 years in the ocean. A-run and B-run steelhead are distinguished, for management purposes, based on fork length with A-run steelhead < 78 cm and B-run steelhead ≥ 78 cm. Hatchery fish are distinguished from wild fish primarily by the adipose fin clip used to mark hatchery reared steelhead. B-run steelhead generally are subject to higher harvest rates, particularly in fisheries above Bonneville Dam, because they are larger, and thus more susceptible to catch in gillnets, and because their run timing coincides with the timing of the fall season fisheries targeting Chinook.

All populations that are designated as B-run steelhead return to the Snake River, although some fish ≥ 78 cm return to other areas. This means that not all fish ≥ 78 cm are B-run steelhead. Some of the SR steelhead populations are also A-run steelhead. All of the populations in the Upper

[9] “Skamania” steelhead is a stock designation used by harvest managers that refers to summer steelhead populations in the LCR DPS. There is also Skamania hatchery stock that was derived from populations in the LCR and MCR DPSs, and used broadly for hatchery production throughout the basin. The Skamania hatchery stock is not listed as part of any DPS. In this biological opinion Skamania steelhead are used as an indicator for LCR summer steelhead populations

Columbia River DPS and most of the populations in the Middle Columbia River DPS are designated as A-run steelhead. Additionally, as indicated above, there are a few winter run populations in the MCR steelhead DPS.

Due to the complexity of the life history, as well as the fact that populations from the various DPSs intermingle, it is difficult to measure harvest impacts on mixed stock fisheries that are specific to each DPS or population. Instead, fisheries are managed using stocks, including: winter and summer; and among summer steelhead, lower river Skamania and upriver A-run and B-run stocks. As a result, it is assumed, for example, that all A-run populations are intermingled and subject to the same level of harvest in mixed stock fisheries. There may in fact be some differential impacts to components of the A-run stock complex or other stock complexes, but the information necessary to assess possible differences is not currently available.

Commercial harvest of steelhead in non-Treaty fisheries has been prohibited since 1975. From 1938 through the mid-1960s, the commercial catch of steelhead ranged from 100,000 to nearly 300,000 steelhead per year. From the mid-1960s until the non-Treaty commercial fisheries were closed, the catch of steelhead was approximately 50,000 fish per year (WDFW and ODFW 2002). These essentially were all wild fish since hatchery production of steelhead was still relatively limited at the time.

Since 1986, recreational anglers in the Columbia Basin have been required to release unmarked, wild steelhead. Wild steelhead are still subject to mortality associated with catch-and-release, but implementation of mark-selective fisheries has greatly reduced the impact to wild steelhead from recreational fisheries.

Beginning in 1988, the Columbia River Fish Management Plan (referred to as the CRFMP or Plan as stated above), developed under the jurisdiction of *U.S. v. Oregon*, provided a framework for managing the mainstem fisheries that impacted steelhead. The Plan limited tribal fishery impacts during the fall season management period to 15% for A-run steelhead, and 32% for B-run steelhead. Although the CRFMP was not formally completed until 1988, fisheries were managed subject to these harvest rate limits as of 1986.

After the ESA listing of SR fall Chinook in 1992, fall fisheries, where most of the steelhead impacts occur, were subject to further constraints in order to reduce the impacts to SR fall Chinook salmon. While the CRFMP limited tribal fishery impacts during the fall season management period to 15% for A-run and 32% for B-run steelhead, the constraints to reduce impacts to SR fall Chinook resulted in reductions in the incidental catch of steelhead.

Snake River Steelhead and Upper Columbia River Steelhead were ESA listed in August 1997. Fall fisheries managed under *U.S. v. Oregon* were reviewed first through ESA consultation in late 1997 and in more detail in 1998. These consultations addressed the incidental impacts on listed steelhead. Beginning in 1998, non-Treaty fall season fisheries were subject to a DPS-specific harvest rate limit of 2%, a provision that applied to the SR steelhead DPS and the MCR steelhead DPS that were later listed in 1999. Similarly, beginning in 1998, treaty-Indian fall season fisheries were subject to a harvest rate limit of 15% for B-run steelhead; a reduction from the prior 32% limit in the CRFMP. This further limitation on B-run steelhead indirectly reduced the impacts to A-run steelhead as well. Additionally, non-Treaty winter, spring and summer season fisheries were subject to a harvest rate limit of 2% for all winter-run populations; a limit that applies to LCR steelhead, UWR steelhead, and the winter-run populations of the MCR steelhead DPSs.

Most of the take of A-run steelhead in *U.S. v. Oregon* fisheries occurs in the fall season. There are some impacts to A-run steelhead in treaty-Indian spring and summer season fisheries, which extend through July 31. The harvest rate for tribal spring and summer season fisheries has averaged 0.2% and 2.2%, respectively (Table 5.6.1-1) (TAC 2008). The yearly total incidental catch of A-run steelhead in tribal fisheries has averaged 6.4% and has ranged from 4.1-12.4% since 1998 (Table 5.6.1-1) (TAC 2008). The harvest rate for non-Indian spring and summer season fisheries has averaged 0.3% and 0.4%, respectively (Table 5.6.1-1). The total yearly incidental catch of A-run steelhead in non-Indian fisheries has averaged 1.6% and has ranged from 1.0 to 1.9% since 1999 (Table 5.6.1-1). The impacts to A-run steelhead from non-Indian fisheries are expected to be similar over the course of this Agreement (TAC 2008). A-run steelhead from the SR DPS have benefited from the protections provided to B-run steelhead.

It is assumed that the harvest rate estimated for A-run steelhead applies to the A-run populations of the SR steelhead DPS. There may in fact be some differential harvest impacts to various components of the A-run stock complex, but as indicated above, the information necessary to assess possible differences is not currently available.

The incidental take of B-run steelhead from non-Treaty fisheries has averaged 1.4% of the run since 1998, and has ranged from 1.1 to 2.0% (Table 5.6.1-2).The treaty-Indian fall season fisheries impacts for B-run Steelhead have averaged 17.9% from 1990 to 2003, and 12.2% from 1998 to 2006 (Table 5.6.1-2). This further limitation on B-run steelhead indirectly reduced the impacts to A-run steelhead from treaty-Indian fisheries as well.

The yearly incidental catch of winter-run steelhead populations in non-Indian fisheries has averaged 1.9% and has ranged from 0.2-9.3% since 2001 (Table 5.6.1-3). The high harvest rate observed in 2002 (i.e. 9.3%) was due to a lack of proper in-season management guidelines. These guidelines subsequently corrected in 2003 and have been in place since this time. The yearly incidental take of winter-run steelhead populations in tribal fisheries, which is limited to winter populations above Bonneville Dam, has averaged 2.2% and has ranged from 0.8-5.8% since 2001 (Table 5.6.1-4). Winter-run steelhead above Bonneville Dam can be part of the LCR and MCR steelhead DPSs. It is assumed that harvest impacts on winter populations above Bonneville Dam are proportioned equally among populations of the two affected DPSs.

Treaty Indian fisheries in some or all of the following tributaries also occur throughout the year: Wind, Little White Salmon (Drano Lake), Hood, White Salmon, Klickitat, Deschutes, Umatilla, Walla Walla, and Yakima Rivers as well as in Icicle Creek (tributary to the Wenatchee). These fisheries target primarily non-ESA-listed spring Chinook, fall Chinook, and coho salmon, and well as hatchery-reared steelhead. Table 5.6.1-6 lists the fisheries by tributary, the average number of natural-origin steelhead harvested by fishery and the affected DPS (TAC 2008). Fisheries in Drano Lake and the Big White Salmon River may also incidentally harvest ESA-listed B-run steelhead, but these would be included in the overall impact limit of Table 5.5.1-2.

The yearly incidental catch of summer-run steelhead populations of the LCR steelhead ESU in non-Indian fisheries has averaged 0.3% and has ranged from 0.2-0.5% since 1999 (Table 5.6.1-5). The yearly incidental take of summer-run steelhead populations of the LCR steelhead ESU in tribal fisheries, which is limited to LCR summer-run populations above Bonneville Dam, is assumed to be the same than for A-run summer steelhead, and has ranged from 4.1 to 12.8 with an average of 6.4% (Table 5.6.1-1).

Table 5.6.1-1. Harvest rates of A-run steelhead in spring, summer, and fall season fisheries expressed as a proportion of the Skamania and A-run steelhead run size (TAC 2008).

Year	Treaty Indian				Non-Indian			
	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
1985	0.20%	NA	19.40%	19.50%				
1986	0.10%	NA	12.60%	12.70%				
1987	0.10%	NA	14.70%	14.80%				
1988	0.20%	NA	16.10%	16.20%				
1989	0.00%	4.00%	14.90%	18.90%				
1990	0.40%	3.50%	14.10%	18.00%				
1991	0.20%	1.90%	14.40%	16.40%				
1992	0.50%	2.00%	15.20%	17.60%				
1993	0.10%	1.40%	14.60%	16.20%				
1994	0.20%	1.10%	9.70%	10.90%				
1995	0.10%	2.20%	10.00%	12.20%				
1996	0.70%	2.30%	8.40%	11.40%				
1997	0.10%	2.70%	10.10%	12.80%				
1998	0.10%	3.80%	8.40%	12.40%				
1999	0.10%	2.10%	5.20%	7.40%	0.10%	0.30%	0.60%	1.00%
2000	0.10%	1.00%	4.00%	5.10%	0.10%	0.60%	1.00%	1.70%

Year	Treaty Indian				Non-Indian			
	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
2001	0.10%	2.10%	3.80%	6.00%	0.10%	0.40%	0.60%	1.10%
2002	0.10%	2.10%	2.40%	4.70%	0.40%	0.40%	0.80%	1.60%
2003	0.10%	2.80%	2.50%	5.40%	0.60%	0.30%	1.00%	1.90%
2004	0.10%	3.90%	3.00%	7.00%	0.40%	0.40%	1.00%	1.80%
2005	0.10%	2.30%	3.60%	5.90%	0.40%	0.40%	0.90%	1.70%
2006	0.20%	0.80%	5.00%	6.00%	0.30%	0.40%	1.20%	1.90%
2007	0.10%	0.50%	3.50%	4.10%	0.30%	0.30%	0.80%	1.40%
1985-07 average	0.2%	2.2%	9.4%	11.4%				
1989-07 average	0.2%	2.2%	8.0%	10.4%				
1998-07 average	0.1%	2.1%	4.1%	6.4%	0.3%	0.4%	0.9%	1.6%

Table 5.6.1-2. Harvest rates of B-run steelhead in treaty Indian fisheries and non-Treaty fisheries expressed as a proportion of the B-run index steelhead run size (TAC 2008).

Return Year	Non-Indian Harvest Rates (%)	Treaty-Indian Harvest Rates (%)	Total Harvest Rates (%)
1985	2.0%	30.4%	32.4%
1986	2.0%	26.2%	28.2%
1987	2.0%	36.5%	38.5%
1988	2.0%	23.0%	25.0%
1989	2.0%	34.3%	36.3%
1990	2.0%	21.1%	23.1%
1991	2.0%	29.4%	31.4%
1992	2.0%	25.8%	27.8%
1993	2.0%	18.7%	20.7%
1994	2.0%	18.2%	20.2%
1995	2.0%	18.3%	20.3%

Return Year	Non-Indian Harvest Rates (%)	Treaty-Indian Harvest Rates (%)	Total Harvest Rates (%)
1996	2.0%	33.9%	35.9%
1997	2.0%	14.0%	16.0%
1998	2.0%	15.3%	17.3%
1999	1.0%	12.4%	13.4%
2000	1.4%	14.1%	15.5%
2001	1.1%	11.3%	12.4%
2002	1.1%	3.3%	4.4%
2003	1.8%	14.6%	16.4%
2004	1.2%	11.1%	12.3%
2005	1.3%	12.0%	13.3%
2006	1.3%	15.6%	16.9%
Average 1885-2006	1.7%	20.0%	21.7%
Average 1990-2003	1.7%	17.9%	19.6%
Average 1998-2006	1.4%	12.2%	13.5%

Table 5.6.1-3. Non-Indian harvest rates of winter-run steelhead expressed as a proportion of the total winter-run steelhead run size (TAC 2008).

Year	Non-Indian
2001	0.6%
2002	9.3%
2003	1.0%
2004	0.9%
2005	0.6%
2006	0.2%
2007	0.6%
Average 2001-2007	1.91%

Table 5.6.1-4. Treaty Indian harvest rates of winter-run steelhead expressed as a proportion of the unmarked winter-run steelhead counts at Bonneville Dam in the winter season (TAC 2008).

Year	Treaty Indian
2001	3.40%
2002	0.30%
2003	5.80%
2004	0.80%
2005	0.80%
2006	1.80%
2007	2.30%
Average 2001-2007	2.17%

Table 5.6.1-5. Non-Indian harvest rates for summer-run populations of the LCR steelhead DPS (TAC 2008).

Year	Non-Indian
1998	
1999	0.5%
2000	0.4%
2001	0.3%
2002	0.4%
2003	0.4%
2004	0.2%
2005	0.3%
2006	0.3%
2007	0.3%

Table 5.6.1-6. Expected average incidental take of natural-origin steelhead associated with prospective tribal tributary fisheries (TAC 2008).

Fishery	Upper Columbia DPS	Snake River A-run	Snake River B-run	Mid-Columbia DPS	Lower Columbia DPS	Upper Willamette DPS	Total natural-origin
Tributary Total	46	19		285	31	0	355
Willamette River	0	0	0	0	0	0	0
Wind River Summer	0	0	0	0	4	0	4
Wind River Winter					1		
Drano/LWS Spring [1]	1	1	0	1	2	0	5
Drano/LWS Fall [2]	17	17	5	19	17	0	75
White Salmon River [1]	1	1	0	1	2	0	5
Hood River Summer	0	0	0	0	5	0	5
Hood River Winter				5			
Klickitat River Summer [3]	0	0	0	180	0	0	180
Klickitat River Winter				10			
Deschutes River [4]	0	0	0	40	0	0	30
John Day River	0	0	0	5	0	0	5
Umatilla River	0	0	0	10	0	0	10
Walla Walla River	0	0	0	5	0	0	0
Yakima River	0	0	0	9	0	0	9
Icicle River	27	0	0	0	0	0	27
Total by DPS	46	19	5	285	31	0	355
Total Summer By DPS	46	19	5	270	30		370
Total Winter By DPS				15	1		16

Notes:
[1] Based on CWT recoveries in Non-treaty fisheries steelhead caught in Drano and White Salmon may be from any DPS.
[2] Based on CWT recoveries in Non-treaty fisheries steelhead caught in Drano and White Salmon may be from any DPS. Impacts to B-Index steelhead in fall season Drano fisheries are counted with mainstem impacts.
[3] Based on 1986-2006 average from Klickitat Master Plan.
[4] May include some "dip-in" fish from other populations. Estimate for the Deschutes fishery is a maximum, a

Fishery	Upper Columbia DPS	Snake River A-run	Snake River B-run	Mid-Columbia DPS	Lower Columbia DPS	Upper Willamette DPS	Total natural-origin
release mortality of 0-40 wild fish is anticipated.							

Lower Columbia River Chinook

Tables 5.6.1-7, 5.6.1-8 and 5.6.1-9 provide estimates of historic harvest impacts and their distribution across fisheries for spring, bright, and tule populations in the Lower Columbia River Chinook ESU. Exploitation rates were for Cowlitz spring Chinook population (as a surrogate for all spring Chinook populations of the LCR Chinook ESU) generally higher prior to the mid 1990s, averaging 50% through 1994 (Table 5.6.1-7). Total exploitation rates have averaged approximately 27% since 1995 (Table 5.6.1-7). The average exploitation rates for non-Indian fisheries in the Columbia River for these same periods were 27% and 12% respectively (Table 5.6.1-7).

Table 5.6.1-7. Total adult equivalent exploitation rates for the Cowlitz spring Chinook population (as an example of exploitation rates for LCR spring Chinook) (Simmons 2008).

Year	Total Exploitation Rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian	Indian
			WCVI	Other Canada	PFMC	PgtSd	Exp Rate	Exp Rate
1980	52%	2%	5%	4%	17%	0%	24%	0%
1981	48%	3%	5%	4%	17%	0%	20%	0%
1982	55%	2%	5%	3%	15%	0%	30%	0%
1983	57%	2%	9%	5%	9%	0%	32%	0%
1984	54%	2%	11%	5%	4%	0%	31%	0%
1985	43%	1%	5%	3%	8%	0%	25%	0%
1986	52%	1%	5%	3%	12%	0%	31%	0%
1987	45%	1%	5%	3%	11%	0%	25%	0%
1988	49%	1%	5%	2%	16%	0%	26%	0%
1989	50%	1%	3%	3%	19%	0%	25%	0%
1990	57%	1%	5%	2%	23%	0%	26%	0%
1991	54%	1%	4%	3%	14%	0%	32%	0%
1992	46%	1%	5%	3%	19%	0%	19%	0%
1993	48%	1%	5%	3%	15%	0%	25%	0%
1994	45%	1%	4%	3%	3%	0%	35%	0%
1995	10%	1%	2%	1%	4%	0%	1%	0%

Year	Total Exploitation Rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian	Indian
			WCVI	Other Canada	PFMC	PgtSd	Exp Rate	Exp Rate
1996	11%	1%	0%	0%	7%	0%	2%	0%
1997	16%	1%	1%	2%	5%	0%	7%	0%
1998	12%	1%	0%	2%	9%	0%	0%	0%
1999	38%	1%	1%	1%	15%	0%	20%	0%
2000	38%	1%	3%	1%	9%	0%	25%	0%
2001	21%	1%	2%	1%	7%	0%	10%	0%
2002	43%	1%	2%	2%	13%	0%	24%	0%
2003	34%	1%	3%	2%	13%	0%	16%	0%
2004	31%	1%	3%	2%	13%	0%	11%	0%
2005	36%	1%	4%	2%	17%	0%	11%	0%
2006	34%	1%	4%	3%	16%	0%	11%	0%

Table 5.6.1-8 provides estimates of harvest estimates to the North Fork Lewis bright Chinook population (as a surrogate for all “bright” Chinook populations of the LCR Chinook ESU). Total exploitation rates were generally higher through 1989 (averaging 56%), declining during the decade of the 1990s (averaging 36%), and increased slightly since 2000 (averaging 38%) (Table 5.6.1-8). The average exploitation rates for non-Indian fisheries in the Columbia River for these same periods were 25%, 14% and 16% respectively (Table 5.6.1-8).

Table 5.6.1-8. Total adult equivalent exploitation rate for the North Fork Lewis bright Chinook population (Simmons 2008).

Year	Total exploitation rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian Exp Rate	Indian Exp Rate
			WCVI	Other Canada	PFMC	PgtSd		
1979	64%	9%	8%	6%	9%	2%	29%	0%
1980	68%	11%	8%	7%	8%	2%	33%	0%
1981	39%	11%	6%	6%	6%	2%	7%	0%
1982	43%	9%	6%	6%	8%	2%	12%	0%
1983	42%	10%	11%	6%	4%	3%	8%	0%
1984	58%	10%	15%	7%	2%	2%	22%	0%
1985	54%	6%	7%	6%	5%	3%	27%	0%

Year	Total exploitation rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian Exp Rate	Indian Exp Rate
			WCVI	Other Canada	PFMC	PgtSd		
1986	64%	5%	8%	6%	6%	4%	35%	0%
1987	65%	5%	8%	5%	5%	3%	39%	0%
1988	68%	6%	10%	5%	7%	3%	38%	0%
1989	44%	7%	3%	4%	4%	1%	24%	0%
1990	38%	8%	6%	4%	7%	2%	12%	0%
1991	57%	7%	5%	5%	5%	2%	33%	0%
1992	57%	7%	9%	6%	7%	3%	25%	0%
1993	51%	7%	6%	4%	7%	3%	25%	0%
1994	38%	7%	11%	9%	1%	3%	7%	0%
1995	36%	7%	3%	2%	1%	1%	22%	0%
1996	16%	7%	0%	0%	2%	2%	3%	0%
1997	25%	11%	2%	3%	2%	2%	7%	0%
1998	23%	11%	0%	2%	1%	1%	8%	0%
1999	19%	6%	1%	2%	7%	2%	0%	0%
2000	24%	6%	5%	1%	5%	2%	5%	0%
2001	31%	7%	4%	1%	6%	3%	11%	0%
2002	41%	9%	3%	3%	7%	3%	15%	0%
2003	50%	11%	3%	4%	5%	2%	24%	0%
2004	40%	9%	2%	2%	3%	1%	22%	0%
2005	50%	8%	6%	5%	8%	3%	20%	0%
2006	32%	10%	2%	3%	3%	1%	13%	0%

Table 5.6.1-9 provides estimates of harvest impacts for tule Chinook populations based on an aggregate of coded wire tag indicator stocks. Total exploitation rates were generally higher through 1993 (averaging 69%), lower from 1994 to 1999 (averaging 34%), then increasing since 2000 (averaging 49%) (Table 5.6.1-9). From 2002 to 2006 fisheries were managed subject to a 49% exploitation rate limit. Total exploitation rates have been higher in some years but have averaged 49% from 2002 to 2006 (Table 5.6.1-9). The average exploitation rates for non-Indian fisheries in the Columbia River for these same periods were 16%, 8% and 9% respectively (Table 5.6.1-9).

Table 5.6.1-9. Total adult equivalent exploitation rates for LCR tule populations (Simmons 2008).

Year	Ocean					Columbia River	
	Total Exp. Rate	SEAK Exp. Rate	Canada Exp. Rate	PFMC Exp. Rate	Pgt Snd Exp. Rate	Non-Treaty Exp. Rate	Treaty Exp. Rate
1983	69%	4%	34%	21%	3%	7%	0%
1984	70%	4%	40%	6%	3%	16%	1%
1985	66%	4%	35%	16%	3%	9%	0%
1986	82%	3%	38%	15%	4%	22%	0%
1987	82%	2%	27%	20%	4%	28%	0%
1988	81%	3%	25%	15%	2%	36%	0%
1989	59%	4%	19%	10%	3%	23%	0%
1990	60%	4%	26%	19%	3%	9%	0%
1991	63%	3%	28%	15%	4%	12%	0%
1992	65%	3%	31%	21%	4%	8%	0%
1993	61%	3%	27%	18%	3%	9%	0%
1994	33%	4%	26%	2%	1%	0%	0%
1995	36%	4%	21%	6%	2%	3%	1%
1996	26%	3%	4%	7%	1%	9%	0%
1997	35%	5%	12%	7%	2%	10%	0%
1998	33%	4%	13%	6%	0%	9%	0%
1999	42%	3%	10%	13%	0%	15%	0%
2000	48%	4%	23%	9%	0%	13%	0%
2001	51%	2%	29%	12%	0%	7%	0%
2002	51%	3%	24%	14%	0%	9%	0%
2003	47%	4%	21%	10%	0%	12%	0%
2004	45%	4%	25%	9%	0%	7%	0%
2005	51%	4%	28%	11%	0%	7%	0%
2006	51%	4%	28%	12%	0%	7%	0%

Lower Columbia River Coho

Table 5.6.1-9 includes the available information on exploitation rates of Lower Columbia River coho in ocean and freshwater fisheries. Previously, Oregon Coast Natural coho were used as a surrogate for estimating ocean fisheries impacts to Lower Columbia River coho. In 2006, largely as a consequence of increased attention resulting from its listing, the methods for assessing harvest in ocean fisheries were changed so that these were more specific to natural-origin Lower Columbia River coho.

Until 1993 the exploitation rates in salmon fisheries on Lower Columbia River coho have been very high, contributing to their decline (Table 5.6.1-10). The combined ocean and in-river exploitation rates for Lower Columbia River coho averaged 91% through 1983, averaged 68% from 1984-1993, and decreased to an average of 17% from 1994-2007.

Table 5.6.1-10. Estimated Ocean (all marine area fisheries) and Inriver Exploitation Rates on Lower Columbia River Natural Coho, 1970-2006.

Year	Ocean Exploitation Rate	Inriver Exploitation Rate	Total Exploitation Rate
1970	65.2%	28.4%	93.6%
1971	82.5%	9.9%	92.4%
1972	84.3%	8.6%	92.9%
1973	81.9%	11.2%	93.1%
1974	83.5%	9.2%	92.7%
1975	81.4%	10.1%	91.5%
1976	89.9%	5.5%	95.4%
1977	88.8%	5.3%	94.1%
1978	82.5%	7.9%	90.4%
1979	79.4%	9.5%	88.9%
1980	73.1%	24.5%	97.6%
1981	81.1%	6.8%	87.9%
1982	61.6%	20.8%	82.4%
1983	78.7%	3.9%	82.6%
1984	31.9%	27.0%	58.9%
1985	43.2%	22.3%	65.5%
1986	33.5%	39.7%	73.2%
1987	59.5%	19.4%	78.9%
1988	56.4%	20.3%	76.7%
1989	55.3%	22.7%	78.0%
1990	68.9%	7.5%	76.4%
1991	45.4%	19.1%	64.5%
1992	50.9%	8.7%	59.6%

Year	Ocean Exploitation Rate	Inriver Exploitation Rate	Total Exploitation Rate
1993	42.3%	10.5%	52.8%
1994	7.0%	3.5%	10.5%
1995	12.0%	0.3%	12.3%
1996	8.0%	4.4%	12.4%
1997	12.0%	1.6%	13.6%
1998	8.0%	0.2%	8.2%
1999	9.0%	18.5%	27.5%
2000	7.0%	17.5%	24.5%
2001	7.0%	6.4%	13.4%
2002	12.0%	2.1%	14.1%
2003	14.0%	8.9%	22.9%
2004	15.0%	9.3%	24.3%
2005	11.0%	6.5%	17.5%
2006	6.8%	6.5%	13.3%
2007	11.9%	6.7%	18.6%

Columbia River Chum

Columbia River (CR) chum salmon are not caught in tribal fisheries above Bonneville Dam. CR chum are caught occasionally in non-Indian fall season fisheries below Bonneville. There are no fisheries in the Columbia River that target hatchery or natural-origin chum. The later fall return timing of chum is such that they are vulnerable to relatively little potential harvest in fisheries that target primarily Chinook and coho. CR chum rarely take the kinds of sport gear that is used to target other species.

Harvest rates are difficult to estimate since NOAA Fisheries does not have good estimates of total run size. However, the incidental catch of chum amounts to a few tens of fish per year. The harvest rate in proposed state fisheries in the lower river is estimated to be 1.6% per year and is almost certainly less than 5%.

5.7 Large-scale Environmental Variation

Salmonid population abundance is substantially affected by inter-annual changes in the freshwater and marine environments, particularly by conditions early in their life histories. Generally, the inland environment (including rivers, tributaries, and the associated uplands) is most favorable to salmon when there is a cold, wet winter, leading to substantial snowpack. This normally results in higher levels of runoff during spring and early summer, when many of the juvenile salmon are migrating to the ocean. The higher levels of runoff are associated with lower water temperatures, greater turbidity, and higher velocity in the river, all of which are beneficial to juvenile salmon. However, severe flooding may constrain populations. The low return of Lewis River bright fall Chinook salmon in 1999, for example, has been attributed to flood events during 1995 and 1996.

Within the ocean environment, near-shore upwelling, which brings nutrients up from depth into the photic zone, is a key determinant of ocean productivity as it affects the availability of food for juvenile salmon at the critical point when they first enter the ocean. The upwelling results from ocean currents that appear to be driven by spring and early summer winds which, in turn, result from oscillations in the jet stream that follow certain cycles. Within a year, there are cycles of 20-40 days that affect upwelling, and among years there are longer-lasting conditions, such as El Nino/La Nina cycles of 2-3 years and the Pacific Decadal Oscillation (PDO) which may have cycles of 30-40 years or more that influence upwelling.

Scheuerell and Williams (2005) showed that the coastal upwelling index is a strong determinant of year-class strength and subsequent smolt-to-adult return ratios. The Northwest Fisheries Science Center currently monitors a number of ocean conditions and provides a forecast on their website for salmon returns to the Columbia River based on these and other observations.

In some instances, the inland conditions and ocean conditions appear to be correlated; that is, the same weather patterns producing a cold, wet winter with good snowpack and high spring runoff are also likely to bring the later winds that yield good upwelling and favorable feeding conditions in the ocean. However, it is also possible for inland and ocean conditions to diverge, and years have been observed where there have been favorable river conditions but poor ocean conditions, and vice versa.

While strong salmon runs are a product of both good in-river conditions and good ocean conditions, favorable ocean conditions appear to be especially important. For example, 2001 was the second-lowest flow year recorded on the Columbia River, but the near-shore temperatures were generally cool, observed ocean productivity was good, and resulting adult returns from the 2001 juvenile outmigration class were in the average or better range for most of the runs.

This section discusses inter-annual climatic variations (e.g. El Niño and La Niña), longer term cycles in ocean conditions pertinent to salmon survival (e.g. Pacific Decadal Oscillation), and ongoing global climate change and its implications for both oceanic and inland habitats and fish survivals. Because these phenomena have the potential to affect salmonids survival over their entire range and multiple life stages, they are an area of substantial scientific investigation.

5.7.1 The Southern Oscillation Index, El Niño & La Niña

In an effort to predict the likely strength of the annual monsoons over India, which greatly affected human life through floods and famines, in the 1920s Sir Gilbert Walker conducted extensive statistical analyses of long-term weather observations for many locations around the globe. Among his many findings was that deviations from long-term average seasonal differences in atmospheric pressure between the western Pacific and the eastern Pacific (typically Darwin, Australia to Tahiti), correlated strongly with subsequent climatic conditions in other parts of the globe. Walker termed these deviations, the "Southern Oscillation Index" (SOI). In general, substantial negative SOIs tend to correlate well with above average tropical sea-surface temperatures and positive SOIs tend to correlate with below average sea-surface temperatures, particularly in the eastern Pacific. Both have been found to have "teleconnections" to climatic and oceanic conditions in regions far distant from the south Pacific, including the Pacific Northwest. Although in modern usage a broader array of oceanic and atmospheric characteristics have been found to provide greater predictive power, these teleconnections between conditions in the south Pacific and subsequent climatic conditions elsewhere have come into routine use, including pre-season predictions of runoff in some portions of the Columbia basin.

Atmospheric conditions correlated with unseasonably warm south Pacific sea-surface temperatures are termed El Niños. El Niños typically last 6 to 18 months. Among the consequences are warmer near-surface ocean water temperatures along the U.S. west coast and generally warmer, drier weather in the inland Pacific Northwest, particularly during the winter. When winds do not blow south, the forces that create upwelling off the U.S. coast are reduced, as are nutrient inputs to the euphotic zone (well lit, near surface zone), reducing near-shore ocean productivity. This reduction in ocean productivity has been shown to reduce juvenile salmon growth and survival (Scheurell and Williams 2005). Warmer surface waters can also change the spatial distribution of marine fishes with potential predator-prey effects on salmon.

The warmer, drier weather in the Pacific Northwest often associated with El Niño can also cause or increase the severity of regional droughts. Droughts reduce streamflows through the Columbia and Snake River migratory corridor, increase water temperatures, and reduce the extent of suitable habitat in some drainages. Each of these physical effects has been shown to reduce salmon survival. Thus, El Niño events are associated with poor returns of salmon and steelhead.

Unseasonably cool south Pacific sea surface temperatures, typically associated with a positive SOI, tend to have quite different effects in the north Pacific and the Columbia basin. Termed La Niña, positive SOIs tend to be associated with cooler north Pacific surface water temperatures, and cooler, wetter fall and winter conditions inland. Conditions associated with La Niña tend to increase snowpack and runoff in the Columbia basin, improving outmigration conditions, and ocean conditions tend to be more conducive for coastal upwelling early in the spring, providing better feeding conditions for young salmon.

Currently, NOAA Physical Sciences Division calculates a "Multivariate El Niño Southern Oscillation Index" or MEI, which effectively inverts the SOI relationships: a positive MEI indicates El Niño conditions and a negative MEI a La Niña. Once established, El Niño and La Niña conditions tend to persist for a few months to two years although prevalent El Niño conditions have dominated the Pacific since 1977 and persisted from 1990 through 1995 (Figure 5.7.1-1 below). It is likely that the dominance of El Niño conditions since the late 1970s has contributed to the depressed status of many stocks of anadromous fish in the PNW.

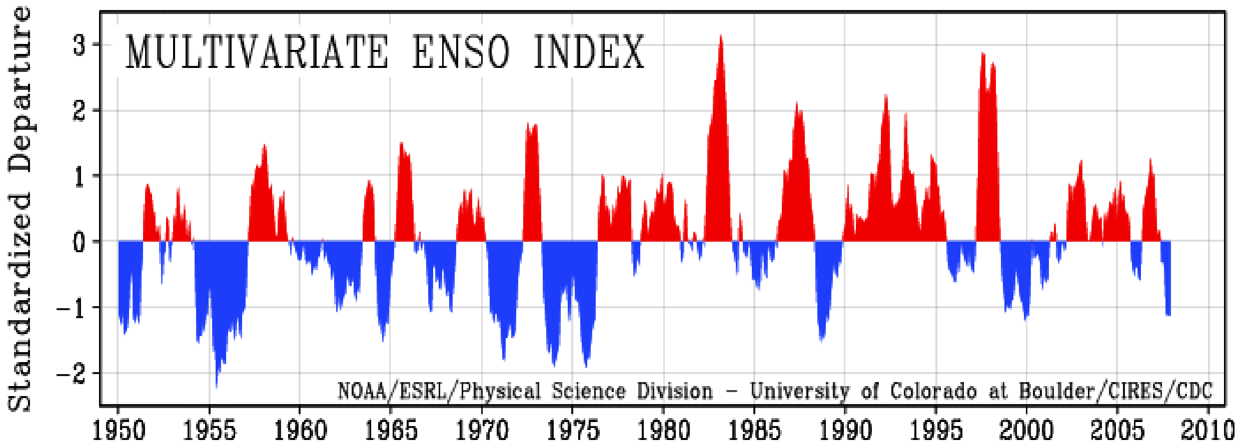


Figure 5.7.1-1. Time-series of MEI conditions from 1950 through November 2007. Source: NOAA 2008

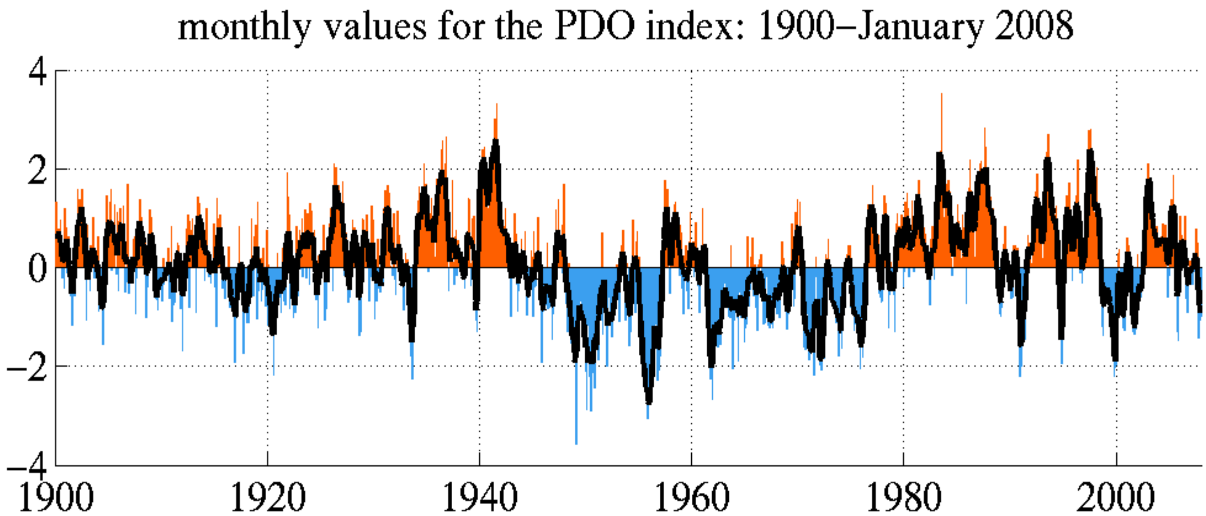
5.7.2 PDO

First defined by Steven Hare in 1996, the Pacific Decadal Oscillation (PDO) index is the leading principal component (a statistical term) of North Pacific sea surface temperature variability (poleward of 20° N to the 1900-1993 period (Mantua et al. 1997).

Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cool PDO eras have seen the opposite north-south pattern of marine ecosystem productivity (e.g., Hare et al. 1999). Thus, smolt-to-adult return ratios for Columbia basin salmon tend to be high when the PDO is in a cool phase and low when the PDO is in a warm phase.

Two main characteristics distinguish the PDO from El Niño: first, 20th century PDO "events" persisted for 20-to-30 years, while typical El Niño events persisted for 6 to 18 months; second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics – the opposite is true for El Niño. Several independent studies find evidence for just two full PDO cycles in the past century: "cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid-1990s (Figure 5.7.2-1). Shoshiro Minobe (1997) has shown that 20th century PDO fluctuations were most energetic in two general periods, one from 15 to 25 years, and the other from 50 to 70 years.

Figure 5.7.2-1. Monthly Values for the PDO Index: 1900-January 2008.



Mantua and Hare (2002) state, "The physical mechanisms behind the PDO are not currently known." Likewise, the potential for predicting this climate oscillation is not known. Some climate simulation models produce PDO-like oscillations, although often for different reasons. Discovery of mechanisms giving rise to the PDO will determine whether skillful decades-long PDO climate predictions are possible. For example, if a PDO arises from air-sea interactions that require 10 year ocean adjustment times, then aspects of the phenomenon could, theoretically, be predictable at lead times of up to 10 years. Even in the absence of a theoretical understanding, PDO climate information improves season-to-season and year-to-year climate forecasts for North America because of its strong tendency for multi-season and multi-year persistence. From the perspective of societal impact, recognition of PDO is important because it shows that "normal" climate conditions can vary over time scales (decades) used to describe the length of a human's lifetime.

Recent evidence suggests that marine survival of salmonids fluctuates in response to the PDO's 20 to 30 year cycles of climatic conditions and ocean productivity (Cramer et al. 1999). Ocean conditions that affect the productivity of Northwest salmonid populations appear to have been in a low phase of the cycle for some time and to have been an important contributor to the decline of many stocks. The survival and recovery of these species will depend on their ability to persist through periods of unfavorable hydrologic and oceanographic conditions.

5.7.3 Global Climate Change

Ongoing global climate change has implications for the current and likely future status of anadromous fish in the Pacific Northwest. Recent studies, particularly by the Independent Scientific Advisory Board (ISAB),[10] describe the potential impacts of climate change in the

[10] ISAB (Independent Scientific Advisory Board). 2007c. Climate change impacts on Columbia River basin fish and wildlife. ISAB, Report 2007-2, Portland, Oregon.

Columbia River Basin. These effects, according to the ISAB, may alter precipitation and temperature levels in the basin and, in particular, impact the hydrosystem and habitat life-stages of Columbia Basin salmon and steelhead. In a basin reliant on cooler winter temperatures to store a spring/summer water supply in the snowpack, alterations to the precipitation and temperature levels may have the following physical impacts:

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, the snowpacks will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted earlier in the season, resulting in lower streamflows in the June through September period.
- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures will continue to rise, especially during the summer months when lower streamflow and warmer air temperatures will contribute to the warming regional waters.

Such responses to warming air temperatures and precipitation alterations will not be spatially homogeneous across the entire Columbia River Basin. Following anticipated air temperature increases, the distribution and duration of snowpack in those portions of the basin at elevations high enough to maintain temperatures well below freezing for most of the winter and early spring would be less affected. Low-lying areas that historically have received scant precipitation contribute little to total streamflow. This condition would also be relatively unaffected. The most noticeable changes will occur in the "transient snow" watersheds where the threshold between freezing and non-freezing temperatures is much more sensitive to warming (e.g. the Willamette Basin). Not only would changes in the distribution of precipitation between rain and snow affect the shape of the annual hydrograph and water temperature regimes, but more frequent and more severe rain on snow events could affect flood frequency with implications for scouring out incubating and young-of-the-year-fish (ISAB 2007c).

According to the ISAB report, it is anticipated that large-scale ecological changes will also occur over a 35 year time period. For example, the scale of insect infestations of forested lands and the frequency and intensity of forest fires are likely to become more prevalent during this time period as well. As reported by the ISAB (2007c), "fire frequency and intensity have already increased in the past 50 years, and especially the past 15 years, in the shrub steppe and forested regions of the West. Drought and hot, dry weather already have led to an increase in outbreaks of insects in the Columbia Basin, especially mountain pine beetle, and insect outbreaks are likely to become more common and widespread."[11] Such landscape changes have implications for salmon habitat and survival.

The ISAB (2007c) identified the following list of likely effects of projected climate changes on Columbia basin salmon:

- Anticipated water temperature increases, and the subsequent depletion of cold water habitat, could reduce the areal extent of suitable inland salmon habitats. O'Neal (2002, as cited in ISAB 2007c) assessed the potential impacts of climate warming on Pacific Northwest salmon habitat. Locations that were likely to experience an average weekly maximum temperature that exceeded the upper thermal tolerance limit for a species were considered to be lost habitat. Projected salmon habitat loss would be most severe in Oregon and Idaho with potential losses exceeding 40% of current by 2090. Loss of salmon habitat in Washington would be a less severe case of about 22% loss by 2090. O'Neal's approach assumed a high rate of greenhouse gas emissions and used a climate model that projected a 5 degree C in global temperatures by 2090, a value that is higher than the scenarios considered most likely (ISAB 2007c). This conservative estimate of potential habitat loss does not consider the associated impact of changing hydrology.

- Variations in intensity of precipitation may alter the seasonal hydrograph. With reduced snowpack and greater rainfall, the timing of stream flow will likely shift, depreciably reducing spring and summer stream flow, and increasing peak river flows (ISAB 2007c). This reduction in stream flow may impact the quality and quantity of tributary rearing habitat, greatly affecting spring and summer salmon and steelhead runs. In addition, the Pacific Northwest's low late-summer and early-fall stream flows are likely to be further reduced. Reduced late-summer and early-fall flows, in conjunction with rising water temperatures, are likely to adversely impact juvenile fall Chinook and chum salmon by depleting essential summer shallow mainstem rearing habitat.

- Considering both the water temperature and hydrologic effects of climate change, Crozier et al. (2008) showed that the abundance of four studied Snake River spring/summer Chinook populations would be substantially decreased (20-50% decline from simulated average abundance based on historical 1915-2002 climate) and extinction risks substantially increased by long-term exposure to climate conditions likely to exist in 2040. Hydrologic and physical changes in the Pacific Northwest environment have implications for the habitat, populations, and spatial distributions of Pacific salmonids (Zabel et al. 2006).

[11] Removal of trees from riparian areas by fire or insects will lead, at least temporarily, to an increase in solar radiation reaching the water and exacerbate the water temperature. The potential for climate-induced fire and insect outbreaks has the potential to disproportionately impact habitats of key importance to native fish and wildlife populations (ISAB 2007c).

- Eggs of fall and winter spawning fish, including Chinook, coho, chum, and sockeye salmon, may suffer higher levels of mortality when exposed to increased flood flows. Higher winter water temperatures also could accelerate embryo development and cause premature emergence of fry.

- Increases in seasonal mainstem Snake and Columbia River water temperature would accelerate the rate of egg development of fall Chinook that spawn in the mainstem of the Snake and Columbia rivers, and lead to earlier emergence at a smaller average size than historically. Also, dam and reservoir passage survival is affected by water temperatures with the lowest rates of survival typically occurring when water temperatures are warmest. Potential impacts of increased water temperatures on adult salmon include delay in dam passage, failure to enter fish ladders, increased fallback, and loss of energy reserves due to increased metabolic demand. Increases in mortality also may be caused by fish pathogens and parasites as these organisms often do not become injurious until their host becomes thermally stressed.

- Earlier snowmelt and earlier, higher spring flows, warmer temperatures, and a greater proportion of precipitation falling as rain rather than snow, may cause spring Chinook and steelhead yearlings to smolt and emigrate to the estuary and ocean earlier in the spring. The early emigration coupled with a projected delay in the onset of coastal upwelling could cause these fish to enter the ocean before foraging conditions are optimal. The first few weeks in the ocean are thought to be critical to the survival of salmon off Oregon and Washington, so a growing mismatch between smolt migrations and coastal upwelling would likely have significant negative impacts on early ocean survival rates.

- Within the Columbia estuary, increased sea levels in conjunction with higher winter river flows could cause the degradation of estuary habitats created by increasing wave damage during storms. Numerous warm-adapted fish species, including several non-indigenous species, normally found in freshwater have been reported from the estuary and might expand their populations with the warmer water and seasonal expansion of freshwater habitats. Climate change also may affect the trophic dynamics of the estuary due to upstream extension of the salt wedge in spring-early summer caused by reduced river flows. The landward head of the salt wedge is characterized by a turbulent region known as the estuary turbidity maximum, an area with high concentrations of fish food organisms such as harpacticoid copepods. Changes in the upstream extension of the salt wedge will influence the location of this zone, but it is difficult to forecast the effect this change will have on juvenile salmon.

- Scientific evidence strongly suggests that global climate change is already altering marine ecosystems from the tropics to polar seas. Physical changes associated with warming include increases in ocean temperature, increased stratification of the water column, and changes in the intensity and timing of coastal upwelling. These changes will alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migrations of salmonids.

- Changing ocean temperatures may alter salmon behavior, distribution, and migrations, increasing the distance to migrations from their home streams to ocean feeding areas. Energetic demands are increased at warmer temperatures, requiring increased consumption of prey to maintain a given growth rate. This could lead to intensified competition among species, as well as an increased reduction in growth rates, further exacerbating the prey/predator relationship. In addition, food availability in the ocean may be altered by climate change. Increasing concentrations of CO_2 in the oceans lowers pH, which reduces the availability of carbonate for shell-forming marine animals. Pteropods are expected to be negatively affected, and they can comprise up to 40% or more of the diet of some salmon species although another suitable prey item might replace them in the ecosystem. If salmon migrate farther to the north and/or food is less available, longer times may be required to reach maturity, delaying the usual times of adult migrations into coastal water and rivers.

- Global climate change in the Pacific Northwest may be similar to those experienced during past periods of strong El Niños and warm phases of the PDO.

The effects of climate change are considered both quantitatively and qualitatively in Chapter 7 of this document. In addition, the Biological Opinion explicitly considers actions which are consistent with the ISAB's mitigation recommendations (see ISAB recommendations in Chapter 8.1 for further detail). However, the time frame, and the scope of climate change is not clear. Many climate change predictions describe changes up to 100 years. For the ten year term of this Opinion, NOAA Fisheries employs conservative assumptions and sets the stage for mitigation actions should they become necessary.

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Chapter 6

Cumulative Effects

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Chapter 6 Cumulative Effects

As part of the Biological Opinion Collaboration process, the states of Oregon, Washington, and Idaho provided information on various ongoing and future or expected projects that NOAA Fisheries determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin (see lists of projects in Chapter 17 in Corps et al. 2007a). All of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[1] Examples of these projects specific to each species are given in the section on Cumulative Effects in each species chapter. They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve conditions for the species considered in this consultation. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of

[1] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects submitted as reasonably certain to occur.

these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

Chapter 7

Analytical Methods for Salmonids

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Chapter 7
Analytical Methods for Salmonids

These are the methods NOAA Fisheries used to detail how the Prospective Actions identified in Chapter 2 are likely to affect the thirteen listed species of salmon and steelhead of the Columbia River and the critical habitat designated for twelve of those species (please see Chapter 4 for further detail).

Ultimately the purpose of this analysis is to apply the jeopardy and critical habitat degradation standards of ESA § 7(a)(2) as discussed in § 1.7 of the FCRPS Biological Opinion, § 1.5 of the USBR Upper Snake Biological Opinion, and § 1.1 of the 2008-2017 *United States v. Oregon* Management Agreement Biological Opinion. The analysis in this SCA serves the application of those standards in the associated biological opinions. The results of the analysis described in this chapter are presented in Chapter 8 for each listed species of salmon or steelhead.

These species of anadromous fish have similar biological requirements and a hierarchical structure of populations and major population groups (MPGs) that make up the ESA-listed unit (either ESUs or, for steelhead, DPS') as detailed in Chapter 4 (See Figure 4.3-1 for example, and in Chapter 8 for each species). There are also important differences among these listed species that requires that NOAA Fisheries' analytical methods be tailored for the application of the ESA standards. The status of each species varies, the amount of relevant quantitative information available for each varies, and the extent to which the Prospective Actions are likely to affect them also varies. For this reason, NOAA Fisheries divides the thirteen species and their critical habitat into the following groups:

Interior Columbia River species with sufficient data to evaluate relevant quantitative metrics:

- Snake River Spring/Summer Chinook
- Snake River Fall Chinook
- Snake River Steelhead
- Upper Columbia River spring Chinook
- Upper Columbia River steelhead
- Middle Columbia River steelhead

Interior Columbia River species without data sufficient to evaluate relevant quantitative metrics:

- Snake River Sockeye

Lower Columbia River species which are less affected by most Prospective Actions than interior populations:

- Lower Columbia River Chinook

- Lower Columbia River steelhead
- Lower Columbia River Coho
- Lower Columbia River Chum
- Upper Willamette River Chinook
- Upper Willamette River steelhead

NOAA Fisheries performed a quantitative analysis of the status of the six Interior Columbia River ESUs or DPS' for which there is sufficient empirical data available to support such an analysis. Generally, that analysis evaluated the most relevant empirical data which serves as its base or starting point. Since productivity, trend and extinction risk estimates require multiple years of recent observations, portions of these "base period" observations are influenced by management actions that have been superseded by current management actions and therefore are no longer relevant. The next step in the analysis, therefore, was to adjust the base information to account for changes made to activities affecting the listed fish, such as operations at the dams, since the base period empirical data was gathered. In this way, NOAA Fisheries reaches its judgment about the current status of the listed species derived from what it calls the "base-to-current adjustment." The final phase of the analysis was to further adjust the current status to predict the status of the species that is likely to result from the effects of the Prospective Actions, such as further modifications at the dams, on the current status of these species.

In addition to this quantitative analysis for the six Interior Columbia River listed species, NOAA Fisheries conducted a qualitative analysis further evaluating their status and considering information that cannot be numerically measured or quantified. NOAA Fisheries also conducted a qualitative analysis for the remaining seven listed species.

In particular, this chapter describes:

- Methods for evaluating life-cycle effects at the population level that are applicable to the jeopardy standard (Section 7.1);
- Methods to evaluate action-specific and life-stage-specific effects that contribute to the life-cycle jeopardy analysis (Section 7.2);
- The method for evaluating effects at the MPG and species level (Section 7.3);
- Methods for evaluating effects on critical habitat for the adverse modification analysis (Section 7.4).

Methods for evaluating life-cycle effects at the population level (7.1)

Section 7.1.1 describes quantitative methods applicable to populations of six interior species and Section 7.1.2 describes qualitative methods for the same six species, plus the remaining seven species. The purpose of both the quantitative and the qualitative analyses is to evaluate whether:

- Short-term extinction risk is sufficiently low to meet the *survival prong* of the jeopardy standard; and whether
- The populations within a species are expected to be on a trend toward recovery, the *potential for recovery* prong of the jeopardy standard.

Within the Section 7.1.1 quantitative analysis, NOAA Fisheries evaluates certain metrics indicative of the survival prong of the jeopardy standard (24-year extinction risk) and indicative of the recovery potential prong (average returns-per-spawner, median population growth rate, and abundance trend). While each metric primarily informs one of the two prongs of the jeopardy standard, each metric contributes to both prongs. For example, a population with high productivity (e.g., average returns per spawner) is less likely to go extinct than one with low productivity.

As described above, this is a three-step process: For each of these metrics, NOAA Fisheries first determines what the values have been over the last two decades (referred to as "base" metrics). Then, because some management actions have changed over this time period, the metrics are adjusted to reflect "current" management practices. Finally, the metrics are further adjusted to reflect new management actions that are included in the Prospective Actions and to represent a range of expectations regarding future climate and other environmental factors.

It is not possible to evaluate the metrics quantitatively for every population of every species, so Section 7.1.2 includes additional qualitative approaches to determine if populations of a species are on a trend to recovery and if they are likely to have a low risk of extinction in the near term. Some qualitative factors include whether safety-net hatcheries protect important populations, if limiting factors are being addressed and threats reduced through management actions, and consideration of recent abundance levels and changes in abundance over time.

Methods to evaluate action-specific and life-stage-specific effects

Section 7.2 describes detailed action-specific methods that are necessary to support the analysis in Section 7.1. Because the analysis in Section 7.1 requires information about changes from the base-to-current management practices and additional changes associated with Prospective Actions, effects of those changes must be calculated. Section 7.2 describes the methods of evaluating changes in survival associated with hydro actions, tributary and estuary habitat actions, harvest, hatchery actions, RM&E actions, and changes in predation resulting from management actions.

Methods for evaluating effects at the MPG and species level

All of the methods described in Sections 7.1 and 7.2 apply to individual populations of listed salmon and steelhead. Section 7.3 describes methods for evaluating these population-level effects at the MPG and ESU level. The approach is qualitative, based largely on information regarding the importance of particular populations to each MPG and other information pertinent to MPG and ESU evaluations from recovery plans and TRT documents.

Methods for evaluating effects on critical habitat for the adverse modification analysis

Sections 7.1 through 7.3 apply to the jeopardy analysis, but an analysis of the effect of Prospective Actions on critical habitat is also necessary. Section 7.4 describes the qualitative methods that are applied to this evaluation. These methods describe the effects of the Prospective Actions on the functioning of primary constituent elements and the resulting effects on the conservation value of critical habitat.

7.1 Life-cycle analyses to evaluate whether populations are likely to have a sufficiently low short-term extinction risk and are likely to trend toward recovery

This analysis must first determine the short-term extinction risk and the expected trend of populations for each listed species. The following section describes the calculations and metrics used to inform the aggregate analysis for the populations of six interior Columbia species.

7.1.1 Population-level quantitative analytical methods for six interior Columbia Basin species

Data Sets

Information is sufficient to conduct quantitative analyses for populations of six interior Columbia River species. These species include:

- SR spring/summer Chinook,
- SR steelhead,
- SR fall Chinook,
- UCR spring Chinook,
- UCR steelhead, and
- MCR steelhead.

All estimates in the Supplemental Comprehensive Analysis (SCA) are derived from data sets produced by the Interior Columbia River Technical Recovery Team (ICTRT). The data sets have been updated since the 2007 Draft SCA, and match data used by the ICTRT in recent analyses submitted to the ISAB (ICTRT 2007c, ICTRT and Zabel 2007). For further information regarding the specific data sources, please see the tables in Chapter 8 and the Aggregate Analysis Appendix of the SCA.

Survival Gaps

The values of metrics that indicate a trend toward recovery are described in Section 7.1.1.2. The "survival gap," as defined by NOAA Fisheries, refers to the change in density-independent survival[1] that would need to occur in order to change the current value to the desired value of a given metric. Methods for estimating the survival gap differ, depending on whether the metric represents an annual (e.g., median population growth rate, or "lambda") or brood-cycle process (e.g., returns-per-spawner, or R/S). Annual estimates of the survival gap must be raised to the power of the mean generation time. The fundamental principle, common to all metrics, is that the quantitative component of the jeopardy analysis seeks to determine if the survival changes associated with the Prospective Actions, after taking into consideration the environmental baseline and cumulative effects, meet or exceed the remaining survival gap.

It is important to understand that the "survival gap" terminology applies to the needed survival change associated with achieving any goal, based on any survival-based metric. Here, it applies to the goal of being on a trend toward recovery and having a low short-term risk of extinction. The ICTRT (2007c, 2006) also uses the "survival gap" terminology. The ICTRT defines survival gaps associated with the long-term viability of populations. These ICTRT viability survival gaps are based on somewhat different target metrics, and represent the gap between the condition of populations over approximately the last two decades and the condition that the ICTRT considers viable. If a sufficient mixture of populations reaches this level, then the species is considered viable.

In contrast, this analysis is directed at a different question than the ICTRT's analysis of long-term recovery. This analysis focuses on the survival changes needed to ensure that populations support species (ESU or DPS) that are on a "trend toward recovery;" i.e., moving toward recovery even though full recovery of the species may not be achievable during the period of the Prospective Actions. In general, the needed survival changes for full recovery are higher than the needed survival changes associated with the "trend toward recovery."

The ICTRT (2007c) noted that some populations, particularly several of the MCR steelhead populations, currently have relatively high productivity but are below minimum abundance thresholds. For these populations, the ICTRT states that gaps are expressed as proportional increases in productivity, but could also be filled by increasing the "effective capacity" of the population. The effective capacity can be increased either by making new habitat available for spawning and rearing or by increasing the productivity (e.g., smolts per adult) of existing habitat.

NOAA Fisheries has not identified quantitative values of metrics that would indicate a sufficiently low short-term risk of extinction because the estimation of extinction risk is dependent on specific

[1] "Density-independent" refers to a change in survival that is not influenced by the number of fish in the population. Generally speaking, most factors influencing survival after the smolt stage are assumed to be density independent. During the egg-to-smolt stage, the density of adults and juveniles can influence survival as a result of competition for limited habitat or other factors. For evaluation of survival gaps, estimates of survival changes resulting from actions affecting early life stages of salmon and steelhead are made under the assumption of low density.

model functions and assumptions (such as quasi-extinction abundance threshold, QET, and treatment of listed hatchery fish) about which there is considerable uncertainty. The ability of a particular set of actions to achieve a goal of no more than any assumed percentage risk of extinction may vary considerably among models and assumptions. For convenience, the SCA includes estimates of survival gaps necessary to reduce 24-year extinction risk to no more than 5%, given the range of assumptions considered in the analysis. Ultimately, the acceptable level of short-term extinction risk is a qualitative policy determination made by NOAA Fisheries consistent with the ESA and its implementing regulations.

General Approach: Base, Current, and Future (with Prospective Actions) Analyses

Figures 7.1-1 and 7.1-2 demonstrate the approach for evaluating each metric according to the survival and potential for recovery prongs of the jeopardy analysis. Figure 7.1-1 demonstrates the approach for directly assessing the effect of the Prospective Actions on metrics such as average returns-per-spawner (R/S). In doing so, the Marsh Creek population of SR Spring/Summer Chinook is used as an example. Figure 7.1-2 demonstrates an indirect method for assessing the effect of the Prospective Actions on closing the "survival gap" between the base status of a metric, such as extinction risk, and the desired status. Again, the Marsh Creek population of SR Spring/Summer Chinook is used as an example. The sections following Figures 7.1-1 and 7.1-2 describe these general approaches.

Figure 7.1-1. Schematic showing the method of applying survival changes that have occurred during the base period to a "base-to-current" productivity adjustment factor and method of applying expected prospective survival changes to a "current-to-future" productivity adjustment factor. Detailed methodology is described in the accompanying text. This example uses average returns-per spawner (R/S) as the productivity estimate, applied to the Marsh Creek population of SR Spring/ Summer Chinook salmon.

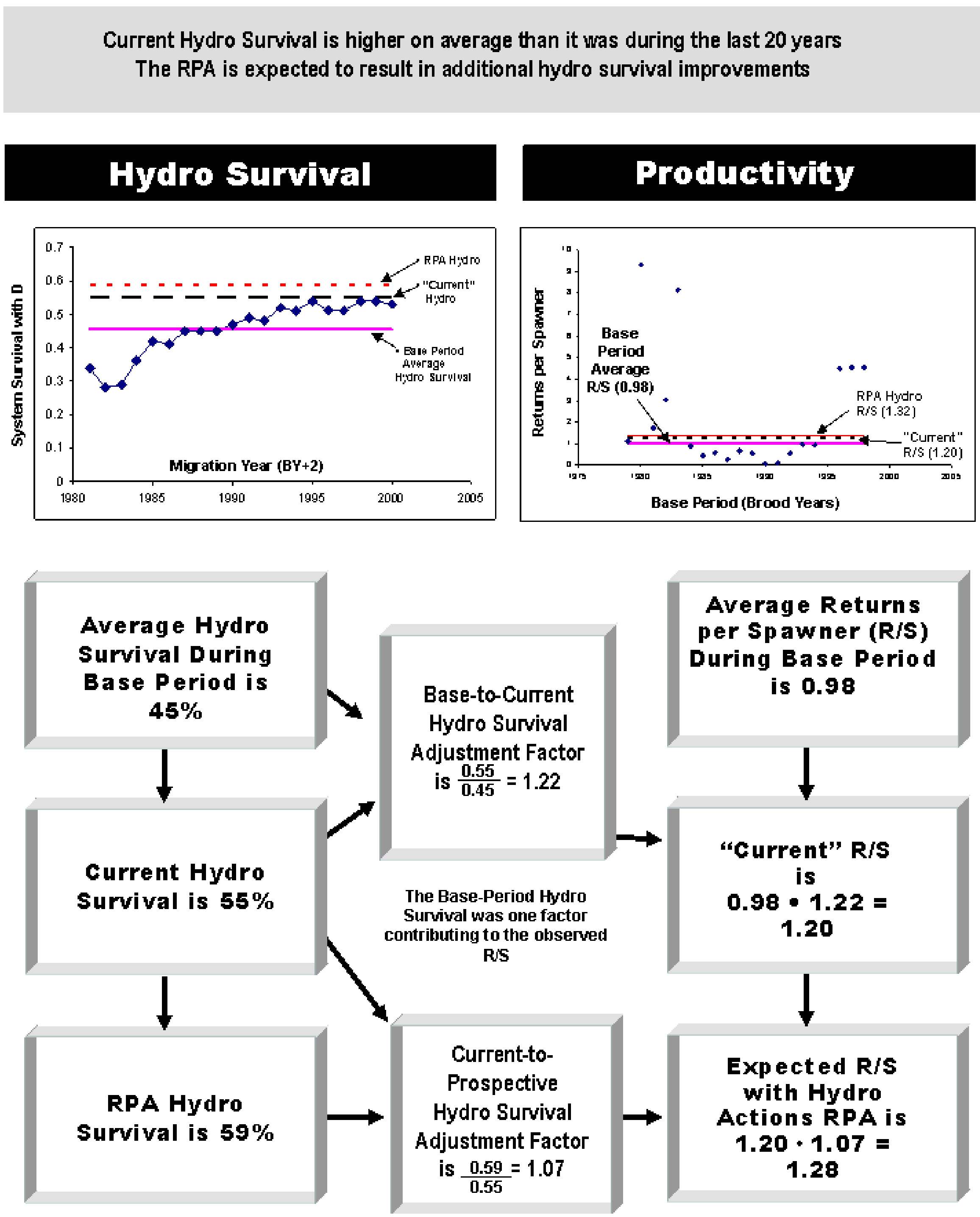
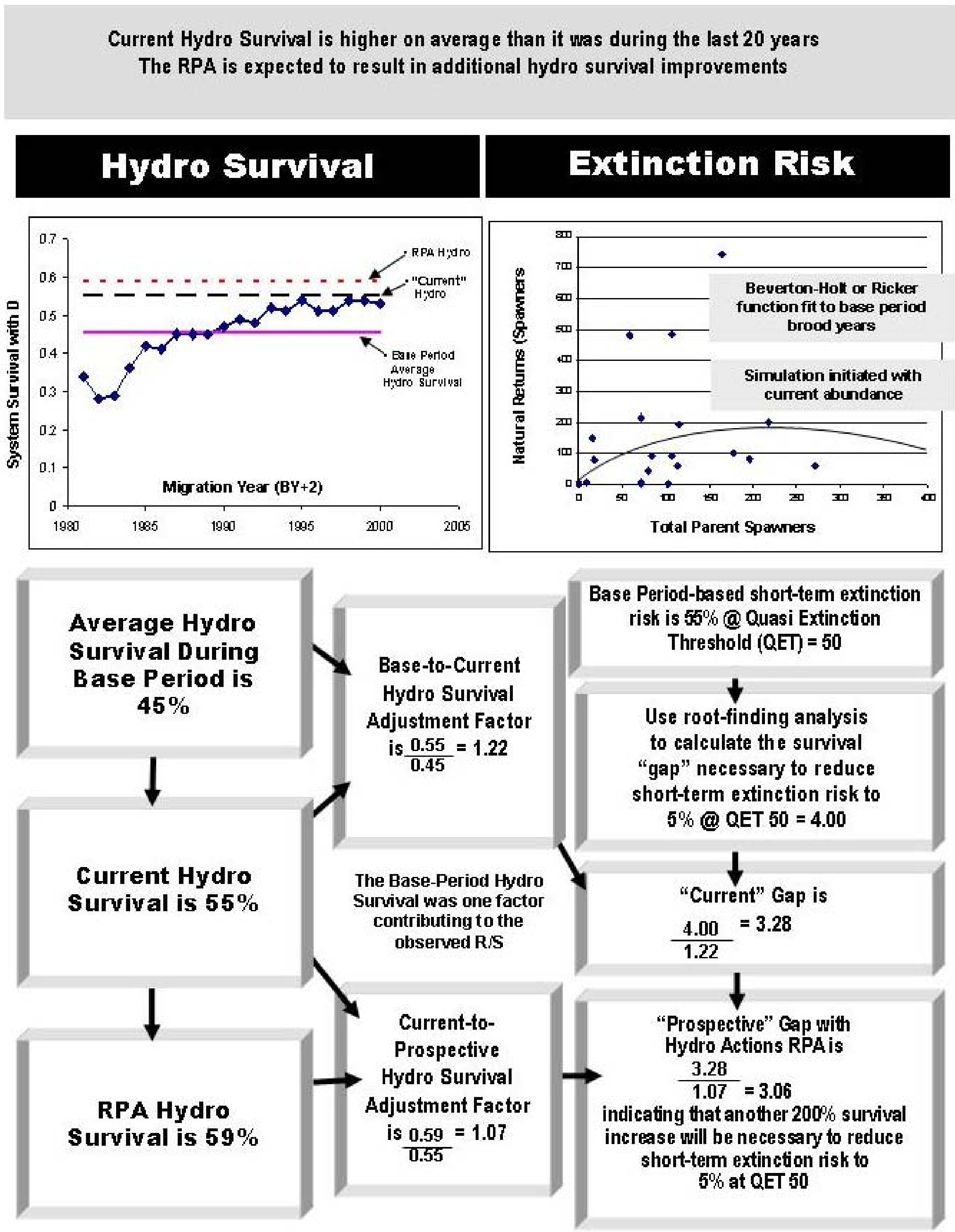


Figure 7.1-2. Schematic showing the method of applying survival changes that have occurred during the base period to a "base-to-current" adjustment factor for an extinction risk survival gap and method of applying expected prospective survival changes to a "current-to-future" adjustment factor. Detailed methodology, including estimation of survival gaps, is described in the accompanying text. This example uses a survival gap based on 24-year extinction risk and QET=50, applied to the Marsh Creek population of SR Spring/Summer Chinook salmon.



Base-to-Current and Current-to-Future Adjustments

Various metrics can inform the analysis of the survival and potential for recovery prongs of the jeopardy analysis. All life-cycle metrics considered here are based on the retrospective performance of populations during a historical time period and an assumption that, unless something affecting the survival or reproduction of the population changes in the future, the future performance can be projected from the pattern of past performance. NOAA Fisheries evaluated alternative historical time periods for these "base" estimates, but focused on the time period used by the ICTRT for recovery planning, which encompasses approximately the 1980 through 1999 brood years (which include spawner returns at age through about 2004 or 2005). Apart from the precedent of the ICTRT's use of this time period, it also corresponds approximately with that considered in the 2000 FCRPS Biological Opinion. NOAA Fisheries considers this time period a reasonable representation of a long enough time period to encompass variability in climate and biological performance. Additionally, the 1980 through 1999 brood years is considered a sufficiently recent time period to include many of the major changes in management actions that have occurred in recent decades.

As indicated by the ICTRT (2007c), some factors such as hydro operations and configuration have continued to change over that time period, and if the current management actions continue into the future, the projected biological performance will be different from that predicted from base period patterns alone. The ICTRT (2007c) includes an analysis that adjusts productivity estimates to reflect current hydro operations and configuration. The ratio between current hydro survival and the average hydro survival during the base period is calculated as an adjustment factor.

For the jeopardy analysis, adjustment factors are calculated for all ongoing and completed management activities that are likely to continue into the future. The product of these life-stage specific adjustment factors represents the "base-to-current survival adjustment factor." A similar process is used to estimate the survival changes likely to occur as a result of the Prospective Actions and cumulative effects, and to calculate the product of the changes as the "current-to-prospective survival adjustment factor."

For some metrics, such as R/S, the prospective R/S can be estimated by multiplying the base period R/S by the survival adjustment factors. To evaluate survival gaps, such as that associated with a particular level of extinction risk, the base survival gap is divided by the survival adjustment factors.

This approach of evaluating proportional changes in mean survival rates is consistent with the methods used during discussions in the *NWF v. NMFS* remand collaboration process resulting from Judge Redden's Order of October 7, 2005. It is also consistent with the approach used to evaluate recovery actions in the Final Recovery Plan for Upper Columbia River Spring Chinook Salmon and Steelhead (NMFS 2007c). Alternative methods of evaluation using more complex models that incorporate density dependence in estimating future trends following survival rate changes exist but, to date, have only been available for a limited number of populations. These more complex models also rely on a broader set of assumptions and parameter estimates that have not been thoroughly evaluated at the time this document was prepared. Therefore, they are not used in this analysis.

It is important to understand that the proportional change approach applied in this analysis (and the others described above) has a single time step. This means that the analysis assumes that all survival changes occur instantaneously and that average life-cycle survival is immediately affected. For the extinction risk analysis, two alternatives for considering implementation of Prospective Actions were considered, as described below in Section 7.1.1.1. However, for productivity estimates, the time period associated with the estimates begins with full implementation of the expected survival changes. The best way to think of the productivity estimates is that they represent the initial productivity following achievement of the expected survival rate changes resulting from the Prospective Actions. As described in Section 7.1.1.2, there is a relationship between abundance and productivity, such that abundance will increase following a change in survival and productivity. However, as abundance increases, density-dependent interactions will also increase, which will reduce average productivity over time. Therefore, the estimates of average prospective productivity calculated in this analysis are not expected to be maintained indefinitely and over time will be reduced to a lower rate.

Weather and Climate Assumptions

Qualitative considerations of weather and climate, as it affects salmon and steelhead survival, are described in Section 5.7 (Environmental Baseline). That section also summarizes recent literature on potential climate change, such as the Independent Scientific Advisory Board's comprehensive review (ISAB 2007c). This section describes how weather and climate information is applied in quantitative analyses to both the ocean and freshwater life-stages of salmon and steelhead. Qualitative analyses are described in Section 7.1.2.

Mechanically, the quantitative analyses, unless otherwise specified, apply the same climate conditions that influenced survival throughout the life cycle during the "base period" to projections regarding the future. That is, the analysis can be thought of as the base period repeating itself, except for the specific survival changes (e.g., resulting from management actions) that are applied. As described above, the "base period" from which productivity and extinction risk are derived is that used by the ICTRT: completed brood returns generally between 1980 and approximately 2001 (influenced by adult returns through approximately 2005). The exact tie period differs by population and by the particular metric being evaluated. Use of the 1980-2001 time period represents a conservative assumption for climate effects on salmon, compared to a longer historical record. As discussed in Section 5.7, only 4 of the 22 years during this time period had negative (favorable) Pacific Decadal Oscillation (PDO) averages and 18 of the 22 years had positive (unfavorable) PDO averages during the months influencing salmon survival. Similarly, from 1980 through 2001 the El Niño index (MEI) has been dominated by positive deviations from the long-term average (see Figure 5.7.1-1 in Chapter 5) – conditions known to reduce salmon survival. The baseline period therefore represents a regime that is less favorable to salmon than would typically have occurred in the past century.

While climate assumptions in this analysis clearly are conservative relative to climate patterns observed during the past century, many comments on the 2007 Draft Biological Opinion questioned whether NOAA Fisheries was sufficiently cautious in the face of continuing global climate change. As discussed in Section 5.7, Pacific Northwest air temperatures have increased by approximately 1 degree C since 1900 and are expected to increase 0.1-0.6 degrees C per decade over the next century. The ISAB (2007c) described various mechanisms by which this increase in temperature could reduce survival of salmon and steelhead in freshwater and marine life stages.

Ocean Climate Assumptions

In response, NOAA Fisheries explicitly modeled a climate scenario that addresses potentially worsening survival of salmon and steelhead in the ocean. The ISAB (2007c) stated that global climate change in the Pacific Northwest is predicted to result in changes in coastal ecosystems and salmon production that "may be similar to or potentially even more severe than those experienced during past periods of strong El Niño events and warm phases of the PDO." The choice of a 1980-2001 base period largely addresses this concern because it is dominated by El Niño and warm PDO events, representing climatic conditions expected to increase in the future. However, because of the uncertainty in future climate effects, a sensitivity analysis of alternative weather and climate scenarios is included in the Aggregate Analysis Appendix of the Supplemental Comprehensive Analysis. This sensitivity analysis includes an alternative weather-related early-ocean survival multiplier from ICTRT (2007 c) and ICTRT and Zabel (2007) that represents a future climate regime associated with poorer survival of salmon than was experienced during the base period (warm PDO climate scenario of ICTRT 2007c). This scenario is based on the survival experienced by the 1975-1997 brood years, all of which were associated with warm phases of the PDO. Survival under the warm PDO climate scenario is 12% lower than the "base" period survival for SR spring summer Chinook, 3% lower for Upper Columbia River spring Chinook, and 2% lower for listed interior Columbia River steelhead species (ICTRT 2007a).

The ISAB (2008) commented that future climate change may result in ocean conditions even worse than those captured in the warm PDO ocean climate scenario. While that may be true over a longer time period, it is unlikely to apply to the period of the Prospective Actions and the metrics considered in this opinion. The ISAB (2008) also commented that "there has been quite a bit of modeling of what to expect, and there are a range of scenarios available to the NOAA team." NOAA Fisheries requested clarification of which models the ISAB was referring to and if they were specific to ocean conditions. Huntly and Pearcy (2008) replied that "We are referring to general circulation models (GCMs) as provided in the IPCC-2007 report and others, which clearly predict increased global warming in the future. Others predict increased ocean stratification. We are not referring to regional models for ocean conditions in the Northeast Pacific that predict future conditions (5-10 years from now) such as the frequency and intensity of PDOs and ENSOs and coastal upwelling that will affect the ocean survival of Columbia River salmonids. We are not aware of any such models."

A second, more optimistic, alternative climate scenario affecting early ocean survival is also included as a sensitivity analysis. This scenario is included because the ICTRT (2007c) stated that, while at this time it is not technically possible to identify likely specific future conditions, the alternative future scenarios discussed in this section "bound a likely plausible range of future scenarios." It also responds to a comment on the 2007 Draft Biological Opinion that the 1980-present base period is biased toward poor ocean conditions because it is too short to include periods of more favorable climate. The second alternative climate scenario represents a longer historical period of 50 or more years that encompasses both good and bad ocean conditions ("Historical Climate Scenario" of ICTRT 2007c). Survival under the historical climate scenario is 37% higher than the "base" period survival for SR spring summer Chinook, 44% higher for Upper Columbia spring Chinook, and 11-19% higher for listed interior Columbia steelhead species (ICTRT 2007c).

Freshwater Climate Assumptions

Expected changes in climate can also affect survival during freshwater life stages, as described in Section 5.7 and ISAB (2007c). NOAA Fisheries did not attempt to explicitly model quantitative effects of climate change on survival during freshwater life stages; rather, Section 7.1.2 describes use of a qualitative approach. The primary reason for not attempting quantitative modeling is lack of available information regarding effects of climate change on survival of anadromous salmonids of the Columbia basin. The sole quantitative approach that we are aware of is that of Crozier et al. (2008), which is based on instantaneous attainment of expected 2040 climate conditions and its affect on life-stage survival, abundance, and population growth rate (lambda). Crozier et al.'s (2008) estimated reduction in life-stage survival, compared to survival estimated under current climate conditions, is significant (18-34% decline in parr-smolt survival with combination of 10 climate prediction models) but the applicability of this estimate to the base period survival estimates used in the SCA analysis is unclear (i.e., it is not clear whether the 18-34% decline is relative to the SCA base period survival or relative to another survival rate). Additionally, the instantaneous implementation of 2040 climate is of questionable relevance to the time period under consideration in the SCA, especially without a modeled ramp-up to the 2040 condition. Finally, Crozier et al. (2008) note that density-dependent processes compensated for declines in parr-smolt survival to some extent. This is an important study and analytical approach to evaluating effects of climate change on anadromous salmonids of the Columbia basin, but at this point additional information is needed before attempting to quantify effects of climate change on freshwater survival over the course of the SCA actions. The method of qualitative evaluation, based on ISAB recommendations for pro-active actions, is described in Section 7.1.2.1.

7.1.1.1 Quantitative Methods Applied to Interior Columbia Species for Assessing the Survival Prong of the Jeopardy Analysis

Extinction Risk Methods

As described in Hinrichsen (2008), which is Attachment I to the "Aggregate Analysis Appendix," quantitative assessment of short-term (24-year) extinction risk is calculated in a manner that is similar to that used by the ICTRT for calculating long-term (100-year) extinction risk. This analysis encompasses the entire lifecycle and, therefore, applies to the entire action area of all associated biological opinions. Briefly, observed abundance and productivity estimates during the base period are used to define a stock-recruitment function that predicts the number of progeny that will return to spawn from a given number of parental spawners. The production functions are the Beverton-Holt (for spring Chinook ESUs) and Ricker (for steelhead DPSs and SR fall Chinook), which are standard in fisheries literature. The Ricker function is used for steelhead because valid parameter estimates could not be found with the Beverton-Holt function for about half the steelhead populations. The hockey stick, which is used by the ICTRT, Beverton-Holt, and Ricker functions all predict high numbers of recruits per parental spawner at low spawner densities and lower recruitment at higher densities, up to a capacity limit. There is uncertainty in the estimates caused by random error and by the tendency of a series of high-or low-survival years to follow each other (autocorrelation).

Estimates of extinction probability are based on simulations. These start with current abundance and then project a 24-year time series of future spawners. Each projection will have a different outcome due to random error and autocorrelation terms, so the projections are repeated thousands of times to generate a range of outcomes. The proportion of simulation runs that fall below the quasi-extinction threshold within the 24-year time period represents the probability of short-term extinction. That is, of 1000 simulations, if 300 predict salmon abundance that is below QET at the end of the 24-years there is a 30% risk of extinction.

Survival "gaps," as defined in Section 7.1.1, were calculated for Chinook populations with sufficient data by determining the change in the slope at the origin of the Beverton-Holt production function that corresponded to short-term extinction risk of 5% or less (see Hinrichsen 2008, included as Attachment 1 to the Aggregate Analysis Appendix). The change in survival was estimated strictly from changes in this slope parameter, with no changes in the Beverton-Holt capacity parameter. This conservative approach estimates a larger survival gap for a given data set than will an approach that assumes density-independent survival improvements that would also affect the capacity parameter, such as the approach the ICTRT used to estimate long-term extinction risk gaps (ICTRT 2007a, 2007c). Similar estimates were not possible for steelhead because of mathematical constraints of using this procedure with the Ricker production function.

Determining the Quasi-Extinction Threshold (QET)

Extinction, for the purpose of this analysis, was defined as falling below a quasi-extinction threshold (QET) four years in a row (representing a full brood cycle of mature male and female spawners) per the ICTRT (2007a). Choice of QET level can significantly influence extinction risk estimates. In the 2000 FCRPS Biological Opinion, the QET was set to the absolute extinction level of one fish:

> Absolute extinction is used instead of a quasi-extinction level because of the unambiguous interpretation of this criterion, whereas quasi-extinction levels such as 20, 50, or 100 fish have different meanings for populations of different sizes and capacities in different river systems. (NMFS 2000b)

The problem with the use of absolute extinction as a criterion is that it is very difficult to predict the dynamics of populations at extremely low abundance. Various reviews since the 2000 FCRPS Biological Opinion have suggested that it would be more appropriate to evaluate extinction risk relative to a higher quasi-extinction threshold. Such a threshold does not necessarily represent true biological extinction, but it represents an abundance below which there is great concern from a management perspective and high analytical uncertainty regarding persistence. As the Independent Scientific Advisory Board pointed out in their review of the ICTRT's draft viability criteria (ISAB 2007d):

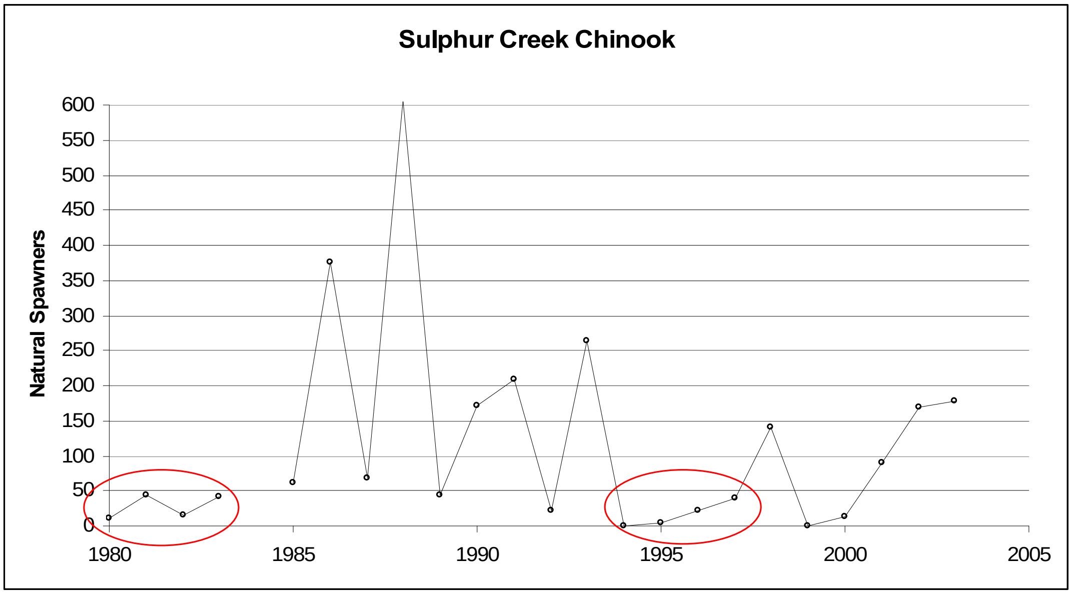
> The probabilities of quasi-extinction should not be considered equivalent to the probability of biological extinction. Rather, the former should be interpreted as the probability of entering a state where the risk of extinction cannot be modeled but is considered to be unacceptably high. The true probability of extinction could be bounded by probabilities derived using quasi-extinction thresholds of 1 and 100.

For their 100-year extinction risk analysis, the ICTRT selected a QET of 50 fish. The ICTRT (2007a) selected 50 fish based on four considerations; [1] consistency with theoretical analyses of increasing demographic risks at low abundance; [2] uncertainty regarding low abundance productivity of Interior Columbia ESU populations due to paucity of escapements of less than 50 spawners in the historical record; [3] sensitivity analyses indicating that the probability of multiple very low escapements increases substantially as the QET approaches one spawner per year; and [4] consistency with the Puget Sound and Lower Columbia/Willamette TRTs.

The ICTRT further elaborated on the first point by stating that three factors contributing to highly elevated extinction risk at low density (presumably 50 fish) are demographic stochasticity (the impact of random events and processes that could drive a small population to zero), Allee effects (such as inability to find mates at low densities), and loss of genetic variability. The first two of these factors likely affect short-term as well as long-term risk of extinction. However, the loss of genetic variability may be expressed over a longer time period and may be less likely to influence short-term extinction risk.

While the ICTRT's observation of a paucity of observations of less than 50 spawners is true across a broad range of populations in the Columbia basin, there are certain populations that have dropped below 50 fish over four years (in some cases more than once) and that have not gone extinct. An example is displayed in Figure 7.1-3.

Figure 7.1-3. Adult spawners in the Sulphur Creek population of SR spring/summer Chinook salmon. Circles indicate four consecutive return years that are below 50 spawners. ICTRT abundance estimates are from Cooney (2007).



The ICTRT does not address nor recommend a reasonable QET for shorter-term extinction risk. The analysis in this SCA includes the 50-fish QET recommended for evaluating 100-year extinction risk by the ICTRT, but it includes also a sensitivity analyses to alternative choices of QET. These may also be appropriate for assessment of short-term extinction risk since many populations in the Columbia Basin have dropped below 50 fish and returned to higher abundance levels during the past 20 years.

The ICTRT determined that for single years in which spawner numbers are as low as 10 fish, successful reproduction is highly uncertain (referred to as the "reproductive failure threshold," RFT). The analysis in this SCA also is based on RFT = 10 and assumes, as did the ICTRT, that successful reproduction occurs when abundance is greater than 10 fish. A sensitivity analysis of QET=1 assumed a RFT of two spawners, as described in the Aggregate Analysis Appendix. This assumption was also applied by the ICTRT for a sensitivity analysis to QET=1 (ICTRT 2007a).

Assessing Short-Term Extinction Risk

Short-term extinction risk with the Prospective Actions in place is estimated with a range of adjustment factors. While many of these actions will occur in the near future and have near-term biological effects, others will take longer to implement and have a biological impact. Because the analysis is based on a single time step and because the exact timing of Prospective Actions and attainment of biological effects is unknown, two adjustment factors are considered: A conservative approach assumes that extinction risk will not be influenced by any improvements associated with Prospective Actions. Only actions that are implemented already and that are captured in the base-to-current adjustment factor, as described in Section 7.1.1, are included in this calculation. A more optimistic assumption is that all Prospective Actions and all effects of those actions expected to occur within the next 10 years will affect the short-term risk of extinction. This approach includes Prospective Actions that will be implemented quickly, but is also optimistic because it includes actions that may not result in biological improvements for up to 10 years. The true extinction risk associated with the Prospective Actions is expected to be somewhere between these two extremes.

Uncertainty about the extinction risk estimates in the form of 95% confidence intervals is calculated using statistical bootstrapping methods, as described in the Aggregate Analysis Appendix. The confidence intervals are one method of indicating the statistical uncertainty of the quantitative extinction risk estimates and the degree to which they should be relied upon for decisions.

NOAA Fisheries received several comments on the 2007 Draft Biological Opinion regarding this approach to analyzing the survival prong of the jeopardy standard.

Some suggested that NOAA Fisheries evaluate a 100-year extinction risk time horizon, rather than a 24-year period, or else set standards for both periods. The rationale was that the 24-year extinction risk is lower than the 100-year extinction risk (i.e., it “inflates” survival probability compared to the 100-year time horizon). It has been well-documented that extinction risk increases with longer time horizons, with the probability of extinction “approaching 100% for all species if the period is long enough” (NRC 1995). For example, Oregon’s comments (page 5) include a Figure 2 that shows a low likelihood of extinction over 24 and 48 years and a high likelihood of extinction over 100 years for Upper John Day spring Chinook. This population is not listed under ESA, and is considered by the state of Oregon to be healthy (ODFW 2006a). While NOAA Fisheries is not familiar with the data or assessment methodology used in Oregon’s 100-year extinction risk estimates for this population, their result suggests that even healthy salmon stocks may appear to have a high likelihood of extinction under this assumption. It has been equally well-documented that the precision of the risk estimate decreases with longer time horizons. For example, Fieberg and Ellner (2000) estimated that reliable estimates of extinction risk may only be possible when the number of base period observations is 5-10 times greater than the number of years in the time horizon.

NOAA Fisheries continues to rely primarily on the 24-year time horizon for this analysis because the main purpose of the metric is to inform our judgment regarding the ability of the species to survive while actions to promote recovery are implemented under the Prospective Actions and through other processes. The 24-year period is more than twice that of most of the Prospective Actions and is identical to the short-term period considered in the 2000 FCRPS Biological Opinion (NMFS 2000b). However, NOAA Fisheries did calculate extinction risk over the 100-year time horizon to allow comparison of the 24-year extinction risk results with the 100-year extinction risk results of interest to some parties in the region. The 100-year extinction risk estimates and associated confidence intervals are reported in the Aggregate Analysis Appendix.

Some comments on the 2007 Draft Biological Opinion (NMFS 2007d) recommended that NOAA Fisheries use only a QET of 50 or higher (up to 100) in assessing extinction risk and disregard the sensitivity analysis of QET=30, 10, and 1. These comments said that NOAA Fisheries did not provide adequate explanation for considering results less than QET=50 in reaching conclusions. On the other hand, one comment stated that QET=50 is conservative and recommended displaying and discussing QET=10 more prominently. The same commenter opined that the real ESA standard is absolute extinction (QET=1), not "entering a state where the risk of extinction can't be modeled" (ISAB 2007c) definition of quasi-extinction threshold).

NOAA Fisheries primarily considered QET=50 in evaluating extinction risk because this is the threshold used by the ICTRT for long-term extinction risk. For the reasons discussed above, this threshold may be overly conservative for smaller populations, particularly those that have demonstrated the ability to return to higher levels after dropping below 50 spawners (e.g., Figure 7.1-3), and it may also be conservative for short-term extinction risk since at least one of the ICTRT's reasons for QET=50 is related to long-term genetic considerations. Regarding suggestions for higher QET levels, a population of at least 50 spawners clearly has not gone extinct and no evidence was presented in comments to suggest that a population below some higher level (e.g., 100) is more helpful in determining real extinction risk. Regarding emphasizing lower QET levels, NOAA Fisheries agrees that "true extinction" is defined as dropping to 0 or 1 spawner four years in a row. However, the ability of available data and models to accurately predict population behavior at this low level is extremely limited and the risk tolerance in such an analysis would have to be extremely low. It is reasonable to evaluate "quasi-extinction" thresholds above 1 fish, although there is little information favoring use of any particular level.

Two comments on the 2007 Draft Biological Opinion questioned details of the analytical approach used to calculate extinction risk. The first questioned whether variability and autocorrelation were adequately considered in the extinction risk analysis. NOAA Fisheries agrees that variance and autocorrelation are important parameters in any extinction risk analysis, and therefore both were estimated and used in developing the extinction risk estimates. The nonlinear regression method for estimating these parameters was carefully developed and details of methodology are included in the Aggregate Analysis Appendix. That appendix also outlines how these estimates were used in developing estimates of extinction probability. In short, as variance increases and autocorrelation increase, extinction probability estimates increase. Extinction probability curves were not used, although their use was assumed in the comment. Instead NOAA Fisheries used the best estimates of productivity, density dependence, current abundance, variance, and autocorrelation and estimated the resulting extinction probability. The exercise of developing hypothetical extinction probability curves was not needed.

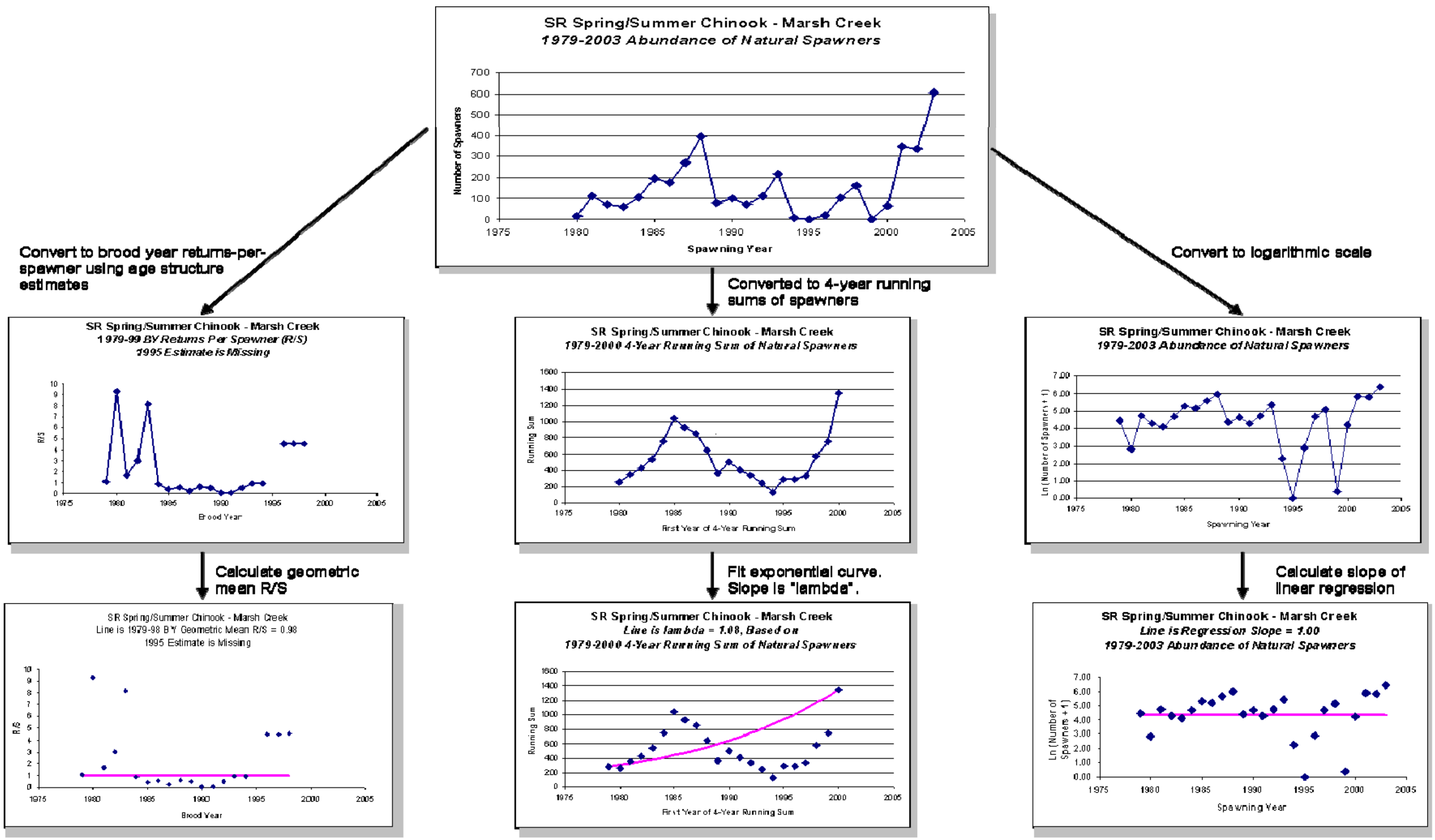
A second technical comment opined that use of the Beverton-Holt function "alpha" parameter (i.e., the slope at the origin) to estimate the extinction risk survival gap under estimates this gap, compared to the methods used by the ICTRT. In fact, this approach generally results in very similar or larger survival gaps than the ICTRT method, as can be seen by comparing the SR spring/summer Chinook base 100-year extinction risk gap at QET=50 in the Aggregate Analysis Appendix with the ICTRT (2007c) 5% risk "observed" survival gap. Most of the estimates differ only slightly between the two approaches, with approximately equal numbers being higher in one or the other model. However, there are five populations with very different survival gap estimates, all of which are much larger (i.e., a much greater improvement is needed) using the Beverton-Holt approach. For steelhead, SCA gaps using the Ricker function are nearly always higher than gaps using the ICTRT hockey-stick function.

It is clear from many of the comments and from the results of the analyses that quantitative estimates of extinction risk are subject to considerable uncertainty. In light of this, NOAA Fisheries also considered a variety of qualitative factors, which are described in Section 7.1.2. Included among these factors are important considerations that are not captured in quantitative assessments, such as the relevance of safety-net hatchery programs for reducing or eliminating short-term extinction risk for some populations.

7.1.1.2 Quantitative Methods Applied to Interior Columbia Species for Assessing the Potential for the Recovery Prong of the Jeopardy Standard

Figure 7.1-4 compares the three quantitative metrics indicative of the potential for recovery prong of the jeopardy analysis. All three metrics encompass the entire lifecycle and, therefore, applies to the entire action area of all associated biological opinions. There is great uncertainty in the calculations that characterize the current status of most populations, as well as in estimates of projected performance. The three metrics considered to evaluate the potential for recovery for the jeopardy analysis have different strengths and weaknesses, particularly with respect to the most recent returns included in the analysis, the treatment of hatchery-origin fish, and the level of complexity (number of assumptions) and data requirements. NOAA Fisheries looks at all available tools because the Independent Scientific Advisory Board recommended that policy-makers draw on all available analytical tools (ISAB 2001a).

Figure 7.1-4. **Graphic comparison of methods used to calculate average returns-per-spawner (R/S), mean population growth rate (lambda), and the BRT abundance trend (regression of log-transformed abundance). All calculations are based on 1979- 2003 spawner abundance estimates for the Marsh Creek SR spring/summer Chinook population. The estimates in this figure match those in Table 8.2.2-1 for the "base case" Marsh Creek population. The Marsh Creek population has no hatchery-origin spawners; this simplifies the methods compared to populations with both hatchery-origin and natural-origin spawners.**



Viable Salmonid Population (VSP) Characteristics

McElhany et al. (2000) define characteristics of viable salmonid populations that are likely to result in persistence for at least 100 years. The VSP characteristics are adequate abundance, productivity (or population growth rate), population spatial structure, and biological diversity. The ICTRT (2007a) apply these general characteristics to interior Columbia River populations in the form of long-term viability criteria. In the context of the SCA, all four VSP characteristics relate to the recovery prong of the jeopardy analysis. This section presents methods for quantitative estimation of abundance and productivity metrics relevant to the jeopardy analysis at the population level. Section 7.1.2 discusses qualitative methods relevant to spatial structure and diversity, as well as qualitative factors relevant to abundance and productivity for those populations with insufficient data for quantitative estimates. Section 7.3 discusses the consideration of these population-level criteria at the MPG and species level.

Average Returns-Per-Spawner (R/S)

Returns-per-spawner (also referred to as recruits-per-spawner) is a measure that determines whether a population is maintaining itself, declining, or growing. If 100 parental spawners produce 100 progeny that survive to maturity and successfully spawn, then R/S=1.0 and the population abundance has been maintained over that brood cycle. If, however, only 80 progeny survive to spawn, then R/S=0.8 and the population is declining. Since each female produces thousands of eggs, there is also the potential for much higher return rates. So, for example, 200 progeny might survive to spawn, which would result in R/S=2.0. In this case, the population abundance has doubled in one generation.

This analysis considers average R/S, with the average calculated as the geometric mean of brood year R/S estimates over the base period. The geometric mean is consistent with the general patterns in variability of annual return rates of anadromous salmon. Use of this metric reduces the influence of the relatively infrequent, extreme high-survival years during the period of interest. The sources of the average R/S estimates used are the ICTRT's Current Status Summaries and a summary of the average R/S metrics generated using the ICTRT data base (Cooney and Matheson 2006), updated to incorporate more recent data from the ICTRT (ICTRT 2007d; Cooney 2007, 2008a)

The estimates of average R/S in Hinrichsen (2008; included as Attachment 1 to the SCA Aggregate Analysis Appendix) applied a slightly different time period and different data sets for some populations. To avoid confusion, only the (ICTRT) estimates of average R/S were used in the SCA calculations for the jeopardy analysis.

It is important to distinguish the average R/S productivity estimates generated from the ICTRT data base from *intrinsic* productivity, which is a critical productivity metric in the ICTRT's long-term risk calculations. Intrinsic productivity, as applied by the ICTRT, is the R/S productivity calculated from the base period years with low spawner abundance (ICTRT 2007a). In other words, average productivity is based on R/S for all brood cycles during the time period of interest. Intrinsic productivity, however, considers a subset of those brood cycles with the lowest parental spawner abundance. The reason the ICTRT places importance on intrinsic productivity is because it represents one method of displaying the resilience of populations to declines in abundance. High intrinsic productivity indicates that populations can increase their abundance after periods of low abundance.

The reason the SCA uses average productivity, rather than intrinsic productivity, as an indicator of a trend toward recovery is because it is a metric that can be calculated and updated over any time period and therefore it is more suitable for a 10-year biological opinion. The relevant brood years in the ICTRT base period for intrinsic productivity are primarily the low abundance years in the late 1980s through mid-1990s for many populations. Intrinsic productivity cannot be recalculated directly until the populations again drop to low levels, and the productivity of the new low-abundance brood years cannot be calculated until their progeny return to spawn in another 4-6 years. Alternative methods of estimating intrinsic productivity based on fitting a stock-recruit function would also be dependent on progeny return data from the same time frame. It may take a decade to update intrinsic productivity estimates, whereas average productivity can be updated and monitored continuously. Average productivity may not be the best indicator of the resiliency of a population, but it is a clear indicator of the current status. When average R/S is greater than 1.0, the population is surviving at a rate that leads to increasing abundance.

R/S, as calculated by the ICTRT (2007a), considers all fish that spawn naturally in the parental generation (i.e., as the S in the R/S calculation). That is, the parents include natural-origin natural spawners and hatchery-origin natural spawners. The returning spawners in the next generation, however, are only the fish produced by those parents (i.e., the recruits are all natural-origin spawners). Therefore, hatchery-origin spawners cannot count in the R part of the R/S calculation. With this approach, one need not attempt to distinguish the productivity of natural-origin natural spawners from that of hatchery-origin natural spawners, at least not for the base period calculations.[2] However, if changes in either the proportion of hatchery-origin fish or the survival of hatchery-origin fish are relevant to base-to-current or current-to-future adjustments, a more complex approach is required (Section 7.2.4 and Quantitative Hatchery Appendix).

Of the three metrics relevant to the recovery prong of the jeopardy standard, average R/S provides the most realistic assessment of the likelihood that a population will trend toward recovery in the absence of continued hatchery programs. This is because the metric considers only the survival of natural-origin fish. This metric also requires the most data for each population, since brood-year specific estimates of hatchery fraction and age structure are necessary. For a number of populations, this requires assumptions and extrapolations from other populations or time periods. Because R/S evaluates brood cycles, it is only as current as the last completed brood cycle. As discussed previously, the last complete brood year is generally 1999, which makes this metric the least up-to-date of the productivity estimates.

Uncertainty associated with average R/S is calculated using the method of the ICTRT, which assumes a geometric distribution of R/S and calculates standard error and the t-statistic based on this distribution (Cooney and Matheson 2006). Cooney and Matheson (2006) also provide a formula for estimating 95% confidence intervals about the geometric mean from those statistics, which is applied

[2] Please note that this approach differs from one of the methods of calculating productivity that is described in the SCA Artificial Propagation for Pacific Salmon Appendix. The description of "productivity" in Section 2.1.2 of that appendix refers to the productivity of natural-origin spawners only.

in the SCA. A second method included in the Aggregate Analysis Appendix is bootstrap estimation techniques to calculate 95% confidence intervals (Hinrichsen 2008). This method generally results in wider confidence intervals than the ICTRT method, in part because it incorporates serial correlation in the estimates. However, to avoid confusion, only the ICTRT approach is applied in the SCA calculations for the jeopardy analysis.

NOAA Fisheries received a comment on the 2007 Draft Biological Opinion that the R/S level associated with the recovery prong of the jeopardy standard should be 1.42, rather than 1.0. This productivity rate would result in doubling population size within two generations, or approximately 10 years. NOAA Fisheries defined the goal for this metric as simply being greater than 1.0 because it is not possible to define a specific level greater than 1.0 that would be relevant to all populations, since they are all of different sizes, with different carrying capacities, and at different levels of current abundance versus carrying capacity. Proponents did not describe why they believed that R/S=1.42 was necessary to avoid jeopardy for every population. However, conclusions in the 2007 Draft Biological Opinion relied in part on estimates of R/S and other productivity measures being higher than 1.0 for many populations, and in some cases the estimates were substantially higher than 1.42. NOAA Fisheries continues to conclude that a goal of R/S greater than 1.0 is reasonable, with consideration of the mix of populations at higher levels an important qualitative consideration for reaching species-level conclusions. NOAA Fisheries does note that results are presented in the Aggregate Analysis Appendix in a manner that allows comparison to 1.42 or any other particular average R/S level of importance to parties in the region.

Median Population Growth Rate (Lambda, λ)

The median population growth rate is the metric primarily relied on in the 2000 FCRPS Biological Opinion. This metric indicates the change in 4-year running sums of population abundance over time. The ICTRT includes lambda estimates in its Current Status Summaries and ICTRT staff provided an updated summary of their average lambda estimates (Cooney 2008b, c). The lambda estimates are calculated using NOAA Fisheries' Salmon Population AnalyZer (SPAZ) model (McElhany and Payne 2006).

The SPAZ model has several options for calculating lambda. The lambda estimates included in the 2007 Draft Biological Opinion did not distinguish between hatchery-origin and natural-origin spawners; however, the ICTRT has changed its approach and now bounds the range of lambda estimates by either assuming that hatchery-origin spawners have success equal to that of natural-origin spawners (HF=1) or that they are entirely unsuccessful (HF=0). Lambda estimates based on HF=1 are similar to R/S estimates, while those based on HF=0 are similar to BRT trend estimates for populations with a significant hatchery influence.

Like R/S, a mean population growth rate of 1.0 indicates a stable population, lambda > 1.0 indicates that the population is growing, and lambda < 1.0 indicates that the abundance is decreasing.

This metric requires less information than R/S, since an average age structure is assumed by the 4-year running sums. But unlike the lambda estimates included in the 2007 Draft Biological Opinion, estimates of the fraction of hatchery-origin natural spawners are now required. New lambda estimates are based on the estimates of hatchery fraction that are used to calculate R/S productivity. Lambda can be generated from any index of abundance, such as redd counts, without being converted into numbers of spawners. Lambda, like R/S, involves a time lag such that the most recent 4-year running sum is approximately the 2001-2004 spawning years.

Uncertainty is also calculated by the SPAZ model using standard statistical methods, and results include estimates of the 95% confidence limits and the probability that the estimate is greater than 1.0. The 95% confidence limits are estimated for both the base and the prospective lambda estimates. Based on comments on the 2007 Draft Biological Opinion recommending that NOAA Fisheries display the probability that the productivity is greater than 1.0, this metric is included in the Aggregate Analysis Appendix. It was calculated, using the methods in (McElhany and Payne 2006). Although one commenter recommended that the "potential for recovery" prong of the jeopardy standard required demonstrating with 95% confidence that the estimated productivity is greater than 1.0, NOAA Fisheries did not adopt a particular statistical standard and displays this metric only for comparison with alternative goals recommended by others. This metric was calculated only for lambda estimates, but because of the wide range of hatchery assumptions, the results are similar to those expected from both the R/S and BRT trend estimates.

NOAA Fisheries received a comment on the 2007 Draft Biological Opinion that the population growth rate associated with the recovery prong of the jeopardy standard should be 1.08, rather than 1.0. This productivity rate would result in doubling population size within two generations, or approximately 10 years. NOAA Fisheries defined the goal for this metric as simply being greater than 1.0 because it is not possible to define a specific level greater than 1.0 that would apply to all populations, for reasons described above. However, conclusions in the 2007 Draft Biological Opinion relied in part on estimates of lambda and other productivity measures being higher than 1.0 for many populations, and in some cases the estimates were substantially higher than 1.08. NOAA Fisheries continues to conclude that a goal of lambda greater than 1.0 is reasonable, with consideration of the mix of populations at higher levels an important qualitative consideration for reaching species-level conclusions. However, results are presented in a manner that allows comparison to 1.08 or any other particular lambda value of importance to parties in the region

Biological Review Team (BRT) Trend

NOAA Fisheries' West Coast BRT completed a status review of all listed Pacific Coast salmon and steelhead in 2005 (Good et al. 2005). In addition to estimating lambda and R/S for selected populations, the BRT calculated simple trends in abundance for all available populations. Trend is calculated as the slope of the regression of the number of natural-origin spawners (log-transformed) over the time series (Good et al. 2005). To mediate for zero values, 1 was added to the natural spawners before transforming the data. The BRT calculated the trend for 1990 to the most recently available year and for the longest time period available. The most recent year available was generally 2001 for interior Columbia River populations.

For this SCA, NOAA Fisheries updated the BRT to include returns through the most recent year available, which was generally 2004 or 2005, using the SPAZ model (Cooney 2008b, c; McElhany and Payne 2006). The methods NOAA Fisheries used are identical to the BRT's methods and the data used is the detailed population data set provided by the ICTRT (Cooney 2007, 2008a). Only the abundance of natural-origin natural spawners was considered in the analysis. To be consistent with the other two productivity metrics and to attempt to be as consistent as possible with recent management actions, the BRT's longer time period was set to 1980 as the earliest year.

Based on the log-transformed data, a slope of 1.0 indicates a stable population (if the data were back-transformed to the original units, this slope would be zero). If the log-transformed slope is greater than 1.0, the population abundance is increasing; if it is less than 1.0, the abundance is decreasing.

The BRT trend does not track the ability of the population to sustain itself and grow in the absence of hatchery production like the R/S estimates. However, it does depict the trend in abundance of natural-origin natural spawners (including F2 progeny of hatchery-origin natural spawners) under current management, which can also be a useful characterization of status. This metric requires less information than R/S, since age structure is not required. Like the estimation of lambda described above, it is necessary to have an estimate of hatchery fraction each year. Also, like lambda, the BRT trend can be generated from any representative index of abundance consistent across a time series, such as redd counts, without being converted into numbers of spawners. The BRT trend reflects the most recent data more strongly than the other indices, since the most recent year's spawner abundance is weighted equally to all other years (i.e., not just a fraction of the last 5-year running sum or the last brood year returns).

In addition to the method of estimating uncertainty using the BRT approach as applied in the SPAZ model, a second method is also applied in the Aggregate Analysis Appendix. The second method uses a statistical bootstrap technique to generate 95% confidence intervals for the slope. This method does not match the BRT method of estimating uncertainty, which assumes that the observations are normally distributed and independent.

Alternative Productivity Metrics & Goals

NOAA Fisheries received comments on the 2007 Draft Biological Opinion suggesting the adoption of alternative productivity metrics and goals indicative of the "potential for recovery" prong of the jeopardy standard. Two have been described in previous sections: a goal of achieving R/S = 1.42 and a goal of achieving lambda = 1.08. As described above, NOAA Fisheries does not agree that it is possible to define a specific level greater than 1.0 that would be relevant to all populations, since they are all of different sizes, with different carrying capacities, and at different levels of current abundance relative to carrying capacity. However, the Aggregate Analysis Appendix does provide results that can be directly compared with these alternative goals.

One commenter also suggested an alternative goal of achieving the ICTRT's 5% abundance/productivity goal, which represents a combination of reaching the ICTRT viability abundance threshold and of reducing extinction risk to 5% or less. This goal is associated with recovery and delisting in the Final Recovery Plan for Upper Columbia River Spring Chinook Salmon and Steelhead (NMFS 2007c) and in drafts of other Interior recovery plans. It therefore goes beyond the "potential for recovery" prong of the jeopardy standard and would require attainment of abundance and productivity associated with long-term recovery. While NOAA Fisheries does not agree that a jeopardy determination depends on achieving this goal. Nonetheless, NOAA Fisheries finds that it is relevant to compare the survival changes expected from the Prospective Actions with the survival changes needed to attain this recovery goal. NOAA Fisheries provides this information in figures in the Aggregate Analysis Appendix.

Some comments on the 2007 Draft Biological Opinion recommended that NOAA Fisheries pay closer attention to certain steps within the *NWF v. NMFS* remand collaboration process and set goals based on work products of the remand collaboration process. In particular, a collaboration workgroup prepared a report to support "Step 4" of the collaboration's analytical framework and attempted to apportion the ICTRT's survival gap among different sources of human-caused mortality, including the existence and operation of the FCRPS, based on the estimated magnitude of each source of mortality (Framework Work Group 2006). NOAA Fisheries does not consider the apportionment of survival gap responsibility of Step 4 of the Collaboration Framework to be relevant to a jeopardy analysis. Nonetheless, NOAA Fisheries presents results of a Step 4 analysis in the Aggregate Analysis Appendix so that they can be compared with this alternative goal. The specific estimates of needed survival change are derived from the relative proportional impacts in Framework Work Group (2006) applied to the ICTRT's 5% viability gaps in an analysis presented in various chapters of the CA. The CA results are displayed in the Aggregate Analysis Appendix.

Abundance versus Productivity

NOAA Fisheries received comments on the 2007 Draft Biological Opinion suggesting adoption of an explicit abundance metric and abundance "performance standards." Discussions with some of the commenters clarified that they are primarily interested in tracking abundance during implementation of the Prospective Actions and comparing it to benchmarks such as the ICTRT's abundance viability thresholds, rather than recommending a prospective analysis of the probability of reaching a particular abundance level under the Prospective Actions. Reporting requirements during implementation of the Prospective Actions are described in Section 2 (Proposed Action) and/or Section 4 (RPA) of the biological opinions associated with each of the Prospective Actions, and it is anticipated that population status, including abundance, will be reported.

These comments do point to a larger issue regarding the relationship between the productivity metrics included in this analysis and population abundance. As described in Section 7.1.1, the estimates in this analysis represent the *initial* productivity that would be expected following an instantaneous survival rate change. That initial change in productivity would lead to greater abundance of spawners, which in turn would lead to density-dependent interactions that would reduce the productivity rate over time. The ICTRT and Zabel (2007) used a matrix simulation model to analyze the expected changes in productivity and abundance over time for a few populations with sufficient data, following incremental changes in FCRPS hydro survival. Three examples for populations of SR spring/summer Chinook salmon are displayed in Figures 7.1-5 through 7.1-7. These examples compare the initial productivity (R/S) calculated by the proportional change method with average R/S and spawner abundance over time, projected by the simulation model.

Figure 7.1-5. Abundance and productivity (R/S) of the Catherine Creek population of SR spring/summer Chinook salmon predicted in ICTRT and Zabel (2007, their Table 7) using a matrix simulation model. A 6.5% survival improvement is applied to the model at simulation year 1. The matrix model estimates represent means of 100,000 model runs. Matrix model results are compared to an estimate of the initial R/S productivity following instantaneous achievement of a 6.5% survival improvement using the proportional increase method in the SCA.

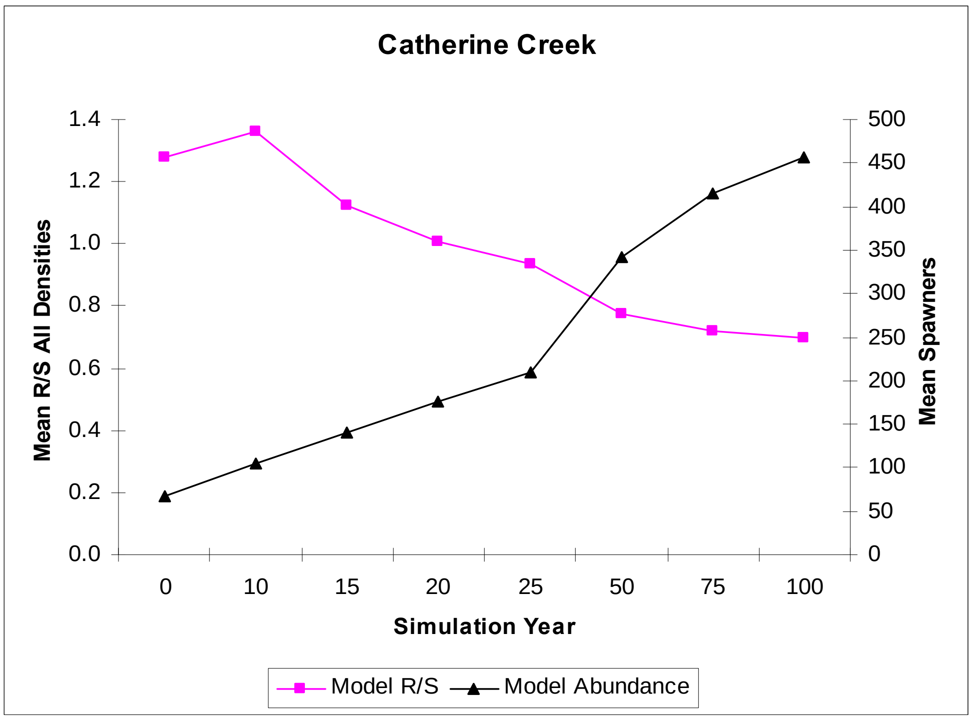


Figure 7.1-6. Same as Figure 7.1-5 for the South Fork Salmon River population of SR spring/summer Chinook salmon

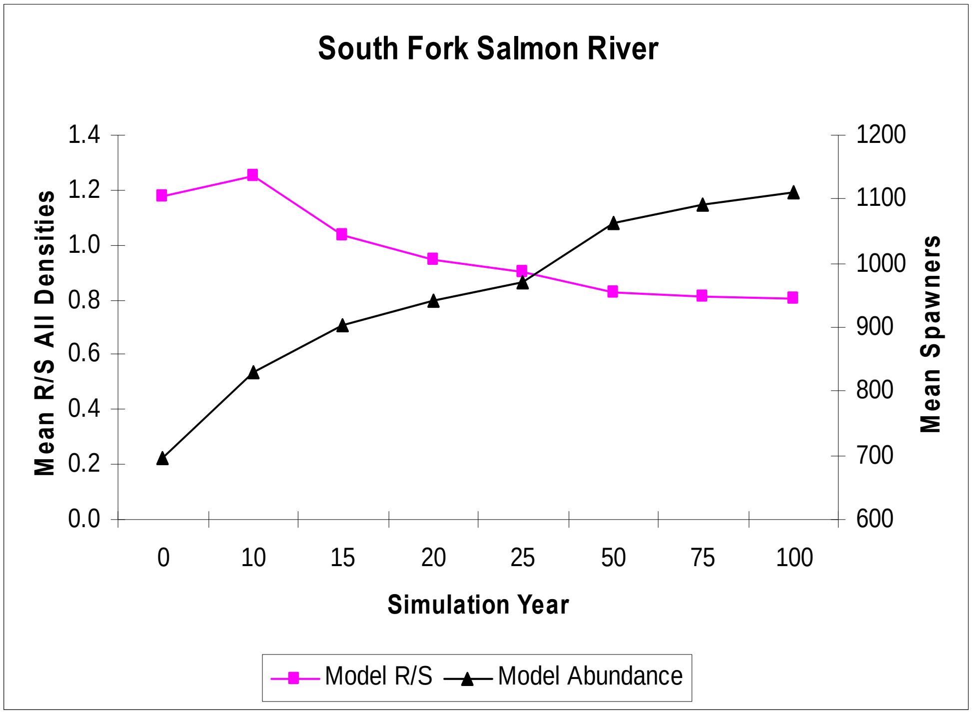
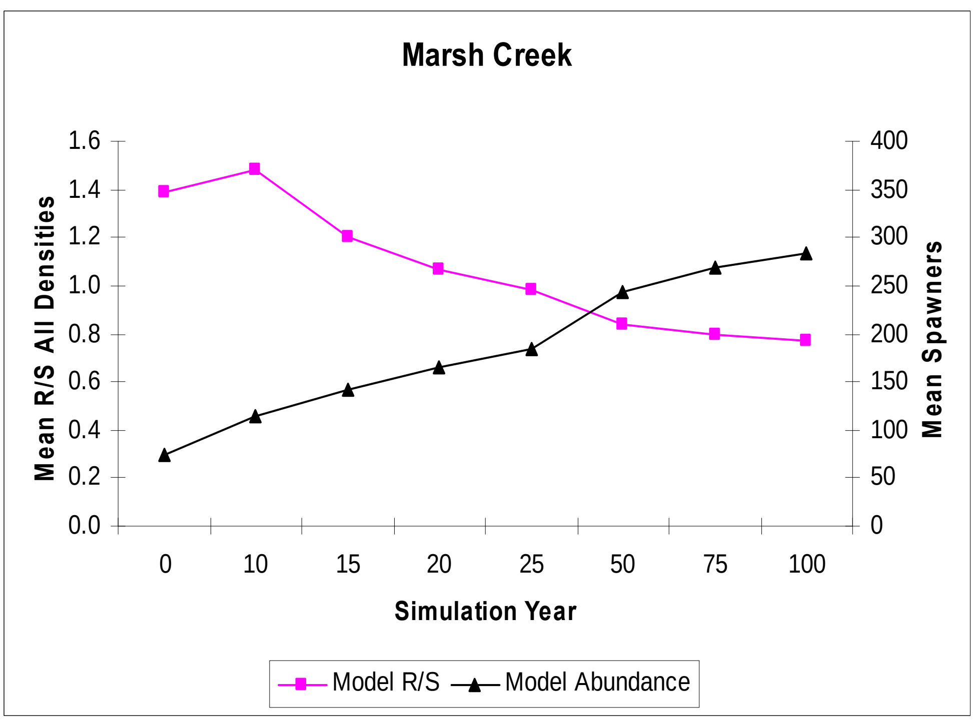


Figure 7.1-7. Same as Figure 7.1-5 for the Marsh Creek population of SR spring/summer Chinook salmon.



7.1.1.3 Summary of Key Assumptions in Analyses

Table 7.4-1 displays key assumptions in the analysis. They are characterized by whether they are somewhat optimistic, pessimistic, or neutral.

Table 7.4-1 Key analytical assumptions for the life-cycle analysis, characterized by their effect on conclusions.

Optimistic Assumptions	*The response to survival changes in terms of a change in productivity is not affected by density*. Moreover, the change in productivity represents the initial change that would occur before abundance increases. It is considered optimistic because, as abundance increases in response to the higher survival rate, productivity will decline over time due to density-dependent effects such as competition for resources. This approach is considered a reasonable way of characterizing the potential for recovery and expected progress toward recovery with the simple productivity ratio method described in this analysis and used in the *NWF v. NMFS* remand collaboration process. However, more complex modeling approaches incorporating density dependence are currently available only for a limited number of populations. *All actions are implemented and biological responses occur in a single time step.* This assumption will underestimate short-term extinction risk; therefore, risk is bounded by the assumption that no Prospective Actions will help to reduce risk (only continuation of current actions), as well as the more optimistic assumption that all Prospective Actions will be implemented within a time period that will influence the risk of short-term extinction. *Climate effects are explicitly analyzed only for early ocean survival*. Climate change will also affect survival in freshwater life stages but it was not possible to quantify this effect. Therefore, it is treated qualitatively by considering factors described in Section 7.1.21, such as consistency of Prospective Actions with ISAB recommendations for proactive actions in response to climate change.
Neutral Assumptions	*The base range of uncertainty also applies to current and prospective estimates.* This is identical to the ICTRT assumption that the base variance applies to alternative scenarios. In the absence of data suggesting that variability will change, this is the most supportable assumption. *Processes affecting population dynamics during the base period will continue into the future (i.e., they are stationary) unless modified in the analysis by explicit changes in survival expected from management actions or alternative climate conditions.* This assumption is supported primarily by choice of a 1980-present

	time period that is long enough to capture variability in biological processes but short enough to be influenced primarily by the significant management changes that have occurred in recent years. *The quasi-extinction threshold (QET) is no higher than 50 spawners (ICTRT QET for long-term recovery level), and may be lower for short-term risk*, especially for historically small populations that have not gone extinct after dropping below 50 spawners for four years in a row. This analysis also considers results of sensitivity analyses for QET less than 50 spawners. *Reproductive failure in a given year occurs at or below 10 fish*, per the analysis in ICTRT (2007a). Productivity at different spawner abundance levels can be described by Beverton-Holt and Ricker functions for short-term extinction risk analyses.
Pessimistic Assumptions	*The climate scenario given the greatest weight is that base period climate will continue.* This "Current" ICTRT climate scenario is dominated by poor ocean conditions and does not include a full cycle of favorable ocean conditions. This assumption is much more pessimistic than the historical climate record and is only marginally more optimistic than the worst of the recent years. For further discussion, please see Section 7.1. *Quantitative survival changes expected to result from habitat actions only are those anticipated to accrue within 10 years*. It is likely that many habitat actions will result in additional survival improvements after 2018; however, it was not possible to estimate their effects quantitatively. *Expected survival changes as a result of new actions are not affected by density*. Only density-independent survival changes are considered. For example, quantitative survival changes related to increasing habitat capacity only represent the effects of increased capacity at low density. The benefit of opening up new habitat would likely be greater at higher densities. *Short-term extinction risk estimates are based on the assumption that supplementation ceases immediately*. Sensitivity analyses to demonstrate effects of continuing supplementation on short-term extinction risk are included for selected populations. *Hatchery operations in the basin will continue unchanged, except where specified changes are occurring or will soon occur (e.g., 8.6.5.4)*. Current hatchery practices

	have varying effects ranging from positive to adverse. Due to the instances where there are adverse hatchery effects, NOAA Fisheries considers the continuation of current hatchery practices a pessimistic assumption. As described in RPA 39, hatchery reform is a component of the proposed action but will be evaluated in future site-specific consultations.

7.1.2 Population-Level Qualitative Analytical Methods for all Thirteen Columbia Basin Species

In addition to the quantitative methods described above for six interior Columbia species, the jeopardy analysis considers qualitative factors for all species.

7.1.2.1 Climate Change Considerations for Both the Survival & Recovery Prongs of the Jeopardy Analysis

Qualitative considerations of weather and climate, as it affects salmon and steelhead survival, are described in Section 5.7 (Environmental Baseline). That section also summarizes recent literature on potential climate change, such as the Independent Scientific Advisory Board's comprehensive review (ISAB 2007c). Section 7.1.1 describes how weather and climate information is applied in quantitative analyses. This section describes how climate change was considered qualitatively in evaluating the effects of the Prospective Actions on listed species.

The primary qualitative method NOAA Fisheries uses to evaluate the Prospective Actions is to determine the degree to which the Prospective Actions implement recommendations by the ISAB (2007c) to reduce impacts of climate change on anadromous salmonids. The specific recommendations against which the Prospective Actions are evaluated are described in Table 7.1.2.1-1.

NOAA Fisheries also evaluates the Prospective Actions on the basis of the extent to which the Prospective Actions include:

- monitoring climate change effects on listed salmon and steelhead;
- a mechanism for continually updating and synthesizing new information regarding the effects of climate change on listed salmon and steelhead; and
- mechanisms for modifying implementation plans as necessary to respond to new information about climate change.

Table 7.1.2.1-1. Measures recommended by ISAB (2007c) to mitigate the anticipated adverse effects of climate change on Columbia basin salmon and steelhead.

Tributary Habitat
1. Minimize temperature increases in tributaries by implementing measures to retain shade along stream channels and augment summer flow. a. Protect or restore riparian buffers, particularly in headwater tributaries that function as thermal refugia. b. Remove barriers to fish passage into thermal refugia
2. Manage water withdrawals to maintain as high a summer flow as possible to help alleviate both elevated temperatures and low stream flows during summer and autumn. a. Buy or lease water rights b. Increase efficiency of diversions
3. Protect and restore wetlands, floodplains, or other landscape features that store water to provide some mitigation for declining summer flow. a. Identify cool-water refugia (watersheds with extensive groundwater reservoirs) b. Protect these groundwater systems and restore them where possible c. May include tributaries functioning as cool-water refugia along the mainstem Columbia where migrating adults congregate

Mainstem & Estuary Habitat (Non-Hydro)
Remove dikes to open backwater, slough, and other off-channel habitat to increase flow through these areas and encourage increased hyporheic flow to cool temperatures and create thermal refugia.

Mainstem Hydropower
1. Augment flow from cool/cold water storage reservoirs to reduce water temperatures or create cool water refugia in mainstem reservoirs and the estuary. - May require increasing storage reservoirs, but must be cautious with this strategy.
2. Use removable spillway weirs (RSW) to move fish quickly through warm forebays and past predators in the forebays. - Target to juvenile fall Chinook salmon
3. Reduce water temperatures in adult fish ladders

Mainstem Hydropower
a. Use water drawn from lower cool strata of forebay b. Cover ladders to provide shade
4. Transportation a. Develop temperature criteria for initiating full transportation of juvenile fall Chinook salmon b. Explore the possibility of transporting adults through the lower Snake River when temperatures reach near-lethal limits in late summer c. Control transportation or in-river migration of juveniles so that ocean entry coincides with favorable environmental conditions.
5. Reduce predation by introduced piscivorous species (e.g., smallmouth bass, walleye, and channel catfish) in mainstem reservoirs and the estuary

Harvest
1. Harvest managers need to adopt near- and long-term assessments that consider changing climate in setting annual quotas and harvest limits a. Reduce harvest during favorable climate conditions to allow stocks that are consistently below sustainable levels during poor phase ocean conditions to recover their numbers and recolonize areas of freshwater habitat b. Use stock identification to target hatchery stocks or robust wild stocks, especially when ocean conditions are not favorable

7.1.2.2 Qualitative Factors Affecting the Survival Prong of the Jeopardy Analysis

As defined by the ESA regulations, §402.02, "'recovery' means improvement in the status of the listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act." This is consistent with ESA §4(c)(2) where a determination to remove a species from the list "shall be made in accordance with the" listing criteria. NOAA has stated that recovery depends on two types of criteria. "[E]valuating a species for potential de-listing requires both an explicit analysis of population or demographic parameters (biological recovery criteria) and also of the physical or biological conditions that affect the species' continued existence, categorized under the five ESA listing factors (listing factor criteria). Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B)." See "Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance," May 1, 2007, found at: http://www.nwr.noaa.gov/ Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/ Adaptive_ Mngmnt.pdf. The qualitative factors relevant to evaluation of the potential for recovery prong of the jeopardy standard therefore are biological factors and listing factors, also referred to as "threats." The

VSP factors (abundance, productivity, spatial structure, and diversity; see Section 7.1.1.2) inform the biological factors evaluation.

Recent abundance

Particularly low abundance levels (especially levels currently below the QET) would indicate relatively high short-term extinction risk due to factors such as demographic stochasticity (tendency for populations at low abundance to bounce around, possibly going to zero) and Allee effects (difficulty finding mates at low abundance). Conversely, relatively high abundance, especially if coupled with an indicator of sufficient productivity, would indicate a reduced likelihood of short-term extinction.

Recent productivity

In some cases productivity can be estimated but extinction risk cannot. In these cases, recent productivity, especially if coupled with information regarding abundance, can be informative. If productivity is low (e.g., the population is not replacing itself each generation or the trend in abundance has been declining), the risk of short-term extinction may be high. Conversely, a growing population can indicate a lower risk of short-term extinction.

The Degree to which Safety-Net and/or Supplementation Programs Meet Program Objectives

Some hatchery programs provide a short-term cushion to prevent extinction while longer-term recovery measures are being implemented. The hatchery programs that would serve this function are described in the individual species sections of this document, Sections 8.2 through 8.14.

The Degree to which Limiting Factors are Addressed

For some populations it is either not possible to quantify the survival changes associated with current actions and the Prospective Action or there is great uncertainty in the estimates. In this situation a qualitative description of the degree to which current and Prospective Actions reduce limiting factors is relevant to the assessment of extinction risk. Previously implemented actions and Prospective Actions with expected near-term biological benefits would likely reduce extinction risk if they substantially reduce limiting factors and threats.

Monitoring and Adaptive Management

Because there is uncertainty associated with quantitative estimates of risk and expected biological effects of current and prospective actions, it is important to have an effective monitoring program and adaptive management contingencies. It is possible to accept higher uncertainty in the ability of the Prospective Actions to avoid short-term extinction risk if a monitoring program will ensure that unexpected reductions in species status are detected in a timely manner so that contingent adaptive management actions can be implemented in response.

7.1.2.3 Qualitative Factors Affecting the Recovery Potential Prong of the Jeopardy Analysis

The qualitative factors relevant to evaluation of the potential for recovery prong of the jeopardy standard are the VSP factors: abundance, productivity, spatial structure, and distribution.

Abundance and Productivity

It is not possible to quantify abundance and/or productivity for many populations. In these cases, qualitative considerations include the similarity of populations without adequate data to populations with adequate data. In some cases, data is available for one time period but not another, so again, a qualitative consideration can substitute for quantitative analysis in those particular time periods.

Snake River steelhead is an example of a species with limited quantitative information. Data supporting abundance and productivity estimates are available for only three of the 24 extant populations. The ICTRT also estimates average abundance of A-run and B-run populations based on dam counts and assumptions about the distribution of steelhead among populations (ICTRT 2007a, c). Here, the average A-run and B-run base period estimates are applied to individual A-run and B-run populations, respectively. Then population-specific survival changes (e.g., resulting from prospective tributary habitat actions) are applied to the individual populations. This approach is taken because of a desire to match population specific actions with individual populations and the need to consider effects at the MPG level as an intermediate step to making species conclusions.

Snake River sockeye salmon are at very low abundance levels with current returns originating from a captive rearing program. As a result of the virtual absence of naturally produced returns in recent years, specific quantitative estimates of trend and productivity of that component of the ESU are not currently feasible. Qualitative characterizations of abundance and productivity are apparent just from inspection of available information.

The analysis of lower Columbia River species relies more on qualitative analysis than that for interior Columbia River species. The BRT (Good et al 2005) and the Willamette/Lower Columbia TRT (WLCTRT 2004, and McElhany et al. 2007) estimated abundance and trends for available populations in the Willamette and lower Columbia Rivers, but little or no information was available for many populations. The available data sets for Washington populations generally ended in 2001 and those for Oregon populations ended in 2005. No attempt was made to quantify changes from base period productivity to current productivity or to productivity resulting from the Prospective Action. Instead, changes were expressed mainly in terms of direction (improvement/reduction) with qualitative descriptions of magnitude.

Action-specific and life stage-specific survival trends are considered quantitatively in analyses if appropriate (e.g., hydro adjustment factors for interior Columbia River species' productivity estimates), but are also considered qualitatively for all species. An important consideration is whether improving trends in abundance and productivity are solely a result of fortuitous climate conditions or if they are also a result of beneficial human activities. Correspondence of changes in human activities, trends in life-stage survival influenced by those management activities, and trends in population abundance and productivity support the qualitative conclusion that changes in management actions are contributing to improved population status.

The qualitative factors described under Section 7.1.2.1 also apply to the recovery potential prong of the jeopardy standard, with the exception of safety-net hatcheries.

Spatial Structure

The ICTRT (2007a) and WLCTRT (2003) describe viability criteria for spatial structure. These include consideration of the number and spatial arrangement of major spawning areas (MaSA) and minor spawning areas (MiSA), the proportion of the historical range that is occupied, and increases or decreases in gaps between occupied MaSAs. The ICTRT Current Population Status Summaries (Cooney 2007) characterize the current status of spatial structure as “very low” through “high” risk for each population. The WLCTRT (2004) viability assessment provides a formalized expert opinion-based characterization and numerical rating of the spatial structure of each Willamette and lower Columbia River population. Although the ratings are presented as numbers, they actually represent qualitative categories scored through a structured expert opinion process.

In this analysis, Prospective Actions are evaluated in the context of whether they are contributing toward improving spatial structure for affected populations.

Diversity

The ICTRT (2007a) and WLCTRT (2003) described viability criteria for diversity. These include retention of major life history expressions (e.g., summer vs. spring runs), maintenance of phenotypic and genetic variability, maintenance of natural patterns of gene flow (including various criteria for assessing impacts of hatchery programs), and reduction of selective changes resulting from human activities (e.g., large fish selection in fisheries). The ICTRT Current Population Status Summaries (2007d) characterize the current status of diversity as “very low” through “high” risk for each population. The WLCTRT (2004) viability assessment provides a formalized expert-opinion-based characterization and numerical rating of the diversity of each Willamette and lower Columbia River population. Although the ratings are presented as numbers, they actually represent qualitative categories scored through a structured expert opinion process.

In the SCA, Prospective Actions are evaluated in the context of whether they are contributing toward improving diversity for affected populations.

7.2 Life-Stage-Specific & Action-Specific Analyses to Support the Life-Cycle Analysis and to Estimate Incidental Take

Section 7.1 describes methods to estimate productivity and extinction risk that incorporate population survival throughout the life cycle. In conducting the analyses described in Section 7.1, information regarding the effects of specific actions that affect survival at different life stages is needed. Section 7.2 describes methods of estimating effects of actions relevant to particular life stages. These methods also apply to the estimation of incidental take associated with Prospective Actions.

7.2.1 Hydro Methods

This section describes NOAA Fisheries’ analytical approaches to estimating how proposed changes in FCRPS system and individual project operations and changes in individual project configurations (e.g. new RSWs, etc.), collectively termed Hydro Actions, will affect fish survival This involves a quantitative analysis of the hydrologic effects of the Prospective Actions, detailing how proposed operations affect flows through the system and the distribution of flows through various systems at each project (i.e. spillway, versus turbine flow). These operational effects are then combined with proposed changes in system configuration and known and estimated performance characteristics of those systems to estimate the fish survival effects of the Hydro Actions through quantitative biological modeling (when possible) or through qualitative evaluations. Section 3.2.1 and Appendix B-1 of the CA provide more detailed descriptions of these analytical methods.

Sufficient information is available to quantitatively assess the effects of the hydro actions on SR spring/summer Chinook and steelhead, UCR spring Chinook and steelhead, and MCR steelhead (Section 7.2.1.1). This assessment also provides surrogate information that is pertinent to populations of lower river ESUs that migrate to and from tributaries entering the Columbia River between Bonneville and The Dalles dams. For the remaining ESUs, a more qualitative assessment was required for assessing hydro effects. This approach is described in 7.2.1.2.

7.2.1.1 Quantitative Juvenile Analysis of Hydro Actions on Five Interior ESUs

General Approach

In developing the overall analysis of the effects of the Proposed Hydro Action on listed anadromous fish, this SCA relies on hydrologic, operations, and biological model outputs and previous analyses for assessing the effects of the hydropower system on ESA-listed salmon and steelhead. In general, the analysis consists of an ESU-by-ESU analysis for three primary time periods of hydropower system existence, the Base (corresponding to the general conditions that were experienced by juveniles during the 1980-2001 outmigrations), Current (2004 FCRPS Biological Opinion operations and actions implemented through 2006), and Prospective conditions with results reported as the average across all years (the 70 year water record included the 1929 to 1998 water years).

The SCA's quantitative analysis begins with baseline survival estimates primarily provided by the TRT or other relevant sources, with consideration of estimates for key parameters (i.e., direct in-river survival, percent transported). Next, the effects of operation and configuration changes that have already occurred (Current) were estimated and compared to the Base condition (Base to Current adjustment).[3] And finally, the effects of future changes in hydrosystem operations and configurations (Prospective) were estimated and compared to the Current condition (Current to Prospective adjustment). The resultant Hydro adjustments were incorporated into the life-cycle analysis (Section 7.1).

Because juvenile migrant survival is affected by flows and project operations (e.g., spill rates) and because river flows vary due to both natural climate variation and project operations, a series of

[3] Note: The Base-to-Current adjustment assumes no changes have occurred in post-Bonneville survival relationships between the Base and Current periods. This is likely a conservative assumption because many actions that were implemented in the latter part of the Base period through the Current condition (increased spill, improved juvenile bypass systems, RSWs, etc.) should have generally improved the fitness (quality) of fish arriving at the Bonneville tailrace compared to the average fitness of fish observed during the entire Base period.

models were employed to estimate the survival effects of alternative operating strategies. These models were:

- A hydrologic model
- An operations model (HYDSIM)
- A survival model (COMPASS)

Hydrologic Modeling

Historical streamflows, to the extent measured data are available, are inadequate for system regulation studies because through time, differing levels of storage and irrigation development have affected streamflows and reservoir operations. Thus, even if precipitation conditions were similar during a recent year to that experienced decades earlier, total streamflow and the streamflow pattern at a given point could be quite different due to changes in water development. For this reason, the FCRPS Action Agencies have simulated the flow conditions that would have existed throughout a 70-year hydrologic record had the current (circa 2000) level of water development been in existence during the entire period. Termed "Modified Streamflow," the 70-year time-series used for the hydro system effects analyses conducted for this consultation approximates the expected flow conditions that would occur today over the range of hydrologic conditions experienced over the period (October 1928 through September 1998). BPA 2004 provides details on how this hydrologic simulation was accomplished.

Operations Modeling

Operations modeling refines the output of the hydrologic models, storing and releasing water from reservoirs according to operations defined by the Prospective Actions. Two system operations models were used to route the modified flows described above through the hydro system. Reclamation's MODSIM model (updated Upper Snake MODSIM - May and June 2007 runs) was used for the upper Snake River above Brownlee Reservoir, and BPA's HYDSIM model was used for the remainder of the Snake and Columbia River basins.

MODSIM was used to estimate inflows to Brownlee Reservoir resulting from the existence and operation of Reclamation's upper Snake River projects and all private diversions and depletions. Input hydrology into the model includes 1928 through 2000 historical water supply period of record. The model is then configured to represent the current level of basin development, including diversions and groundwater pumping, as well as Reclamation's operations. Thus, the model takes into account Reclamation operations (water storage, flood control releases, irrigation deliveries, delivery for flow augmentation), current level of ground water pumping, irrigation return flows, and current private activities (private water surface diversions and subsequent return flows).

The Brownlee Reservoir inflows developed by MODSIM and modified streamflows for the remainder of the Columbia basin were then incorporated into BPA's HYDSIM model. Hydro Simulator Program (HYDROSIM, also known as HYDSIM) (BPA 1997) simulates operation of all Columbia basin projects, excluding those on the Snake River upstream from Brownlee Reservoir. For this analysis we assumed that Idaho Power Company's Brownlee Reservoir would be operated in a manner designed to protect downstream anadromous fish including: refilling by July 1 each year, drafting 237 thousand acre-feet (kaf) during July each year, and operating through the fall and winter to maintain spawning and incubation flows for SR fall Chinook salmon.[4]

The model produces an array of outputs including reservoir elevation, generation, and spill. User supplied constraints allow simulation of a wide array of operations. Such constraints include specified spill schedules for fish protection, reservoir drafting and refill operations for flood control, electrical power demands, reservoir drafts for flow augmentation, and irrigation withdrawals.

System operations are simulated for 14 periods per year, one for each month with April and August each divided into two periods. Based on inflows and user supplied constraints, the model routes inflows through the system creating a set of operational outputs (e.g. generation, total outflow, spill flow, reservoir storage) for each project. HYDSIM's project-specific time-series of total flow and spill flow are principal inputs to the fish survival modeling process.

Using historical flow data for each water year in the 70-year record, MODSIM and HYDROSIM can be used to project how water would pass through the upper Snake, lower Snake, and Columbia River systems, respectively. For example, the models can be used to project how flows would be distributed through any one of the periods (14 for HYDSIM and 12 for MODSIM) for multiple locations in the system for a selected high-, medium-, or low-flow year and the models can estimate the water distribution effects of alternative project operations.

The output of HYDSIM is then modulated into estimated daily flows (NMFS 2008g) for use in the biological modeling – which incorporates flow as a predictive variable for estimating fish survival through the FCRPS. The overall results of the hydroregulation modeling are presented in CA Appendix B.

Biological Modeling

In collaboration with regional parties, NOAA's Northwest Fisheries Science Center developed a Comprehensive Fish Passage (COMPASS) model (see Corps et al. 2007a Appendix B.3) to assess the likely effects of alternative hydrosystem operations on juvenile survival and post-Bonneville dam survival for five interior basin ESUs: SR spring/summer Chinook salmon, SR steelhead, UCR spring Chinook salmon, UCR steelhead, and MCR steelhead. The model was populated with the best empirically derived estimates of route-specific passage and survival rates available for juvenile Chinook or steelhead to reflect the current configuration of the hydrosystem. The FCRPS Action

[4] In order to provide an analysis of the aggregate effects of both the Upper Snake Reclamation projects and the FCRPS projects on flows in the lower Snake and Columbia Rivers, some assumption of the operation of Idaho Power Company's Hells Complex (which includes Brownlee Reservoir) was required, because of its physical location between these two systems. NOAA Fisheries chose to assume an operation that is generally reflective of recent operations of this project. However, because the relicensing of the Hells Canyon Complex is a future Federal action that has not yet undergone consultation, NOAA Fisheries does not otherwise consider the effects of this project in this Supplemental Comprehensive Analysis.

Agencies assessed the likely benefits of prospective action configuration actions to assess their overall effect on survival in the prospective analysis. The operations modeling results were modulated into appropriate formats for input into COMPASS (daily flows and spill rates) (NMFS 2008g), and then the model was run to estimate the effects (across the 70 year water record) of Current and Prospective operations of the mainstem Snake and Columbia River dams and reservoirs on fish survival.

A paper describing the COMPASS model has been provisionally accepted for publication in Hydrobiologia (Zabel et al. 2007). The COMPASS model is composed of five modules: 1) reservoir survival, 2) dam passage and survival, 3) fish travel time, 4) hydrology, and 5) post-Bonneville survival. The COMPASS model was generally reviewed by the Independent Scientific Advisory Board (ISAB) during its development (ISAB 2006a, b). The ISAB also reviewed post-Bonneville survival hypotheses, including the Scheuerell – Zabel hypothesis used in the COMPASS model for the analysis in this SCA (ISAB 2007b). NOAA Fisheries considers the COMPASS model to represent the best scientific information available for the purposes of assessing the biological effects of alternative hydrosystem operations. A detailed description of the COMPASS model can be found in the COMPASS model documentation (NMFS 2008g).

Key parameters estimated by the COMPASS model provided for both the Current and Prospective operations include:

- direct system survival (combined survival of both in-river and transported fish starting at Lower Granite Dam for Snake River ESUs and McNary Dam for Upper Columbia River ESUs) to the Bonneville Dam tailrace;
- smolt to adult returns (SARs) of both transported and in-river migrating juveniles from the Bonneville dam tailrace, to the ocean, and back to the Lower Granite Dam for Snake River fish, or to Rock Island dam for Upper Columbia River fish (Scheuerell and Zabel 2007**);**
- total SARs for Snake River (system survival estimates) *x* (post-Bonneville smolt to adult returns).

For the Snake and Upper Columbia River ESUs, total SARs were used to inform the hydro adjustment (current-to-base). For upper Columbia River ESUs, the biological effects were aggregated with the observed (base-to-current) or expected (current-to-prospective) survival improvements resulting from actions taken to improve juvenile survival through the mid-Columbia PUD dams. This was a result of settlement agreements and Biological Opinions (NMFS 2006e hydro module for recovery planning) (effects that are in the environmental baseline considered in this SCA). For Mid Columbia River steelhead, which includes populations that migrate through one to four lower Columbia River dams, there was insufficient information to assess a post-Bonneville survival relationship. For this ESU, the CA only utilizes changes in estimates of system survival in the Base, Current, and Prospective adjustments and does not include an assumption that post-Bonneville survival might be affected through the implementation of the Prospective Actions. The Current and Prospective condition estimates are provided in Chapters 5, 7, 8, 9 and 10 of the CA and in Appendices B.3 and B.4. The COMPASS modeling results for the Prospective Actions considered in this SCA are located in the SCA Hydro Modeling Appendix.

It should be specifically noted that the in-river survival estimates reported for the Base, Current, and Prospective analysis, aggregate the three primary sources of mortality (existence, operational, and natural) between Lower Granite dam on the Snake, Rock Island Dam on the middle Columbia, and Bonneville dam tailrace. Natural mortality certainly existed prior to the existence and operation of the FCRPS. However, no attempt is made to distinguish current natural mortality from other sources within the hydro analysis for this document.

7.2.1.2 Analysis for Juvenile Migrants of Other ESUs

For the Lower Columbia and Willamette ESUs and for Snake River Sockeye, for which existing information is not sufficient for quantitative analysis of hydropower system effects, NOAA Fisheries must rely on a more qualitative approach.

The first approach uses information obtained through the quantitative assessment described in 7.2.1.1 for the more data rich ESUs. They provide a surrogate analysis for the effect of the FCRPS hydro actions on ESUs having one or more populations that commonly migrate through Bonneville reservoir and dam (LCR Chinook salmon, Coho salmon, and steelhead). Specifically, the in-river Bonneville reservoir and dam survival estimates (for the most closely related species) produced by COMPASS for the Current and Prospective periods are used as the estimated hydro survival adjustment for those populations spawning upstream of Bonneville Dam. For LCR coho salmon, the expected benefit for spring Chinook salmon would be used. NOAA Fisheries also considers qualitatively, information provided by the FCRPS Action Agencies in the CA's species specific analysis (CA Chapters 12, 13, and 14) in considering the overall effects of the FCRPS and the hydro actions required by the RPA on these ESUs.

The second approach relies on providing professional judgment to qualitatively assess the likely effect of the FCRPS hydro actions on the ESUs for which empirical information is insufficient to provide useful quantitative assessments (SR fall Chinook salmon, SR sockeye, and CR chum). In this case, NOAA Fisheries considers the qualitative assessment made by the FCRPS Action Agencies in the CA and also any other information that would aid in the assessment of how these species are currently affected by the FCRPS and their likely response to the hydro actions required by the FCRPS RPA.

Lastly, no portion of the UWR Chinook salmon and steelhead ESUs migrate upstream of Bonneville Dam, other than as infrequent strays. For this ESU, NOAA Fisheries assumes that the FCRPS effects on the quantity and timing of flows (as described in the Environmental Baseline) will continue to affect these ESUs, but hydro actions required by the Prospective Actions will not benefit these ESUs in any substantial way.

7.2.1.3 Methods for Adult Migrants of All ESUs

Recent survival of adult salmon and steelhead migrating through the FCRPS was assessed to identify ESU specific adult performance standards (and to estimate incidental take). NOAA Fisheries and the FCRPS Action Agencies, in collaboration with the Policy Work Group, adopted a methodology that removes the influence of several confounding variables (harvest and "natural" or transportation related stray rates)[5] that obscure the true effect of the mainstem FCRPS dams on the survival of migrating adults. The assessment is based on returning adults[6] detected at Bonneville Dam and redetected upstream at McNary dam or Lower Granite Dam (depending upon the ESU in question). Only returning adults of known origin, PIT-tagged as juveniles that migrated in-river to below Bonneville were included in the analysis to correct for the confounding variables identified above. See BA Section 2.1.2.2, Appendix B.2.6-2, and SCA Adult Survival Estimate Appendix for a more detailed description of this methodology.

This methodology is also used to develop standards for adult steelhead, recognizing the limitations/uncertainties of the harvest rate information available at this time. Similarly, this methodology is applied to the available information for Lake Wenatchee and Okanogan River sockeye salmon as a surrogate for adult Snake River sockeye survival. In this analysis, NOAA Fisheries qualitatively assesses the likely survival and effects of the Prospective Actions on migrating adults from these ESUs.

7.2.2 Tributary Habitat Analysis Methods

The approach the Action Agencies used to estimate habitat improvement and survival benefits, which NOAA Fisheries adopts for its analysis, is briefly described here and more fully described in Appendix C of the CA. For the reasons that follow, NOAA Fisheries finds that this approach utilizes the best science available for the task of assessing the effects of actions occurring across the basin, affecting a variety of listed salmonid ESUs/DPSs.

The method to identify the status and potential to improve survival and recovery of listed salmon and steelhead through improvement of tributary habitat conditions is based on an approach developed by the Remand Collaboration Habitat Workgroup (CHW). The CHW convened at the request of the Policy Work Group (PWG), formed as part of the court-ordered remand of NOAA Fisheries' 2004 FCRPS Biological Opinion. The CHW reviewed and updated the method described in Appendix E of the 2004 FCRPS Biological Opinion (NMFS 2004a). The Appendix E method was employed by NOAA Fisheries in 2004 to estimate the potential improvement from habitat mitigation actions. The approach in Appendix E used the best available information at the time to estimate effects of the tributary habitat proposed action for the 2004 FCRPS Biological Opinion. However, additional information has become available from recovery planning and other efforts that have occurred since the 2004 FCRPS Biological Opinion was issued.

The CHW met regularly during the spring and summer of 2006 (See § 2.2.1, Appendix C, Attachment C-1, of Corps et al. 2007a). CHW members included representatives from the sovereign States and

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[5] As will be demonstrated in Chapter 8, for some species, transportation of fish as juveniles results in elevated straying rates of returning adults.
[6] Chinook salmon jacks (small, male fish returning to freshwater to spawn after spending only one year in the ocean) were excluded because these smaller fish are not as vulnerable to the fisheries upstream of Bonneville Dam as are the larger 2+ ocean "adult" fish.

Tribes and Federal Agencies involved in the Collaboration process. The CHW consideration of a number of approaches, such as best professional judgment and EDT. Ultimately the CHW developed a process and provided information that could be used to update the Appendix E method from the 2004 FCRPS Biological Opinion. Appendix C of the Action Agencies' CA contains a full description of their approach.

The CHW's approach to estimating habitat benefits relies on the following sequence of steps:

1. Identify the primary factors limiting the recovery of salmon and steelhead populations,

2. Identify the tributary habitat actions (or types of actions) that could be implemented to address those limiting factors,

3. Estimate the current habitat function,

4. Estimate the habitat function that could be obtained by 2018 (within 10 years) by implementing all tributary habitat restoration actions that were identified for implementation by 2018,

5. Estimate the habitat function that could be obtained after 2018 (within 25 years) by implementing all tributary habitat restoration actions that were identified as planned by 2018, and

6. Convert estimated overall habitat functions to survival estimates.

This sequence of steps can produce estimates of the habitat condition and of the potential for salmon survival improvement from habitat actions. Briefly, the logic path began with the identification of individual populations and the population-specific limiting factors. If limiting factors could be further differentiated by subpopulation, the proportional subpopulation area was identified. Then, the degree that actions implemented to address those limiting factors in those areas would improve habitat quality in that subarea was estimated. This logic path provided the basis for estimating changes in habitat function for salmon and steelhead populations as a result of implementing habitat actions. Local biologists provided information for steps 1-5, the products of which the Action Agencies use to complete step 6 based on general habitat/survival relationships developed within the CHW.

This approach is thus based on best available information from local field biologists and recovery planners and general empirical relationships between habitat quality and salmonid survival. Local biologists considered the primary limiting factors identified in recovery planning as well as the tributary habitat actions needed to address those limiting factors. These biologists then estimated the change in habitat function that would accrue if habitat actions were completed as intended. Professional judgment by expert scientists provided a large part of the determination of habitat function in all locations given the limited extent of readily-available empirical data and information. Although NOAA Fisheries recognizes that empirical data and information provides the best insight for determining habitat functioning and salmonid survival, the extent of readily-available empirical data was not adequate to make a precise determination of habitat function and salmonid response uniformly throughout the

Columbia River Basin. NOAA Fisheries finds that the approach developed, and information gathered, through the CHW and subsequently applied here represents the best available information that consistently can be applied over the larger Columbia Basin to estimate the survival response of salmonids to habitat mitigation actions.

The Action Agencies used this method to estimate survival improvement from specific actions completed from 2000 to 2006 and those to be implemented from 2007 to 2009 (see Table 1-6 in Attachment B.2.2-2 to Appendix B of the FCRPS BA [Corps et al. 2007b]). The FCRPS Action Agencies also identified further survival commitments for specific populations which will guide their development of projects to be implemented from 2010-2018. These population-specific survival commitments are identified in CA Appendix C-1, Tables 1-5 (Corps et al. 2007a). Although these future projects have not yet been identified, the resulting estimated survival will be determined during the project selection process using the same approach as described in Appendix C of the CA. The performance of this habitat mitigation program will be measured against these survival commitments.

NOAA Fisheries finds, from available scientific literature on the subject of salmon habitat restoration, that many habitat restoration projects can improve salmon survival over relatively short periods of time. Examples include increases in instream flow, access improvements to blocked habitat and reducing mortality resulting from entrainment at water diversion screens. However, other habitat improvements, such as sediment reduction in spawning gravels and the restoration of riparian vegetation and stream structure, may take decades to realize their full benefit (Beechie et al. 2003). NOAA Fisheries was able to quantitatively or qualitatively consider the post-2018 effect of identified actions proposed for implementation between 2007 and 2009 (Corps et al. 2007a, Appendix C Attachment C-1). In contrast, because the specific habitat projects that will be funded between 2010 and 2018 have not been identified, the type and magnitude of the long-term benefits emerging beyond 2018 cannot be described. NOAA Fisheries recognizes that there will be qualitative improvements that accrue for some populations beyond 2018 even thought the actual benefit cannot be quantified at this time. Nevertheless, NOAA Fisheries expects that future projects will be selected in a similar method as those identified for 2007 through 2009, as the Action Agencies have committed to implement habitat projects that address population-specific limiting factors to achieve identified population survival commitments. The Action Agencies will implement a habitat restoration strategy which will result in both short and longer-term accrual of survival benefits to focus populations. In NOAA Fisheries' analysis it is assumed that for the duration of the Biological Opinion the Action Agencies will continue to implement a mixture of actions which will result in short and long-term accrual of survival benefits to those populations.

NOAA Fisheries' analysis of the effect of the habitat Proposed Actions is based on the assumption that all estimated life-stage and population-specific survival benefits (or ESU/DPS for the estuary) estimated by the Remand Collaboration Habitat Workgroup process will be realized as a result of implementing actions to improve overall habitat quality. NOAA Fisheries' confidence in this assumption is supported by the following observations. First, the application of the general empirically-based relationships between habitat quality and salmonid survival that the CHW method uses to convert improvement in habitat quality into salmonid survival response is a reasonable approach given the qualitative nature of the information available. Second, the survival improvements estimated to accrue as a result of the Proposed Actions are within the range of potential survival benefits identified in completed or developing recovery plans. NOAA Fisheries' analysis and conclusions are based on those biological survival commitments by the Action Agencies which NOAA Fisheries finds can be achieved through project implementation through 2018.

7.2.3 Estuary Habitat Analysis Methods

Habitat projects in the Columbia River estuary were evaluated for their potential to improve the survival of salmon and steelhead in the estuary, which extends from Bonneville Dam at River Mile 146 to the mouth of the Columbia, including the river's plume. The approach used builds on information in the *Guidance from the Habitat Technical Subgroup of the FCRPS Hydropower BiOp Remand Collaboration for Providing Columbia River Basin Estuary Habitat Action Information*, provided to the Policy Work Group on August 18, 2006 (Habitat Technical Subgroup 2006a).To estimate project-specific survival benefits, each project was linked to a recommended recovery action which addressed significant limiting factors in NOAA Fisheries' draft *Columbia River Estuary Recovery Plan Module* (NMFS 2006b), and then evaluated in terms of the project's relative contribution to complete implementation of the recommended recovery action. The evaluation included baseline projects (those completed between 2000 and 2006), current projects in various stages of development (2007 through 2009), and future anticipated projects not yet identified (years 2010 through 1017). The approach used to estimate habitat improvement and survival benefits is fully described in Appendix D, Attachment D-1 of the CA. The projects are described in the CA, Appendix D, Attachment D pages D-1-7-10.

7.2.4 Hatchery Methods

Qualitative and quantitative assessments for analyzing hatchery effects are used in this Supplemental Comprehensive Analysis.

7.2.4.1 Qualitative Assessments of Hatchery Effects

Available information, including NOAA Fisheries' Salmonid Hatchery Inventory and Effects Evaluation Report (SHIEER [NMFS 2004b]), the Hatchery Effects Appendix, and NOAA Fisheries' Artificial Propagation for Pacific Salmon Appendix were used to provide qualitative assessments of every hatchery program located in the Columbia Basin, including programs in the lower Columbia and Willamette Rivers.

7.2.4.2 Quantitative Assessment of Hatchery Effects

The hatchery benefits estimation methodology is described in Stier and Hinrichsen (2008), which is included as Attachment 1 of Quantitative Analysis of the Hatchery Actions Appendix. This methodology was quantitatively applied to assess hatchery effects on the UCR steelhead DPS and on SR spring/summer Chinook in the Grande Ronde MPG. The following considerations are important for using the Stier and Hinrichsen (2008) methodology and are used by NOAA Fisheries to estimate changes in natural productivity from hatchery reform actions for Upper Columbia River steelhead, Upper Columbia River spring Chinook and Snake River spring/summer Chinook salmon.

The Stier and Hinrichsen (2008) methodology:

- is most useful when direct measures of natural productivity are not available,
- estimates changes in productivity for natural-spawning hatchery fish, and not naturally-spawning, natural-origin fish,
- is particularly sensitive to the quality and quantity of spawner composition data (i.e., the number and proportion of natural spawners comprised of hatchery-origin and natural-origin fish) and to natural-origin and hatchery-origin natural spawner spatial and temporal distribution data,
- assumes density-independent population dynamics,
- should not be used to estimate prospective changes in natural productivity when hatchery reforms are not reasonably certain to occur. Reforms included in NOAA Fisheries' approved Tribal Resource Management Plans, Hatchery and Genetic Management Plans, and Endangered Species Act Section 10 permits or Section 7 consultations are considered reasonably certain to occur,
- does not account for genetic and ecological effects on natural productivity from naturally spawning hatchery-origin fish quantitatively, so NOAA Fisheries will describe these factors qualitatively in the effects analysis (Chapter 8) for each species, and
- recognizes and accounts for limiting factors that reduce or preclude the potential for hatchery reform to increase natural productivity (see Artificial Propagation for Pacific Salmon Appendix). For example, hatchery supplementation may offer little potential to increase the number of recruits and establish a trend toward recovery if the quality and or quantity of spawning habitat is limiting natural productivity.

Where natural-origin fish (NOF) and hatchery-origin fish (HOF) spawn naturally, estimating the natural productivity of a population requires estimates of the proportion of natural spawners comprised of HOF, and the relative effectiveness of HOF. Information on historical natural spawner composition is provided by the ICTRT and is used in the Quantitative Analysis of Hatchery Effects Appendix estimates. Berejikian and Ford (2004) provide the basis for hatchery effectiveness estimates and the Quantitative Analysis of Hatchery Effects Appendix also uses results from Araki et al. (2007a).

Four categories, based on broodstock management scenarios, are used for determining HOF effectiveness relative to NOF:

Category 1 includes non-local domesticated broodstock, HOF<30% as effective as NOF,

Category 2 hatchery broodstock is comprised almost exclusively of local-origin NOF broodstock, HOF 90-100% as effective as NOF,

Category 3 includes local-origin NOF and HOF broodstock, <30% (6-45% based on Araki et al. 2007a) as effective as NOF,

Category 4 includes captive and farmed broodstocks.

7.2.5 Predation Methods

7.2.5.1 Tern Predation Analysis Methods

The estimated benefit of reducing predation on juvenile salmon and steelhead by Caspian terns on East Sand Island was calculated by modeling a reduced prospective tern population level. This prospective population was based on the 'Future 2' population objective, or 3,125 breeding pairs established in the 2005 *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary FEIS* (USFWS 2005) The effect of reducing tern predation was estimated at the ESU level since insufficient information was available at the level of the individual population. A more detailed treatment of the method used to estimate the benefit of reducing Sand Island tern predation is presented in Chapter 3 and Appendix F, Attachment F-2 of the CA.

Any estimate benefit of reduced tern predation is sensitive to assumptions about the additive or compensatory nature of mortality from tern predation. The projected benefits identified in the CA (Appendix F) assume complete additivity (no compensatory mortality), i.e., every salmonid not consumed by terns survives all other sources of mortality. However, if some portion of the tern's predation consists of salmonids predestined to die as a result of illness, poor condition or other predators, the survival improvements modeled above would need to be reduced accordingly to estimate the actual survival improvements from tern relocation. Since current literature and empirical data do not identify more specific estimates or ranges, NOAA Fisheries assumes that tern predation likely falls between being completely additive or completely compensatory (Roby et al. 2003). Consequently, in estimating the effect of reducing tern predation NOAA Fisheries assumed a hypothetical compensatory mortality of 50% (Roby et al. 2003).

7.2.5.2 Pikeminnow Predation Analysis Methods

To assess the likely effect (current-to-prospective survival adjustments for juvenile salmon and steelhead) of continuing the expanded Northern Pikeminnow Management Program (NPMP) on salmon and steelhead populations, NOAA Fisheries uses the methodology described in CA Appendix F-1.1. This methodology relies on the Oregon Department of Fish and Wildlife's evaluations of the effectiveness of the NPMP to date and on modeling (consistent with the general assumptions and model parameters used in evaluating the cumulative benefits of the NPMP) the juvenile salmon survival benefits associated with implementing an increased incentive program (Prospective Predation Management Action 1 – BA Section 2.6.1). The general approach employed by NPMP analysts involves applying an appropriate northern pikeminnow consumption rate on juvenile salmonids (temporally and spatially) to the number of additional northern pikeminnow removed (temporally and spatially) to determine "number of smolts" not eaten. This provides an indication of potential incremental benefit of increased removals, assuming no significant inter-or intra-specific compensation.

7.2.5.3 Marine Mammals Predation Analysis Methods

The method NOAA Fisheries uses to assess the likely effect (base-to-current survival adjustment) of marine mammal predation on adult salmon and steelhead in the Bonneville Dam tailrace is described in NMFS 2007e. The analysis generally relies on estimates of annual consumption made by Robert Stansell (Corps) reported in WDFW et al. (2006) updated with 2007 estimates and fishway counts of Chinook salmon and steelhead at Bonneville Dam through May 31. Based on the effectiveness of management actions taken to date, NOAA Fisheries assumes Predation Management Action 7 (Corps et al. 2007 Section 2.6.3) to limit or reduce the potential for sea lion predation in the future will prevent increases above current levels in the future (i.e., the current-to-prospective adjustment is zero).

7.2.6 Methods for Evaluating the Effect of RM&E Actions

The research and monitoring Prospective Actions which will be implemented to ensure hatchery-and habitat-based RM&E actions are comparable (and often identical) to those analyzed in several recently completed scientific research and enhancement biological opinions (NMFS 2004a; NMFS 2005f, 2005g, 2005h, 2005i, 2005j, 2005k, 2005l, 2005m; NMFS 2006f and 2006g). NOAA Fisheries used these analyses within these Biological Opinions as a basis for evaluating the effects of the research and monitoring actions covered in the habitat and hatchery Prospective Actions. Similarly, hydro-related RM&E Prospective Actions are likely to be qualitatively and quantitatively similar to hydro RM&E activities that occurred in 2007 and their effects are likely to be nearly identical to the level of injury and mortality authorized in 2007.

7.3 Methods for Considering Population Level Analysis at ESU/DPS level

The Jeopardy and Metrics memos outline NOAA Fisheries' expected technical considerations in making its jeopardy determination in biological opinions that reference this Supplemental Comprehensive Analysis and state in part:

> In the end, NOAA Fisheries will exercise its best scientific and professional judgment as to whether the mitigation measures are sufficient to reasonably expect that: (1) the ESUs currently on a trend toward recovery will maintain that trend, and (2) ESUs not currently on such a trend will be started on such a trend. [NMFS 2006h]

Additionally, NOAA Fisheries considers that:

> [t]he ESA requires the jeopardy determination to be made at the ESU level. NOAA Fisheries will consider metrics and other information relevant to the population and major population group (MPG) in making a jeopardy determination for an ESU. [NMFS 2006h]

Consistent with this, NOAA Fisheries evaluated all information at the population and MPG level in its ESU level determination, including the TRT products and other relevant scientific information (NMFS 2006h). Both the Willamette/Lower Columbia and Interior Columbia TRTs, when considering long term recovery goals, recommended that for an ESU/DPS to be considered at low risk of extinction (and therefore viable), all MPGs in that ESU/DPS should be at low risk.

Based on these TRT recommendations, other information and the two guidance memos cited above, NOAA Fisheries considered the population level analyses described earlier in this chapter in assessing the trend of each MPG. For this jeopardy analysis, NOAA Fisheries considered an MPG to have a trend toward recovery if a sufficient number of populations within the MPG have a trend toward recovery.

NOAA Fisheries has determined that it may not be necessary for all of the populations to have a trend toward recovery in order for an MPG to have a trend toward recovery, and likewise, it may not be necessary for all of the MPGs to have a trend toward recovery in order for the ESU/DPS as a whole to be on such a trend. In other words, there is more than one combination of populations and MPGs at various risk levels and trends that constitutes an ESU/DPS on a trend toward recovery. In making this determination, NOAA Fisheries considered all factors, including the importance of each population in the ESU/DPS, the strength of each population, and the presence of safety net programs.

In its assessments, NOAA Fisheries considered the aggregated effects of the environmental baseline, cumulative effects and the Prospective Actions, using quantitative analyses at the population level as well as qualitative considerations. NOAA Fisheries also identified any limiting factors (i.e., threats) at the population level likely to be affected by the Prospective Action.

For species with sufficient data, NOAA Fisheries first describes the performance of each population within an MPG with respect to quantitative and qualitative indicators of short-term extinction risk and a trend toward recovery under the Prospective Actions. If there are differences in performance by population, we review the relative importance of each population to the MPG and ESU, based primarily on information from TRTs and recovery planning documents. For example, some populations may be particularly important because of unique life history characteristics, while others may be important because they are relatively large populations that represent the main repositories of fish in a given area.

The degree to which each population and MPG is individually analyzed varies with the species, due to varying amounts of relevant information as described in previous sections. In general, this process has resulted in more detail for most interior Columbia populations than for lower Columbia populations and Snake River sockeye salmon due to available information and degree of the impact of the FCRPS on the populations.

NOAA Fisheries considers additional factors in evaluating whether the Prospective Actions avoid jeopardy for each species:

- If a particular VSP factor is not expected to be sufficiently addressed by the Prospective Actions, is this because it is affected by a long-term listing factor or threat that will require many years to correct? Correcting some problems may in fact take many generations. In this case, NOAA Fisheries considers whether the Prospective Actions are addressing this factor, and if the level of effort is reasonable in the context of what is feasible to accomplish during the next 10 years.
- If it is unlikely that all important populations in an MPG will have low short-term extinction risk and be on a trend toward recovery under the Prospective Action, is the Prospective Action providing higher benefits for other populations in the MPG to help offset the poorer-performing populations?

In evaluating the likelihood that an ESU will survive and trend toward recovery, NOAA Fisheries has been informed by the descriptions and priorities of the TRTs and other sources. Ultimately, NOAA Fisheries relies on its own judgment to determine if the aggregated effects of the Prospective Actions, environmental baseline, and cumulative effects result in the ESU as a whole, meeting those standards.

One comment on the 2007 Draft Biological Opinion recommended that the jeopardy determination be dependent on achieving MPG viability scenarios recommended by the ICTRT. While NOAA Fisheries considered these scenarios, they were presented by the ICTRT as one possible way of achieving long-term recovery goals and not as the sole method of doing so. They also represent long-term viability scenarios, rather than a product intended to be used in reaching jeopardy determinations.

7.4 Critical habitat analysis methods

The ESA requires, in part, that the Prospective Actions are not likely to result in the destruction or adverse modification of designated critical habitat. ESA § 7(b)(3)(A), see Section1.7 above.

This section describes how NOAA Fisheries determines that the Prospective Action meets this requirement. The value of the species' habitat for their conservation, resulting in their recovery and delisting, is a guiding factor in the designation of critical habitat and therefore also in assessing any destruction or adverse modification. 16 U.S.C.A § 1532(5)(A).

The factors that directly influence the conservation value of critical habitat, and thus are relevant to NOAA Fisheries' assessment of the status of critical habitat within the action area, are the essential physical and biological features of that habitat. These include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water, velocity, space, and safe passage.

The specific habitat requirements for each species differ by life history type and life stage. These are described in more detail for each species in Sections 8.2 through 8.14. NOAA Fisheries uses the following framework for analyzing the effects of a Prospective Action on designated critical habitat for each species (NMFS 2005n).

Status of Designated Critical Habitat—Rangewide and Under the Environmental Baseline [7]

- Identify and describe the primary constituent elements of designated critical habitat for each species.
- Describe the conservation role that the designated critical habitat provides in terms of its primary constituent elements (PCEs) referring to available recovery plans and recovery planning materials.
- Describe the current pre-Prospective Action condition of designated critical habitat relative to the functionality of its PCEs as needed to support the species' near term survival and long term trend toward recovery.

Cumulative Effects

- Describe beneficial and adverse effects of non-Federal actions that are reasonably certain to occur relative to the functionality of PCEs needed to support the species' near term survival and long term trend toward recovery.

Effects of the Proposed Action

- Describe both the beneficial and adverse effects of the Prospective Action, including its mitigation measures, on PCEs and how they will influence PCE function and the conservation role of the various critical habitat areas affected.
- Describe the nature, distribution, magnitude, duration, timing, intensity, frequency, and proximity of the effects and relate these to the species' life history characteristics and requirements.
- Describe the resulting trend of PCEs, including short-term degradations that are eventually offset by mitigation actions.
- Evaluate the certainty of any Prospective Actions intended to improve PCE function and the consequence for the species of any delay expected in their implementation.
- Consider the effects of the action on the success of future recovery planning, i.e., determine whether the Prospective Action limits options available for future recovery planning.

Synthesis and Conclusion

- Describe the aggregate effects of the environmental baseline, cumulative effects and the Prospective Action on PCE function and the conservation value of critical habitat.
- After implementation of the action, would critical habitat remain functional (or retain the current ability for the PCEs to become functionally established) to serve the intended conservation role for the species in the near and long terms?

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[7] For the interior species, the action area encompasses almost all designated critical habitat of the species. Therefore, the description of the status of critical habitat in the action area is the same as that for all designated critical habitat.

Chapter 8

Effects Analysis for Salmonids

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Chapter 8
Effects Analysis for Salmonids

This Chapter builds upon the description of effects in the Environmental Baseline (Chapter 5), describes and adds the anticipated effects of the Prospective Actions and all identified Cumulative Effects (Chapter 6), and; considering the current status of each species and its MPGs (Chapter 3), estimates the likely combined effects on the future status of the species. Wherever possible, these effects are presented in quantitative terms, including the quantitative survival and recovery metrics described in Chapter 7. In those instances where detailed quantitative information is not available for a given species, information is used from other species with similar life histories and geographic ranges. In some instances, where quantitative data is lacking, professional judgment guides this analysis.

Except as noted below, effects identified in the Environmental Baseline (Chapter 5) are expected to continue throughout the life of this opinion.

8.1 General Considerations for Multiple ESUs

One or more life stages of each species considered in this analysis occurs within the action area and is affected by the Prospective Actions. Those species with spawning and rearing habitat upstream from one or more of the FCRPS dams are affected in more direct ways than those which spawn downstream from Bonneville Dam (e.g. Columbia River chum, Upper Willamette River spring Chinook). Similarly, those species which must navigate through eight or more dams are more directly affected by dams and reservoirs than those which pass only one or two.

Though proposed RPA actions in tributary habitat areas may affect multiple ESUs, the anticipated effects of such measures are detailed in the ESU-specific analyses in Sections 8.2 through 8.14 and are not presented here.

8.1.1 Juvenile Migrant Survival Improvement Strategies

The Prospective Actions are expected to continue to adversely affect juvenile migrant survival. Given the substantial effect of hydrosystem passage on juvenile migrant survival, improving juvenile passage survival has been a focus of FCRPS fish protection efforts for at least 30 years. This effort involves:

- efforts to improve dam passage survival (e.g. spill program, turbine bypass systems),

- juvenile collection and transportation systems,

- efforts to improve in-river conditions (e.g. flow management, water temperature control, TDG abatement, and predator control), and

- research, monitoring, and evaluation that inform an adaptive management program to further improve juvenile survival.

The RPA continues each of these strategies. Where hydro measures aimed at improving juvenile migrant survival have the potential to affect adult migrants, or spawning and rearing life stages, the anticipated effects on those life stages is also discussed.

8.1.1.1 Dam Passage Survival Improvements

Improved Juvenile Passage
Dam passage improvements, detailed in the hydropower section of the RPA will increase the survival and reduce the delay of listed juvenile salmon and steelhead. These improvements include both configuration and operation changes at each dam.

Configuration changes proposed in the RPA include structural alterations to the routes used by juveniles to pass through the hydroelectric dams during their migration to the ocean. Juveniles follow the water flow pathways through each dam, which routes them through spillways, sluiceways and powerhouses.

Spillway & Sluiceway Passage
In recent years some FCRPS project spillways have been reconfigured to provide a surface water flow outlet for juvenile migrants to pass through. These surface routes (such as the removable spillway weirs (RSWs) at Lower Granite, Lower Monumental, and Ice Harbor dams; the temporary spillway weirs (TSWs) at McNary and John Day dams; and the corner collector at Bonneville dam) are designed specifically to quickly attract juveniles arriving in the dam forebay and to safely pass them through the dam to the tailrace. Also, sluiceways originally designed to facilitate trash removal from turbine intakes, have been recently modified to provide surface passage routes. For instance, the Bonneville 2nd powerhouse sluiceway was recently altered to provide a safe passageway for juveniles. Studies have confirmed that these surface passage routes provide high survival rates (generally equivalent to spillways) and substantially reduce juvenile delay in the forebays (compared to operating without these structures). Reducing delay decreases the exposure of juvenile migrants to sources of mortality (e.g. predation, disease, thermal stress, metabolic stress), thereby increasing survival. To provide higher passage survival and to reduce migration delay, the RPA calls for continued evaluation of surface passage structures (and related project operations) at Lower Monumental, McNary and John Day dams and the design and implementation of a similar structure at Little Goose dam. NOAA Fisheries expects these future surface passage routes to ultimately perform as well as those already installed.

While surface flow routes are expected to provide the majority of in-river juvenile migrants a safe and quick passage route through many of the FCRPS dams, substantial numbers of fish are expected to continue passing these projects through the unmodified (subsurface) spillbays. At some projects, The Dalles dam for instance, where nearly 80% of the juveniles pass through the spillbays), passage through unmodified spillbays will continue to serve as the primary passage route through the dams for migrating smolts. At the remaining projects, where surface passage routes have been installed or are under development, substantial levels of spill will continue to be necessary to provide “training” spill to ensure quick egress and high survival of smolts through the tailrace.[1] Other elements of the RPA, including improved operations and spillbay modifications developed through the project Configuration and Operations Plans (COPs), will ensure there is continued effort to achieve high rates of survival for all fish passed through the spillway bays, regardless of whether they pass through the modified surface routes or the unmodified spillbays.

Powerhouse Passage

While spillways and surface passage routes are the preferred routes for juveniles to pass through the dams, fish also follow the water flowing into the powerhouse turbine intakes. Intake screen bypass systems are installed at seven of the eight dams in the FCRPS migratory corridor to reduce the number of juveniles passing through the turbine units. These bypass systems consist of large screens, located in the turbine intakes, that guide a high percentage of the fish safely away from (bypassing) the turbine entrance, upward into the gatewell, and from there into a collection channel that routes fish either to the river downstream from the powerhouse or, at those projects where fish transportation is available, to raceways where they are held for transportation (see Section 8.1.1.2). Bypassed fish avoid the relatively high mortality and injury rates experienced by turbine-passed fish

The RPA includes measures to improve the survival and reduce the stress to migrants passing through bypass systems. For instance, the bypass outfall site at McNary dam will be relocated to provide better egress conditions (e.g. less conducive to predators). Also, improvements to the outdated bypass system at Lower Granite Dam are expected to reduce the stress of fish passing through that system. Fish tag detection will be provided in the full flow channels at Lower Granite, Little Goose and Lower Monumental dams, so that fish can be routed directly to the tailrace outfall, further reducing any stress that occurs as a result of the existing dewatering and separation systems.

Inevitably, some juveniles pass through hydroelectric generating turbines and their draft tubes to the tailrace. These juveniles generally experience lower survival rates and higher injury rates than their cohorts which pass through the alternative routes. Engineering efforts combined with biological research in recent years have designed and installed new turbines

[1] A substantial level of juvenile predation often occurs in project tailraces. Spill patterns are designed to 1) minimize the formation of eddies or other hydraulic features in the tailrace that are advantageous to fish or birds preying on salmon and steelhead smolts, and 2) provide tailrace conditions where flows move quickly downstream, away from the dams, reducing the exposure of juveniles to these predators.

with higher fish survival rates, such as the minimum gap runner at the Bonneville Dam 1st powerhouse. The RPA includes continuation of the turbine passage survival improvement work with the development of a fish friendlier replacement unit at Ice Harbor dam. Also, the RPA includes biological index testing at all of the dams to identify how to operate the powerhouse for higher passage survival.

8.1.1.2 Spill & Transportation Programs

Voluntary spill of water and fish through spillways (fish spill) reduces turbine passage and as such is a primary method of improving dam passage survival. The RPA includes an initial spill program, with planning dates and spill rates that may be adjusted through the implementation planning and adaptive management processes as fish survival data become available (Corps et al. 2007b, Table 2.1-15). The RPA also includes additional surface passage actions such as RSWs or similar surface bypass devices, where feasible. These configuration modifications, combined with operational spill levels based on biological performance, are expected to improve juvenile survival, improve forebay and tailrace egress, reduce the potential for predation, and decrease the potential for injury and delayed mortality at Federal dams compared with existing conditions for all ESUs with populations that spawn upstream from Bonneville Dam.

At FCRPS projects without fish collection and transportation facilities (i.e., Ice Harbor, John Day, The Dalles, and Bonneville dams) RPA efforts are aimed at improving dam passage survival. At the collector projects (i.e., Lower Granite, Little Goose, Lower Monumental, and McNary dams) the spill program is integrated with the fish transportation program to best manage both juvenile dam passage survival and the likelihood of adult returns (Corps et al. 2007b, Tables 2.1-15 and 2.1-16). Collection and transportation primarily benefit SR steelhead and SR spring/summer Chinook. The Snake River fall Chinook ESU is also transported, especially in low water flow years. However, the benefits of transportation are more equivocal for this ESU, as discussed below.

Juvenile collection and transportation improves juvenile migrant survival by avoiding both reservoir and dam passage effects. Collection occurs when juveniles are deflected by screens from the turbine intakes and delivered to collection systems at Lower Granite, Little Goose, and Lower Monumental dams.[2] By avoiding dam and reservoir passage, collection and transportation substantially improves direct juvenile survival to release points downstream from Bonneville Dam. Schaller et al. (2007) concluded that wild and hatchery steelhead respond most positively to transportation with average T:M ratio for wild steelhead ~1.7 and average T:M for hatchery steelhead ~1.5. The relatively high transport SARs seen for steelhead suggest that full season transportation would optimize steelhead survival under the current configuration and operation of the hydrosystem (Schaller et al. 2007). Recent smolt-to-adult return data indicates that transported steelhead always benefit from transportation.

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[2] Collection and transportation facilities are also available at McNary Dam but these facilities are expected to be only rarely used – see RPA table.

However, under some conditions for some species (e.g. early migrating SR spring/summer Chinook), transported fish return as adults at lower rates than in-river migrants that survive passage to below Bonneville Dam (Williams et al. 2005). While the causes of this difference in smolt-to-adult return rates are not well understood,[3] the effect suggests that while survival through the hydrosystem is improved by transportation, that survival improvement does not always translate into a higher rate of adult returns. The RPA spill and transportation schedules at FCRPS collector projects are designed in consideration of this effect (Corps et al. 2007 BA, Attachment B.2.1-1).

Collection and transportation require that smolts enter the turbine intakes. Fish attracted by spill to pass the dam via the spillway are not available for collection and transportation. Therefore, the higher the percentage of water spilled at a collector project, the fewer the fish transported. Thus, the decisions whether to spill or transport fish at collector projects are tightly integrated to optimize juvenile survival and the likelihood of adult returns. Factors affecting the numbers of fish collected in the juvenile bypass systems are: operations (e.g. percent spill), the effectiveness of turbine intake screens, and the effectiveness of spill. The effectiveness of spill is a function of the percentage of spill at the dam as well as how spill is configured—i.e., whether the spill is through an RSW, height of spill gate openings, location of gates that are providing spill, and proximity of gates providing spill relative to the power house as well as the combined effects of these parameters.

The RPA includes both initial transportation and spill operations schedules (Corps et al 2007 BA, Tables 2.1-15 and 2.1-16) and an adaptive management strategy to modify those schedules as new information warrants. Under some circumstances, the RPA would direct the Action Agencies to pass as many juvenile fish as possible downstream via the spillway and juvenile bypass systems. Under other circumstances, all bypassed fish would be transported, and under some river conditions, spill would be curtailed to maximize collection and transportation. The conditions and seasons under which each of these strategies would be employed under the initial program are specified based on currently available data (Corps 2007 BA Attachment B.2.1-1). When the anticipated likelihood of adult return of transported smolts (SAR) clearly exceeds that expected for in-river migrants, operations favoring collection and transportation are preferred. When the anticipated survival of in-river migrants exceed those of transportation, operations favoring in-river migration, including spill operations, are preferable. Available information shows that the relative efficacy of in-river migration versus collection and transportation is affected by one or more of the following considerations:

- species,
- flow and water temperature,

[3] Hypothesis range from transportation-induced stress and disease to straying rates and changes in the timing of ocean entrance.

- time of year,
- fish condition,
- status of the migration,
- biological productivity in the estuary/nearshore ocean environment,
- predator status.

A computer simulation of the RPA initial spill and transportation program (known as COMPASS) applied to a 70-year record of river flow conditions predicts that an average of about 83% of SR steelhead and 74% of SR spring/summer Chinook would be transported. Although the COMPASS model does not simulate SR fall Chinook passage, the initial transportation program would also collect and transport a large percentage of SR fall Chinook. Available SAR data suggest that transportation neither harms nor helps SR fall Chinook survival, although it clearly improves juvenile survival to below Bonneville Dam (Williams et al. 2005).

Choosing whether to operate in a manner that favors in-river migration (e.g., spill), or transportation, to maximize SARs for multiple species can be difficult. For example, available dam passage survival and SAR data for SR steelhead passing Lower Granite Dam show that transportation improves survival to adulthood under all observed river conditions (Scheuerell and Zabel 2007). This suggests that collection and transportation would always be the best strategy to improve SR steelhead survival. However, under some observed river conditions, SR spring/summer Chinook show a survival benefit from in-river migration early in the migration season. Later in the season (~early to mid-May) and in low-water years, the SARs of transported Chinook generally exceed those of in-river migrants (Scheuerell and Zabel 2007). Both of these species steelhead and Chinook are migrating at the same time and there is currently no technology available that can physically separate them so that steelhead go into the barge and Chinook are returned to the river. Further, there is considerable variation in the relative survival effects between years, complicating the planning process. Thus, there is no management scheme that would always maximize the benefit to both species.

NOAA Fisheries used the COMPASS model to evaluate the effectiveness of an array of transportation strategies and selected the transportation strategy that best balanced the benefits to SR spring/summer Chinook and SR steelhead.

The anticipated effects of various spill and transportation scenarios are captured in the COMPASS modeling results for Snake River salmon and steelhead. As discussed in Chapter 7, inferences to these results are applied to other species in the species-specific analyses in Sections 8.2 through 8.14.

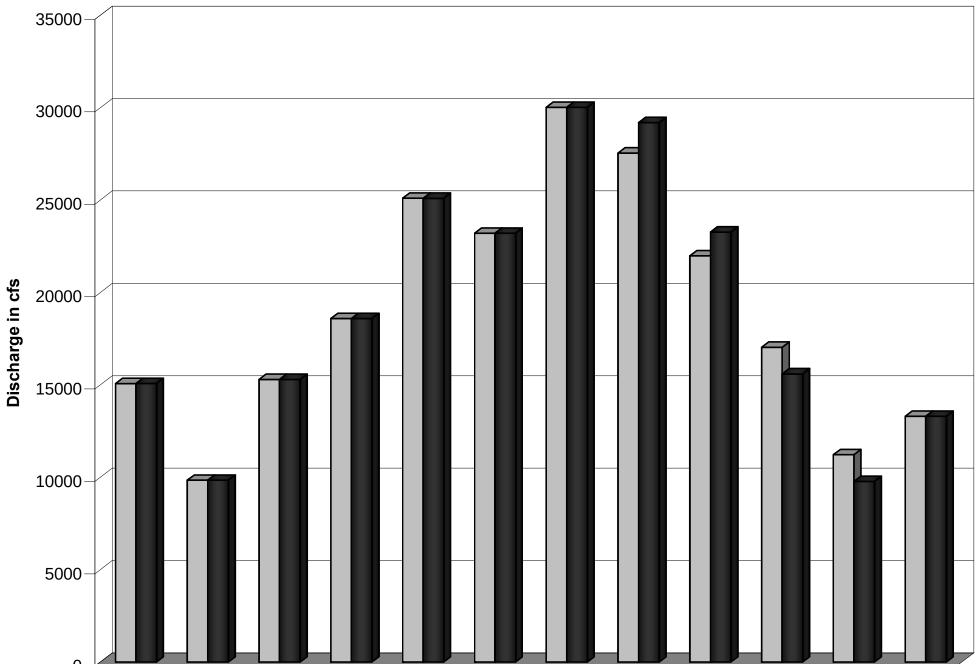
8.1.1.3 Mainstem Flow Effects

The magnitude of flows in the mainstem Snake and Columbia rivers influences water velocity, turbidity, fish travel time, project operations, the amount of spawning habitat and shallow-water rearing habitat below Bonneville Dam for some species, as well as the size and physical characteristics of the Columbia River plume. These effects primarily influence juvenile migrant survival, which generally improves as flows increase, although survival of some species declines during very high flow years (e.g., 1996). Where appropriate, these flow-survival effects are captured in the species-specific juvenile survival modeling presented in Sections 8.2 through 8.14.

Dam and reservoir management to improve flow-related fish survival has been a major aspect of fish protection efforts since the late 1970s. Storage reservoir operations were further revised in successive consultations (1995, 2000, and 2004). In total, 5 to 6 Maf of stored water are annually devoted to enhancing flow conditions in the Snake and Columbia rivers during the juvenile migrations. Winter drafts are also limited to minimize the reduction of flows that occurs each spring while the storage reservoirs are being refilled. Water management was a key component of the collaborative process used to develop the Prospective Actions.

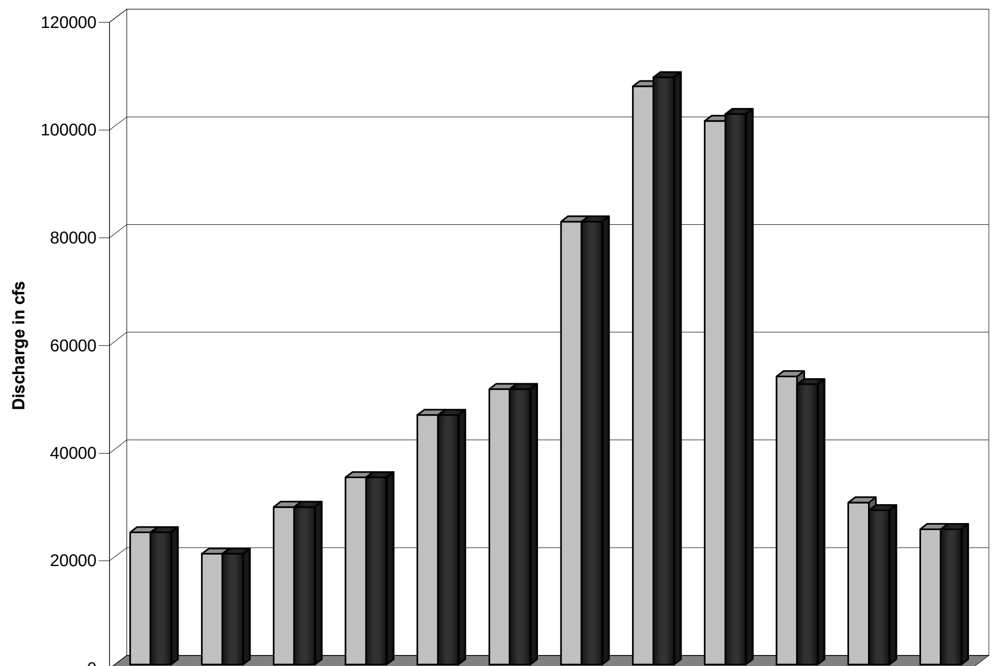
Although the Prospective Action includes modifications of system operating criteria aimed at further improving flow-related survival, the overall changes in flow are modest because much of the potentially beneficial changes in water management have already been accomplished and are part of the environmental baseline (Figures 8.1-1, 8.1-2, 8.1-3, and 8.1-4). By slightly improving flows in April and June compared to current conditions, the Prospective Action slightly improves the functioning of the migration corridor and mainstem juvenile rearing habitat during those months. All ESUs of spring and spring-summer Chinook and steelhead have spring juvenile emigrations.

July and August flows would be slightly reduced at Brownlee, Lower Granite, McNary, and Bonneville dams compared to current conditions. In some years, a substantial fraction of the annual juvenile fall Chinook migration takes place in July and this small reduction in July flows may slightly increase travel time for fall Chinook. If viewed independently, this flow reduction would be expected to slightly decrease juvenile SR fall Chinook survival. However, recent research is showing that the proclivity of juvenile SR fall Chinook to continue migrating as subyearlings diminishes during July (Cook et al. 2006) and through the summer an increasing fraction of SR fall Chinook entering Lower Granite reservoir residualize and migrate during the following year as yearlings. Thus, water temperature, which affects the survival of both migrating and residualized fish, becomes increasingly important. During the hot summer months of July and August, operations at Dworshak Dam, designed to release sufficient cold water to maintain Lower Granite Dam tailrace water temperatures at or below 20 degrees C, likely become the most important factor affecting juvenile SR fall Chinook survival through Lower Granite reservoir.



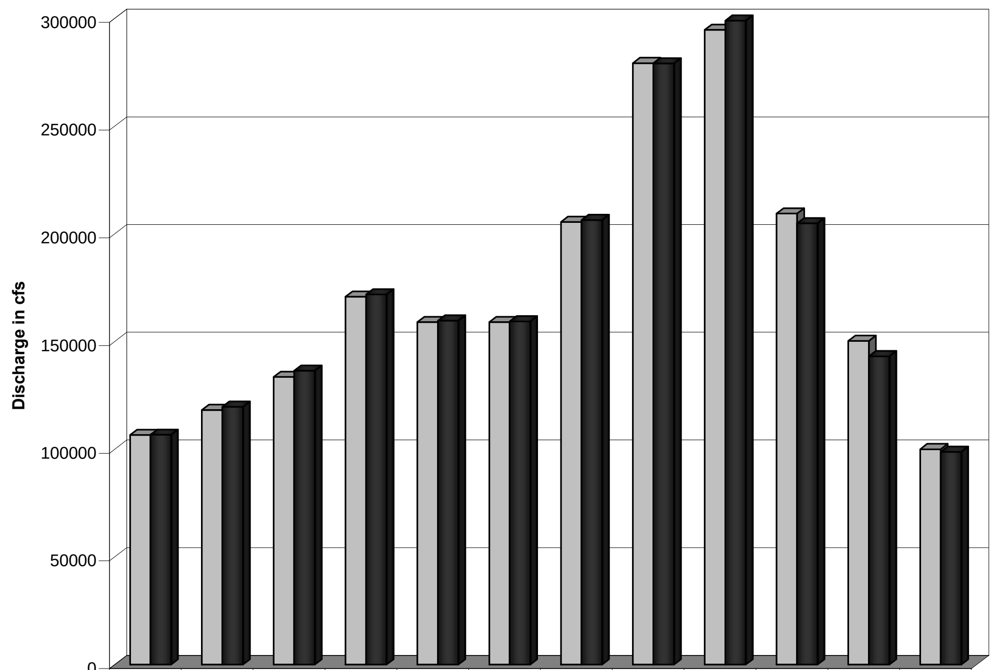
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	15074	9849	15305	18597	25110	23217	30028	27555	21987	17045	11228	13303
Prospective	15079	9848	15305	18597	25105	23217	30028	29199	23275	15599	9784	13303

Figure 8.1-1. Mean monthly Snake River discharge (cfs) at Brownlee Dam under the current operations and under the Prospective Action. Sources: Current Operations, BPA HYDSIM Model run FRIII_07Rerun2004BiOp, dated 4-28-08; Prospective Action, BPA HYDSIM Model run FRIII_final2008BiOp dated 4-28-08.



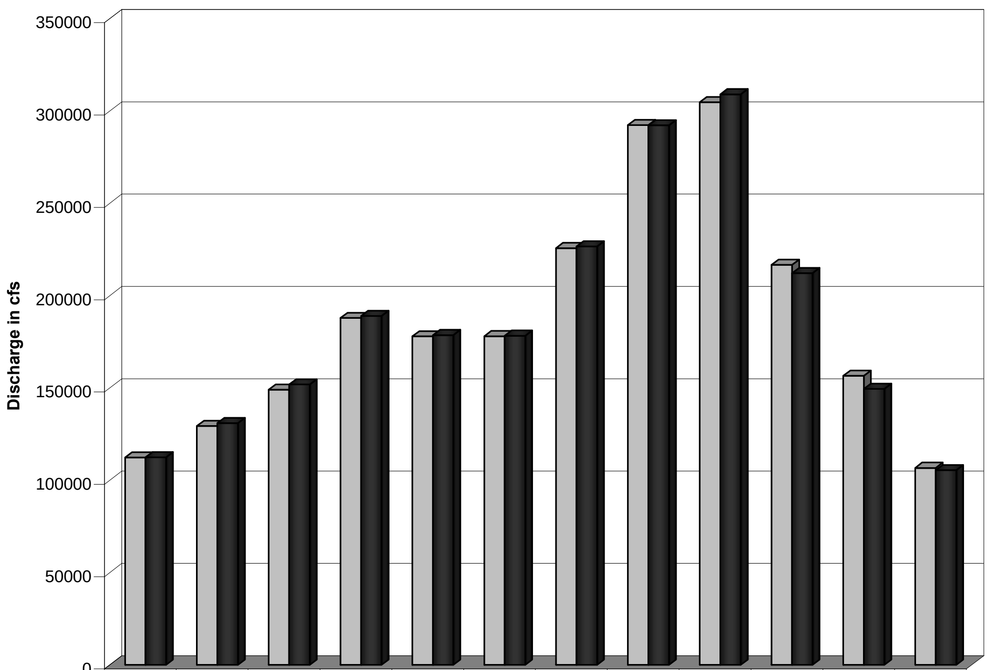
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	24556	20597	29272	34779	46372	51182	82279	107413	100950	53523	30097	25148
Prospective	24561	20596	29272	34779	46367	51180	82281	109057	102237	52076	28653	25148

Figure 8.1-2. Mean monthly Snake River discharge (cfs) at Lower Granite Dam under the current operations and under the prospective operations. Sources: Current Operations, BPA HYDSIM Model run FRIII_07Rerun2004BiOp, dated 4-28-08; Prospective Action, BPA HYDSIM Model run FRIII_final2008BiOp dated 4-28-08.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	106627	118241	133601	170812	159009	159004	205522	279283	294689	209431	150342	100033
Prospective	106735	119727	136488	171856	159717	159331	206450	279127	298988	204884	143205	98799

Figure 8.1-3. Mean monthly Snake River discharge (cfs) at McNary Dam under the current operations and under the prospective operations. Sources: Current Operations, BPA HYDSIM Model run FRIII_07Rerun2004BiOp, dated 4-28-08; Prospective Action, BPA HYDSIM Model run FRIII_final2008BiOp dated 4-28-08.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	112388	129482	149044	187950	177970	178014	225751	292407	304775	216748	156612	106743
Prospective	112493	130971	151932	188995	178678	178341	226681	292261	309062	212199	149473	105505

Figure 8.1-4. Mean monthly Snake River discharge (cfs) at Bonneville Dam under the current operations and under the prospective operations. Sources: Current Operations, BPA HYDSIM Model run FRIII_07Rerun2004BiOp, dated 4-28-08; Prospective Action, BPA HYDSIM Model run FRIII_final2008BiOp dated 4-28-08.

8.1.1.3 Total Dissolved Gas Effects

Following completion of the ongoing flow-deflector construction project at Chief Joseph Dam, TDG conditions throughout the Columbia River migration corridor will be improved during all years that require involuntary spill at that project. In some years this measure would improve smolt survival conditions at both Federal and non-Federal projects in the lower Columbia River. This measure is expected to be completed and totally operational by the 2009 runoff season.

Not only will gas-abatement at Chief Joseph improve downstream water quality, during higher flow years it may also allow increased voluntary spill at downstream projects (e.g. Rock Island, Wanapum) without exceeding state TDG limits. No quantitative estimates of this anticipated benefit are currently available, nevertheless it is reasonable to assume that juvenile migrant survival benefits would accrue during about half of all years with the largest benefits occurring during high and very high flow years when high rates of involuntary spill occur.

All spring migrants will benefit from this reducing TDG concentrations in outflows at Chief Joseph Dam but steelhead smolts, particularly those from the UCR and MCR steelhead DPSs, which are not transported, will likely benefit more than other spring migrants. Steelhead smolts tend to migrate higher in the water column, where gas levels are higher, and are therefore slightly more susceptible to GBT. However, all spring migrants will benefit from increased spill made possible by reducing ambient TDG concentrations.

8.1.1.4 Juvenile Research Monitoring &Evaluation Program

A thoroughly developed and implemented program of research, monitoring, and evaluation (RM&E) can lead to improved fish survival techniques and a greater likelihood of recovery. RM&E inform both in-season and planning decision processes and are integral to adaptive management of the system. The proposed hydrosystem RM&E program is designed to answer the following questions:

- Are salmon and steelhead meeting juvenile and adult hydrosystem passage performance standards and targets?
- Is each project in the hydropower system safely and efficiently passing adult and juvenile migrants?
- What are the most effective configurations and operations for achieving desired performance standards and targets in the FCRPS?
- What is the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville?
- Under what conditions does in-river passage provide greater smolt-to-adult return (SAR) rates than transport?

This action is expected to benefit all ESUs by providing information to support effective adaptive management of the FCRPS throughout the life of the RPA.

8.1.1.5 Other Effects on Juvenile Migrants

Predator Control

The RPA continues the expanded Northern Pikeminnow (*Ptychocheilus oregonensis*) Management Program, which will benefit all species. This program has proven effective in reducing pikeminnow numbers and predation rates and is expected to reduce the total number of smolts lost to pikeminnow predation by about 25% throughout the life of this opinion. These effects are included in the species-specific analyses below.

The proposal to form and coordinate a workshop to review, evaluate, and develop strategies to reduce the impacts of non-indigenous predatory fish such as bass and walleye is an important first step toward assessing and managing predation on salmonids by these species. However such a step is too preliminary for NOAA to predict that a predation reduction is likely to occur as a result. An increasing body of information shows that both walleye and smallmouth bass predation can be locally and seasonally significant. Because NOAA Fisheries cannot yet clearly identify a benefit from this initiative, it has not included any likely benefit in its analysis of effects.

The relocation of the East Sand Island Caspian tern (*Sterna caspia*) colony is expected to benefit all spring migrants and especially all steelhead DPSs. These effects have been quantified and are included in the species-specific analyses below.

RPA Action 47 requires the development of management plans for controlling salmonid predation by double-crested cormorant (*Phalacrocorax auritus*) and Caspian tern nesting at inland sites upstream of Bonneville Dam. Control of these predators would benefit in-river salmonid migrants of all species that spawn upstream from McNary Dam. Developing a plan is only the first necessary step toward achieving benefits for migrating salmon. As this plan is not yet developed, NOAA Fisheries cannot now quantify its likely benefits and has not assigned any benefit to this action in its fish survival modeling.

The proposal to continue avian deterrent actions at all lower Snake and Columbia River dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces. This program continues actions included in the environmental baseline and thus its effects are included in the reach survival estimates base-to-current adjustments used in NOAA Fisheries' quantitative analyses.

8.1.2 Adult Migrant Survival Effects

After accounting for known harvest and estimated stray rates, it appears that the FCRPS has a slight to modest effect on the survival of known origin returning adults. Adult migrant survival through the four to seven dams and reservoirs the interior basin populations must pass ranges from 80% to 90% (see Adult Survival Estimates Appendix).[4]

Downstream of Bonneville dam, the presence of the dam, in combination with increasing numbers of predacious marine mammals (especially California sea lions) in the tailrace of this project, has resulted in a substantial impact to adult spring-run Chinook and winter-run steelhead populations (see SCA – Marine Mammal Predation Appendix). Non-lethal means of managing this impact (exclusion devices, land-and water-based harassment efforts, etc.), though required to continue by the RPA, have proved largely ineffective, as sea lions have proven adept at evading and ignoring such measures. However, current impacts will be substantially reduced as a result of NOAA Fisheries' authorization of the states of Oregon, Washington, and Idaho to remove certain individually identifiable sea lions from this area.[5] NOAA Fisheries expects, that as a result of these activities, sea lion predation rates will be reduced to a continuing average annual impact of about 3.0% for spring Chinook salmon and 7.6% for winter steelhead migrating upstream of Bonneville dam.

Not all adult anadromous salmonids die after spawning. Steelhead adults that survive the rigors of spawning migrate downstream to the ocean soon after spawning. Downriver dam passage survival for these adults, known as kelts, is poor. NOAA Fisheries considers improvement in kelt survival a key element to improving the survival of all steelhead ESUs.

RPA Action 42 requires the Action Agencies to fund the kelt reconditioning program on the Yakima River for MCR steelhead; RPA Action 55 requires the monitoring of kelt passage to improve our understanding; and several configuration and operation improvements of RPA Hydropower Strategy Two (Actions 18 – 28) provide downstream juvenile passage improvements that would also improve kelt dam passage survival. Proposed passage improvements for juvenile salmon and steelhead, including surface passage routes such as RSWs and sluiceways, are likely to also benefit downstream migrating kelts. This should lead to improved survival through the FCRPS. Reduced forebay residence times which lead to a reduction in total travel time may also contribute to an improvement in kelt return rates. It is not possible to calculate the precise amount of improvement expected, because the interactions between improved surface passage and improved kelt survival and return rates are poorly known. However, some improvement is likely.

The RPA (Action 33) requires the Action Agencies to develop, in cooperation with regional salmon managers, and to then implement a Snake River steelhead kelt management plan. The plan would be designed to provide at least a 6% improvement in B-run population productivity. This goal would be achieved by a combination of collection, reconditioning, downstream transport, and dam passage

[4] These estimates may include losses not associated with the hydrosystem such as: unreported or unauthorized harvest, the deaths of fish injured but not killed by marine mammals downstream of Bonneville Dam, as well as natural mortalities.

[5] NOAA Fisheries recently completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho for lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook and winter-run steelhead in the tailrace of Bonneville Dam (Section 5.4.1.3). This action is expected to increase the absolute survival of migrating adult spring-run Chinook by 5.5% and of winter-run steelhead by 14.2%.

survival improvements. Reconditioning programs capture kelts and hold them in tanks where they are fed and treated with antibiotics to enhance survival. Current programs either hold kelts for 3-5 weeks and release them below Bonneville, or hold kelts until they are ready to spawn and release them into their natal streams. Short-term reconditioning efforts have produced average survival rates of 82% (from capture to downstream release) and subsequent kelt returns of 4% to the Yakima River (Branstetter et al. 2006) Long-term reconditioning has produced average survival rates of 35.6%, and all these fish are returned to their natal stream for spawning (Hatch et al. 2006).

There is some concern over the viability of the offspring from long-term reconditioned kelts. Laboratory studies found high rates of post hatching mortality (Branstetter et al. 2006), and studies using DNA analysis to identify the parentage of outmigrating steelhead smolts (Stephenson et al. 2007) have failed to identify any offspring of reconditioned kelts among the juvenile steelhead collected from streams where reconditioned kelts were released. These studies suggest that long-term reconditioning may reduce gamete viability. It is not known if short-term reconditioned kelts may have the same problems with offspring viability; however, because they feed and mature under natural conditions it seems less likely.

Transportation of kelts involves capturing kelts, transporting them to a point downstream of Bonneville Dam, and releasing them. Kelt transportation studies in the Snake River found that not only was there an improvement in FCRPS survival from 4-33% to approximately 98% in transported kelts, transported kelts returned to Lower Granite dam at a rate of 1.7% versus in-river migrating kelts which returned at a rate of 0.5% (Boggs and Peery 2004).

Downstream migrating kelts must be captured before they can be transported and reconditioned. Given kelt preference for surface passage and the potential for future implementation of surface passage routes, the number of kelts which can be collected is limited. Upper and mid-Columbia species present significant challenges to successfully collecting kelts. Existing bypass systems and transportation facilities on the Snake River dams make successful collection of Snake River steelhead more likely. An analysis by Dygert (2007) estimated that 7% (during spill) to 22% (no spill) of the upstream steelhead run could be captured at LGR as downstream migrating kelts. RPA Action 33 would employ collection at both LGR and LGS. NOAA Fisheries' analysis of the likely effects of this RPA action (Steelhead Kelt Appendix) suggests that employing a combination of transportation, reconditioning, and in-stream passage improvements could increase kelt returns enough to increase the number of Snake River B-run steelhead spawners by about 3%. If logistical difficulties associated with capture of upper Columbia River steelhead kelts can be overcome, similar benefits could be expected for that species as well.

8.1.3 Climate Change Considerations

In addition to describing the potential effects of climate change in the Columbia basin, as described in Section 5.7.3 of this document, the ISAB provides a series of mitigation recommendations to address these anticipated effects (ISAB 2007c). These recommendations were taken into consideration in the development of NOAA Fisheries' reasonable and prudent alternatives and by tracking the limiting factors that affect listed species, the Action Agencies will be able to adjust their selection of projects. The ISAB recommendations include:

Planning Actions

1. Assessing potential climate change impacts in each subbasin and developing a strategy to address these concerns should be a requirement in subbasin plan updates. Providing technical assistance to planners in addressing climate change may help ensure that this issue is addressed thoroughly and consistently in the subbasin plans.

2. Tools and climate change projections that will aid planners in assessing subbasin impacts of climate change are becoming more available. Of particular interest for the Columbia Basin is an online climate change streamflow scenario tool that is designed to evaluate vulnerability to climate change for watersheds in the Columbia Basin. Models like this one can be used by planners to identify sensitivities to climate change and develop restoration activities to address these issues.

3. Locations that are likely to be sensitive to climate change and have high ecological value would be appropriate places to establish reserves through purchase of land or conservation easements. Landscape-scale considerations will be critical in choice of reserve sites, as habitat fragmentation and changes of habitat will influence the ability of such reserves to support particular biota in the future. These types of efforts are already supported by the Fish and Wildlife Program, but actions have not yet been targeted to address climate change concerns."

Tributary Habitat

1. Minimize temperature increases in tributaries by implementing measures to retain shade along stream channels and augment summer flow
    - Protect or restore riparian buffers, particularly in headwater tributaries that function as thermal refugia
    - Remove barriers to fish passage into thermal refugia

2. Manage water withdrawals to maintain as high a summer flow as possible to help alleviate both elevated temperatures and low stream flows during summer and autumn
    - Buy or lease water rights
    - Increase efficiency of diversions

3. Protect and restore wetlands, floodplains, or other landscape features that store water to provide some mitigation for declining summer flow
    - Identify cool-water refugia (watersheds with extensive groundwater reservoirs)
    - Protect these groundwater systems and restore them where possible
    - May include tributaries functioning as cool-water refugia along the mainstem Columbia where migrating adults congregate
    - Maintain hydrological connectivity from headwaters to sea

Mainstem and Estuary Habitat

1. Remove dikes to open backwater, slough, and other off-channel habitat to increase flow through these areas and encourage increased hyporheic flow to cool temperatures and create thermal refugia

Mainstem Hydropower

1. Augment flow from cool/cold water storage reservoirs to reduce water temperatures or create cool water refugia in mainstem reservoirs and the estuary

- May require increasing storage reservoirs, but must be cautious with this strategy
- Seasonal flow strategy

2. Use of removable spillway weirs (RSW) to move fish quickly through warm forebays and past predators in the forebays.

- Target to juvenile fall Chinook salmon

3. Reduce water temperatures in adult fish ladders

- Use water drawn from lower cool strata of forebay
- Cover ladders to provide shade

4. Transportation

- Develop temperature criteria for initiating full transportation of juvenile fall Chinook salmon
- Explore the possibility of transporting adults through the lower Snake River when temperatures reach near-lethal limits in later summer
- Control transportation or in-river migration of juveniles so that ocean entry coincides with favorable environmental conditions

5. Reduce predation by introduced piscivorous species (e.g., smallmouth bass, walleye, and channel fish) in mainstem reservoirs and the estuary

Harvest

1. Harvest managers need to adopt near-and long-term assessments that consider changing climate in setting annual quotas and harvest limits

- Reduce harvest during favorable climate conditions to allow stocks that are consistently below sustainable levels during poor phase ocean conditions to recover their numbers and recolonize areas of freshwater habitat
- Use stock identification to target hatchery stocks or robust wild stocks, especially when ocean conditions are not favorable

- Control juvenile migration to ensure that ocean entry coincides with favorable ocean conditions[6]

Addressing ISAB Recommendations

NOAA Fisheries considered many of the ISAB's recommendations in its development of its reasonable and prudent alternatives and applied the recommendations, where applicable, to the actions committed to in this Opinion.

Planning Actions

The RPA contains an array of planning actions, from implementation plans (RPA Action 1) to annual configuration and operations plans (RPA Actions 18-25) to tributary habitat enhancement project identification process (RPA Action 35). The Action Agencies will be required to provide technical assistance to these planning processes, including extensive water quality and fish population modeling (RPA Actions 15, and 53-57). The anticipated effects of climate change will be considered in all applicable planning processes prescribed by this RPA (e.g. those areas where climate change may affect the results).

Tributary Habitat Mitigation

Under RPA Action 34, the Action Agencies will implement an array of habitat improvement projects including, but not limited to: enhancing riparian habitat conditions (e.g. fencing) that would improve stream shading, and the acquisition of water for the purpose of improving summer flows. These actions should improve tributary water temperature conditions. RPA Action 35 requires periodic evaluations of the effectiveness of these tributary habitat enhancement measures and the identification of additional habitat projects in the event that the projected performance of these projects does not meet the specified objectives. The criteria for such additional projects will include consideration of the anticipated effects of global climate change.

For example, the Action Agencies are funding the Methow Salmon Recovery Board to reconnect a side channel of the Methow River. This project will increase off-channel rearing and over-wintering habitat; restore and improve riparian habitat; increase instream complexity; restore natural floodplain processes; restore natural channel process; reestablish side channel rearing habitat; restore-improve riparian forest habitat; add wood complexes in the mainstem; install a rock structure to keep a majority of flow in the mainstem; breach an existing levee; and connect side channels (Fender Mill floodplain restoration) (Corps et al. 2007b, Attachment B.2.2-2).

Additionally, the Action Agencies are funding the John Day Fish Habitat Enhancement Program to enhance production of indigenous wild stocks of spring Chinook and summer steelhead through habitat protection, enhancement and fish passage improvements. During the 2008 to

[6] If the ocean condition becomes less productive, density dependence will be intensified, resulting in increased competition among species and stocks in the ocean. This may result in lower growth and survival rates for wild salmon in the ocean. Reduction in hatchery releases during poor ocean conditions may enhance survival of wild stocks, but more research is necessary (ISAB 2007c).

2009 time period this project will protect riparian areas by installing approximately 15 miles of fencing along tributaries of the John Day River (Corps et al. 2007b, Attachment B.2.2-2).

The Action Agencies are also funding a project to enhance riparian buffers on streams in the Fifteen Mile subbasin and other direct tributaries to the Columbia River in northern Wasco County. A 3-year project goal is to protect riparian areas on approximately 872 acres, covering an estimated 40 miles of anadromous fish streams. Buffer widths will be between 35 and 180 ft. on each side of the stream (Corps et al. 2007b, Attachment B.2.2-2).

Mainstem & Estuary Habitat Mitigation

The RPA requires the Action Agencies to fund estuary habitat programs to achieve estimated species survival benefits (RPAs 36 & 37). For the 2008 to 2009 period, these actions include, but are not limited to: improving mainstem and side channel habitat; acquiring, protecting and restoring off-channel habitat; restoring tidal influence and improving hydrologic flushing; restoring floodplain connectivity by removing or breaking dikes or installing tide gates; removing invasive plants and weeds; replanting native vegetation; protecting and restoring emergent wetland habitat and riparian forest habitat; and restoring channel structure and function. For the remaining term of the Biological Opinion, the Action Agencies will increase the funding for habitat projects. Flexibility is embedded in the RPA to allow the Action Agencies to evaluate the effects of the actions implemented in the 2008 to 2009 period and adaptively tailor projects to better address effects of evolving climatic variation.

Mainstem Hydropower Mitigation

In order to mitigate for the impending effects of climate change on the mainstem hydropower systems of the Snake and Columbia River basins, RPA actions address outflow temperatures, development and implementation of fish passage strategies, transportation, and predation management. These actions are as follows:

- RPA Actions 10 and 11 involve negotiations between the United States and Canada for the management of the Columbia River. To the extent practical the U.S. entity will work to ensure that at least the current level of stored water is delivered to the river during the juvenile salmon migration season (April through August) and will explore opportunities to improve migration season flows.
- RPA Actions 4 and 15 relate to Dworshak releases in July and August for Snake River migrants. These RPAs require that the Action Agencies regulate outflow temperatures at Dworshak in order to maintain Lower Granite tailwater temperatures at or below the water quality standard of 20 degrees C. In addition, they require the expansion of a water temperature modeling program.
- RPA Actions 15, 22 and 23 require the development and completion of effective passage strategies and ensure that RSWs will be implemented at Little Goose and Lower Monumental dams. These measures will provide for efficient passage, ensuring that salmonids are not delayed in forebays nor exposed to increased rates of predation.

- In very dry years, RPA 14 requires the Action Agencies to maximize transport for Snake River migrants in early spring through May 31. Dry years correspond to high temperature years and maximizing transport ensures that migrants are not exposed to near lethal conditions.
- RPA 44 further reduces predation rates by committing the Action Agencies to develop strategies to reduce non-indigenous piscivorous predation by 2009. Beginning in 2010, the Action Agencies will provide annual progress reports detailing the implementation and progress of the actions decided upon.

In addition to these RPA Actions, the Action Agencies are currently implementing projects to maintain/augment summer flow by managing water withdrawals. This is done in order to help alleviate both elevated temperatures and low stream flows during the summer and autumn. For example, the Action Agencies, in the Okanogan subbasin, are funding a project to restore and enhance anadromous fish populations and habitat in Salmon Creek. This project will reconnect Salmon Creek, a productive tributary of the Okanogan River, and involves a water lease with the Okanogan Irrigation District and construction of a low flow channel within the lower reach (Corps et al. 2007b, Attachment B.2.2-2).

Harvest Mitigation

RPA Actions 62, 63, and 64 address harvest and hatchery information needs to improve our ability to both manage and recover these fish. RPA 62 is intended to improve our understanding of the fate of adult migrants, including unreported harvest, straying and other factors contributing to adult conversion rates (i.e., the fraction observed at one dam that passes the next). RPA Action 63 investigates the effectiveness of conservation and safety net hatcheries on species survival and recovery. RPA Action 64 investigates the critical uncertainties if hatchery effects on listed populations (e.g., does the presence of hatchery fish on the spawning grounds reduce population fitness?).

Summary and Conclusion

The full breadth of long-term climate change (ISAB 2007c; Crozier et al. 2008) is unlikely to be realized in the ten-year term of this Opinion. For instance, as stated in Chapter 7, the Crozier et al. (2008) study is based on instantaneous attainment of expected 2040 climate conditions and its affect on life-stage survival, abundance, and population growth rate. The term of this Biological Opinion ceases in 2018. Following completion of the initial set of tributary habitat actions, the Action Agencies, in selecting projects, will focus their efforts on the most recent limiting factors. If, during this time period, various climatic alterations are determined to be limiting factors, the Action Agencies will allocate their projects accordingly. This allows the Action Agencies to address specific, localized impacts of climate change. Measures are in place to ensure that as climatic variation arises, the Action Agencies will be able to adaptively manage to these conditions. NOAA Fisheries concludes that sufficient actions have been adopted to meet current and anticipated climate changes and that sufficient flexibility is available to ensure that those projects yet to be satisfied (2010 to 2018 habitat projects) will take advantage of any new information that may become available, including climate change effects.

8.1.4 Effects of Prospective Research and Monitoring Actions

Effect on Species Status

Under the RPA, numerous measures will be implemented to protect and enhance salmon and steelhead populations and their habitat in the Columbia River Basin. These measures include restoration actions to address, in part, habitat factors limiting the viability of salmonid populations. These altered habitat conditions will affect the distribution and abundance of Chinook, coho, chum, and steelhead, as well as other native and non-native species.

Research and monitoring actions that the FCRPS Action Agencies implement for the FCRPS are of utmost importance because, without sufficient data, it will be impossible to determine whether the RPA performance is as effective as expected. Fish habitat and population monitoring is often conducted to determine if environmental measures, like those included in the proposed action, provide the desired level of protection and enhancement for target fish species and aid in the development of responsive adaptive management strategies. Monitoring is also a necessary tool for providing data critical to adaptive management. Its implementation will ensure that managers have information to determine the effectiveness of the RPA. This monitoring information will also allow adaptive management decisions to be made to ensure the long-term persistence of listed fish species in the Columbia River Basin, as well as the ability to respond to significant changes in environmental conditions.

Under the Research, Monitoring, and Evaluation RPAs, (RPA Actions 50 through 73) the FCRPS Action Agencies will monitor and evaluate the effectiveness of various aquatic measures including fish passage compared to performance standards; adult anadromous salmonid migration, spawning, distribution, productivity and abundance; water quality; habitat quality and quantity, especially when involved in habitat restoration/conservation actions; and hatchery supplementation programs. The FCRPS Action Agencies will prepare annual monitoring reports that include the raw monitoring data complying with regional standards (including, but not limited to: limiting factor data dictionary, protocol manager, habitat project tracking metrics, FGDC metadata). Work will be conducted by the FCRPS Action Agencies, or those hired by the FCRPS Action Agencies to conduct the work (their contractors).

The various monitoring and evaluation activities for anadromous fish measures would cause many types of take (as defined by ESA §3(19) - The term ‘‘take’’ means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct The first part of this Section is devoted to a discussion of the general effects known to be caused by the general potential proposed activities—regardless of where they occur or what species are involved. All of the types of take that would occur during RM&E activities have been considered in previous ESA consultations. Many of the proposed activities that are continuations of research or monitoring projects have been specifically analyzed in annual or multi-year consultation or ESA section 10 permits. They are included here as a programmatic consideration of RM&E activities within the RPA.

Research and monitoring programs identified in the RPA will be funded and/or conducted by the FCRPS Action Agencies. These programs are expected to take listed salmon and steelhead. The activities include: (1) Determining the abundance, distribution, growth rate, and condition of adult and juvenile fish; (2) conducting disease and genetic studies; (3) determining diet composition; (4) evaluating salmonid production (i.e., smolt-to-adult survival rates); (5) determining stock composition, population trends, and life history patterns; (6) evaluating habitat restoration projects; (7) evaluating salmon carcass nutrient restoration and enhancement projects; (8) assessing effectiveness of mine cleanup activities and the bioaccumulation of contaminants; (9) evaluating effects artificial production and supplementation have on listed fish; (10) investigating migration timing and migratory patterns; (11) moving fish beyond impassable barriers; (12) evaluating fish passage facilities, screens, and other bypass systems; (13) investigating fish behaviors in reservoirs and off-channel areas; (14) evaluating salmon spawning below dams; (15) monitoring and mitigating the effects of dam modification and removal; (16) assessing potential impact of a proposed hydroelectric project on fishery resources; (17) assessing point source discharge effects on fish communities; (18) removing non-native fish and excluding hatchery fish to create wild fish sanctuaries; and (19) rescuing and salvaging fish from isolated pools, side channels, project facilities, or other dewatered areas.

The following subsections describe the types of activities that NOAA Fisheries expects the FCRPS Action Agencies will implement in carrying out the research and monitoring requirements of the Prospective Action. The types of activities are organized into the following categories: observation, capture/handle/release, tagging/marking, biological sampling, and sacrifice. Each is described in terms broad enough to apply to every relevant plan informed by previous experience. The activities would be carried out by trained professionals using established protocols and have widely recognized specific impacts. The FCRPS Action Agencies are required to incorporate NOAA Fisheries' uniform, pre-established set of minimization measures, including training, protocol standardization, data management, and reporting for these activities (e.g. electrofishing). These measures will be included in the specific monitoring plans subject to NOAA Fisheries' approval.

Observation

For some studies, fish will be observed in-water (i.e., snorkel surveys). Direct observation is the least disruptive and simplest method for determining presence/absence of the species and estimating their relative abundance. Its effects are also generally the shortest-lived among any of the research activities discussed in this Chapter. Typically, a cautious observer can obtain data without disrupting the normal behavior of a fish. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge behind rocks, vegetation, and deep water areas. In extreme cases, some individuals may temporarily leave a particular pool or habitat type when observers are in their area. Researchers minimize the amount of disturbance by slowly moving through streams, thus allowing ample time for fish to reach escape cover; though it should be noted that the research may at times involve observing adult fish—which are more sensitive to disturbance. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all they can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

Monitoring of population status and the effects of programs and actions will include conducting redd surveys to visually inspect and count the nests or redds of spawning salmon and steelhead. Harassment is the primary form of take associated with these observation activities, and few if any injuries or deaths are expected to occur—particularly in cases where the observation is to be conducted solely by researchers on the stream banks or from a raft rather than walking in the water. Fish may temporarily move off of a redd and seek cover nearby until the observer has past. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all researchers can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

Capture/Handle/Release

Capturing and handling fish causes them stress—though they typically recover fairly rapidly from the process and therefore the overall effects of the procedure are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and the point where fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18 degrees C or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not regularly emptied. Debris buildup at traps can also kill or injure fish if the traps are not monitored and regularly cleared of debris.

The use of capture/handling/release protocols, which are generally standardized throughout the Columbia basin and include maintaining high quality water (appropriate temperature, oxygen levels, anesthetic concentrations) and keeping fish in water to the maximum extent possible, serve to minimize potential adverse impacts on individual fish. Based on experience with the standard protocols that would be used to conduct the research and monitoring, no more than five percent and in most cases, less than two percent of the juvenile salmonids encountered are likely to be killed as an unintentional result of being captured and handled. In any case, researchers will employ the standard protocols and thereby keep adverse effects to a minimum. Finally, any fish unintentionally killed by the research activities in the proposed permit may be retained as reference specimens or used for other research purposes.

Smolt, rotary screw (and other out-migration) traps

Smolt, rotary screw (and other out-migration) traps, are generally operated to gain population specific information on natural population abundance and productivity. On average, they achieve a sample efficiency of four to 20% of the emigrating population from a river or stream, depending on the river size, although under some conditions traps may achieve a higher efficiency for a relatively short period of time (NMFS 2003b). Based on experience in Columbia River tributaries the mortality of fish captured/handled/released at rotary screw type juvenile fish traps would be expected to be two percent or less on target species.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 degrees F (18 degrees C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank. The potential for unexpected injuries or mortalities to ESA-listed fish will be reduced in a number of ways.

Study protocols and ITS terms and conditions define how the potential for stress will be minimized. The action specifies that the trap would be checked and fish handled in the morning. This would ensure that the water temperature is at its daily minimum when fish are handled. Fish may not be handled if the water temperature exceeds 69.8 degrees F (21 degrees C). Sanctuary nets must be used when transferring fish to holding containers to avoid potential injuries. The investigator's hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simple harassment to actually killing the fish. The amount of unintentional mortality attributed to electrofishing may vary widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. Electrofishing can have severe effects on adult salmonids. Spinal injuries in adult salmonids from forced muscle contraction have been documented. Sharber and Carothers (1988) reported that electrofishing killed 50% of the adult rainbow trout in their study. The long-term effects electrofishing has on both juveniles and adult salmonids are not well understood, but long-term experience with electrofishing indicates that most impacts occur at the time of sampling and are of relatively short duration.

The effects electrofishing may have on the threatened species would be limited to the direct and indirect effects of exposure to an electric field, capture by netting, holding captured fish in aerated tanks, and the effects of handling associated with transferring the fish back to the river (see the previous subsection for more detail on capturing and handling effects). Most of the studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish (Sharber and Carothers 1988) and may therefore be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997). McMichael et al. (1998) found a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin. The incidence and severity of electrofishing damage is partly related to the type of equipment used and the waveform produced (Sharber and Carothers 1988; McMichael 1993; Dalbey et al. 1996; Dwyer and White 1997). Continuous direct current (DC) or low-frequency (30 Hz) pulsed DC have been recommended for electrofishing (Fredenberg 1992; Snyder 1995; Dalbey et al. 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (Fredenberg 1992; McMichael 1993; Sharber et al. 1994; Dalbey et al. 1996). Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey et al. 1996; Ainslie et al. 1998). These studies indicate that although some of the fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes they show no growth at all (Dalbey et al. 1996).

NOAA Fisheries' electrofishing guidelines (NMFS 2000d) will be followed in all surveys using this procedure. The guidelines require that field crews be trained in observing animals for signs of stress and shown how to adjust electrofishing equipment to minimize that stress. Electrofishing is used only when all other survey methods are not feasible. All areas for stream and special needs surveys are visually searched for fish before electrofishing may begin. Electrofishing is not done in the vicinity of redds or spawning adults. All electrofishing equipment operators are trained by qualified personnel to be familiar with equipment handling, settings, maintenance, and safety. Operators work in pairs to increase both the number of fish that may be seen and the ability to identify individual fish without having to net them. Working in pairs also allows the operators to net fish before they are subjected to higher electrical fields. Only DC units will be used, and the equipment will be regularly maintained to ensure proper operating condition. Voltage, pulse width, and rate will be kept at minimal levels and water conductivity will be tested at the start of every electrofishing session so those minimal levels can be determined. Due to the low settings used, shocked fish normally revive instantaneously. Fish needing to be revived will receive immediate, adequate care.

The preceding discussion focused on the effects of using a backpack unit for electrofishing and the ways those effects will be mitigated. It should be noted, however, that in larger streams and rivers electrofishing units are sometimes mounted on boats. These units often use more current than backpack electrofishing equipment because they need to cover larger (and deeper) areas, and as a result, can have a greater impact on fish. In addition, the environmental conditions in larger, more turbid streams can limit the operators' ability to minimize impacts on fish. For example, in areas of lower visibility it is difficult for operators to detect the presence of adults and thereby take steps to avoid them. Because of its greater potential to harm fish, and because NOAA Fisheries has not published appropriate guidelines, boat electrofishing has not been given a general authorization and all boat electrofishing projects will be evaluated on a case by case basis.

Angling

Fish that are caught and released alive as part of an RM&E project may still die as a result of injuries or stress resulting from the capture method or handling. The likelihood of mortality varies widely, based on a number of factors including the gear type used, the species, the water conditions, and the care with which the fish is released. As detail for the effects analysis below, general catch-and-release effects for steelhead and Chinook salmon are discussed here.

Catch and Release mortality –The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality is low. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catch and release of adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Data on summer-run steelhead and warmer water conditions are less abundant (Cramer et al. 1997). Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Hooton (1987) because of warmer water and extended freshwater residence of summer fish which make them more likely to be caught. As a result, NOAA Fisheries expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of natural or synthetic bait will reduce juvenile steelhead mortality more than any other angling regulatory change. Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and

White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984) mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found little difference (or inconclusive results) in the mortality of juvenile steelhead associated with using barbed versus barbless hooks, single versus treble hooks, and different hook sizes (Schill and Scarpella 1995; Taylor and White 1992; Mongillo 1984). However, some investigators believe that the use of barbless hooks reduces handling time and stress on hooked fish and adds to survival after release (Wydoski 1977). In summary, catch-and-release mortality of juvenile steelhead is expected to be less than 10% and approaches 0% when researchers are restricted to use of artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay et al. 2004). In hooking mortality studies, hooking location and gear type is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). A large portion of the mortality in the Lindsay et al. (2004) study was related to deep hooking by anglers using prawns or sand shrimp for bait on two-hook terminal tackle. Other baits and lures produced higher rates of jaw hooking than shrimp, and therefore produced lower hooking mortality estimates. The Alaska study reported very low incidence of deep hooking by anglers using lures and bait while fishing for salmon.

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (NMFS 2005c). For similar reasons, NOAA Fisheries currently applies the 10% rate to provide conservative estimates of the hook and release mortality when evaluating the impact of proposed RM&E activities using angling as a monitoring technique.

Tagging and Marking

Techniques such as passive integrated transponder tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

- ***Passive Integrated Transponder (PIT) tag***

A passive integrated transponder (PIT) tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al. 1987; Jenkins and Smith 1990; Prentice et al. 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically-or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Connor et al. 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

- ***Coded wire tags (CWTs)***

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al. 1968, Bordner et al. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon. However, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

- ***Radio tagging***

Radio tagging is another method for tagging fish. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting radio tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

- ***Fin clipping***

Fin clipping is the process of removing part or all of one or more fins to alter a fish's appearance and thus make it identifiable. When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, or severing individual fin rays (Kohlhorst 1979; Welch and Mills 1981). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it. Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 % recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are removed. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality but other studies have been less conclusive.

Regardless, any time researchers clip or remove fins, it is necessary that the fish be handled. Therefore, the same safe and sanitary conditions required for tagging operations also apply to clipping activities.

Stomach Flushing

Stomach flushing is a technique to induce fish to regurgitate the contents of their stomachs without killing the fish. Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light et al. (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100% for the entire observation period. In contrast, Meehan and Miller (1978) determined the survival rate of electrofished, anesthetized, and stomach flushed wild and hatchery coho salmon over a 30-day period to be 87% and 84% respectively.

Biological Sampling

Genetic Samples (fin clips)

Non-lethal sampling to develop population structure and assess parentage.

Sacrifice

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if juveniles are forever removed from the listed species' gene pool; if the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed, but so are all their potential progeny. Thus, killing pre-spawning adults has the greatest potential to affect the listed species. Due to this, NOAA Fisheries rarely allows it to happen. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults. There is no way to mitigate the effects of outrightly sacrificing a fish.

Habitat surveys and installation of monitoring devices

The following potential effects to listed species and their habitats associated with the proposed actions for stream channel, floodplain, and upland surveys and installation of stream monitoring devices - erosion and sedimentation, compaction and disturbance of streambed sediments - are negligible and would have little impact on compaction or instream turbidity. The effect of stream channel, floodplain, and upland surveys and installation of stream monitoring devices activity is described in the HIP Biological Opinion (2.2.1.2.1 Stream Channel, Floodplain, and Uplands Surveys and Installation Stream Monitoring Devices such as Streamflow and Temperature Monitors**) (**NMFS 2003c) as applicable. These actions will incorporate the conservation measures for general construction identified in that Biological Opinion. Similarly, there is the potential for trampling a negligible amount of vegetation during upland and floodplain surveys, but the vegetation would be expected to recover.

Excavated material from cultural resource testing conducted near streams may contribute sediment to streams and increase turbidity. The amount of soil disturbed would be negligible and would have a minimal effect on instream turbidity.

Conservation Measures

The following conservation measures will avoid or minimize the adverse effects discussed above:

- The FCRPS Action Agencies must obtain NOAA Fisheries' review and approval of monitoring and evaluation plans prior to initiating any research-related activities anticipated in this RPA. The plans must identify annual anticipated take levels.

- Listed species must be taken only at the levels, by the means, in the areas, and for the purposes stated in each specific monitoring or evaluation proposal, approved by NOAA Fisheries.

- Workers must not intentionally kill or cause to be killed any listed species unless a specific monitoring or evaluation proposal, approved by NOAA Fisheries, specifically allows intentional lethal take.

- Workers must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided (e.g., the holding units must contain adequate amounts of well-circulated water). When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

- Workers must stop handling listed juvenile fish if the water temperature exceeds 70 degrees F at the capture site. Under these conditions, listed fish may only be visually identified and counted.

- If workers anesthetize listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

- Workers must use a sterilized needle for each individual injection when PIT-tags are inserted into listed fish.

- If workers incidentally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

- If backpack electrofishing methods are used, workers must comply with NOAA Fisheries' Guidelines for Electrofishing (NMFS 2000d) available at http://www.nwr.noaa.gov/1salmon/salmesa/4ddocs/final4d/electro2000.pdf

- The FCRPS Action Agencies must obtain approval from NOAA Fisheries before changing sampling locations or research protocols.

- Except for escapement (redd) surveys, no in-water work will occur within 300 feet of spawning areas during anadromous fish spawning and incubation times.

- Persons conducting redd surveys will be trained in redd identification, likely redd locations, and methods to minimize the likelihood of stepping on redds or delivering fine sediment to redds.

- Workers will avoid redds and listed spawning fish while walking within or near stream channels to the extent possible. Avoidance will be accomplished by examining pool tail outs and low gradient riffles for clean gravel and characteristic shapes and flows prior to walking or snorkeling through these areas.

- If redds or listed spawning fish are observed at any time, workers will step out of the channel and walk around the habitat unit on the bank at a distance from the active channel.

- Snorkel surveys will follow a statistically valid sampling design or rely on a single pass approach.

- Surveyors will coordinate with other local agencies to prevent redundant surveys.

- Excavated material from cultural resource test pits will be placed away from stream channels. All material will be replaced back into test pits when testing is completed.

- Multiple stream sites will be used for field trips to minimize effects on any given stream or riparian buffer area.

- The FCRPS Action Agencies will prepare an annual report of activities, including stream mileage surveyed and inventoried, categorized by method and by WRIA, USGS 6th field HUC, and UTM or other appropriate spatial point information.

Benefits of Monitoring & Evaluation
NOAA Fisheries will not approve a monitoring plan if it operates to the disadvantage of the endangered and/or threatened species that is/are the subject of the plan. In addition, NOAA Fisheries does not approve monitoring plans unless the proposed activities are likely to result in a net benefit to the listed species; benefits accrue from the acquisition of scientific information.

For more than a decade, research and monitoring activities conducted with anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information on anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, PIT-tagging efforts have increased the knowledge of anadromous fish migration timing and survival, and fish passage studies have provided an enhanced understanding of fish behavior and survival when moving past dams and through reservoirs. By approving plans, NOAA Fisheries will enable information to be acquired that will enhance resource manager's ability to make more effective and responsible decisions to sustain anadromous salmonid populations that are at risk of extinction, to mitigate impacts to endangered and threatened salmon and steelhead, and to implement recovery efforts. The resulting data continue to improve the knowledge of the respective species' life history, specific biological requirements, genetic make-up, migration timing, responses to anthropogenic impacts, and survival in the river system.

8.1.5 Effect of Hatchery Programs

An overview of the effects of past and ongoing hatchery factors on the current status of ESA protected salmon and steelhead of the Columbia Basin is provided in NMFS 2004b; the Salmonid Hatchery Inventory and Effects Evaluation Report), in the Hatchery Effects Appendix, and in the Artificial Propagation for Pacific Salmon Appendix.

The hatchery Prospective Actions consist of continued funding of hatcheries as well as reforms to current federally funded programs that will be identified in future hatchery-specific ESA § 7(a)(2) consultations. Subject to these future hatchery consultations, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives; 2) preserve genetic resources; and 3) accelerate trends toward recovery as limiting factors and threats are fixed and natural productivity increases. These benefits, however, are not relied upon for this consultation and are pending completion of the future hatchery consultations.

Hatcheries have a wide variety of purposes and effects, but many hatchery programs are intended to compensate for the effects of hydropower projects, such as blockage of access to or inundation of spawning habitat, and reduced survivals during juvenile and adult migration limiting natural salmon and steelhead productivity (See Section 5.5 of the SCA). The nearly two hundred programs that operate in the Columbia Basin are compensation for Federal and public and private utilities projects and the Action Agencies, through RPA 39, will continue to fund hatchery programs associated with the FCRPS projects. NMFS 2004b provides an overview of hatchery effects at two levels: at the population level and at the ESU or DPS level. For programs in the Interior Columbia (upstream from Bonneville Dam), the Hatchery Effects Appendix, was developed with input provided by members of the Hatchery and Harvest Workgroup of the FCRPS collaboration. The report (1) summarized the major factors limiting salmon and steelhead recovery at the population scale, (2) provided an inventory of existing hatchery programs including their funding source(s) and the status of their regulatory compliance under the ESA and under the National Environmental Policy Act (NEPA), (3) summarized the effects on salmon and steelhead viability from current hatchery operations, and (4) identified new opportunities or changes in hatchery programs likely to benefit population viability. As a follow-up to this report, NOAA Fisheries developed a framework for determining hatchery effects, including a general assessment of Interior Columbia Basin hatchery program effects, and presented this paper and results to the Hatchery and Harvest Workgroup and to the Policy Workgroup in August of 2006. NOAA Fisheries received comments on the paper from members of each workgroup and made numerous revisions (see Artificial Propagation for Pacific Salmon Appendix).

In general, a summary of progress in hatchery reform for Interior Columbia programs is reported in Table 2 of Hatchery Effects Appendix. The overview provided in the Artificial Propagation for Pacific Salmon Appendix identifies six Interior Columbia hatchery programs that are leading factors limiting salmon and steelhead population viability. On the positive or beneficial side, nine hatchery programs were identified as improving viability and population status in the short-term and thirty programs were identified as slowing trends toward extinction or reducing short-term extinction risk. In this later case, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether, but this beneficial effect should be considered transitory because increasing dependence on hatchery intervention results in decreasing benefits and increasing risk (ICTRT 2007a).

For many of the ESUs considered in this analysis, the past effects, and in some instances, continuing effects, of hatchery practices constitute significant factors which may increase risk to the recovery of the ESU (See SCA, Section 5.5). The hatchery Prospective Actions and other on-going hatchery improvement actions are important steps to reducing risk and assuring the long-term viability of these ESUs. These actions are necessary and valuable, and NOAA Fisheries anticipates that they will yield major progress over the next several years with benefits extending into the future. However, by necessity, major hatchery reform of this kind requires that a Hatchery and Genetic Management Plan (HGMP) be submitted to NOAA Fisheries for each hatchery program and detailed review and analysis of each HGMP. The results will be realized in reforms and improvements that are specific to the program involved. At this time, submittal of updated HGMPs to NOAA Fisheries is awaiting recommendations that are pending from science teams and it is not possible to anticipate exactly what those results might be for each of the programs. While we are confident that reforms will occur, in most instances we do not have updated information and analysis to quantify the benefits sufficiently for the quantitative analyses of this SCA.

Because integrated consideration of hatcheries is important to understanding these ESUs, the discussion for these ESUs includes a consideration of the effects of hatchery programs (i.e., overviews without the benefit of proposed hatchery actions and accompanying technical analysis), and where appropriate, a discussion of the effect of potential improvements to these programs. However, except where specifically indicated (such as the consideration of "safety net" hatchery programs to assure survival), the conclusions in this opinion regarding jeopardy and the potential effect of these hatchery improvements can rely only qualitatively on the FCRPS RPA requiring hatchery reform and improvement.

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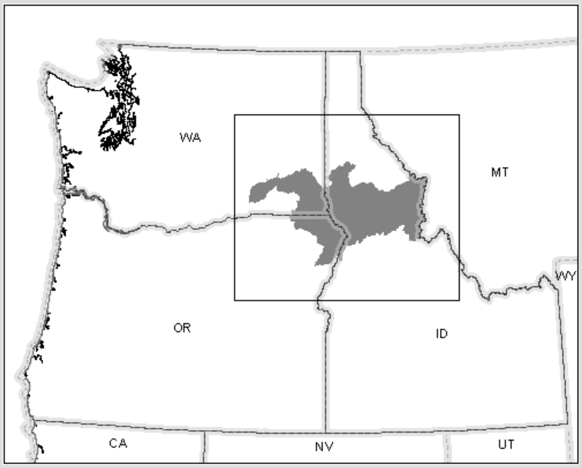
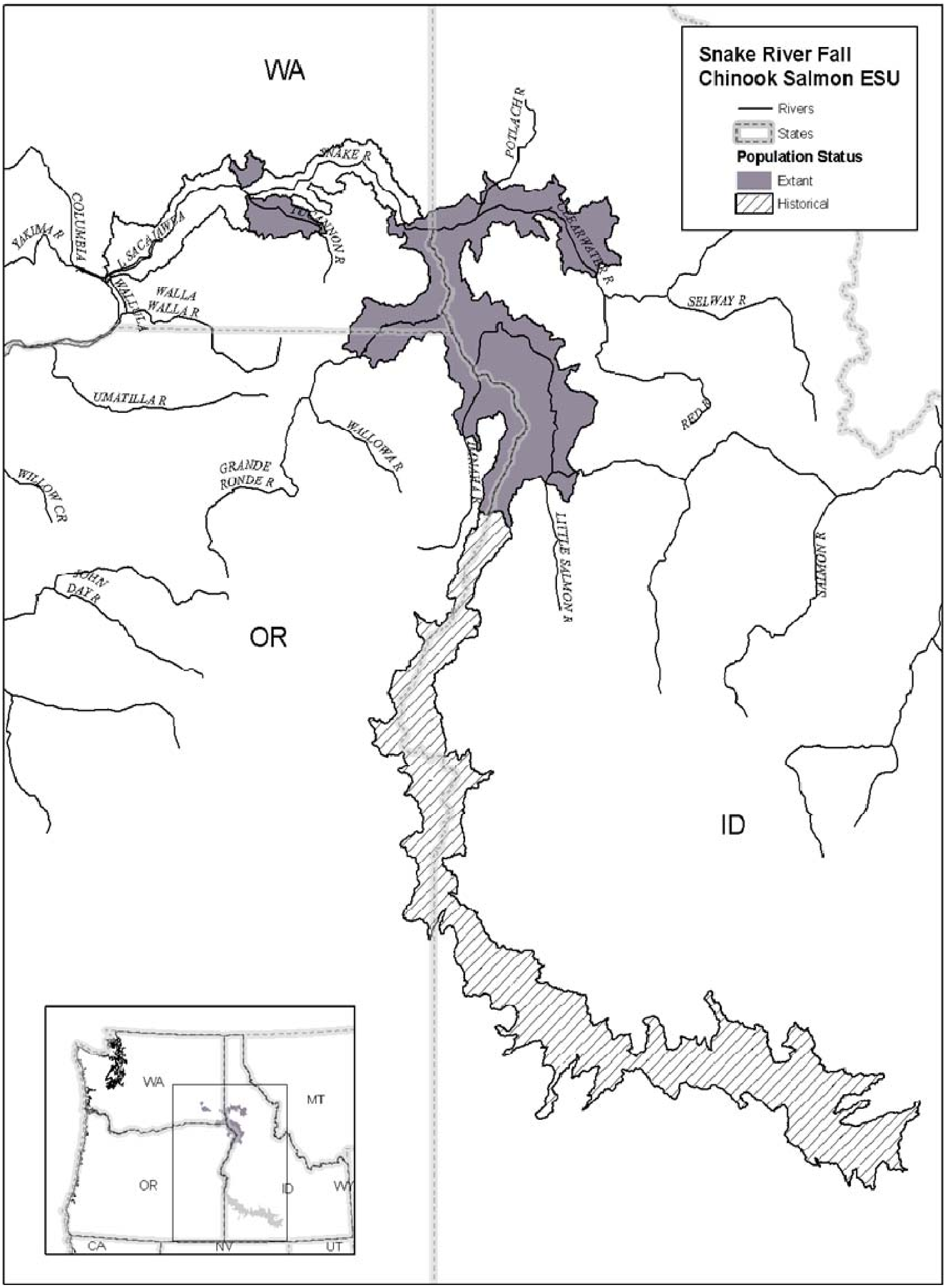
Section 8.2
Snake River Fall Chinook Salmon

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Chinook Salmon ESU
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GRANDE RONDE R
WILLOW CR
JOHN DAY R
SELWAY R
LITTLE SALMON R
SALMON R
MT
WY
CA
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Section 8.2
Snake River Fall Chinook Salmon

Species Overview

Background

The Snake River (SR) fall Chinook salmon ESU is a single population in one major population group (MPG) that spawns and rears in the mainstem Snake River and its tributaries below Hells Canyon Dam. The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901 and the Hells Canyon Complex from 1958 to 1967, which extirpated two of the historical populations. Only 10 to 15% of the historical range of this ESU remains. Hatcheries have played a major role in the production of Snake River fall Chinook since the 1980s. Snake River fall Chinook were listed under the ESA as threatened in 1992.

Designated critical habitat for Snake River fall Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; the Snake River, upstream to Hells Canyon Dam; the lower reaches of the Palouse; and the North Fork Clearwater River (upstream to Dworshak Dam).

Current Status & Recent Trends

The average abundance (1,273) of SR fall Chinook over the most recent 10-year period is below the 3,000 natural spawner average abundance thresholds that the ICTRT identified as a minimum for recovery. Total returns to Lower Granite Dam increased steadily from the mid-1990s to the present. Natural returns increased at roughly the same rate as hatchery origin returns (through run year 2000), but since then hatchery returns have increased disproportionately to natural-origin returns. On average over the last 23 full brood year returns (1977-1999, which includes adult returns through 2004), the natural origin component of the population has not replaced itself.

Limiting Factors and Threats

Limiting factors for SR fall Chinook include mainstem hydroelectric projects in the Columbia and Snake rivers, predation, harvest, hatcheries, the estuary, and tributary habitat. Ocean conditions have also affected the status of this ESU. Generally, ocean conditions have been poor for this ESU over the past 20 years, improving only recently.

Recent Ocean and Mainstem Harvest

SR fall Chinook are present throughout ocean fisheries from Alaska to California, and in fall season fisheries in the mainstem Columbia River. Incidental catch occurs in fisheries that target harvestable hatchery and natural-origin fish. The total ocean fishery exploitation rate averaged 46% from 1986 to 1991, and 31% from 1992 to 2006. Ocean fisheries have been required since 1996, through ESA consultation, to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 base period. In recent years, about 14% of the incidental take has occurred in the southeast Alaska fishery, about 23% in the Canadian fishery (primarily off the west coast of Vancouver Island), about 20% in the coastal fishery (primarily off Washington, and to a lesser degree off Oregon and Northern California), about 11% in the non-Treaty fishery in the Columbia River, and about 30% in the Columbia River tribal treaty-right fishery. The presence of large numbers of harvestable natural-origin fish in the fishing locations from other sources makes it infeasible to distinguish Snake River fall Chinook through means of mark-selective fishing techniques.

SR fall Chinook area also caught in fall season fisheries in the Columbia River with most impacts occurring in Non-Treaty and treaty Indian fisheries from the river mouth to McNary Dam. Fisheries affecting SR fall Chinook have been subject to ESA constraints since 1992. Since 1996, Columbia River fisheries have been subject to a total harvest rate limit of 31.29%. This represents a 30% reduction in the 1988 to 1993 base period harvest rate.

Total harvest mortality for the combined ocean and inriver fisheries can be expressed in terms of exploitation rates which provide a common currency for comparing ocean and inriver fishery impacts (Fisheries in the Columbia River are generally managed subject to harvest rate limits. Harvest rates are expressed as a proportion of the run returning to the river that is killed in river fisheries). The total exploitation rate has declined significantly since the ESA listing. Total exploitation rate averaged 75% from 1986 to 1991, and 45% from 1992 to 2006.

8.2.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.2.2.1 Current Rangewide Status of the Species

Snake River (SR) fall Chinook is a threatened species composed of one extant population in one major population group (MPG). Two historical populations have been extirpated. This population must be highly viable to achieve the ICTRT's suggested viability scenario (ICTRT 2007a, Attachment 2). Key statistics associated with the current status of SR fall Chinook salmon are summarized in Tables 8.2.2-1 through 8.2.2-4.

Limiting Factors and Threats

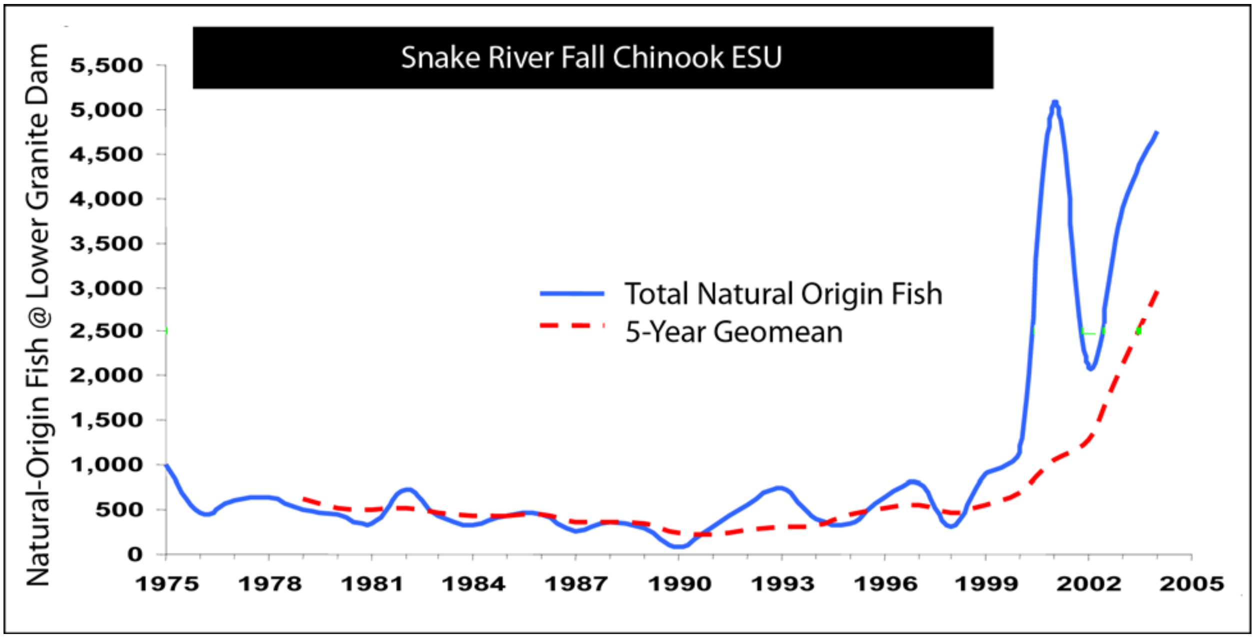
The key limiting factors and threats for the Snake River fall Chinook include hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat. Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall Chinook were generally poor during the early part of the last 20 years.

Abundance

Average abundance (1,273) of SR fall Chinook over the most recent 10-year period is below the 3,000 natural spawner average abundance thresholds that the ICTRT identifies as a minimum for low risk (Table 8.2.2-1).[4] The ICTRT recommends that no fewer than 2,500 of the 3,000 natural-origin fish be mainstem Snake River spawners. Total returns of fall Chinook over Lower Granite Dam increased steadily from the mid-1990s to the present. Natural returns increased at roughly the same rate as hatchery origin returns (through run year 2000), since then hatchery returns have increased disproportionately to natural-origin returns (Figure 8.2.2.1-1). The median proportion of natural-origin has been approximately 32% over the past two brood cycles (Cooney and Ford 2007).

[4] BRT and ICTRT products were developed as primary sources of information for the development of delisting or long-term recovery goals. They were not intended as the basis for setting goals for "no jeopardy" determinations. Although NOAA Fisheries considers the information in the BRT and ICTRT documents in this consultation, its jeopardy determinations are made in a manner consistent with the Lohn memos dated July 12, and September 6, 2006 (NMFS 2006h, i).

Figure 8.2.2.1-1 Snake River Fall Chinook Salmon Abundance Trends (adopted from Fisher and Hinrichsen 2006)



The driving factors for the recent increase may include reduced harvest rates, improved in-river rearing and migration conditions, the development of life history adaptations to current conditions, improved ocean conditions benefiting the relatively northern migration patter, the supplementation program or other factors. As this time, there is insufficient information to estimate the relative contributions of these factors (Cooney and Ford 2007).

"Base Period" Productivity

On average over the last 23 full brood year returns (1977-1999 brood years [BY], including adult returns through 2004), when only natural production is considered, SR fall Chinook populations have not replaced themselves (i.e., average R/S has been less than 1.0; Table 8.2.2-1). R/S productivity was below 1.0 for all but three brood years prior to 1995, and it was above 1.0 between 1995 and 1999 (Cooney and Ford 2007). Additionally, Cooney and Ford (2007) make preliminary estimates for the 2000-2003 brood years, half of which also indicate R/S>1.0.

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at <5% extinction risk (ICTRT 2007c)

The BRT trend in abundance was >1.0 during the 1980-2004 period (Table 8.2.2-1). Median population growth rate (lambda), when calculated with an assumption that hatchery-origin natural spawners do not reproduce effectively (HF=0), also was greater than 1.0 (increasing) for SR fall Chinook (Table 8.2.2-1). When calculated with the HF=1 assumption, lambda has been less than 1.0.

Spatial Structure

The ICTRT does not yet characterize the spatial structure risk to SR fall Chinook, although generic spatial structure criteria have been described in ICTRT (2007d). However, the Biological Review Team (Good et al. 2005) characterizes the risk for the "distribution" VSP factor as "moderately high" (Table 8.2.2-2) because approximately 85% of historical habitat is inaccessible and the distribution of the extant population makes it relatively vulnerable to variable environmental conditions and large disturbances.

Diversity

The ICTRT has not yet characterized the diversity risk to SR fall Chinook, although generic diversity criteria and the presence of five major spawning areas within currently occupied habitat are described in ICTRT (2007d). However, the Biological Review Team (Good et al. 2005) characterizes the risk for the diversity VSP factor as "moderately high" (Table 8.2.2-2) because of the loss of diversity associated with extinct populations and the significant hatchery influence on the extant population. The median proportion of hatchery-origin has been approximately 68% over the past two brood cycles.

Based on NOAA Fisheries' SHIEER document (NMFS 2004b), the hatchery and harvest workgroup (under the Policy Work Group), "Hatchery Effects Report," and Cooney and Ford (2007), there are four primary reasons why the current supplementation program contributes to a diversity risk for Snake River fall Chinook: 1) In order to meet the ICTRT's (2007a) diversity viability goals, the proportion of hatchery fish spawning naturally must be significantly reduced from current levels; 2) In the current configuration of the program, all components of the ESU are supplemented, limiting the options for evaluating the programs; 3) In the mainstem Snake River major spawning areas, the ESU may be at or near carrying capacity, suggesting the further supplementation is unlikely to be beneficial to the ESU; and 4) The proportion of natural origin fish in the broodstock has been low. These issues are discussed in more detail in Cooney and Ford (2007).

"Base Period" Extinction Risk

A draft ICTRT Current Status Summary (ICTRT 2007d) characterizes the long-term (100 year) extinction risk, calculated from productivity and natural origin abundance estimates of SR fall Chinook during the 1977-1999 Brood year "base period" described above for R/S productivity estimates, as "High" (>25% 100-year extinction risk). In these analyses, the ICTRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years (QET=50). The ICTRT also calculated the extinction risk based on the 1990-1999 time period and determined that it was "moderate" (6-25% 100-year extinction risk). The ICTRT indicates that extinction risk is likely between these estimates ("moderate" to "high").

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk, as discussed in Section 7.1.1 of this Supplemental Comprehensive Analysis. Table 8.2.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish) for SR fall Chinook. This short-term extinction risk analysis is also based on the assumption that productivity observed during the "base period" will be unchanged in the future. At QET=50, as well as at lower QET levels, there is less than 5% risk of short-term extinction. Confidence limits on this estimate are extremely wide, ranging from 0 to 100% risk of extinction.

The short-term and ICTRT long-term extinction risk analyses assume that all hatchery supplementation ceases immediately. As described in Section 7.1.1.1 of the SCA, this assumption is not representative of hatchery management under the Prospective Actions. A more realistic assessment of short-term extinction risk will take hatchery programs into consideration, either qualitatively or quantitatively. If hatchery supplementation is assumed to continue at current levels for SR fall Chinook, short-term extinction risk is 0% at all QETs (Hinrichsen 2008, included as Attachment 1 of the Aggregate Analysis Appendix).

Quantitative Survival Gaps

The change in density-independent survival that is necessary for quantitative indicators of productivity to be greater than 1.0 and for extinction risk to be less than 5% are displayed in Table 8.2.2-4. Mean base period R/S survival gap for the 1977-1999 brood year base period is 34%, while the mean survival gap for lambda (HF=1) is 27%. No additional survival improvements are needed for the R/S gap calculated using the 1990-1999 period, for lambda (HF=0) or for BRT trend estimates. Because base short-term extinction risk is 0-1%, no additional improvements are needed to achieve less than 5% risk at QET=50.

8.2.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for SR fall Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls and Dworshak and Hells Canyon dams) in the following subbasins: Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse. The lower Columbia River corridor is among the areas of high conservation value to the ESU 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. 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 1993). The status of critical habitat is discussed further in Section 8.2.3.3.

8.2.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.2.3.1 "Current" Productivity & Extinction Risk

Because the action area, as defined in Chapter 5, encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section, estimates of productivity and extinction risk are based on performance of populations during a 20-year "base period," ending with the 1999 brood year. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone Section 7 consultation and continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity through bank stabilization, shading, etc.).

Quantitative Estimates

Because a number of ongoing human activities have changed in recent years, it is necessary to evaluate changes that have occurred and adjust the "base period" estimates to reflect what would be expected if current management practices continued into the future. For SR fall Chinook, two approaches are used to characterize the current status (Section 7.1.1 of this document).

Base-to-Current Adjustment Approach

The first approach is to adjust the 1977-1999 brood year estimates by estimating a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Section 4.3.1 of the CA. Results are presented in Table 8.2.3-1.

Briefly, reduction in the average base period harvest rate (estimated at approximately a 9% survival change [SCA Harvest Appendix, based on *U.S. v. Oregon* estimates]), estuary habitat projects (a less than 1% survival change, based on CA Appendix D), and a reduction in tern mortality (approximately 2%) result in a quantitative survival improvement for SR fall Chinook. The net result is that, if these human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to increase 12% compared to the 1980-1999 BY average. This also means that the survival "gaps" described in Table 8.2.2-4 would be proportionately reduced by this amount (i.e., ["Gap" ÷ 1.12).

This approach is of limited utility for SR fall Chinook because some of the more important changes from the base period, discussed below, cannot be estimated quantitatively for this species. Therefore, it is only possible to estimate a portion of the survival change that has occurred and the base-to-current survival multiplier represents a very conservative (i.e., negative) estimate of the effect of continuing current hydro operations into the future.

The main change from the base period that cannot be quantified is improvements to hydro configuration and operation for fall Chinook due to uncertainties about the juvenile life history strategies this species employs (Section 8.2.5.1).

Qualitatively, several hydro-related actions have likely contributed to increased productivity of naturally produced SR fall Chinook salmon (base-to-current adjustment). First, Reclamation has provided some level of flow augmentation water (90,000 to 487,000 acre-feet), primarily during July and August, since 1991 (except 1992) to enhance flows (migratory conditions) through the lower Snake and Columbia Rivers (USBR 1998). Second, since 1991, Idaho Power Company has voluntarily provided generally stable outflows (ranging from 8,000 and13,000 cfs depending on prevailing flow conditions in a given year) at Hells Canyon Dam during the fall Chinook spawning season (primarily late October and November); and maintained these flows as minimums throughout the incubation period (primarily late November through April) to enhance the survival of incubating fall Chinook to emergence (IPC 1991 and FERC 2007). During rearing (March through June) peaking at Hells Canyon Complex is known to cause limited entrapment of fall Chinook fry this effect is currently under investigation by IPC and mitigative measures are being evaluated (Brink and Chandler 2006). Third, since 1993, the Corps of Engineers has drafted Dworshak reservoir (north fork, Clearwater River) to enhance juvenile migratory conditions (reduced summer temperatures and enhanced summer flows) in the lower Snake River (Corps et al. 2007b, Appendix 1). By providing suitable water temperatures for over-summer rearing within the Snake River reservoirs, this action apparently has allowed the expression of a productive “yearling” life-history strategy that was not available to this ESU in the past (Connor et al. 2007). Finally, actions required by the 1995 FCRPS Biological Opinion generally resulted in improved dam configurations, better summer flow conditions, and expanded summer spill programs in the lower Columbia River (BA, Appendix A) beginning in 1996 compared to previous years. This likely resulted in improved passage conditions and increased survival rates for in-river migrating juvenile fall Chinook salmon. Together, these factors likely have increased productivity of this species since the base period depicted in the base-to-current survival adjustments.

Hatchery effects are also considered qualitatively. The discussion of diversity under rangewide status (Section 8.2.2.1) also applies to the status of hatchery programs under the environmental baseline.

1990-Present Approach

An alternative approach to adjusting extinction risk is included here because alternative base periods were evaluated by the ICTRT (2007c). In addition to evaluating the 1977-1999 BY time series, the ICTRT evaluated a 1990-1999 BY series. The more recent time series is representative of recent harvest rates and hydro effects, as well as other human impacts. In this sense it is a better representation of current conditions under the environmental baseline than is the 1977-1999 time series. However, there are also two potential drawbacks to the shorter time series. First, because it is a shorter time series it captures less of the variability of the population performance and is generally less reliable for making estimates of productivity and extinction risk. As described in Chapter 7, this is the primary reason why the 20-year time series is emphasized in our quantitative analysis. A second factor is that the more recent time period may include a higher percentage of climatic conditions that appear to be favorable to Columbia basin salmon survival. The base-to-current survival adjustment is intended to represent changes in Columbia basin resource management rather than changes in climate.

The ICTRT (2007c) concluded that "at this time, it is reasonable to assume that the A/P [abundance and productivity] gap falls within the range defined by the two recent scenarios." Therefore, both approaches are used to characterize the current status of SR fall Chinook. The 1990-present productivity estimates are presented in Table 8.2.2-1 and the gaps necessary for productivity >1.0 are included in Table 8.2.2-4. It is not possible to estimate short-term extinction risk for the 1990-present time series (Section 7.1.1). Under this approach, there is no base-to-current adjustment for this metric.

8.2.3.2 Abundance, Spatial Structure & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section.

8.2.3.3 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. Salmon habitat has been altered through activities such as urban development, logging, grazing, power generation, and agriculture. These habitat alterations have resulted in the loss of important spawning and rearing habitat and the loss or degradation of migration corridors. The following are the major factors limiting the conservation value of critical habitat for SR fall Chinook:

- Mainstem lower Snake and Columbia River hydropower system mortality (juvenile migration corridors with safe passage)
- Altered seasonal temperature regimes
- Reduced spawning/rearing habitat due to mainstem lower Snake River hydropower system (spawning areas with gravel, water quality, cover/shelter, riparian vegetation, and space to support egg incubation and larval growth and development)

The FCRPS Action Agencies have taken a number of actions in recent years to improve the conservation value of PCEs. For example, the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at FCRPS dams has been improved by the structural improvements and operations described in Section 4.3.1.1 in Corps et al. (Corps et al. 2007a).

Spawning Areas

Dauble et al. (2003) described the sequence of mainstem hydro development that reduced the spawning range of SR fall Chinook salmon in the Snake River. Idaho Power Company (IPC 2003) has estimated that as many as 450,000 fish returned to the Snake River each year before hydropower development. About 270,000 spawned upstream of the current location of the Hells Canyon Complex, a series of three dams that IPC built between 1958 and 1967, blocking access to 210 miles (338 km) of mainstem riverine habitat. Construction of the four federal dams on the lower Snake River (1962 to 1975) converted almost 147 miles (236 km) of riverine to reservoir habitat. The reservoirs reduced average water velocities and habitat complexity and increased water surface elevations. Since then, the 101-mile Hells Canyon Reach (i.e., between the upper end of Lower Granite Reservoir and the tailrace of Hells Canyon Dam) has been the only continuous stretch of free-flowing mainstem habitat available to fall Chinook for spawning. Garcia et al. (2007) reported a peak count of 1,709 redds in this reach in 2004 (and more than 1,000 redds each year from 2002 through 2006; see Appendix 3 in Garcia et al. 2007). Assuming two fish per redd, the Hells Canyon Reach has recently supported at least 3,400 spawners.

SR fall Chinook also spawned historically in the lower mainstems of the Clearwater, Grande Ronde, Salmon, Imnaha, and Tucannon river systems. At least some of these areas probably supported significant production, but at much lower levels than in the mainstem Snake River. Smaller portions of habitat in the Imnaha and Salmon rivers have supported fall Chinook. Some limited spawning currently occurs in all these areas, although returns to the Tucannon are predominately releases and strays from the Lyons Ferry hatchery program. The Clearwater, Grande Ronde, Salmon, and Imnaha collectively supported a maximum of 852 redds in 2004 (averaging at least 500 each year since 2002; see Appendices 3-7 in Garcia et al. 2007). Thus, under current conditions, the available area below Hells Canyon Dam has demonstrated the capacity to support at least 5,000 spawners. The ICTRT has set a recovery abundance threshold of 3,000 spawners (i.e., to meet viability goals for abundance at <5% risk of extinction (ICTRT 2007c).

As discussed in Section 8.2.3.1 (Current Productivity and Extinction Risk), several recent hydro-related activities have improved the functioning of PCEs for spawning and rearing. Since 1991, IPC has voluntarily stabilized outflows from Hells Canyon Dam during late October and November and kept the redds established during that period “watered” through emergence in April. However, if rearing fry move to the shallow river margin, they can become entrapped in several pool complexes. Idaho Power Company is currently investigating this issue and evaluating mitigative measures (Brink and Chandler 2006).

Factors limiting the functioning and thus conservation value of PCEs in the available spawning areas (i.e., affecting water quality, water quantity, space, and/or spawning gravel) are:

- In the Hells Canyon Reach of the mainstem Snake River—changes in river flow *[reductions in flow entrap and strand fry]*, temperature regime *[warmer in fall when adults arrive for spawning and cooler during the spring incubation period due to the existence and operation of IPC’s Brownlee reservoir (Hells Canyon complex), may delay the emergence of fry production by later* *spawning adults]* and dissolved oxygen *[episodic low dissolved oxygen conditions can persist into early fall when adult fish arrive and stage for spawning]*

- In the Clearwater River below the North Fork—changes in water temperature *[cooler during spring incubation period due to Dworshak operations, slowing development and growth rates in the Clearwater, although cooling the Snake for juvenile fall Chinook migrating from mainstem spawning areas]*

- In the lower Grande Ronde River—sediment in gravel, degraded water quality *[including high temperature and low concentration of dissolved oxygen]*

- In the lower Tucannon River—sediment in gravel *[limits survival in egg to fry stages]*

Rearing Areas & the Juvenile Migration Corridor

Fall Chinook salmon generally begin spawning in the Snake River during the third week of October (Groves and Chandler 1999). Fry emerge from redds during April through June and rear for two months or more in the sandy littoral zone along the river margins (Tiffin et al. 1999). Parr and presmolts move offshore and begin downstream migration and/or extended rearing in the deeper waters of the flowing river and reservoirs. Subyearling smolts are detected passing Lower Granite Dam as early as May and through the late fall when the juvenile fish passage facilities cease operation (Connor et al. 2007). Most of the in-river migrants pass Bonneville Dam by mid-July. Subyearlings that enter the estuary as smolts are thought to reside there for a few weeks before moving into the plume and offshore waters (Fresh et al. 2005). However, recent acoustic tag studies indicate that Snake River fall Chinook subyearling smolts travel from Bonneville Dam to the mouth of the Columbia River in about four days (median value). Survival estimates through this reach (2005-2007) ranged from about 70 to 90% in June, declining to only 20 to 60% in mid-July (McComas et al. 2008).

Several recent hydro-related actions have improved the functioning of PCEs in the juvenile migration corridor. Since 1993, the Corps of Engineers has drafted Dworshak Reservoir to enhance conditions in the juvenile migration corridor by adding cooler water to that in the lower Snake. Reclamation has provided flow augmentation (90,000 to 487,000 acre-feet) from the upper Snake basin to enhance flows in the lower Snake and Columbia rivers during July and August. Actions required by the 1995 FCRPS Biological Opinion have generally resulted in improved dam configurations, better flow conditions, and expanded summer spill programs.

The following are the major factors that limit the functioning and thus the conservation value of rearing areas and the juvenile migration corridor (i.e., affecting water quality, water quantity, cover/shelter, space, food and/or riparian vegetation):

- In the Hells Canyon Reach of the mainstem Snake River, cooler spring temperatures of water released form the Hells Canyon complex *[delays emergence of some fry]*

- In the juvenile migration corridor—scarcity of cover in the reservoirs (as refuge from fish predators – particularly non-native small mouth bass in the in the Snake River); passage mortality *[FCRPS dams and reservoirs];* and warm summer temperatures [*juveniles had typically completed their migration from the Snake River basin by the end of June prior to construction of the Hells Canyon complex and Snake River mainstem dams, excluding Ice Harbor dam.]*

- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management*].

In the mainstem FCRPS migration corridor, the Action Agencies have improved safe passage through the hydrosystem for subyearling Chinook with the construction and operation of surface bypass routes at Lower Granite, Ice Harbor, and Bonneville dams and other configuration improvements. For salmon that use an ocean-type life-history strategy, recent restoration projects in the estuary are improving the functioning of the juvenile migration corridor. Projects that are protecting or restoring riparian areas and breach or lower dikes and levees are providing access to the cover/shelter, food, and riparian vegetation required by this type of juvenile migrant. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality off-channel habitat (see Section 4.3.1.3 in Corps et al. 2007a).

Adult Migration Corridor

The Action Agencies have increased the likelihood of safe passage in the mainstem FCRPS for adult fall Chinook in recent years by improving the collection channel at The Dalles and the ladders at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite dams.

Areas for Growth & Development to Adulthood

Although Snake River fall Chinook probably spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 1993). Therefore, the effects of the Prospective Actions on PCEs in these areas are not considered further in this consultation.

8.2.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the ESU and its designated critical habitat.

The Corps completed several consultations on its Clean Water Act section 404 permitting process (maintenance dredging of a barge slip at near the mouth of the Snake River, construction of a new floating dock at the Port of Clarkston, WA, and installing a new boat launch at Wawawai Landing, WA). NOAA Fisheries also completed a consultation with BPA on replacing wood pole transmission lines north of Lewiston, ID and with the US Army Corps of Engineers on operations of the fish sampling facility at Lower Granite Dam that will reduce risks to fall Chinook diversity by removing stray hatchery fish and increase the proportion of natural-origin fish in hatchery broodstock.

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies also completed consultation on a large number of projects affecting habitat in the lower Columbia River and estuary including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.3.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect the habitat of multiple populations within the ESU. The effects of some on population viability will be positive (habitat restoration; fish sampling at Lower Granite Dam; tar remediation). Other projects, including dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on water quality (habitat restoration with stormwater facilities; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.2.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon, Washington, and Idaho identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin. However, neither the states nor NOAA Fisheries identified any habitat-related actions and programs by non-federal entities that were expected to benefit Snake River fall Chinook.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.2.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have some continuing adverse effects that are described in this section; however, these will be reduced from past levels. The Prospective Actions also require habitat improvement in the estuary and predator reductions, which are expected to be beneficial. Continuation of flow augmentation from the Upper Snake Projects will continue to provide benefits through 2034. These beneficial effects are described in Sections 8.2.5.2, 8.2.5.3, and 8.2.5.5. Some Prospective Actions, implementing habitat restoration and RM&E, may have short-term minor adverse effects, but these will be balanced by short-and long-term beneficial effects, as described in Section 8.2.5.6.

Continued funding of hatcheries by the FCRPS Action Agencies will have both adverse and beneficial effects, as described in the Hatchery Effects Report (SCA Hatchery Effects Appendix.). The Prospective Actions will ensure continuation of the beneficial effects and will reduce threats to the SR fall Chinook population posed by existing hatchery practices.

The effects of NOAA Fisheries' issuance of a Section 10 juvenile transportation permit on this species are discussed in Chapter 11 of the FCRPS Biological Opinion. The expected use of transportation under the permit is included in the effects of the FCRPS Prospective Actions, which is described in Section 8.2.5.1.

8.2.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5) are expected to continue through the duration of the Prospective Actions.

NOAA Fisheries abandoned efforts to parameterize the COMPASS model to estimate the effect of alternative operations on the survival of SR fall Chinook salmon. This was due to critical uncertainties regarding subyearling juveniles' migration pattern in July and August, and their recently observed "yearling" life-history strategy (see Section 7.2.1). Thus, NOAA Fisheries must use qualitative analysis to assess the likely hydro effects of these Prospective Actions on this ESU.[5]

The Prospective Actions strategies for hydro that are most likely to benefit SR fall Chinook salmon include:

1. Further modification to Columbia and Snake river dams to facilitate safe passage (RPA Actions 4, 5, 14, 18-25, 27, 28, 52, 54);

2. Implement operational improvements at Columbia and Snake river dams (RPA Actions 18-25, 52, 54, 55);

3. Operate and maintain juvenile and adult fish passage facilities (RPA Actions 18-25, 28, 29, 30, 54); and

4. Continue to evaluate the best passage management strategy for fall Chinook salmon (i.e., transport vs. in-river) (RPA Actions 18-25, 31, 52, 53, 54, 55, 58, 59, 60, 61).

Of these Prospective Actions, modifying and implementing operations at the Columbia and Snake River dams to facilitate safe passage – which requires the construction and operation of surface

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[5] NOAA Fisheries assumed – for the purpose of the quantitative analysis – that no benefits would accrue from Hydro related prospective actions (CA Table 4-7).

passage routes at Little Goose, Lower Monumental, McNary and John Day Dams,[6] in concert with training spill (amount and pattern) to provide safe egress conditions, are likely to have a large positive effect on juvenile migrants. These structures and operations are expected to reduce travel times within the forebays and tailraces of the individual projects. This is likely to result in survival improvements where predation rates are often the highest, because the juvenile fish will be guided out of the forebay and tailrace faster, reducing their exposure to predators such as the northern pikeminnow (see Section 8.1 of the Supplemental Comprehensive Analysis). Taken together, surface passage routes should increase juvenile migration rates through the migration corridor, and likely improve overall post-Bonneville survival of in-river migrants if faster migrating juveniles are less stressed than is currently the case. Finally, adaptive management of passage strategies should lead to even further improvements in post-Bonneville survival in the future. That is, the continuous evaluation of fish passage performance metrics (RPA Action 52, 53, 54) should ensure that benefits accrued to date or described above as prospective operations and maintenance of juvenile fish passage facilities do not diminish within the time period relevant to the Prospective Actions.

For adult SR fall Chinook salmon migrating from Bonneville Dam upstream to Lower Granite Dam, the Prospective Actions addressing hydro operation and the RM&E program generally should maintain the relatively high levels of survival currently observed in most years. The current average adult survival is 81.0% [7] (about 96.9% per project), taking account of reported harvest and "natural" stray rates within this reach, (BA Table 2.1). If currently, adults die outside of the Bonneville Dam to Lower Granite Dam migration corridor (i.e., after passage to the top-most dam but before spawning, known as delayed mortality), this "delayed mortality" is not expected to be affected by the Prospective Actions.

Effects on Critical Habitat

Although one of the effects of the Prospective Actions on critical habitat will be the continued loss of historical spawning areas due to the existence and operation of the lower Snake River dams, the available habitat will have the capacity (space) to support at least 5,000 spawners as described in Section 8.2.3.3. This will be adequate for meeting the ICTRT's recovery abundance threshold of 3,000 spawners (i.e., to meet viability goals for abundance at <5% risk of extinction). To the extent that the hydro Prospective Actions result in more adults returning to spawning areas, water quality and forage for juveniles could be affected by the increase in marine-derived nutrients. However, this was not identified as a limiting factor for Snake River fall Chinook by the Remand Collaboration Habitat Technical Subgroup.

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[6] Surface bypass facilities are already in place at Lower Granite, Ice Harbor, and Bonneville dams. The RSW at Ice Harbor Dam was first operated in 2005. Therefore, benefits have not yet been reflected in R/S.

[7] NOTE: 81.0% is an average of the minimum survival estimates for the 2002 to 2007 adult migration years. In 2003 and 2004 adult survival (excluding 1-ocean jacks) was estimated to be 98.6 to 93.7% (average of 96.3%), respectively, falling to 71.2% in 2005, and only 58.8% in 2006, increasing to 83.9% in 2007. While NOAA Fisheries is unable to ascertain the cause of this decline at this time, it is highly unlikely that this effect is due solely, or even primarily, to passage through the FCRPS projects. See SCA Adult Survival Estimates Appendix for calculations and to view assumptions about harvest and stray rates. Future research (RPA 52, 55, 56) should provide additional information to identify the causative factors so that they can be addressed through adaptive management.

The survival of juvenile SR fall Chinook in the mainstem migration corridor will increase with the construction of surface passage routes at Little Goose, Lower Monumental, McNary, and John Day dams, in concert with training spill to provide safe egress. In-river migrants will experience reduced travel times past FCRPS dams, reducing predation rates and stress. Continuing efforts under the NPMP and continuing and improved avian deterrence at mainstem dams will also address factors that limit the conservation value of safe passage in rearing areas and the migration corridor. The prospective actions also include passage improvements at The Dalles and John Day dams that will reduce adult delay, which will further improve the conservation value of safe passage in the adult migration corridor.

In addition to increasing flows and reducing travel time in the lower Snake River, releasing cold water from Dworshak Dam will enhance migration conditions by reducing the risk of disease for juvenile migrants. Adult fall Chinook will also continue to benefit from cold water released from Dworshak during summer (improved water quality).

Under the Prospective Actions, flows in the lower Snake River will continue to be reduced during spring compared to an unregulated system (Section 8.1.1.3). However, shifting the delivery of a portion of the Upper Snake flow augmentation water from summer to spring will benefit the subyearling life history type (i.e., ocean-type juveniles) migrating in late spring. This water will be slightly cooler than if delivered during summer, especially in average or dry years, thereby improving water quality in mainstem rearing areas and the migration corridor. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.2.3.3).

8.2.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

Under the RPA (34), the Action Agencies will obtain funding to continue, with the state's Soil and Water Conservation Districts, efforts to reduce soil erosion on the uplands and along the streams of Garfield County. These projects will address the problem of sediment inputs from agricultural lands to gravel in the lower Tucannon River (Section 8.2.3.3), which will support increased productivity of that portion of the population.

Effects on Critical Habitat

Reduced sediment inputs to the lower Tucannon will improve the functioning of spawning gravel.

8.2.5.3 Effects of Prospective Actions in the Estuary

Effects on Species Status

The estimated survival benefit for Snake River fall Chinook (ocean-type life history) associated with the Prospective Actions in the estuary (RPA Actions 36 and 37) is approximately 9.0% (CA Section 4.3.3.3). For ocean-type fish, restoration projects that are placed along the estuary corridor are likely to improve abundance, productivity, life history diversity, and spatial structure by providing off-channel rearing habitat and refugia (Fresh et al 2005).

Effects on Critical Habitat

Estuary habitat restoration projects will address the alteration of channel margin habitats, a factor limiting the functioning of PCEs used by subyearling Chinook migrants from the Snake River. Specifically, the Action Agencies will fund conservation protection and rehabilitation for approximately 380 acres of off-channel rearing habitat, or projects similar in nature, under its LCREP project during FY 2007–2009. Thirty acres of riparian areas, including two linear miles of fencing, will be restored during that period. In addition, the Action Agencies will:

- Install tide gates to increase tidal flushing and fish access to approximately 110 acres of wetlands on the Julia Butler Hanson National Wildlife Refuge near Cathlamet, Washington
- Retrofit a tide gate at Vancouver Lake
- Reestablish hydrologic connectivity between Columbia Slough and the Columbia River to improve floodplain wetland function for approximately 5 acres of currently isolated habitat and to increase the amount (by approximately 2.5 acres) and quality of off-channel rearing and refuge habitat (Ramsey Lake)
- Improve hydrologic flushing and fish access to approximately 3,200 acres of habitat in Sturgeon Lake on Sauvie Island, Oregon (Dairy Creek)
- Breach dike and reestablish flow to a portion of the Sandy River channel in the delta reach; plant native vegetation on over 200 acres and remove invasive wetland plants on 45 acres
- Protect and restore approximately five to 10 acres of emergent wetland and riparian forest (Vancouver Water Resources)

The Action Agencies have not identified the specific projects that they will implement during 2010 to 2017. However, the projects selected will address limiting factors, based on the recommendations of the LCREP Science Workgroup.

Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.2.5.4 Effects of Prospective Hatchery Actions

Effects on Species Status

NOAA Fisheries cannot consult on the operation of existing or new hatchery programs until Hatchery and Genetic Management Plans (HGMPs) are updated and consultation is initiated. For more than 30 hatchery programs in the Snake River basin, including fall Chinook hatcheries, proposed programs are to be submitted to NOAA Fisheries by February 2010 and ESA consultation is expected to be completed by August 2010. Site specific application of BMPs will be defined in ESA Section 7, Section 10, or Section 4(d) limits with NOAA Fisheries to be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies (FCRPS BA, page 2-44). Based on the scientific work to date by the ICTRT and Hatchery Science Review Group (HSRG), NOAA Fisheries expects that implementation of the criteria and practices described in the Prospective Actions (RPA 39) will have a positive effect on the productivity and, particularly, on the diversity of SR fall Chinook.

Subject to subsequent hatchery specific ESA § 7(a)(2) Consultation , implement of MPS in NOAA Fisheries approved HGMPS are expected to 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations

However, Federal agencies have obligations in addition to implementing the Endangered Species Act and NOAA Fisheries must consider the effects of Prospective Actions on the exercise of treaty fishing rights and the Federal government's trust responsibilities to Tribes. Because Snake River fall Chinook provide a substantial contribution to tribal fisheries, the long-term recovery goals for this ESU will take into account tribal treaty rights and the federal trust responsibility. NOAA Fisheries will continue to work closely with the tribal and state fishery managers and evaluate all relevant scientific information, including the work of the Columbia Hatchery Science Review Group (HSRG), to find ways to reduce risk to this ESU, including modifications to hatchery programs, consistent with treaty rights and trust responsibilities.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on the primary constituent elements of critical habitat in subsequent consultations on site-specific actions.

8.2.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

Under the Prospective Action the harvest of SR fall Chinook will vary from year-to-year based on the following abundance-based harvest rate schedule (Table 8.2.5.5-1). Harvest will depend on the abundance of unlisted upriver fall Chinook and natural-origin SR fall Chinook. The allowable harvest rate will range from 21.5% to 45.0%.

Table 8.2.5.5-1. Abundance-based harvest rate schedule for SR fall Chinook (TAC 2008). State/Tribal Proposed Snake River Fall Chinook Harvest Rate Schedule

State/Tribal Proposed Snake River Fall Chinook Harvest Rate Schedule					
Expected URB River Mouth Run Size	Expected River Mouth Snake River Wild Run Size [1]	Treaty Total Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate	Expected Escapement of Snake R. Wild Past Fisheries
60,000	1,000	20%	1.50%	21.50%	784
60,000	1,000	23%	4%	27.00%	730
120,000	2,000	23%	8.25%	31.25%	1,375
200,000	5,000	25%	8.25%	33.25%	3,338
	6,000	27%	11%	38.00%	3,720
	8,000	30%	15%	45.00%	4,400

1. If the Snake River natural fall Chinook forecast is less than level corresponding to an aggregate URB run size, the allowable mortality rate will be based on the Snake River natural fall Chinook run size.

Notes:

Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from August 1-December 31.

Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the confluence of the Snake River and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from August 1-December 31.

The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.

Fishery impacts in Hanford sport fisheries count in calculations of the percent of harvestable surplus achieved.

When expected river-mouth run sizes of naturally produced Snake River Fall Chinook equal or exceed 6,000, the states reserve the option to allocate some proportion of the non-treaty harvest rate to supplement fall Chinook directed fisheries in the Snake River.

Since 1996, fall season fisheries in the mainstem Columbia River have been managed subject to an ESA harvest rate limit of 31.29%. This represented a 30% reduction in the 1988 to 1993 base period harvest rate. The status of Snake River fall Chinook has improved considerably over the last ten to fifteen years, and harvest reductions were among the actions taken to improve the overall status of this species.

The prospective harvest rate schedule modifies the past practice of managing fisheries subject to a fixed harvest rate, providing a management structure that is responsive to the status of the species. Under the new schedule, harvest may vary up or down depending on the overall abundance of unlisted upriver fall Chinook and listed natural-origin Snake River fall Chinook. The harvest rate schedule is generally calibrated to provide higher harvest rates when abundance is high enough to accommodate the increased harvest and still meet the TRT recovery abundance threshold of 3,000 natural-origin fish to Lower Granite Dam. Conversely, when numbers are low, harvest rates are reduced to provide greater protection.

The SCA Harvest Appendix describes an analysis that compares base, current, and future harvest rates and derives multipliers necessary for this analysis. The analysis was provided by a *U.S. v. Oregon* Work Group (*U.S. v Oregon* Workgroup 2008; Quantitative Analysis of Harvest Actions Appendix). As described above, a 1.09 base-to-current multiplier is estimated. The prospective harvest action will result in no change from the base harvest rate if only the authorized harvest rate is considered (i.e., harvest survival multiplier = 1.0). However, since 1996, based on a post season review, actual harvest rates have, with one exception, been less than the ESA-authorized limit. The difference between the allowed and observed harvest rate has ranged from -0.9% to 10.7% (Table 8.2.5.5-2). On average, the observed harvest rate has been 5.1% less than the 31.3% limit in absolute terms (i.e., 83.7% of the 31.3% limit). Assuming that this practice continues, the expected prospective harvest rate is therefore likely to be less than those in Table 8.2.5.5-1 and the survival multiplier associated with the expected prospective harvest rate will be 1.06. The range of prospective harvest multipliers recommended by the *U.S. v. Oregon* Work Group is therefore 1.00-1.06.

Table 8.2.5.5-2 Observed harvest rate on SR fall Chinook compared to the maximum allowable harvest rate limit (Observed HR from TAC 2008).

Year	Observed HR (%)	Allowed HR (%)	Difference
1996	26.4	31.3	4.9
1997	32.2	31.3	-0.9
1998	26.6	31.3	4.7
1999	30.3	31.3	1.0
2000	28.8	31.3	2.5
2001	21.0	31.3	10.3
2002	28.3	31.3	3.0
2003	21.5	31.3	9.8
2004	20.6	31.3	10.7
2005	25.6	31.3	5.7
2006	27.1	31.3	4.2
Average	26.2	31.3	5.1

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Snake River fall Chinook.

8.2.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to Snake River fall Chinook from reduction in Caspian tern nesting habitat on East Sand Island, and subsequent relocation of most of the terns to sites outside the Columbia River Basin (RPA 45) is 0.7% (CA Chapter 4, Table 4-7). Compensatory mortality may occur but based on the discussion in Section 8.2.5.7 is unlikely to significantly affect the results of the action.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA 43) should further reduce consumption rates of juvenile salmon and steelhead by northern pikeminnow. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (CA Appendix F, Attachment F-1: Benefits of Predation Management on Northern Pikeminnow). Continued implementation and improvement of avian deterrence at all lower Snake and Columbia dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces (RPA 48).

Effects on Critical Habitat

Reduction of Caspian tern nesting habitat on East Sand Island, continued implementation of the base Northern Pikeminnow Management Program, continuation of the increased reward structure in the sport fishery, and continued implementation and improvement of avian deterrence at mainstem dam will improve the functioning of the PCE safe passage in the migration corridor for juvenile fall Chinook. These actions will enhance the conservation value of critical habitat over both the short- and long-term.

8.2.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the Supplemental Comprehensive Analysis.

8.2.5.8 Summary: Quantitative Survival Changes Expected from All Prospective Actions

Expected changes in productivity and quantitative extinction risk for those Prospective Actions that can be quantified (estuary habitat restoration, tern relocation, and Northern Pikeminnow reduction) are calculated as survival improvements in a manner identical to estimation of the base-to-current survival improvements. The estimates of "prospective" expected survival changes resulting from the Prospective Actions are described in Sections 8.2.5.1 through 8.2.5.7 and quantitative estimates are summarized in Table 8.2.5-1. The net effect is 11-18% increased survival, compared to the "current" condition, and 24-32% increased survival, compared to the "base" condition (applied only to the

1977-present time series). These represent a subset of the effects of the Prospective Actions because hydro and hatchery effects are only considered qualitatively. These future survival changes expected from implementation of the Prospective Actions are applied to both the 1977-present and 1990-present time series.

8.2.5.9 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Table 8.2.6-1. In addition to this summary table, the SCA Aggregate Analysis Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007 Draft Biological Opinion. Additional qualitative considerations that generally apply to this ESU are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions.

8.2.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects, Summarized By Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared to the importance of each population to MPG and ESU viability. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

The Snake River Mainstem MPG is the only MPG within the Snake River fall Chinook ESU. Because there is only one MPG, Section 8.2.7 applies to both the Snake River Mainstem MPG and the Snake River fall Chinook ESU. The single population in this MPG must be highly viable to achieve the ICTRT's suggested viability scenario (ICTRT 2007a, Attachment 2).

8.2.7 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Snake River Fall Chinook ESU

This section summarized the basis for conclusions at the ESU level.

8.2.7.1 Potential for Recovery

It is likely that the Snake River fall Chinook salmon ESU will trend toward recovery.

The future status of the single extant population and single MPG of Snake River fall Chinook salmon will be improved compared to its current status through the reduction of current adverse FCRPS and Upper Snake project effects and the implementation of Prospective Actions with beneficial effects, as described in Sections 8.2.5, 8.2.6, and 8.2.7.2. Therefore, the status of the ESU as a whole is expected to improve compared to its current condition and to move closer to a recovered condition. This expectation takes into account some short-term adverse effects of Prospective Actions related to estuary habitat improvements (Section 5.2.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this ESU.

The Prospective Actions include hydropower, predation, and estuary habitat actions that address limiting factors and threats and will reduce their negative effects. ICTRT concerns regarding high spatial structure risk and the need to begin assessing the feasibility of reintroducing historical populations above Hells Canyon are being addressed through other processes outside of the FCRPS, Upper Snake, and *U.S. v. Oregon* consultations. ICTRT concerns about high diversity risk are being addressed through hatchery Prospective Actions, which ensure that the Action Agencies will implement programmatic funding criteria, including those that will reform FCRPS hatchery operations to reduce genetic and ecological effects on ESA-listed salmon. This will have a positive effect on the diversity of Snake River fall Chinook. The harvest prospective action is to implement a *U.S. v. Oregon* process harvest rate schedule that is expected to either result in no change (authorized harvest) or a reduction (expected harvest) from the current harvest rates in the environmental baseline.

In addition, the harvest Prospective Action is to implement a *U.S. v. Oregon* process harvest rate schedule that is expected to either result in no change (authorized) or a reduction (expected) from the harvest rates in the environmental baseline.

Some threats to the recovery of Snake River fall Chinook salmon, such as diversity risk from ongoing hatchery actions, will probably take longer than 10 years to correct. The adaptive management Prospective Actions will quantify hatchery fish effectiveness and provide the first information on threats from the hatchery program. The Prospective Actions represent significant improvements that reasonably can be implemented within the next 10 years.

The Prospective Actions include a strong monitoring program to assess if implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 some important improvements include installation of RSWs and other passage improvements to reduce delay and exposure to warm temperatures in project forebays and regulation of late summer water temperatures at Lower Granite by regulating outflow temperatures at Dworshak Dam. Estuary habitat projects include dike removal and opening off-channel habitat, which in some cases is likely to encourage hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

In sum, these qualitative considerations suggest that the Snake River fall Chinook ESU will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of metrics indicating a trend toward recovery also support this conclusion.

Productivity based on R/S, lambda, and BRT trend is expected to be greater than 1.0 for SR fall Chinook, using both the base-to-current method with the 1977-present time series and the unadjusted 1990-present method, except for estimated lambda of 0.99 with HF=1 for the 1977-present series (Table 8.2.6-1 for results; description in Section 8.2.3.1). Note that hydro improvements have not been quantified for this species, so all estimates would be greater than 1.0 if these improvements had been included in the calculations. This means that survival will be sufficient for the population to grow and that the abundance of spawners will have a positive trend.

Some important caveats that apply to all three quantitative estimates are as follows:

- In addition to unquantifiable hydro improvements, other beneficial effects of the Prospective Actions could not be quantified (e.g., habitat improvements that accrue over longer than a 10-year period), so these quantitative estimates of prospective productivity are low.

- This summary of productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. The ICTRT was not able to estimate ocean climate factors for this species. However, because productivity estimates were all greater than 1.0 based on the recent climate period, it is likely that under a longer historical ocean climate assumption all three metrics would also be greater than 1.0, and the positive trends would likely be greater. Under a "Warm PDO" ocean climate assumption, it is possible that productivity would be less than 1.0 for one or more metrics.

- The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, the three metrics are generally less than 1.0 for the lower 95% confidence limits and are consistently higher than 1.0 at the upper 95% confidence limits (SCA Aggregate Analysis Appendix). This uncertainty is an important reason that NOAA Fisheries also considers qualitative factors in reaching its conclusions.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change were considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

Taken together, the combination of all the qualitative and quantitative factors indicates that the ESU as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. Quantitative estimates indicate that survival will be sufficient for the population to grow and that the abundance of spawners will have a positive trend. Prospective Actions, which will implement programmatic funding criteria including those that will reform FCRPS hatchery operations to reduce genetic and ecological effects on ESA-listed salmon, will reduce the current diversity risk of SR fall Chinook.

This does not mean, however, that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes resulting from the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the ESU being on a trend toward recovery.

8.2.7.2 Short-term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through survival improvements resulting from the Prospective Actions and a continuation of other current management actions in the environmental baseline, as described in Sections 8.2.3 and 8.2.5.

As described above and in Section 8.2.6, Snake River fall Chinook abundance is expected to increase and natural productivity (R/S) is expected to be sufficient for population growth. The recent 10-year geometric mean abundance has been 1,273 natural spawning fish, which is well above the 50 fish QET (Table 8.2.2-1). Snake River fall Chinook have not dropped below 50 fish in any single year (Cooney and Ford 2007). These factors also indicate a decreasing risk of extinction.

Snake River fall Chinook are heavily supplemented and the hatchery fish are part of the ESU, contributing to total abundance and thereby reducing short-term extinction risk. Over time, this level of supplementation may result in a higher level of long-term risk to diversity and natural productivity than would occur in an un-supplemented population and there is uncertainty over whether the apparent increases in productivity and abundance reflect temporary or more sustained improvements in survival. However, it appears possible to further improve hatchery practices and reduce supplementation impacts on some portions of this ESU without reducing the overall level of hatchery production. The risks associated with supplementation will be reduced through on-going hatchery reviews and consultations as indicated in Section 8.2.5.4.

The Prospective Actions include a strong monitoring program (RPA Actions 50-73) to assess if implementation is on track and to signal potential problems early. The Prospective Actions include the monitoring of hatchery fish effectiveness and risk to the population. Other Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations (RPA Actions 1-3) to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24 year) extinction risk also support this conclusion.

The base period 24-year extinction risk is estimated to be 0-1%, depending on QET level (Table 8.2.2-3). Therefore, no survival improvement would be needed to reduce risk to <5%, so no additional survival gap was identified. Improvements associated with the Prospective Actions would further support the conclusion of low short-term extinction risk.

The base period extinction risk analysis described above assumes that all supplementation ceases. There is an ongoing hatchery program, which is included in both the environmental baseline and the Prospective Actions, to further reduce short-term extinction risk. A quantitative analysis of extinction risk with a continuing supplementation program indicates 0% risk over either 24- or 100-year periods (Hinrichsen 2008, included as Attachment 1 of the Aggregate Analysis Appendix).

In addition to unquantifiable hydro improvements, other beneficial effects of the Prospective Actions could not be quantified (e.g., habitat improvements that accrue over a longer than 10-year period), so quantitative estimates of improvements in Table 8.2.5-1 may be low.

This summary of extinction risk estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described above for recovery metrics and in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. The ICTRT was not able to estimate ocean climate factors for this species. However, because productivity estimates were all greater than 1.0 based on the recent climate period, it is likely that under a longer historical ocean climate assumption all three metrics would also be greater than 1.0, and the positive trends would likely be greater. Under a "Warm PDO" ocean climate assumption, it is possible that productivity would be less than 1.0 for one or more metrics.

Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an under-estimate of the short-term extinction risk, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While we do not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from 0 to near 100% for SR fall Chinook (Table 8.2.2-3). This uncertainty is an important reason that NOAA Fisheries also considers qualitative factors in reaching its conclusions.

Taken together, the combination of all the factors above indicates that the SR fall Chinook ESU is likely to have a low short-term extinction risk when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements will result in lower short-term extinction risk than in recent years. Current abundance is well above the quasi-extinction threshold considered by the ICTRT. Quantitative analyses also support this conclusion. In addition, there are hydrosystem improvements with benefits that cannot be quantified, which will further reduce this risk compared to quantitative estimates. SR fall Chinook are heavily supplemented and the hatchery fish are part of the ESU, contributing to abundance and thereby reducing short-term extinction risk. However, over time this level of supplementation poses long-term risks to diversity and natural productivity as described in Section 8.2.5. Implementation of the Prospective Actions will help to reduce this long-term diversity risk and will confirm the benefits and risks of the hatchery mitigation program. In summary, it is likely that the SR fall Chinook ESU will have a low short-term extinction risk.

8.2.7.3. Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for SR fall Chinook salmon including all Columbia River estuarine areas and river reaches upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. The environmental baseline within the action area, which encompasses all of these areas, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for SR fall Chinook. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Snake and Columbia rivers; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, excess sediment in gravel, and high summer temperatures in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at Little Goose, Lower Monumental, McNary, and John Day dams, in concert with training spill to provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns and northern pikeminnows will further improve safe passage for juveniles. Habitat work in estuarine areas used for rearing and migration will improve the functioning of water quality, natural cover/shelter, forage,` riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.2.2-1. Status of SR fall Chinook salmon with respect to abundance and productivity VSP factors. Productivity is estimated using two base time periods, as described in Section 8.2.3.

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	MPG	Population	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope[4]	Lower 95% CI	Upper 95% CI
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-	1273	1995-2004	3000	0.81	0.46	1.21	1.09	0.91	1.30	0.95	0.80	1.12	1.09	1.06	1.13
		Lower Mainstem Fall Chinook 1990-	1273	1995-2004	3000	1.24	0.93	1.66	1.18	0.89	1.56	1.01	0.79	1.27	1.23	1.16	1.31

1 Most recent year for 10-year geometric mean abundance is 2004. ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from draft ICTRT (2007c).
2 Mean returns-per-spawner are estimated from the most recent periods of 1977-2004 (1977 through 1999 brood years) and 1990-2004 (1990 through 1999 brood years). Averages are calculated from information in Cooney and Ford (2007), updated with information in Cooney (2007).
3 Median population growth rate (lambda) are estimated from the most recent periods of 1977-2004 (1977 through 1999 brood years) and 1990-2004 (1990 through 1999 brood years) using estimates from Cooney (2008d).
4 Biological Review Team (Good et al. 2005) trend estimates updated for recent years in Cooney (2008d).

Table 8.2.2-2. Status of SR fall Chinook salmon with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	BRT Current Risk For Distribution[1]	BRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook	"Moderately High" (Large portion of historical habitat is inaccessible and the distribution of the extant population makes it vulnerable to variable environmental conditions and large disturbances)	"Moderately High" (Loss of diversity associated with extinct populations and significant hatchery influence for the extant population)	0.46

1 The ICTRT has not assigned specific risk levels to this population at this time. Biological Review Team (BRT) assessments are from Good et al. (2005).
2 Average fraction of natural-origin natural spawners from ICTRT (2007c).

Table 8.2.2-3. Status of SR fall Chinook salmon with respect to extinction risk. Short-term (24-year) extinction risk is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY). It was not possible to estimate short-term extinction risk from the more recent 1990-1999 BY data set.

			24-Year Extinction Risk											
ESU	MPG	Population	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.01	0.00	1.00
		Lower Mainstem Fall Chinook 1990-												

1 Short-term (24-year) extinction risk from Hinrichsen (2008), in the Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.2.2-4. Changes in density-independent survival ("gaps") necessary for indices of productivity to equal 1.0 and estimates of extinction risk no higher than 5% for SR fall Chinook salmon. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated "gaps" are based on population performance during the "base period" of approximately the last 20 brood years or spawning years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-	1.34	2.17	0.83	0.68	1.52	0.31	1.27	2.73	0.59	0.67	0.78	0.58	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1990-	0.80	1.07	0.60	0.48	1.66	0.14	0.98	2.86	0.34	0.39	0.51	0.30				

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.2.2-1.

2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.2.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.

3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.2.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.

4 Extinction risk survival gap is calculated as the exponent of a Beverton-Holt "a" value from a production function that would result in 5% risk, divided by the exponent of the base period Beverton-Holt "a" value. Estimates are from Hinrichsen (2008), in the Aggregate Analysis Appendix.

Table 8.2.3-1. Proportional changes in average base period survival expected from completed actions and current human activities that are likely to continue into the future. Factors greater than one result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average). The 1990-present estimate, which likely includes recent harvest and hydro survival, is not adjusted.

			Base-to-Current Adjustment (Survival Multiplier)						
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Harvest[5]	Hatcheries[6]	Total Base-to-Current Survival Multiplier[7]
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-	N/A	1.00	1.01	1.02	1.09	N/A	1.12
		Lower Mainstem Fall Chinook 1990-							1.00

1 Hydro survival cannot be quantified or compared between the base and current periods for this species.
2 No tributary habitat actions are relevant per CA Section 4.3.1.2.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the “Current 2 S/Baseline 2 S” approach, as described in Attachment F-2.
5 From SCA Quantitative Analysis of Harvest Actions Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
6 Hatchery survival is not quantified for comparison between the base and current period
7 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column.

Table 8.2.5-1. Proportional changes in survival expected from the Prospective Actions. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Survival Multiplier)										
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2] (2007-2017)	Estuary Habitat[3]	Bird Predation[4]	Pike-minnow Predation[5]	Hatcheries[6]	Low Harvest[7]	High Harvest[7]	Non-Hydro Current-to-Future Survival Multiplier[8]	Total Current-to-Future Survival Multiplier[9]	Total Base-to-Future Survival Multiplier[10]
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	1.00	1.00	1.09	1.01	1.01	1.00	1.00		1.11	1.11	1.24
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	1.00	1.00	1.09	1.01	1.01	1.00		1.06	1.18	1.18	1.32
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	1.00	1.00	1.09	1.01	1.01	1.00	1.00		1.11	1.11	1.11
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	1.00	1.00	1.09	1.01	1.01	1.00		1.06	1.18	1.18	1.18

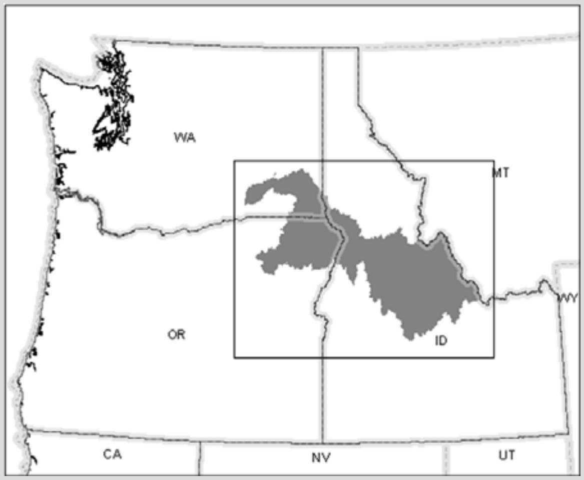
1 Hydro survival cannot be quantified or compared between the base and current periods for this species.
2 No tributary habitat actions are relevant per CA Section 4.3.3.2.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 Hatchery survival is not quantified for comparison between the current and future period
7 Harvest estimates from SCA Quantitative Analysis of Hatchery Actions Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
8 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
9 Same as Footnote 7, except it is calculated from all Prospective Actions. For SR fall Chinook, hydro survival changes cannot be quantified, so this number represents a minimum survival change.
10 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier from Table 8.2.3-1. For SR fall Chinook, hydro survival changes cannot be quantified, so this number represents a minimum survival change.

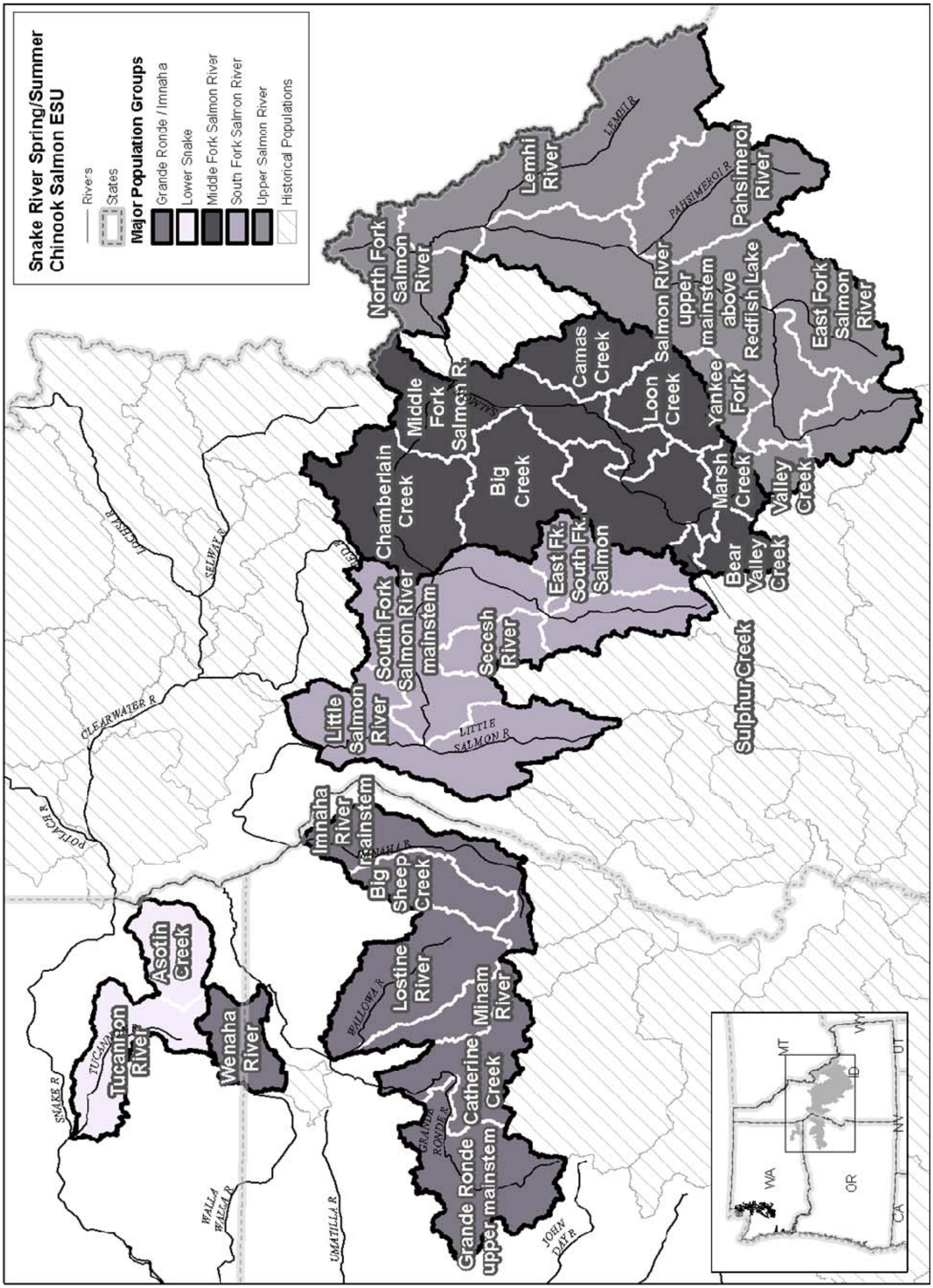
Table 8.2.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for SR fall Chinook. The 1977-present time series was adjusted for base-to-current survival changes other than hydro, which could not be estimated quantitatively. The 1990-present time series was not adjusted for base-to-current changes. Estimates of productivity expected under the Prospective Actions do not include future hydro survival improvements, which could not be quantified for this species.

ESU	MPG	Population	R/S Recent Climate[1]	Lambda Recent Climate @ HF=0[2]	Lambda Recent Climate @ HF=1[3]	BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	1.01	1.14	0.99	1.15	Must be HV	All three metrics >1, with both a base-to-current adjusted 1977-present time series or a 1990-present time series with no base-to-current adjustment, except for lambda = 0.99 with HF=1 for the 1977-1999 series. Note that hydro improvements have not been quantified for this species.	"Moderately High" (Large portion of historical habitat is inaccessible and the distribution of the extant population makes it vulnerable to variable environmental conditions and large disturbances)	"Moderately High" (Loss of diversity associated with extinct populations and significant hatchery influence for the extant population)
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	1.07	1.16	1.01	1.16				
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	1.38	1.21	1.03	1.26				
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	1.47	1.22	1.04	1.28				

1 Calculated as the base period R/S productivity from Table 8.2.2-1, multiplied by the total base-to-future survival multiplier in Table 8.2.5-1.
2 Calculated as the base period mean population growth rate (lambda) from Table 8.2.2-1, multiplied by the total base-to-future survival multiplier in Table 8.2.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
3 Calculated as the base mean BRT abundance trend from Table 8.2.2-1, multiplied by the total base-to-future survival multiplier in Table 8.2.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007a), Attachment 2
5 From Table 8.2.2-2

Section 8.3
Snake River Spring/Summer Chinook Salmon




Snake River Spring/Summer Chinook Salmon ESU
Rivers
States
Major Population Groups
Grande Ronde / Imnaha
Lower Snake
Middle Fork Salmon River
South Fork Salmon River
Upper Salmon River
Historical Populations
North Fork Salmon River
Lemhi River
Pahsimeroi River
Salmon River upper mainstem above Redfish Lake
East Fork Salmon River
Yankee Fork
Valley Creek
Camas Creek
Loon Creek
Middle Fork Salmon R.
Marsh Creek
Bear Valley Creek
Chamberlain Creek
Big Creek
East Fk. South Fk. Salmon
South Fork Salmon River mainstem
Secesh River
Sulphur Creek
Little Salmon River
Imnaha River mainstem
Big Sheep Creek
Lostine River
Minam River
Catherine Creek
Grande Ronde upper mainstem
Wenaha River
Asotin Creek
Tucannon River
LEMHI R.
PAHSIMEROI R.
LITTLE SALMON R.
CLEARWATER R.
SELWAY R.
LOCHSA R.
POTLATCH R.
SNAKE R.
TUCANNON R.
WALLA WALLA R.
UMATILLA R.
JOHN DAY R.
WALLOWA R.
GRANDE RONDE R.
IMNAHA R.
MT
WY
ID
UT
WA
OR
NV
CA

Section 8.3
Snake River Spring/Summer Chinook Salmon

Species Overview

Background

The Snake River (SR) spring/summer Chinook consists of five major population groups that spawn and rear in the tributaries of the Snake River between the confluence of the Snake and Columbia rivers and the Hells Canyon Dam. The factors that contributed to their decline include intensive harvest and habitat degradation in the early and mid 1900s, high harvest in the 1960s and early 1970s, and Federal and private hydropower development, as well as poor ocean productivity in the late 1970s through the late 1990s. Snake River spring/summer Chinook were listed under the ESA as threatened in 1992.

Designated critical habitat for SR spring/summer Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers and a number of tributary subbasins.

Current Status & Recent Trends

The SR spring/summer Chinook's five major population groups (MPGs) are further composed of 28 extant populations. Abundance has been stable or increasing on average over the last 20 years. In 2007, jack counts (a qualitative indicator of future adult returns) were the second highest on record. However, on average, the natural-origin components of SR spring/summer Chinook populations have not replaced themselves.

Limiting Factors and Threats

Limiting factors for the Snake River spring/summer Chinook include the Federal and private hydropower projects, predation, harvest, the estuary, and tributary habitat. Ocean conditions have also affected the status of this ESU. These conditions have been generally poor for this ESU over the at least the last four brood cycles, improving only in the last few years. Although hatchery management is not identified as a limiting factor for the ESU as a whole, the ICTRT has indicated potential hatchery impacts for a few individual populations.

Recent Ocean and Mainstem Harvest

The ocean fishery mortality on Snake River spring/summer Chinook is very low and, for practical purposes, assumed to be zero. Incidental take of Snake River spring/summer Chinook occurs in spring and summer season fisheries in the mainstem

Columbia River that target harvestable hatchery and natural-origin stocks. The fisheries on harvestable runs were limited to ensure that incidental take of ESA-listed Snake River Spring/Summer Chinook does not exceed a rate of from 5.5 to 17%. The incidental take of natural-origin upriver spring/summer Chinook averaged 10.2% since 2001.

8.3.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is the scientific analysis of species' status, which forms the basis for the listing of the species as endangered or threatened.

8.3.2.1 Current Rangewide Status of the Species

Snake River (SR) spring/summer Chinook is a threatened species composed of 28 extant populations in five major population groups (MPGs). Key statistics associated with the current status of SR spring/summer Chinook salmon are summarized in Tables 8.3.2-1 through 8.3.2-4 and are discussed below.

Limiting Factors and Threats

The key limiting factors and threats for the Snake River spring/summer Chinook include hydropower projects, predation, harvest, degraded estuary habitat, and degraded tributary habitat. Ocean conditions generally have been poor for this ESU over the last 20 years, improving only in the last few years. Eleven populations spawn in wilderness areas, where the habitat is considered functional. Limiting factors are discussed in detail in the context of the conservation value of critical habitat in Section 8.3.3.3.

Abundance

For all populations, average abundance over the most recent 10-year period is below the average abundance thresholds that the ICTRT identifies as a minimum for low risk (Table 8.3.2-1).[1] Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels near the recovery abundance thresholds in a few years in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s (Corps et al. 2007a Chapter 5, Figure 5-2 showing annual abundance of combined populations). The 2007 Snake River jack counts at Lower Monumental Dam are the second highest on record. Qualitatively, Chinook jacks are an indicator of future adult returns. While jack returns include both hatchery and wild fish, these numbers suggest a larger than average return of adults from the 2005 brood year. The majority of these fish will return in 2008 and 2009.

Although recovery criteria rely on the abundance of individual spawning populations, evaluated at the MPG and ESU level, the quality of information varies among populations. The aggregate abundance of all populations of natural-origin SR spring/summer Chinook has been measured since 1962 by counts at the four dams on the lower Snake River. Since 1975 counts have been made at Lower

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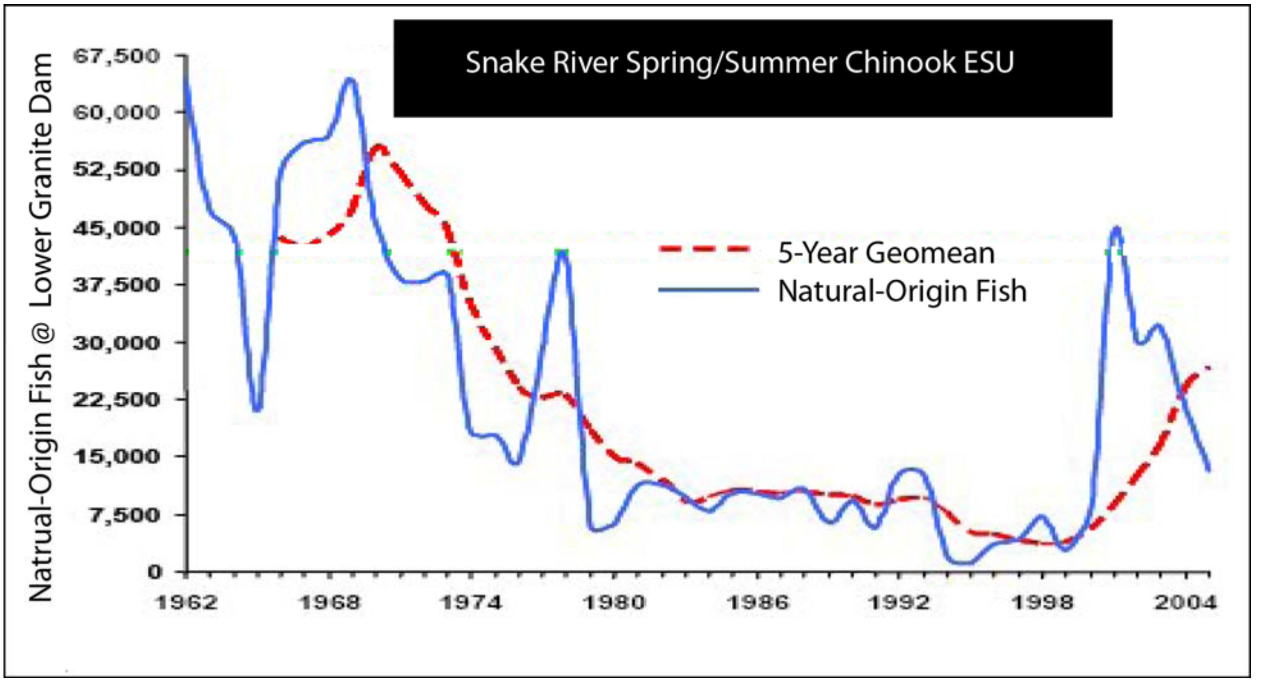
[1] BRT and ICTRT products were developed as primary sources of information for the development of delisting or long-term recovery goals. They were not intended as the basis for setting goals for "no jeopardy" determinations. Although NOAA Fisheries considers the information in the BRT and ICTRT documents in this consultation, its jeopardy determinations are made in a manner consistent with the Lohn memos dated July 12, and September 6, 2006 (NMFS 2006h, i).

Granite Dam, which encompass most populations within the ESU. Abundance and a rolling 5-year geometric mean of abundance for the aggregate of most populations in the ESU are shown in Figure 8.3.2-1. Geometric mean abundance peaked in the late 1960s and continued to decrease until the late 1990s. Geometric mean abundance since the late 1990s has increased substantially for the Lower Granite aggregate count. Geomean abundance of natural-origin fish for the 2001 to 2005 period was 25,957 compared to 4,840 for abundance of natural-origin fish for the 1996 to 2000 period, a 436 percent improvement (Fisher and Hinrichsen 2006). As a point of reference, the sum of the TRT's minimum abundance thresholds for all populations in this ESU is 26,500 (ICTRT 2007c).

Figure 8.3.2-1. Snake River Spring Summer Chinook Abundance Trends (adopted from Fisher and Hinrichsen 2006)



"Base Period" Productivity

On average over the last 20 full brood year returns (~1980-1999 brood years [BY], including adult returns through ~2004), approximately two-thirds of SR spring/summer Chinook populations have not replaced themselves (Table 8.3.2-1) when only natural production is considered (i.e., average R/S has been less than 1.0). In general, R/S productivity was relatively high during the early 1980s, low during the late 1980s and 1990s, and high again in the most recent brood years (brood year R/S estimates in ICTRT Current Status Summaries, ICTRT 2007d, updated with Cooney 2007b.

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at ≤5% extinction risk (ICTRT 2007c).

While natural productivity has been, for most populations, low during this period, the BRT trend in abundance of natural fish has been stable or increasing for nearly all populations (Table 8.3.2-1).

Median population growth rate (lambda) results are intermediate to those of R/S and the BRT trend. When calculated with an assumption that hatchery-origin natural spawners do not reproduce successfully (HF=0), results are similar to the BRT trend, and when calculated with an assumption that hatchery-origin natural spawners' fitness and effectiveness are as successful as natural-origin natural spawners (HF=1), results are similar to the average R/S (Table 8.3.2-1). The ICTRT is incorporating this range of hatchery effectiveness assumptions into updated lambda estimates in the ICTRT Current Status Summaries, so NOAA Fisheries considers the full range.

In summary, abundance of natural-origin and total spawners has been stable or increasing for most SR spring/summer Chinook populations over the last 20 full brood years, based on lambda (HF=0) and BRT trend estimates, generally >1.0. For many populations, this stability or increase has been at least partially dependent on production from naturally spawning hatchery fish, the progeny of which (F2 generation) are considered natural-origin fish in these calculations. For most populations, natural survival rates have not been sufficient for spawners to replace themselves, as indicated by average R/S and lambda (HF=1) estimates <1.0. The presence of hatchery-origin natural spawners does not explain, in its entirety, the differences among the three metrics, as evidenced by populations in the Middle Fork Salmon MPG which are not affected by hatcheries. As described in Chapter 7, each metric requires different types of information and assumptions, and each encompasses a somewhat different time period.

Spatial Structure

The ICTRT characterizes the spatial structure risk to nearly all SR spring/summer Chinook populations as "low" or "moderate" (Table 8.3.2-2). "High" risk exceptions are the Upper Grande Ronde and Lemhi populations, which are a result of accessible but currently unoccupied historically significant spawning areas.

Diversity

The ICTRT characterizes the diversity risk to nearly all SR spring/summer Chinook populations as "low" or "moderate" (Table 8.3.2-2). "High" risk exceptions are found in the Upper Salmon MPG. Factors indicating high risk include loss of the summer-run life history characteristic for the Lemhi population. Ten of the fourteen hatchery programs use fish included in the ESU and are thought to have preserved some of the remaining diversity in this ESU, particularly when individual populations declined to very low numbers in 1994 and 1995 (See NMFS' May 2004 SHIEER NMFS 2004b).

"Base Period" Extinction Risk

The ICTRT Current Status Summaries (ICTRT 2007d) have characterized the long-term (100 year) extinction risk, calculated from productivity and natural origin abundance estimates of populations during the "base period" described above for R/S productivity estimates, as "Moderate" (5-25% 100-year extinction risk) for most SR spring/summer Chinook populations. The ICTRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50). Those populations classified at "high" long-term risk of extinction (>25% risk) are the Tucannon, Upper Grande Ronde, Lemhi, Yankee Fork Salmon R., East Fork Salmon R., and Pahsimeroi populations. Six populations are characterized as having a "low" risk of long-term extinction (<5% risk).

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk, as discussed in Section 7.1.1.1 of this Supplemental Comprehensive Analysis. Table 8.3.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish). This "base" short-term extinction risk analysis assumes that productivity observed during the "base period" will be unchanged in the future. At QET=50, nearly all populations have greater than a 5% risk of extinction. The exceptions are the three South Fork Salmon MPG populations and the Upper Salmon River population. Confidence limits on these estimates are extremely high, with many estimates ranging from 0% to close to 100% risk of extinction.

A QET of less than 50 may also be considered a reasonable indicator of short-term risk, as discussed in Section 7.1.1.1. At QET levels below 50 spawners, more populations have <5% short-term extinction risk.

The short-term and ICTRT long-term extinction risk analyses assume that all hatchery supplementation ceases immediately, which is not consistent with the Prospective Actions. As described in Section 7.1.1.1, this assumption is not representative of hatchery management under the Prospective Actions. When hatchery supplementation is assumed to continue at current levels for those populations affected by hatchery programs, the estimated extinction risk is lower for the affected populations, even at QET=50 (Hinrichsen 2008 in the Aggregate Analysis Appendix).

Quantitative Survival Gaps

The change in density-independent survival (see Table 7.4.1) that would be necessary for quantitative indicators of productivity to be greater than 1.0 and for extinction risk to be less than 5% are displayed in Table 8.3.2-4. Mean base period R/S survival gaps range from no needed change to approximately 3-fold needed survival improvements, depending on population. Many populations have no lambda or BRT gaps, but some populations require nearly 2-fold survival improvements. While a few populations have no extinction risk gap at QET=50, most populations have gaps between approximately 1.2 and 5.4. Gaps are much smaller at QET levels less than 50 spawners.

8.3.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for SR spring/summer Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers, and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam (NMFS 1999a). Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls, including Napias Creek Falls, and Dworshak and Hells Canyon dams) in the following subbasins: Hells Canyon, Imnaha, Lemhi, Little Salmon, Lower Grande Ronde, Lower Middle Fork Salmon, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon-Panther, Pahsimeroi, South Fork Salmon, Upper Middle Fork Salmon, Upper Grande Ronde, Upper Salmon, and Wallowa. The lower Columbia River corridor is among the areas of high conservation value to the ESU 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. 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 1999a). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005b). The status of critical habitat is discussed further in Section 8.3.3.3.

8.3.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.3.3.1 "Current" Productivity & Extinction Risk

Because the action area encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section, estimates of productivity and extinction risk were based on performance of populations during a 20-year "base period," ending in most cases with the 1999 brood year. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone Section 7 consultation and continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity through bank stabilization, shading, etc).

Quantitative Estimates

Because a number of ongoing human activities have changed over the last 20 years, Table 8.3.3-1 includes estimates of a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Chapter 7.2 and the Aggregate Analysis Appendix of this document). Results are presented in Table 8.3.3-1.

Briefly, reduction in the average base period harvest rate (estimated at approximately a 4% survival change [see Quantitative Analysis of Harvest Actions Appendix in the SCA, based on *U.S. v .Oregon* estimates]), improvements in FCRPS configuration and operation (approximately a 20% survival change, based on ICTRT base survival and COMPASS analysis of current survival in the SCA Hydro Modeling Appendix), and estuary habitat projects (a less than 1% survival change, based on Corps et al. 2007a Appendix D) result in a survival improvement for all SR spring/summer Chinook populations. Tributary habitat projects and changes in hatchery operations result in survival improvements for some specific populations within the ESU. Populations affected by tributary improvements experience survival changes ranging from 1-4% (CA Chapter 5, Table 5-7). In contrast, development of tern colonies in the estuary results in less than a 1% reduction in survival for all populations. Additionally, increased adult Chinook predation by marine mammals (primarily California sea lions) in the Columbia River immediately downstream of Bonneville Dam has likely resulted in approximately a 8.5% reduction in survival for SR spring Chinook salmon populations (SCA Marine Mammal Appendix).

Base-to-current adjustments in survival resulting from changing hatchery practices are described in the SCA Quantitative Analysis of Hatchery Actions Appendix. Hatchery reforms in the Grande Ronde have eliminated the use of broodstock originating from outside the area and ESU and have reduced straying, likely resulting in increased hatchery fish effectiveness or fitness in the wild and reduced impacts on genetic diversity. Some populations affected by hatchery operational changes experience improvements estimated at up to 39%. Adjustments in survival are described in the SCA Hatchery Effects Appendix, as estimated survival improvements in Table 5-7 of the CA use hatchery fish effectiveness values that are too high. Effectiveness values reported by Berejikian and Ford 2004 and Araki et al. 2007b were used to generate survival changes in this analysis.

The net result is that, if these recent human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to increase 21-68%, depending on the particular population (Table 8.3.3-1). This also means that the survival "gaps" described in Table 8.3.2-4 would be proportionately reduced by this amount (i.e., ["Gap" ÷ 1.21] to ["Gap" ÷ 1.68], depending on the population).

8.3.3.2 Abundance, Spatial Structure & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section.

8.3.3.3 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. Tributary habitat conditions vary widely among the various drainages occupied by SR spring/summer Chinook salmon. Factors affecting the conservation value of critical habitat vary from mortality in the mainstem hydrosystem to lack of adequate pool/riffle channel structure in tributaries, high summer water temperatures, low flows, poor overwintering conditions due to loss of connection to the floodplain, and high sediment loads.

Spawning & Rearing Areas

SR spring/summer Chinook salmon spawn at high elevations in the headwater tributaries of the Clearwater, Grande Ronde, Salmon, and Imnaha rivers. Spawning is complete by the second week of September. Natural-origin juveniles start moving downstream the following autumn, but typically overwinter in streams, becoming active seaward migrants during the following spring as yearlings (stream-type juvenile life history) (Connor et al. 2005).

The following are the major factors that have limited the functioning and thus the conservation value of tributary habitat used by SR spring-summer Chinook salmon for these purposes (i.e., spawning and juvenile rearing areas with spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Physical passage barriers *[culverts; push-up dams; low flows]*
- Reduced tributary stream flow, which limits usable stream area and alters channel morphology by reducing the likelihood of scouring flows *[water withdrawals]*
- Altered tributary channel morphology *[bank hardening for roads or other development and livestock on soft riparian soils and streambanks]*
- Excess sediment in gravel *[roads; mining; agricultural practices; livestock on soft riparian soils and streambanks, and recreation]* [2]
- Degraded tributary water quality including high summer temperatures and in some cases, chemical pollution from mining *[water withdrawals; degraded riparian condition]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions to address limiting factors for this ESU in spawning and rearing areas. These include acquiring water to increase streamflow, installing or improving fish screens at irrigation facilities to prevent entrainment, removing passage barriers and improving access, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects provided immediate benefits and some will result in long-term benefits with improvements in PCE function accruing into the future.

Juvenile & Adult Migration Corridors

Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers [*push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles*]

[2] In some subbasins (e.g., Upper Middle Fork and Upper Salmon), high levels of sediment in gravel are due, at least in part, to the geologically unstable nature of the watershed.

- Juvenile and adult passage mortality [*hydropower projects in the mainstem lower Snake and Columbia rivers*]
- Pinniped predation on adults due to habitat changes in the lower river [*existence and operation of Bonneville Dam and an increased sea lion population*]
- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators [*Caspian terns and double-crested cormorants*]

In the mainstem FCRPS migration corridor, the Action Agencies have improved safe passage through the hydrosystem for yearling Chinook with the construction and operation of surface bypass routes at Lower Granite, Ice Harbor, and Bonneville dams and other configuration improvements listed in section 5.3.1.1 in Corps et al. (2007a). NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the absolute survival of spring-run Chinook by 5.5%. Thus, the continuing negative impact of sea lions will likely be approximately 3% for spring Chinook populations.

The safe passage of yearling Chinook through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown since that time. For juvenile Chinook with a stream-type life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood

Although SR spring/summer Chinook spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 1993). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.3.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking Database (PCTS) for Federal actions that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that could be used to adjust the status of the populations between the base and current periods. No such actions were found for the extant population within the Lower Snake MPG (Tucannon River population). Results for the other MPGs/populations are described below.[3]

Grande Ronde/Imnaha MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that affect the Wenaha or Lostine river populations.

Catherine Creek

The USFS consulted on a single forestry thinning project to reduce fire danger.

Upper Mainstem Grande Ronde

The USFS consulted on two grazing allotments and a rangeland analysis and the Federal Highways Administration consulted on a bridge repair project.

Imnaha River

The USFS consulted on a timber harvest/vegetation management project in the Upper Imnaha and a bridge replacement project in the Middle Imnaha River watershed. The USFS also consulted on granting a special use permit to private energy companies for operating and maintaining transmission lines in the Upper Imnaha River watershed. The USFS also consulted on a culvert replacement project in the upper Imnaha watershed that was designed to restore access to 3.5 miles of rearing habitat.

South Fork Salmon River MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that affect the South Fork Salmon River mainstem, Secesh River, or East Fork South Fork Salmon River populations. Under the 2000 RPA and 2004 Biological Opinion, Reclamation decommissioned a water diversion structure—restoring fish passage to three miles of Squaw Creek—and consolidated water rights from Squaw Creek with those in the Little Salmon River, increasing flows in Squaw Creek 4 cfs (enough to support a low temperature thermal refuge at the confluence with the Little Salmon River). Reclamation also consulted on a culvert replacement that will improve access to four miles of habitat in Squaw Creek and will improve habitat complexity in Squaw and Papoose creeks. The USFS consulted on a project to treat weeds within a wilderness area at a rate of approximately 6,250 acres per year.

During the summer of 2007, wildfires burned approximately 310,000 acres of forested habitat within the range of South Fork and Middle Fork Salmon River (see below) MPGs. NOAA Fisheries expects that instream habitats will experience increased temperatures, sediment, and large woody debris delivery in the near term. Recovery times for pre-existing conditions will depend on the effects of the fire at each location, which are unknown at this time.

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[3] This information does not include any habitat conservation or restoration projects funded by BPA under NOAA Fisheries' programmatic Biological Opinion for the Habitat Improvement Program (HIP). The effects of those projects are already taken into account in the base-to-current adjustment for species/population status.

Middle Fork Salmon River MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that affect the Middle Fork Salmon River populations above or below Indian Creek or the Big, Camas, Loon, Sulphur, Bear Valley, or Marsh Creek populations. The USFS consulted on a timber sale/salvage project in the lower South Fork Salmon River.

Upper Salmon River MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that would affect the Yankee Fork or Valley Creek populations.

North Fork Salmon River

The USFS consulted on a culvert replacement project in the North Fork Salmon River, designed to restore both access and the hydraulic processes that transport sediment and large wood.

Lemhi River

The FHWA/IDT consulted on the construction of a pedestrian bridge over the Salmon River (Middle Salmon River—Williams Creek watershed).

The USFS consulted on a bank stabilization project at Bog Creek Crossing (Upper Lemhi watershed) and two projects to rehabilitate stream channels and their respective riparian zones in the Middle Salmon River—Carmen Creek and Hayden Creek watersheds. The USFS also consulted on a riparian restoration project in Big Creek.

NOAA Fisheries consulted with itself on funding to screen a water diversion on Kenney Creek and to remove a barrier that will restore passage to 144 miles of rearing habitat and will increase flows 7 to 12 cfs over at least three miles in the Upper Lemhi River (Whitefish Ditch Project). Both projects are in the Eighteenmile Creek watershed.

Lower Mainstem Salmon River—below Redfish Lake

The USFS consulted on a whitebark pine treatment project and FHWA/IDT consulted on two bridge construction/repair projects. The USFS consulted on habitat improvement projects in Slate Creek (Salmon River—Slate Creek watershed), which are expected to add LWD and pool structure while preventing the introduction of excess sediment from forest roads.

Pahsimeroi

The Corps consulted on a project to prevent a hatchery facility from contaminating the naturally spawning population in the upper Pahsimeroi River watershed with disease. The BLM proposed to rehabilitate Fall Creek and its associated riparian zone (Middle Pahsimeroi River watershed). NOAA Fisheries and USFWS each consulted on projects intended to remove passage barriers and improve stream flows by modifying water diversions and irrigation practices in the Lower Pahsimeroi River watershed. The Natural Resources Conservation Service consulted on instream flow work (conversion from flood irrigation to sprinklers) along Iron Creek.

East Fork Salmon River

The USFS consulted on a road reconstruction and maintenance project in the Lower East Fork Salmon River watershed.

Upper Mainstem Salmon River—above Redfish Lake

The USFS consulted on an emergency fire project and whitebark pine treatment in the Salmon River—Pole Creek and Salmon River—Redfish Lake watersheds. The USFS also consulted on the Alturas Spur Road Obliteration and Cabin Creek Reconnect projects. These projects removed fish passage barrier in Cabin Creek and may reduce road generated sediment from entering Alturas Lake Creek (Alturas Lake Creek watershed).

Panther Creek

The Corps consulted on a culvert and wetlands fill project in Upper Panther Creek, which will result in the conversion of irrigated agricultural land to low density residential housing. The project is expected to increase safe passage for fish in upper Panther Creek and in the mainstem Salmon River by eliminating rapid drawdowns when water was withdrawn from irrigation ditches. The BLM consulted on watershed rehabilitation activities associated with while managing waste from the abandoned Twin Peaks Mine (Lower Panther Creek).

Projects Affecting Multiple MPGs/Populations

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.3.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

Federal agencies are implementing numerous projects within the range of SR spring/summer Chinook salmon that will improve access to blocked habitat, prevent entrainment into irrigation pipes, increase channel complexity, and create thermal refuges. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of Federal projects, including forest thinning, grazing, bridge repairs, whitebark pine treatment, bank stabilization, and road construction/maintenance, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Future Federal restoration projects will improve the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PCEs. However, all of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.3.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon, Washington, and Idaho identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin. These are detailed in the lists of projects that appear in Chapter 17 of the FCRPS Action Agencies' Comprehensive Analysis which accompanied their Biological Assessment (Corps et al. 2007a). They include tributary habitat actions that will benefit the Lemhi and Asotin populations as well as actions that should be generally beneficial throughout the ESU. Generally, all of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[4] Many address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly

[4] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects submitted.

improve conditions for Snake River spring/summer Chinook. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.3.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in Sections 8.3.5.1 and 8.3.5.2. However, the Prospective Actions will ensure that these adverse effects will be reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Flow augmentation from the Upper Snake Project (NMFS 2008b) will also provide some benefits. Some habitat restoration and RM&E actions may have short-term minor adverse effects, but these will be more than balanced by short -and long- term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix and in this section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

The effects of NOAA Fisheries' issuance of a Section 10 juvenile transportation permit on this species are discussed in Chapter 10 of the FCRPS Biological Opinion. The expected use of transportation under the permit is discussed in the effects of the FCRPS Prospective Action, which is described in Section 8.3.5.1.

8.3.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5) are expected to continue through the duration of the Prospective Actions.

The effects of the Prospective Actions on mainstem flows have been included in the HYDSIM modeling used to create the 70-year water record for input into the COMPASS model (Section 8.1.1.3). As such, the effect of diminished spring-time flows on juvenile migrants is aggregated in the COMPASS model results used to estimate the effects of the Prospective Actions in the productivity and extinction risk analysis (See SCA Sections 7.2.1 and 8.1.1.3).

Based on COMPASS modeling of hydro operations for the 70-year water record, full implementation of the Prospective Actions is expected to increase the in-river survival (from Lower Granite to the Bonneville tailrace) of SR spring/summer Chinook salmon from 48.5% (Current) to 55.0% (Prospective), a relative change of 13.3%. The average proportion of juveniles destined for transportation is expected to drop from 78.1 to 73.5%. The altered timing of spill and transportation operations (see FCRPS RPA Table 3) will, in most years (about 80%) result in (1) no fish being collected and transported prior to April 21 (when SARs generally favor in-river migrants), (2) > 90% of juveniles being transported after May 15 (when SARs generally favor transported juveniles), and (3) an intermediate number of juveniles being transported between April 21 and May 14 (when SARs do not clearly favor in-river or transported migrants on a consistent basis). During the lowest flow years (about 20% of years when spring flows are predicted to be < 65 kcfs at Lower Granite Dam), over 95% of juveniles are likely to be transported to below Bonneville Dam.

Implementation of the Prospective Actions is not expected to substantially affect total system survival. The total percentage of fish arriving at Lower Granite Dam expected to survive to below Bonneville Dam via in-river migration and transportation should increase slightly from about 85% to nearly 87%. However, the COMPASS model estimates that Lower Granite Dam to Lower Granite Dam smolt-to-adult returns (LGR to LGR SARs) are expected to increase from about 0.87 to 0.91% (a relative improvement of 5.2%) as a result of the hydro Prospective Actions governing spill and transport operations and their effect on migration timing to below Bonneville Dam (see discussion above).[5]

The hydro Prospective Actions, including the RM&E program are likely to maintain the high levels of survival currently observed for adult SR spring/summer Chinook salmon migrating from Bonneville Dam upstream to Lower Granite Dam. The current PIT tag based average survival estimate, taking

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[5] NOTE: The COMPASS model estimates SARs for in-river and transported migrants separately before combining them (with the estimated percentage of in-river and transported juveniles surviving to below Bonneville Dam) to provide an overall LGR to LGR SAR. Thus, the COMPASS model SAR estimates include (through the transport SAR estimate) the increased stray rates that are often observed for adult fish transported as juveniles (compared to stray rates of those that migrated in-river as juveniles) – a negative effect of transportation.

account of harvest and "natural" stray rates within this reach, is 91.0% (about 98.6% per project) for spring and summer Chinook populations (SCA, Adult Survival Estimates Appendix). Any delayed mortality of adults (mortality that occurs outside of the Bonneville Dam to Lower Granite Dam migration corridor) that currently exists is not expected to be affected by the Prospective Actions.

The Prospective Actions are also likely to positively affect the survival of SR spring/summer Chinook salmon in ways that are not included in the quantitative analysis. To be clear, NOAA Fisheries considers these expected benefits qualitatively below, but has not been able to quantify these effects.

The Prospective Actions requiring implementation of surface passage routes at Little Goose, Lower Monumental, McNary and John Day dams, in concert with training spill (amount and pattern) to provide safe egress, should reduce juvenile travel times within the forebays of the individual projects where predation rates are currently often the highest (see Section 8.1.1.1.) Taken together, surface passage routes should increase migration rates (decrease travel time) of in-river migrants through the migration corridor, which is likely to improve the post-Bonneville survival (i.e., SARs) of in-river migrants to a greater degree than has been estimated in the quantitative analysis. Additional benefits are likely to the extent that faster migrating juveniles would be in better condition (i.e., are less stressed, have more energy reserves, etc.) upon reaching the Bonneville tailrace than is currently the case.

Continuing efforts under the NPMP and continuing and improved avian deterrence at mainstem dams will also address sources of juvenile mortality. In-river survival from Lower Granite Dam to the tailrace of Bonneville Dam, which is an index of the hydrosystem's effects on water quality, water quantity, water velocity, project mortality, and predation, will increase to nearly 68%. A portion of the 39% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that yearling Chinook would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of yearling SR spring/summer Chinook in a hypothetical unimpounded Columbia River would be 78%. Therefore, approximately 56% (22%/39%) of the expected mortality experienced by in-river migrating juvenile spring/summer Chinook is probably due to natural factors.

In recent years, scientists in the U.S. and Canada have started to investigate survival in unimpounded rivers (West Coast River Survival Appendix). Results for the Thompson-Frasier basin are preliminary, but the 78% natural survival rate assumed for the Snake-Columbia migration corridor in the 2004 FCRPS Biological Opinion may have been high.[6] That is, yearling survival through the Prospective operations and configuration of the hydrosystem may be closer to "natural" than previously thought.

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[6] The West Coast River Survival Appendix describes a presentation by Dr. David Welch (Kintama Research, Nanaimo, BC) in July 2007. Dr. Welch presented survival data from acoustic tag studies with yearling Chinook in 2006. Additional studies will be needed before NOAA Fisheries considers these data reliable indicators of juvenile survival through a free flowing reach.

The direct survival rate of adults through the FCRPS is already quite high. The Prospective Actions include additional passage improvements (to the collection channel at The Dalles and to the ladders at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite dams and other improvements in section 5.3.3.1 in Corps et al. 2007a). Adult spring/summer Chinook survival from Bonneville to Lower Granite Dam will be approximately 91.0%.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will benefit the yearling migrants by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.3.3.3).

Effects on Critical Habitat

The Prospective Actions described above will improve the functioning of safe passage in the juvenile and adult migration corridors by addressing water quality, water velocity, project mortality, and exposure to predators. To the extent that these improvements result in more adults returning to spawning areas, the hydro Prospective Actions will improve water quality and forage for juveniles by increasing the return of marine derived nutrients. However, the Remand Collaboration Habitat Technical Subgroup did not identify nutrients as a limiting factor for this species.

8.3.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

The population-specific effects of the tributary habitat Prospective Actions on survival are listed in CA Table 5-9, p. 5-20. For targeted populations in this ESU the effect is a <1 - 41% expected increase in low density egg-smolt survival, depending on population, as a result of implementing tributary habitat Prospective Actions that improve habitat function by addressing significant limiting factors and threats.[7] For example, water withdrawals in the Lemhi watershed (upper Salmon River subbasin) currently reduce streamflow enough to block access to spawning and rearing habitat and unscreened water diversions entrain yearling Chinook. As part of their implementation of the RPA (Action 34), the Action Agencies will address this limiting factor by securing water to improve baseflow in the Lemhi River and move points of diversion downstream (to provide more flow in the upstream reach). The Action Agencies will also complete riparian improvement projects and take actions to reduce entrainment. The Action Agencies will assess stream crossings and determine actions needed to provide passage where culverts create barriers the upper mainstem Salmon River.

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[7] The Action Agencies identified the projects that will improve these PCEs and that they will fund by 2009 in Tables 3b; 4a; and 5a,b in Attachment B.2.2-2 to Corps et al. (Corps et al. 2007b).

Effects on Critical Habitat

As described above, the tributary habitat Prospective Actions will address factors that have limited the functioning and conservation value of habitat that this species uses for spawning and rearing. PCEs expected to be improved are water quality, water quantity, cover/shelter, food, riparian vegetation, space, and safe passage/access.

Restoration actions will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.3.5.3 Effects of Estuary Prospective Actions

Effects on Species Status

The estimated survival benefit for Snake River Spring/Summer Chinook (stream-type life history) associated with the specific Prospective Actions to be implemented from 2007-2010 is 1.4 %. The survival benefit for Snake River Spring/Summer Chinook (stream-type life history) associated with actions to be implemented from 2010 through 2017 is 4.3 %. The total survival benefit for Snake River Spring/Summer Chinook, as a result of Prospective Actions implemented to address estuary habitat limiting factors and threats, is approximately 5.7% (Corps et al. 2007a Section 5.3.3.3). Estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM 40 will provide habitats needed by yearling Chinook migrants from the Snake River to increase life history diversity, and spatial structure. The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the value of the estuary as habitat for this species (section 5.3.3.3 in Corps et al. 2007a). These include restoring riparian function and access to tidal floodplains.

Effects on Critical Habitat

The estuary habitat Prospective Actions will address factors that have limited the functioning of PCEs in the estuary needed by yearling Chinook from the Snake River (safe passage). Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction (Section 8.5.5.2) are expected to be minor, occur only at the project scale, and persist for a short time.

8.3.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Hatchery actions are summarized in Section 5.3.3.5 of the CA. The actions fall into two general categories, reforms of existing hatchery programs and new programs that are part of a specific initiative to recover any ESA-listed anadromous salmonid. The reforms and new programs will be determined after site specific consultations guided by available scientific information and Best Management Practices (BMPs) (Framework Work Group 2006).

The hatchery Prospective Actions include the continued funding of hatcheries and the adoption of programmatic criteria or BMPs for operating salmon and steelhead hatchery programs. The criteria for making future funding decisions on hatchery programs for the FCRPS that incorporate BMPs is described in NOAA Fisheries' guidance (See Artificial Propagation for Pacific Salmon Appendix) and Appendix F of the CA. Site specific application of BMPs will be defined in subsequent discussions regarding ESA Section 7, Section 10, or Section 4(d) limits with NOAA Fisheries, to be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies (FCRPS Biological Assessment, page 2-44).

NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated. The Prospective Actions (RPA Action 39) require the submittal of updated HGMPs for the more than 30 hatchery programs in the Snake River basin and initiation of ESA consultation with NOAA Fisheries by February 2010. Hatchery reforms will be implemented upon NOAA Fisheries' completion of these ESA consultations in August 2010. Available information, principles, and guidance for operating hatchery programs are described in the SCA Artificial Propagation for Pacific Salmon Appendix. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPS are expected to: 1) preserve mitigation obligations and integrate hatchery mitigation and conservation objectives; 2) preserve genetic resources; and 3) accelerate trends toward recovery as limiting factors and threats are fixed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations

Future actions described in Section 5.3.3.5 of the CA are important because they will effectively integrate hatchery mitigation and conservation objectives, which additionally will support ESU recovery. The Prospective Actions call for implementing new scientific information at existing federally funded spring/summer Chinook hatchery programs. The hatchery programs are mitigation for construction and operation of Federal hydro projects and are interrelated and interdependent to the continued operation of the FCRPS itself. Continued reform of these facilities will preserve genetic resources, and accelerate the trend toward recovery as limiting factors and threats are addressed and natural productivity increases.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.3.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

Under the Prospective Action the harvest of SR spring/summer Chinook will vary from year-to-year based on an abundance-based harvest rate schedule (Table 8.3.5.5-1). Harvest will depend on the total abundance of upriver spring, natural-origin SR spring/summer Chinook, and may be further limited by natural-origin Upper Columbia River spring Chinook (see footnote 4 of table 8.3.5.5-1). The allowable harvest rate will range from 5.5% to 17%. As indicated in Table 8.3.5.5-1, most of the prospective harvest would occur in treaty Indian fisheries.

Table 8.3.5.5-1. Abundance-based harvest rate schedule for upriver spring Chinook and Snake River spring/summer Chinook in spring management period fisheries (TAC 2008).

Harvest Rate Schedule for Chinook in Spring Management Period					
Total Upriver Spring and Snake River Summer Chinook Run Size	Snake River Natural Spring/Summer Chinook Run Size[1]	Treaty Zone 6 Total Harvest Rate [2,5]	Non-Treaty Natural Harvest Rate [3]	Total Natural Harvest Rate[4]	Non-Treaty Natural Limited Harvest Rate[4]
<27,000	<2,700	5.0%	<0.5%	<5.5%	0.5%
27,000	2,700	5.0%	0.5%	5.5%	0.5%
33,000	3,300	5.0%	1.0%	6.0%	0.5%
44,000	4,400	6.0%	1.0%	7.0%	0.5%
55,000	5,500	7.0%	1.5%	8.5%	1.0%
82,000	8,200	7.4%	1.6%	9.0%	1.5%
109,000	10,900	8.3%	1.7%	10.0%	
141,000	14,100	9.1%	1.9%	11.0%	
217,000	21,700	10.0%	2.0%	12.0%	
271,000	27,100	10.8%	2.2%	13.0%	
326,000	32,600	11.7%	2.3%	14.0%	
380,000	38,000	12.5%	2.5%	15.0%	
434,000	43,400	13.4%	2.6%	16.0%	
488,000	48,800	14.3%	2.7%	17.0%	

1. If the Snake River natural spring/summer forecast is less than 10% of the total upriver run size, the allowable mortality rate will be based on the Snake River natural spring/summer Chinook run size. In the event the total forecast is less than 27,000 or the Snake River natural spring/summer forecast is less than 2,700, Oregon and Washington would keep their mortality rate below 0.5% and attempt to keep actual mortalities as close to zero as possible while maintaining minimal fisheries targeting other harvestable runs.
2. Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from January 1-June 15. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.
3. Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the Hwy 395 Bridge in the Tri-Cities and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from January 1-June 15; Wanapum tribal fisheries, and Snake River mainstem recreational fisheries upstream to the Washington-Idaho border from April through June. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.
4. If the Upper Columbia River natural spring Chinook forecast is less than 1,000, then the total allowable mortality for treaty and non-treaty fisheries combined would be restricted to 9% or less. Whenever Upper Columbia River natural fish restrict the total allowable mortality rate to 9% or less, then non-treaty fisheries

would transfer 0.5% harvest rate to treaty fisheries. In no event would non-treaty fisheries go below 0.5% harvest rate.

5. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.

The prospective harvest schedule is similar to that first used in 2001, as well as in the most recent 2005 to 2007 Agreement. Since 2001, the allowable harvest rates ranged from 5.5 to 17%. The 2001 schedule did not include SR summer Chinook as part of the abundance indicator. The 2005 schedule was modified to included SR summer Chinook, but the abundance levels were adjusted accordingly to provide a comparable level of harvest for the adjusted run size. The harvest rate schedule proposed for use in 2008 and beyond differs from the 2005 schedule only in that it adjusts the allocations between the treaty Indian and non-treaty fisheries, but the total allowable harvest for all abundance levels is otherwise unchanged from the 2005 Agreement.

Harvest rates under the Prospective Actions will be the same as they have been in recent years. Therefore, no additional current-to-future survival adjustment is necessary for the prospective harvest action for this species.

It is also pertinent to consider the potential effects of conservative management. Fisheries directed at upriver spring Chinook can be managed with relative precision. Catch is tracked on a daily basis, and runsize estimates can be adjusted in-season using counts at Bonneville dam. Since 2001, actual harvest rates have ranged between 1.1 and 2.6% less than those allowed (Table 8.3.5.5-2). Any analysis that assumes that the allowed harvest rates will always be fully used would therefore be conservative.

Table 8.3.5.5-2. Actual harvest rate on SR spring/summer Chinook, & those allowed under the applicable abundance based harvest rate schedule (Observed HR from TAC 2008).

Year	Actual HR (%)	Allowed HR (%)	Difference (%)
2001	14.6	16.0	1.4
2002	12.7	14.0	1.3
2003	9.4	12.0	2.6
2004	10.8	12.0	1.2
2005	7.9	9.0	1.1
2006	8.0	10.0	2.0

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for SR spring/summer Chinook salmon.

8.3.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to Snake River spring/summer Chinook from the reduction in Caspian tern nesting habitat and subsequent relocation of most of the terns to sites outside the Columbia River Basin (RPA Action 45), is 2.1 % (CA Attachment F-2, Table 4).

The projected benefit of reduced tern predation is sensitive to assumptions about the additive or compensatory nature of mortality from tern predation. The projected benefits identified in the CA (Appendix F) assume complete additivity (no compensatory mortality (i.e., every salmonid not consumed by terns survives all other sources of mortality)). However, if some portion of the tern's prey consists of salmonids predestined to die as a result of illness or poor condition or to be caught by other predators, the survival improvements modeled above would need to be reduced. Although tern predation likely falls in a class between completely additive and completely compensatory (Roby et al. 2003), current literature and empirical data do not identify more specific estimates or ranges. However, assuming a hypothetical compensatory mortality of 50% (Roby et al. 2003), the range of survival benefits from reducing tern predation across the affected ESUs would decline from 0.7 - 3.4% to 0.3 - 1.7%, approximately. As a result of the small incremental reduction in survival that results from reducing predation by terns nesting on East Sand Island, consideration of compensatory mortality does not significantly alter the estimated benefits of this action.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 34) should further reduce consumption rates of juvenile salmon by northern pikeminnow. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (CA Appendix F, Attachment F-1: Benefits of Predation Management on Northern Pikeminnow). Continued implementation and improvement of avian deterrence at all lower Snake and Columbia dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces (RPA Action 48).

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island, continued implementation of the base Northern Pikeminnow Management Program, continuation of the increased reward structure in the sport-reward fishery, and continued implementation and improvement of avian deterrence at mainstem dams are expected to improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.3.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the Supplemental Comprehensive Analysis.

8.3.5.8 Summary: Quantitative Survival Changes Expected from All Prospective Actions

Expected changes in productivity and quantitative extinction risk are calculated as survival improvements in a manner identical to estimation of the base-to-current survival improvements. The estimates of "prospective" expected survival changes resulting from the Prospective Actions are described in Sections 8.3.5.1 through 8.3.5.8 and are summarized in Table 8.3.5-1. Improvements in hydro operation and configuration, estuary habitat improvement projects, and further reductions in bird and fish predation are expected to increase survival above current levels for all populations in the ESU. Tributary habitat Prospective Actions are expected to increase survival for selected populations. The net effect, which varies by population, is 15-62% increased survival, compared to the "current" condition, and 39-115% increased survival, compared to the "base" condition.

8.3.5.9 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Tables 8.3.6-1 and 8.3.6-2 and in Figures 8.3.6-1 through 8.3.6-4. In addition to these summary tables and figures, the SCA Life Cycle Modeling Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007 Draft Biological Opinion. Additional qualitative considerations that generally apply to multiple populations are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions at the MPG and ESU level.

8.3.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects, Summarized By Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared to the importance of each population to MPG and ESU viability. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

Lower Snake River MPG

This MPG consists of only one extant population (Tucannon), which must be highly viable to achieve the ICTRT's suggested MPG viability scenario. The ICTRT also recommends conducting scoping efforts for re-introduction of the functionally extirpated Asotin population.

The estimated prospective trend in abundance for the Tucannon population (based on R/S, lambda with the HF=0 assumption, and BRT trend) is greater than 1.0, meaning that with implementation of the Prospective Actions the population is expected to replace itself and grow (Table 8.3.6.1-1). When hatchery-origin spawners are considered as effective as natural-origin spawners (HF=1), lambda is estimated to be less than 1.0 (0.98). However, there is considerable uncertainty regarding the reliability of quantitative estimates of productivity. The broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix) suggests that other qualitative information should also be considered:

- Life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival and survival in tributary habitat as a result of the Prospective Actions, as described in Section 8.3.5.1 through 8.3.5.6. These survival improvements indicate that, other factors being equal (i.e., as long as survival in some other life stage does not decrease), survival over the life cycle should also increase. It also indicates that estimates of productivity greater than 1.0 for this population are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "moderate," as defined by the ICTRT (Table 8.3.2-2). The MPG can achieve the ICTRT-suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds. The Prospective Actions are unlikely to negatively affect spatial structure and diversity, so spatial structure and diversity risks are not expected to increase under the Prospective Actions. In the near term, the Tucannon hatchery supplementation program provides a reserve for maintaining diversity, potentially accelerating recovery pending increases in natural productivity. In the longer term, proportional contributions of hatchery fish to natural spawning would have to be reduced to achieve the ICTRT diversity criteria associated with low risk.

- Prospective Actions include tributary habitat improvements in the Asotin River. These actions are a necessary step toward potentially re-establishing the Asotin population. The problems facing this ESU, such as the need to re-establish the functionally extirpated Asotin population, will take longer than 10 years to resolve; however, the Prospective Actions take the necessary steps within the next ten years.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario the Tucannon population is expected to have R/S considerably greater than 1.0 (SCA Aggregate Analysis Appendix). Under the ICTRT "Warm PDO" climate scenario, in which all years are anomalously warm, the estimate is lower but still greater than 1.0.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Short-term extinction risk is estimated to be <5% at QET=50, whether Prospective Actions occur immediately or not (Table 8.3.6.1-2).

As discussed in Section 7.1.1.1 of the Supplemental Comprehensive Analysis, QET levels less than 50 fish may be relevant to short-term extinction risk. Sensitivity analyses to QET levels of 30 fish or less also indicate <5% extinction risk, even if no Prospective Actions were to be implemented immediately (Table 8.3.6.1-2).

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (see 95% confidence limits in Table 8.3.2-3). For this reason, other qualitative information is also considered:

- There is a safety-net hatchery program for this population, which is required to continue under the Prospective Actions, to further reduce short-term extinction risk.

- The recent 10-year geometric mean abundance has been 88 fish, which is above the 50 fish QET (Table 8.3.2-1). Only 2 of the last 25 years of returns have been below 50 fish (Cooney 2007).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Grande Ronde/Imnaha MPG

This MPG consists of six extant populations. The ICTRT recommends that four of these populations be viable or highly viable for MPG viability. Key populations within this MPG include the Imnaha because of its unique life history strategy (summer spawning timing and associated juvenile rearing patterns) and the Lostine/Wallowa, which is one of only three "large" populations. The ICTRT also suggests choices among two pairs of populations: Catherine Creek or Upper Grande Ronde (both representing "large" populations) and Minam or Wenaha (populations least affected by hatchery fish and with little spatial structure or diversity impairment). The ICTRT considers two additional populations (Big Sheep Creek and Lookingglass Creek) functionally extirpated. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

All of the populations are likely to increase in abundance, based on estimated lambda (HF=0) and BRT trends greater than 1.0 with the implementation of the Prospective Actions (Table 8.3.6.1-1). Additionally, three of the six populations are likely to have R/S and lambda (HF=1) greater than 1.0, indicating natural survival sufficient for the population to grow, and three of the populations are not likely to have R/S and lambda (HF=1) greater than 1.0. Furthermore, two of three populations with R/S<1 (Imnaha and either Catherine Creek or the Upper Grande Ronde) would need to be viable or highly viable under the ICTRT's recommended MPG viability scenario. Additional survival improvements of 8% for Catherine Creek and 20% for the Imnaha would be necessary for two of these populations to exceed 1.0 for R/S (Aggregate Analysis Appendix).

There is considerable uncertainty regarding the reliability of quantitative productivity estimates because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix). For this reason, other qualitative information is also considered:

- As a result of the Prospective Actions, life-stage-specific survival rates are expected to improve for mainstem hydro survival, estuarine survival, and survival in selected tributaries, as described in Sections 8.3.5.1 through 8.3.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for this population are not solely determined by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "low" to "moderate" for all populations except the Upper Grande Ronde, which is at a "high" spatial structure risk because of unoccupied major and minor spawning areas (Table 8.3.2-2). The Upper Grande Ronde hatchery program has transitioned into a supplementation program that will build genetic resources and diversity. The MPG can achieve the ICTRT-suggested MPG viability scenario with the remaining populations having "low" to "moderate" risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- For these populations, the problems that must be addressed, in order to have higher R/S, will take longer than 10 years to resolve. In particular, the water quality and quantity problems in the lower reaches of the Upper Grande Ronde and Catherine Creek will require a long-term program working with private landowners.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the “historical” ocean scenario all populations in the Grande Ronde MPG are expected to have R/S greater than 1.0 (SCA Aggregate Analysis Appendix). Under the ICTRT “Warm PDO” climate scenario, in which all years are anomalously warm, four of six populations are expected to have R/S less than 1.0.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of short-term extinction risk indicate <5% risk at QET=50 or less for two populations (Minam and Imnaha), but >5% risk at QET=50 for the remaining four populations (Catherine Creek, Upper Grande Ronde, Wenaha, and Lostine/Wallowa; Table 8.3.6.1-2). For the Wenaha population, nearly all of the Prospective Actions survival improvements would have to occur immediately to reduce risk below 5% at QET=50. This is not expected to occur. For Catherine Creek, Lostine/Wallowa, and Upper Grande Ronde, extinction risk would be >5%, even if all Prospective Actions were implemented immediately.

As discussed in Section 7.1.1.1, CA Chapter 3, and the Aggregate Analysis Appendix, QET levels less than 50 fish are also relevant to short-term extinction risk. Sensitivity analyses to QET levels of 30 fish or less indicate approximately 5% extinction risk for the Lostine/Wallowa population (Table 8.3.6.1-2). QET levels of 10-30 (depending on speed of Prospective Actions implementation) or less would result in <5% risk for the Upper Grande Ronde population.

There is considerable uncertainty regarding the reliability of quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for base extinction risk range from 0 to nearly 100% for these populations; Table 8.3.2-3). For this reason, other qualitative information is also considered:

- The recent 10-year geometric mean abundance is above 50 fish for all populations except the Upper Grande Ronde (Table 8.3.2-1).
- The Upper Grande Ronde, Catherine Creek, and Lostine/Wallowa populations have dropped below 50 fish in some individual years since 1980 (Cooney 2007). No other populations have fallen below 50 fish.
- There is a hatchery program, which is required to continue under the Prospective Actions, acting as a safety net for most of the affected populations to reduce short-term extinction risk.
- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

South Fork Salmon MPG

This MPG consists of four extant populations. The two largest of the four populations (South Fork Mainstem and East Fork South Fork) must be viable or highly viable to achieve the ICTRT suggested MPG viability scenario**.** Please see Section 7.3 of the SCA for a discussion of these MPG viability scenarios.

The productivity (based on all three metrics: R/S, lambda, and BRT trend) is expected to be greater than 1.0 with implementation of the Prospective Actions (Table 8.3.6.1-1). This means that these populations are expected to have survival sufficient to grow and that the abundance of spawners will increase.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix) for two of the three populations. For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival and survival in selected tributaries as a result of the Prospective Actions, as described in Sections 8.3.5.1 through 8.3.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. These improvements also indicate that estimates of productivity >1 for this population are not driven solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "low" to "moderate" (Table 8.3.2-2). The MPG can achieve the ICTRT-suggested recovery scenario with moderate risk for these factors and sufficient productivity, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario all South Fork Salmon MPG populations are expected to have R/S greater than 1.0 and to be farther above 1.0 than under the recent climate scenario (SCA Aggregate Analysis Appendix). Under the ICTRT "Warm PDO" climate scenario, in which all years are anomalously warm, all populations are expected to have R/S greater than 1.0.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of extinction risk indicate <5% risk at QET=50 or less for all three populations for which estimates can be made, even if no Prospective Actions are implemented immediately (Table 8.3.6.1-2).

There is some uncertainty regarding the reliability of quantitative estimates of extinction risk because of the range of statistical results (95% confidence limits in Table 8.3.2-3). For this reason, other qualitative information is also considered:

- There is a safety-net hatchery program for the East Fork South Fork (including Johnson Creek) population in this MPG to further reduce short-term extinction risk.

- The recent 10-year geometric mean abundance is above 50 fish for all three populations (Table 8.3.2-1). Returns have not dropped below 50 fish in individual years (Cooney 2007). Population abundance is expected to increase in the future as a result of actions already completed and additional Prospective Actions.

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Middle Fork Salmon MPG

There are nine populations in this MPG and five must be viable or highly viable to achieve the ICTRT suggested MPG viability scenario. Important populations include: Big Creek (the only large population), Chamberlain Creek (unique geographical position between MPGs and one of two needed "intermediate" sized populations), Bear Valley/Elk Creek (a second "intermediate" sized population, after Chamberlain Creek), Marsh Creek (one of two needed "basic" sized populations, with a larger production area and somewhat less isolation than others), and either Camas Creek or Loon Creek (one of which is needed for second "basic" sized population). Please see Section 7.3 for a discussion of these MPG viability scenarios.

Quantitative information is sufficient to estimate productivity for six of the nine populations (R/S, lambda, and BRT trend). Productivity (based on all three metrics: R/S, lambda, and BRT trend) is estimated to be greater than 1.0 for all 6 populations under the Prospective Actions (Table 8.3.6.1-1). This means that the populations will have survival sufficient to grow and that the abundance of spawners will achieve a positive trend.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1 for most of the R/S estimates; Aggregate Analysis Appendix). For this reason, other qualitative information is also considered:

- As a result of the Prospective Actions, life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival and tributary habitat survival (in Big Creek only), as described in Sections 8.3.5.1 through 8.3.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of expected productivity >1 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "very low" to "moderate" (Table 8.2.2-2). The MPG can achieve the ICTRT-suggested recovery scenario with moderate risk for these factors and sufficient productivity, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the ICTRT "historical" ocean scenario, all populations in the Middle Fork MPG are expected to have productivity (all three metrics) greater than 1.0 (SCA Aggregate Analysis Appendix). Under the "Warm PDO" ocean scenario, in which all years are anomalously warm, 5 of 6 populations in the Middle Fork MPG are expected to have productivity (all three metrics) greater than 1.0.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Although quantitative estimates of extinction risk are not available for five of the nine populations in this MPG, quantitative estimates of extinction risk indicate that each of the four populations with sufficient data to make an estimate have >5% risk at QET=50 under current conditions (Table 8.3.6.1-2). If the Prospective Actions result in at least a 4% immediate improvement, then the Bear Valley/Elk Creek population will have <5% risk.

As discussed in Section 7.1.1.1, QET levels of less than 50 fish may be relevant to short-term extinction risk. This may be especially relevant for the small populations in the Middle Fork MPG, which have fallen below 50 spawners frequently during the last 20 years and yet survived (Cooney 2007; Figure 7.1-3). Within the last 20 years, seven populations in this MPG have fallen below 50 spawners four years in a row, yet have survived and rebounded to much higher levels (although not as high as historical abundance). This lends some empirical support to the view that QET=50 spawners may overstate the risk of actual biological extinction for some of these populations. A QET level of 30 spawners would result in <5% extinction risk for one of the four populations in this MPG for which quantitative estimates are possible, while a QET of 10 spawners would result in <5% risk for three of the four populations.

There is considerable uncertainty regarding the quantitative estimates of extinction risk, both because of the broad range of statistical results (95% confidence limits for base period extinction risk range from 0 to nearly 100% for these populations; Table 8.3.2-3) and because of uncertainty regarding the appropriate QET for short-term risk. For this reason, other qualitative information is also considered:

- There is not a safety-net hatchery program operating in the Middle Fork Salmon MPG to further reduce extinction risk but the hatchery Prospective Actions require the FCRPS Action Agencies to "identify and plan for additional safety-net programs. This MPG is primarily located in National Forest and wilderness areas and has been managed for wild fish production.
- The recent 10-year geometric mean abundance is above 50 fish for Big Creek, Bear Valley/Elk, and Loon Creeks, but is below 50 fish for Marsh, Sulphur, and Camas Creeks (Table 8.3.2.1-1). No estimates are available for the Upper Middle Fork, Lower Middle Fork, or Chamberlain populations. Since 1980, returns have dropped below 50 fish in individual years for all six populations for which abundance estimates are available (Cooney 2007). Population abundance is expected to increase in the future as a result of actions already completed and additional Prospective Actions.
- Fish management agreements do not currently support hatchery supplementation for these populations. However, if these populations fall to critically low levels, a hatchery safety net program could be implemented.
- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Upper Salmon MPG

There are eight populations in the Upper Salmon MPG, five of which have to be viable or highly viable to achieve the ICTRT suggested recovery scenario. Important populations include: Lemhi River (one of two very large populations, connectivity to other MPGs), Pahsimeroi River (unique life history pattern), East Fork Salmon River (one of two needed large populations), Upper Salmon River (second needed large population), and Valley Creek (historically larger production than most basic-sized populations). Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

Quantitative information is sufficient to estimate 20-year productivity for six of the eight populations (lambda, R/S, and BRT trend). Only 15 brood years are available for the Pahsimeroi population, but

R/S based on these 15 years is also displayed for this population. Productivity (based on all three metrics: R/S, lambda, and BRT trend) is estimated to be 1.0 or greater than 1.0 for all 6-7 populations under the Prospective Actions (Table 8.3.6.1-1). This means that the population will have survival sufficient to grow and that the abundance of spawners will achieve a positive trend.

For most of the populations with sufficient information for productivity estimates, there is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1, while lower 95% confidence intervals indicate productivity <1; Aggregate Analysis Appendix). For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival, and survival in tributaries as a result of the Prospective Actions, as described in Sections 8.3.5.1 through 8.3.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for this population are not driven solely by favorable environmental conditions.
- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario all Upper Salmon MPG populations are expected to have R/S greater than 1.0 (SCA Aggregate Analysis Appendix). Under the ICTRT "Warm PDO" (poor) climate scenario, five of seven populations are expected to have R/S greater than 1.0.
- Current risk associated with spatial structure and diversity is "high" for the Lemhi population and risk associated with diversity is "high" for the East Fork Salmon and Pahsimeroi populations, which also must be viable to achieve the long-term viability scenario suggested by the ICTRT (Table 8.3.2-2). Problems for these populations include unoccupied major and minor spawning areas and loss of the summer life history strategy for the Lemhi population.
- The problems associated with these populations that need to be addressed in order to have lower short-term extinction risk will take longer than 10 years to resolve. In particular, the occupation of sufficient major and minor spawning areas and loss of the Lemhi summer life history strategy involve long-term improvements.
- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.
- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to

reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Short-term extinction risk could be estimated quantitatively for only three populations (Valley Creek, Upper Salmon, and Lower Salmon). Quantitative estimates of extinction risk indicate that the Upper Salmon River population has <5% risk at QET=50 (Table 8.3.6.1-2). The other two populations have >5 risk at QET=50.

As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Sensitivity analyses indicate that QET would need to be between 10-30 spawners (depending on the degree to which Prospective Actions are implemented immediately) to conclude that two of the three available populations have <5% extinction risk (Table 8.3.6.1-2).

There is considerable uncertainty regarding the quantitative estimates of extinction risk, both because of the broad range of statistical results (95% confidence limits for base period extinction risk range from 0 to nearly 100% for these populations; Table 8.3.2-3) and because of uncertainty regarding the appropriate QET for short-term risk. For this reason, other qualitative information is also considered:

- There is a captive rearing program to reduce short-term extinction risk for the Yankee Fork population. A captive broodstock program for the Lemhi has existed since 1995. There are no other safety-net hatchery programs for other populations in the Upper Salmon MPG.
- The recent 10-year geometric mean abundance is above 50 fish for the Lemhi, Upper Salmon, Lower Salmon, East Fork Salmon, and Pahsimeroi populations, but mean abundance is below 50 fish for the Valley Creek and Yankee Fork populations (Table 8.3.2-1). No estimates are available for the North Fork Salmon population. Returns have dropped below 50 fish in individual years since 1980 for all seven populations for which abundance estimates are available (Cooney 2007).
- While NOAA Fisheries would have greater confidence that populations in this MPG will not go extinct while recovery actions are being implemented if results showed a low likelihood of dropping below QET=50 fish, these populations have dropped below 50 spawners in the past and then increased dramatically when survival conditions were more favorable. For example, the abundance of Yankee Fork spawners ranged from 0-21 in the eight years between1993-2000. However, from 2001-2003 (the last available year in the ICTRT data set) abundance has ranged from 92-161 (Cooney 2007).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

8.3.7 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Snake River Spring/Summer Chinook Salmon ESU

This section summarizes the basis for conclusions at the ESU level.

8.3.7.1 Potential for Recovery

It is likely that the Snake River spring/summer Chinook salmon ESU will trend toward recovery.

The future status of all populations and MPGs of SR spring/summer Chinook salmon will be improved from their current status through the reduction of current adverse effects and the implementation of Prospective Actions with beneficial effects, as described in Sections 8.3.5, 8.3.6, and 8.3.7.2. Therefore, the status of the ESU as a whole is expected to improve compared to its current condition and to move closer to a recovered condition. This expectation takes into account some short-term adverse effects of Prospective Actions related to habitat improvements (Section 8.3.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this ESU.

The Prospective Actions include hydropower, predation, and estuary and tributary habitat actions that address limiting factors and threats and will reduce their negative effects. As described in Section 8.3.1, key limiting factors and threats affecting the current status of this species (abundance, productivity, spatial structure, and diversity) include: hydropower development, predation, harvest, and degradation of tributary and estuary habitat. Prospective habitat improvements will initiate and at least partially address concerns regarding high spatial structure risk for the Lemhi and Lostine/Wallowa populations. In addition to Prospective Actions, Federal actions in the environmental baseline and non-Federal actions appropriately considered cumulative effects also address limiting factors and threats. The harvest Prospective Action is to implement a *U.S. v. Oregon* harvest rate schedule that is expected to be no change from the current harvest rates in the environmental baseline. Although hatchery management is not identified as a current limiting factor for the ESU as a whole, the ICTRT has identified concerns for a few individual populations with high diversity risk. Additionally, the longer hatchery programs continue the more likely their effects will limit recovery potential. The Prospective Actions include measures to ensure that hatchery management changes that have been implemented in recent years will continue, that safety-net hatchery programs will continue, and that further hatchery improvements will be implemented to reduce the likelihood of longer-term problems associated with continuing hatchery programs although subject to future hatchery-specific consultations after which these benefits may be realized.

Some of the problems limiting recovery of SR spring/summer Chinook salmon, such as tributary habitat problems affecting some Grande Ronde MPG populations, will probably take longer than 10 years to correct. However, actions included in the Prospective Actions represent significant improvements that reasonably can be implemented within the next 10 years. Additionally, the Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 some important improvements include installation of RSWs and other passage improvements to reduce delay and exposure to warm temperatures in project forebays and regulation of late summer water temperatures at Lower Granite by regulating outflow temperatures at Dworshak Dam. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects include dike removal and opening off-channel habitat which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

In sum, these qualitative considerations suggest that the SR spring/summer Chinook ESU will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of metrics indicating a trend toward recovery also support this conclusion.

Return-per-spawner (R/S) estimates are indicative of natural survival rates (i.e., the estimates assume no future effects of hatchery supplementation). As such, they are somewhat conservative for populations with ongoing supplementation programs, but R/S may be the best indicator of the ability of populations to be self-sustaining. R/S estimates incorporate many variables, including age structure and fraction of hatchery-origin spawners by year. The availability and quality of this information varies, so in some cases R/S estimates are less certain than lambda and BRT trend metrics.

As described in Section 8.3.6, R/S is expected to be >1.0 for 19 of 23 populations in this ESU for which estimates are available in this ESU and stable (1.0) for one additional population (Figure 8.3.6-1). R/S is expected to be >1.0 for most of the important populations identified by ICTRT in four of the five MPGs in this ESU (Table 8.3.6.1-1). The Grande Ronde is the MPG with key populations that are expected to have R/S<1.0 after implementation of the Prospective Actions.

Populations for which R/S is expected to be greater than 1.0 generally have estimates that are considerably greater than 1.0 (range 1.1-2.4; mean 1.5). By providing additional benefits to stronger populations, the Prospective Actions help offset problems with more poorly performing populations, supporting the viability of the ESU as a whole.

Population growth rate (lambda) and BRT trend estimates are indicative of abundance trends of natural-origin and combined-origin spawners, assuming that current supplementation programs continue. The method of calculating lambda leads to a range of results for populations influenced by hatchery production, depending upon assumed effectiveness of hatchery-origin spawners. These estimates require fewer assumptions and less data than R/S estimates, but still depend on data quality. Because of the hatchery assumptions these metrics may be less indicative of a trend toward recovery than R/S for populations significantly influenced by or dependent on hatchery programs, since recovery implies self-sustaining populations.

With implementation of the Prospective Actions, all populations in this ESU have lambda (with the HF=0 assumption that hatchery-origin spawners are completely ineffective) and BRT trends that are expected to be greater than 1.0, as described in Section 8.3.6. For lambda under the HF=1 assumption that hatchery-origin spawners are as effective as natural-origin spawners, estimates are less than 1.0 for four populations in two MPGs (Lower Snake and Grande Ronde). As with R/S, the estimates that are greater than 1.0 are considerably higher. Therefore, all important populations identified by the ICTRT are expected to have lambda (HF=0) and BRT trend greater than 1.0 for all five MPGs, but key populations in two of the five MPGs have expected lambda (HF=1) less than 1.0.

Some important caveats that apply to all three quantitative estimates are as follows:

- Not all beneficial effects of the Prospective Actions could be quantified (e.g., habitat improvements that accrue over a longer than 10-year period), so quantitative estimates of prospective R/S may be low.
- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate and effects on early ocean survival will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario, all but one population are expected to have R/S greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.3.6-2). Under the ICTRT "Warm PDO" climate scenario, in which all years are anomalously warm, the number of populations with R/S less than 1.0 increases to seven (out of 22), compared to three under the "recent" climate scenario.
- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change were considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

- The mean results represent the most likely future condition, but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, R/S, lambda, and the BRT trend are expected to be greater than 1.0 at the upper 95% confidence limits for all populations. R/S is expected to be less than 1.0 for most populations at the lower 95% confidence limits (SCA Aggregate Analysis Appendix; Figure 8.3.6-1). This uncertainty indicates that it is important to also consider qualitative factors in reaching conclusions.

Taken together, the combination of all the qualitative and quantitative factors indicates that the ESU as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. NOAA Fisheries cannot demonstrate quantitatively that all populations (including important populations in the Upper Grande Ronde MPG) will be increasing as a result of the actions considered in the aggregate analysis and as indicated by expected R/S>1. However, the majority of populations are likely to increase in abundance and enough populations are likely to be increasing to conclude that the ESU as a whole will be trending toward recovery. Those populations that do have R/S greater than 1.0 have considerably higher R/S, in part due to the Prospective Actions. These populations with high productivity help offset problems with more poorly performing populations, making the ESU as a whole more viable.

This does not mean that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes resulting from the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the ESU being on a trend toward recovery.

8.3.7.2 Short-term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through survival improvements resulting from the Prospective Actions and a continuation of other current management actions in the environmental baseline, as described above and in Sections 8.3.3 and 8.3.5. Additionally, implementation of Prospective Actions in other life stages is expected to further improve survival and reduce extinction risk.

As described in Section 8.3.6, abundance is expected to be stable or increasing for most populations and natural productivity (R/S) is expected to be sufficient for most populations to grow. These factors also indicate a decreasing risk of extinction.

A number of critical populations are supported in part by safety-net hatchery supplementation programs. These programs ensure that the affected populations will not go extinct in the short term, although, as described above, they increase diversity risk to the ESU if continued over a long time period. Safety-net hatchery supplementation programs protect the single extant population in the Lower Snake MPG, all high-risk populations in the Grande Ronde MPG, the East Fork South Fork Salmon population in the South Fork Salmon MPG, and the Yankee Fork population in the Upper Salmon MPG. There are no hatchery programs affecting the Middle Fork Salmon MPG.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 and above, some important improvements include installation of RSWs and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

The Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24 year) extinction risk also support this conclusion.

As described in Section 8.3.6, short-term extinction risk is expected to be ≤ 5% at QET=50 for seven to nine of 17 populations in this ESU for which estimates were available (Figure 8.3.6-3). Critical populations have ≤ 5% risk at QET=50 for three of the five MPGs. The range reflects whether the estimate is based on a continuation of current baseline management practices (low estimate) or if the Prospective Actions are considered (higher estimate). These estimates assume no continued hatchery supplementation and assume that the population will be extinct if it falls below 50 fish for four years in a row.

Quantitative estimates of short-term extinction risk, assuming base period conditions and that supplementation continues (Hinrichsen 2008, included as Attachment 1 of the Aggregate Analysis Appendix), indicate that the Lostine and Imnaha populations in the Grande Ronde MPG have ≤ 5% risk at QET=50 and the Upper Grande Ronde and Catherine Creek populations have greatly reduced extinction risk, although it is still >5% at QET=50. These estimates do not consider base-to-current improvements and improvements expected from Prospective Actions. If an analysis, assuming continued supplementation, were applied to all populations with safety-net hatchery programs, it is likely that only a few populations would remain with a high extinction risk at QET=50. Most of these populations are in the Middle Fork Salmon MPG, which has no supplementation program.

For the Middle Fork Salmon MPG, it was only possible to quantitatively estimate short-term extinction risk for four of the nine populations. One of these populations has $\leq$ 5% at QET=50 if some of the Prospective Actions achieve immediate benefits and the other three populations have higher risk. While these results are a cause for concern, two factors indicate that the short-term extinction risk for the Middle Fork Salmon MPG populations may not be as high as indicated by these quantitative results.

- First, as discussed in Section 7.1, the ICTRT selected a QET of 50 fish to represent a point at which long-term (100-year) extinction risk is qualitatively high, based on a combination of demographic considerations that would also apply in the short term and genetic considerations that may have less relevance to short-term survival. It is likely that a lower QET could be equally relevant to an assessment of short-term risk.
- Second, as described in Section 7.1, a QET of 50 overstates the true extinction risk of populations that have averaged less than 50 fish during the extinction model's base period. These populations must by definition have a very high extinction risk when the projection model compares to a 50 fish quasi-extinction threshold, yet the empirical evidence indicates that the populations in question clearly have not gone extinct during this period. Within the last 20 years, seven populations in the Middle Fork MPG have fallen below 50 spawners four years in a row, yet have survived and rebounded to much higher levels (although not as high as historical abundance).

At a QET of 10 fish, three out of four populations for which extinction risk could be estimated have low risk.

This summary of quantitative extinction risk estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario 10-11 of 17 populations are expected to have $\leq$ 5% risk at QET=50 (Aggregate Analysis Appendix; Figure 8.3.6-4). Under the ICTRT "Warm PDO" climate scenario, in which all years are anomalously warm, the number of populations with $\leq$ 5% risk at QET=50 decreases to 5-7, compared to 7-9 under the "recent" climate scenario.

Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While we do not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from near 0% to near 100% for many populations. This uncertainty indicates that it is important to also consider qualitative factors in reaching conclusions.

Taken together, the combination of all the factors above indicates that the ESU as a whole is likely to have a low risk of short-term extinction when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements result in lower short-term extinction risk than in recent years. NOAA Fisheries cannot demonstrate quantitatively that all populations or all MPGs will have a low short-term extinction risk, as indicated by quantitative estimates and a quasi extinction threshold of 50 fish, which the ICTRT associated with long-term viability. These extinction risk estimates assume that all hatchery supplementation ceases. However, most of the populations with high short-term extinction risk are protected from extinction by safety-net hatchery programs. Quantitative estimates, with an assumption of continuing supplementation, indicate that supplemented populations have low short-term extinction risk. The exceptions are populations in the Middle Fork Salmon MPG, which are not influenced by hatchery programs. The Middle Fork MPG is a concern and these populations will be closely monitored under the Prospective Actions to ensure that any changes in status are detected and appropriate actions taken. However, although these populations appear to have high risk at QET=50, it is likely that a lower QET level is appropriate for some of the smaller populations. Most of these populations have dropped to levels below 50 fish, and in some cases for four years in a row, yet have not gone extinct and have increased to higher numbers in recent years. In summary, enough populations are likely to have a low enough risk of extinction to conclude that the ESU as a whole will have a low risk of short-term extinction.

8.3.7.3 Effect of Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for SR spring/summer Chinook salmon including all Columbia River estuarine areas and river reaches upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; and river reaches presently or historically accessible in the Hells Canyon, Imnaha, Lemhi, Little Salmon, Lower Grande Ronde, Lower Middle Fork Salmon, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon-Panther, Pahsimeroi, South Fork Salmon, Upper Middle Fork Salmon, Upper Grande Ronde, Upper Salmon, and Wallowa subbasins. The environmental baseline within the action area, which encompasses these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for SR spring/summer Chinook. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Snake and Columbia rivers; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, excess sediment in gravel, and high summer temperatures in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at Little Goose, Lower Monumental, McNary, and John Day dams, in concert with training spill to provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns, double-crested cormorants, and northern pikeminnows will further improve safe passage for juveniles and the removal of sea lions known to eat spring Chinook in the tailrace of Bonneville Dam will do the same for adults. Habitat work in tributaries used for spawning and rearing and in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.3.2-1. Status of SR spring/summer Chinook salmon with respect to abundance and productivity VSP factors. Productivity is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	MPG	Population	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: 20-yr non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope: 1980 - Current[4]	Lower 95% CI	Upper 95% CI
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	82	1997-2006	750	0.72	0.48	1.10	0.96	0.67	1.38	0.87	0.63	1.21	0.92	0.85	0.99
		Asotin - Functionally Extirpated															
	Grande Ronde / Imnaha	Catherine Creek	107	1996-2005	1000	0.44	0.22	0.84	0.93	0.66	1.30	0.81	0.53	1.26	0.92	0.87	0.98
		Lostine/Wallowa Rivers	276	1996-2005	1000	0.72	0.41	1.26	0.95	0.77	1.17	0.82	0.59	1.13	1.01	0.96	1.06
		Minam River	337	1996-2005	750	0.80	0.47	1.37	1.05	0.82	1.35	0.98	0.71	1.36	1.02	0.97	1.07
		Imnaha River	380	1996-2005	750	0.59	0.40	0.86	1.04	0.80	1.37	0.93	0.65	1.33	0.98	0.94	1.02
		Wenaha River	376	1996-2005	750	0.66	0.41	1.08	1.03	0.78	1.36	0.94	0.68	1.32	1.04	0.99	1.10
		Upper Grande Ronde	38	1996-2005	1000	0.32	0.18	0.57	1.00	0.74	1.36	0.85	0.67	1.09	0.92	0.87	0.97
		Big Sheep Creek - Functionally Extirpated															
		Lookingglass- Functionally Extirpated															
	South Fork Salmon	South Fork Salmon Mainstem	601	1994-2003	1000	0.86	0.59	1.28	1.09	0.83	1.43	0.99	0.74	1.33	1.05	1.01	1.10
		Secesh River	403	1996-2005	750	1.19	0.81	1.76	1.06	0.86	1.32	1.06	0.85	1.31	1.05	1.01	1.09
		East Fork S. Fork Salmon (including Johns	105	1994-2003	1000	0.97	0.67	1.41	1.06	0.88	1.28	1.05	0.87	1.26	1.02	0.97	1.08
		Little Salmon River (including Rapid R.)			500												
	Middle Fork Salmon	Big Creek	90	1995-2004	1000	1.20	0.66	2.19	1.09	0.78	1.53	1.09	0.78	1.53	1.02	0.94	1.10
		Bear Valley/Elk Creek	182	1994-2003	750	1.35	0.82	2.22	1.11	0.79	1.55	1.11	0.79	1.55	1.05	0.98	1.13
		Marsh Creek	42	1994-2003	500	0.95	0.52	1.75	1.09	0.78	1.52	1.09	0.78	1.52	1.01	0.92	1.10
		Sulphur Creek	21	1994-2003	500	0.97	0.45	2.09	1.07	0.68	1.68	1.07	0.68	1.68	1.02	0.94	1.11
		Camas Creek	28	1995-2004	500	0.79	0.39	1.62	1.04	0.69	1.57	1.04	0.69	1.57	1.00	0.93	1.07
		Loon Creek	51	1995-2004	500	1.11	0.54	2.31	1.12	0.79	1.58	1.12	0.79	1.58	1.07	0.98	1.16
		Chamberlain Creek			500												
		Lower Middle Fork Salmon (below Ind. Cr.)			500												
		Upper Middle Fork Salmon (above Ind. Cr.)			750												
	Upper Salmon	Lemhi River	79	1994-2003	2000	1.08	0.63	1.84	1.03	0.66	1.59	1.03	0.66	1.59	0.98	0.92	1.05
		Valley Creek	34	1994-2003	500	1.07	0.61	1.87	1.07	0.72	1.59	1.07	0.72	1.59	1.03	0.96	1.11
		Yankee Fork	13	1994-2003	500	0.61	0.28	1.29	1.06	0.67	1.68	1.06	0.67	1.68	1.05	0.96	1.15
		Upper Salmon River (above Redfish L.)	246	1996-2005	1000	1.51	0.84	2.72	1.04	0.74	1.46	0.98	0.69	1.38	1.01	0.95	1.06
		North Fork Salmon River			500												
		Lower Salmon River (below Redfish L.)	103	1996-2005	2000	1.20	0.75	1.92	1.03	0.76	1.40	1.03	0.76	1.40	1.00	0.95	1.05
		East Fork Salmon River	148	1996-2005	1000	1.06	0.54	2.08	1.05	0.70	1.57	1.02	0.66	1.56	1.01	0.94	1.09
		Pahsimeroi River	127	1996-2005	1000	0.51	0.22	1.18									
		Panther - Extirpated															

1 ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from the ICTRT (2007c).
2 Mean returns-per-spawner are estimated from the most recent period of approximately 20 brood years in Cooney (2007). Actual years in average vary by population.
3 Median population growth rate (lambda) during the most recent period of approximately 20 years. Actual years in estimate vary by population. Lambda estimates are from Cooney (2008c).
4 Biological Review Team (Good et al. 2005) trend estimates and 95% confidence limits updated for recent years in Cooney (2008c).

Table 8.3.2-2. Status of SR spring/summer Chinook salmon with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	ICTRT Current Risk For Spatial Structure[1]	ICTRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	Currently Moderate Risk	Currently Moderate Risk	0.47
		Asotin - Functionally Extirpated			
	Grande Ronde / Imnaha	Catherine Creek	Currently Moderate Risk	Currently Moderate Risk	0.71
		Lostine/Wallowa Rivers	Currently High Risk (Loss of occupancy in 1.5 MaSA and 2 MiSA)	Currently Moderate Risk	0.72
		Minam River	Currently Low Risk	Currently Moderate Risk	0.96
		Imnaha River	Currently Low Risk	Currently Moderate Risk	0.35
		Wenaha River	Currently Low Risk	Currently Moderate Risk	0.95
		Upper Grande Ronde	Currently Low Risk	Currently Moderate Risk	0.77
		Big Sheep Creek - Functionally Extirpated			
		Lookingglass- Functionally Extirpated			
	South Fork Salmon	South Fork Salmon Mainstem	Currently Low Risk	Currently Moderate Risk	0.62
		Secesh River	Currently Low Risk	Currently Low Risk	0.96
		East Fork S. Fork Salmon (including Johns	Currently Low Risk	Currently Low Risk	0.90
		Little Salmon River (including Rapid R.)			
	Middle Fork Salmon	Big Creek	Currently Low Risk	Currently Low Risk	1.00
		Bear Valley/Elk Creek	Currently Very Low Risk	Currently Moderate Risk	1.00
		Marsh Creek	Currently Low Risk	Currently Low Risk	1.00
		Sulphur Creek	Currently Low Risk	Currently Moderate Risk	1.00
		Camas Creek	Currently Low Risk	Currently Moderate Risk	1.00
		Loon Creek	Currently Low Risk	Currently Moderate Risk	1.00
		Chamberlain Creek	Currently Low Risk	Currently Low Risk	
		Lower Middle Fork Salmon (below Ind. Cr.)	Currently Moderate Risk	Currently Moderate Risk	
		Upper Middle Fork Salmon (above Ind. Cr.)			
	Upper Salmon	Lemhi River	Currently High Risk (Loss of occupancy of 2 upstream MaSA and 1 downstream MiSA)	Currently High Risk (Loss of summer-run life history)	1.00
		Valley Creek	Currently Low Risk	Currently Moderate Risk	1.00
		Yankee Fork	Currently Moderate Risk	Currently High Risk (Out of population and out of MPG hatchery straying)	1.00
		Upper Salmon River (above Redfish L.)	Currently Very Low Risk	Currently Moderate Risk	0.75
		North Fork Salmon River	Currently Low Risk	Currently Low Risk	
		Lower Salmon River (below Redfish L.)	Currently Low Risk	Currently Low Risk	1.00
		East Fork Salmon River	Currently Low Risk	Currently High Risk (Genetic diversity and legacy effects of hatchery fish)	0.92
		Pahsimeroi River	Currently Moderate Risk	Currently High Risk (High proportion of hatchery fish in multi-year program)	0.58
		Panther - Extirpated			

1 ICTRT conclusions for Snake River spring/summer Chinook are from ICTRT Current Status Summaries (ICTRT 2007d).
2 Average fractions of natural-origin natural spawners are from the ICTRT (Cooney 2007).

Table 8.3.2-3. Status of SR spring/summer Chinook salmon with respect to extinction risk. Extinction risk is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			24-Year Extinction Risk											
ESU	**MPG**	**Population**	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Snake River Spring/ Summer Chinook Salmon	**Lower Snake**	Tucannon	0.00	0.00	0.13	0.00	0.00	0.30	0.02	0.00	0.55	0.07	0.00	0.71
		Asotin - Functionally Extirpated												
	Grande Ronde / Imnaha	Catherine Creek	0.09	0.00	0.77	0.23	0.00	0.90	0.37	0.00	0.96	0.45	0.01	0.98
		Lostine/Wallowa Rivers	0.00	0.00	0.46	0.03	0.00	0.62	0.10	0.00	0.74	0.18	0.00	0.81
		Minam River	0.00	0.00	0.31	0.00	0.00	0.42	0.02	0.00	0.57	0.06	0.00	0.68
		Imnaha River	0.00	0.00	0.22	0.01	0.00	0.45	0.04	0.00	0.66	0.09	0.00	0.73
		Wenaha River	0.00	0.00	0.35	0.04	0.00	0.57	0.15	0.00	0.74	0.26	0.00	0.83
		Upper Grande Ronde	0.00	0.00	0.11	0.09	0.00	0.57	0.41	0.01	0.89	0.70	0.07	0.97
		Big Sheep Creek - Functionally Extirpated												
		Lookingglass- Functionally Extirpated												
	South Fork Salmon	South Fork Salmon Mainstem	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.07	0.00	0.00	0.13
		Secesh River	0.00	0.00	0.17	0.00	0.00	0.26	0.01	0.00	0.35	0.02	0.00	0.42
		East Fork S. Fork Salmon (including Johns	0.00	0.00	0.02	0.00	0.00	0.14	0.01	0.00	0.33	0.04	0.00	0.48
		Little Salmon River (including Rapid R.)												
	Middle Fork Salmon	Big Creek	0.00	0.00	0.60	0.04	0.00	0.80	0.20	0.00	0.89	0.37	0.00	0.93
		Bear Valley/Elk Creek	0.00	0.00	0.40	0.00	0.00	0.53	0.03	0.00	0.63	0.09	0.00	0.71
		Marsh Creek	0.03	0.00	0.64	0.21	0.00	0.82	0.43	0.00	0.92	0.56	0.00	0.95
		Sulphur Creek	0.00	0.00	0.65	0.06	0.00	0.79	0.33	0.00	0.88	0.55	0.00	0.92
		Camas Creek												
		Loon Creek												
		Chamberlain Creek												
		Lower Middle Fork Salmon (below Ind. Cr.)												
		Upper Middle Fork Salmon (above Ind. Cr.)												
	Upper Salmon	Lemhi River												
		Valley Creek	0.00	0.00	0.32	0.13	0.00	0.76	0.50	0.01	0.96	0.75	0.07	0.99
		Yankee Fork												
		Upper Salmon River (above Redfish L.)	0.00	0.00	0.37	0.00	0.00	0.53	0.00	0.00	0.64	0.00	0.00	0.71
		North Fork Salmon River												
		Lower Salmon River (below Redfish L.)	0.00	0.00	0.41	0.00	0.00	0.80	0.13	0.00	0.97	0.37	0.00	0.99
		East Fork Salmon River												
		Pahsimeroi River												
		Panther - Extirpated												

1 Short-term (24-year) extinction risk and 95% confidence limits from Hinrichsen (2008), in the Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.3.2-4. Changes in density-independent survival (“gaps”) necessary for indices of productivity equal to 1.0 and estimates of extinction risk no higher than 5% for SR spring/summer Chinook salmon. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated “gaps” are based on population performance during the “base period” of approximately the last 20 brood years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 1980-current BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.38	2.09	0.91	1.18	5.90	0.24	1.85	8.06	0.90	1.48	2.10	1.04	0.33	0.57	0.86	1.13
		Asotin - Functionally Extirpated																
	Grande Ronde / Imnaha	Catherine Creek	2.30	4.45	1.19	1.40	6.40	0.31	2.55	18.17	0.54	1.42	1.85	1.09	1.28	2.18	3.07	3.88
		Lostine/Wallowa Rivers	1.39	2.44	0.79	0.88	3.09	0.25	1.30	5.82	0.76	0.96	1.20	0.76	0.49	0.87	1.27	1.60
		Minam River	1.25	2.13	0.73	0.80	2.50	0.26	1.09	4.67	0.86	0.92	1.12	0.75	0.27	0.50	0.79	1.06
		Imnaha River	1.70	2.50	1.16	1.00	3.97	0.25	2.06	6.14	0.93	1.10	1.34	0.90	0.41	0.69	0.97	1.18
		Wenaha River	1.51	2.45	0.93	0.83	2.79	0.24	1.39	7.00	0.73	0.83	1.04	0.66	0.55	0.95	1.38	1.71
		Upper Grande Ronde	3.09	5.47	1.75							1.46	1.84	1.16	0.55	1.11	1.87	2.65
		Big Sheep Creek - Functionally Extirpated																
		Lookingglass- Functionally Extirpated																
	South Fork Salmon	South Fork Salmon Mainstem	1.16	1.71	0.78	0.69	2.33	0.20	1.04	3.83	0.91	0.79	0.94	0.66	0.16	0.27	0.37	0.45
		Secesh River	0.84	1.23	0.57	0.76	2.01	0.28	0.78	2.06	0.84	0.81	0.97	0.68	0.32	0.52	0.69	0.84
		East Fork S. Fork Salmon (including Johnson	1.03	1.49	0.71	0.78	1.80	0.34	0.81	1.86	0.82	0.90	1.12	0.72	0.39	0.63	0.81	0.94
		Little Salmon River (including Rapid R.)																
	Middle Fork Salmon	Big Creek	0.83	1.51	0.46	0.67	3.09	0.15	0.67	3.09	0.71	0.93	1.29	0.66	0.42	0.96	1.84	2.70
		Bear Valley/Elk Creek	0.74	1.21	0.45	0.63	2.84	0.14	0.63	2.84	0.80	0.79	1.08	0.59	0.27	0.53	0.90	1.26
		Marsh Creek	1.05	1.93	0.57	0.69	3.11	0.15	0.69	3.11	0.46	0.97	1.45	0.65	0.89	1.82	3.11	4.28
		Sulphur Creek	1.03	2.23	0.48	0.73	5.56	0.10	0.73	5.56	0.76	0.90	1.33	0.62	0.29	1.06	2.66	4.25
		Camas Creek	1.26	2.58	0.62	0.84	5.38	0.13	0.84	5.38	1.00	1.02	1.41	0.73				
		Loon Creek	0.90	1.86	0.43	0.61	2.87	0.13	1.11	0.79	1.58	0.75	1.09	0.52				
		Chamberlain Creek																
		Lower Middle Fork Salmon (below Ind. Cr.)																
		Upper Middle Fork Salmon (above Ind. Cr.)																
	Upper Salmon	Lemhi River	0.93	1.59	0.54	0.89	6.31	0.13	0.89	6.31	1.00	1.08	1.43	0.82	0.00	0.00	0.00	0.00
		Valley Creek	0.94	1.64	0.53							0.88	1.21	0.64	0.32	1.28	3.28	5.37
		Yankee Fork	1.65	3.52	0.77							0.82	1.23	0.54				
		Upper Salmon River (above Redfish L.)	0.66	1.19	0.37	0.85	3.97	0.18	1.11	5.17	0.97	0.98	1.24	0.77	0.07	0.21	0.47	0.74
		North Fork Salmon River																
		Lower Salmon River (below Redfish L.)	0.83	1.33	0.52	0.87	3.40	0.22	0.87	3.40	0.90	0.99	1.24	0.79	0.19	0.57	1.37	2.18
		East Fork Salmon River	0.94	1.84	0.48	0.82	5.08	0.13	0.93	6.40	1.00	0.96	1.35	0.69	0.00	0.00	0.00	0.00
		Pahsimeroi River	1.97	4.59	0.85							0.00	0.00	0.00				
		Panther - Extirpated																

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.3.2-1.

2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.3.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.

3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.3.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.

4 Extinction risk survival gap is calculated as the exponent of a Beverton-Holt “a” value from a production function that would result in 5% risk, divided by the exponent of the base period Beverton-Holt “a” value. Estimates are from Hinrichsen (2008), in the Aggregate Analysis Appendix.

Table 8.3.3-1. Proportional changes in average base period survival of SR spring/summer Chinook salmon expected from completed actions and current human activities that are likely to continue into the future. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average).

			Base-to-Current Adjustment (Survival Multiplier)							
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Marine Mammal Predation[5]	Harvest[6]	Hatcheries[7]	Total Base-to-Current Survival Multiplier[8]
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.20	1.04	1.00	1.00	0.97	1.04	1.00	1.25
		Asotin - Functionally Extirpated								
	Grande Ronde / Imnaha	Catherine Creek	1.20	1.04	1.00	1.00	0.97	1.04	1.20	1.51
		Lostine/Wallowa Rivers	1.20	1.01	1.00	1.00	0.97	1.04	1.03	1.26
		Minam River	1.20	1.00	1.00	1.00	0.97	1.04	1.22	1.47
		Imnaha River	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.22
		Wenaha River	1.20	1.00	1.00	1.00	0.97	1.04	1.39	1.68
		Upper Grande Ronde	1.20	1.04	1.00	1.00	0.97	1.04	1.21	1.52
		Big Sheep Creek - Functionally Extirpated								
		Lookingglass- Functionally Extirpated								
	South Fork Salmon	South Fork Salmon Mainstem	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Secesh River	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		East Fork S. Fork Salmon (including Johnson	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Little Salmon River (including Rapid R.)	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
	Middle Fork Salmon	Big Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Bear Valley/Elk Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Marsh Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Sulphur Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Camas Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Loon Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Chamberlain Creek	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Lower Middle Fork Salmon (below Ind. Cr.)	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Upper Middle Fork Salmon (above Ind. Cr.)	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
	Upper Salmon	Lemhi River	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		Valley Creek	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		Yankee Fork	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Upper Salmon River (above Redfish L.)	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		North Fork Salmon River	1.20	1.00	1.00	1.00	0.97	1.04	1.00	1.21
		Lower Salmon River (below Redfish L.)	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		East Fork Salmon River	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		Pahsimeroi River	1.20	1.01	1.00	1.00	0.97	1.04	1.00	1.21
		Panther - Extirpated								

1 From SCA Hydro Modeling Appendix Based on differences in average base and current smolt-to-adult survival estimates.
2 From CA Chapter 5, Table 5-7.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the

"Current 2 S/Baseline 2 S" approach, as described in Attachment F-2.
5 From SCA Marine Mammal Appendix
6 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
7 From SCA Quantitative Analysis of Hatchery Actions Appendix. Additional basis is in Section 8.3.3.1. Relevant calculation methods are described in the Aggregate Analysis Appendix.
8 Total base-to-current survival improvement multiplier is the product of the survival improvement multipliers in each previous column.

Table 8.3.5-1. Proportional changes in survival of SR spring/summer Chinook salmon expected from the Prospective Actions. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Survival Multiplier)								
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2] (2007-2017)	Estuary Habitat[3]	Bird Predation[4]	Pike-minnow Predation[5]	Hatcheries[6]	Non-Hydro Current-to-Future Survival Multiplier[7]	Total Current-to-Future Survival Multiplier[8]	Total Base-to-Future Survival Multiplier[9]
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.05	1.17	1.06	1.02	1.01	1.00	1.28	1.35	1.68
		Asotin - Functionally Extirpated									
	Grande Ronde / Imnaha	Catherine Creek	1.05	1.23	1.06	1.02	1.01	1.00	1.34	1.41	2.13
		Lostine/Wallowa Rivers	1.05	1.02	1.06	1.02	1.01	1.00	1.11	1.17	1.47
		Minam River	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.70
		Imnaha River	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.42
		Wenaha River	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.93
		Upper Grande Ronde	1.05	1.23	1.06	1.02	1.01	1.00	1.34	1.41	2.15
		Big Sheep Creek - Functionally Extirpated									
		Lookingglass- Functionally Extirpated									
	South Fork Salmon	South Fork Salmon Mainstem	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.40
		Secesh River	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.40
		East Fork S. Fork Salmon (including Johnson)	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Little Salmon River (including Rapid R.)	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.40
	Middle Fork Salmon	Big Creek	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.40
		Bear Valley/Elk Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Marsh Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Sulphur Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Camas Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Loon Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Chamberlain Creek	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Lower Middle Fork Salmon (below Ind. Cr.)	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Upper Middle Fork Salmon (above Ind. Cr.)	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
	Upper Salmon	Lemhi River	1.05	1.07	1.06	1.02	1.01	1.00	1.17	1.23	1.49
		Valley Creek	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.41
		Yankee Fork	1.05	1.30	1.06	1.02	1.01	1.00	1.42	1.49	1.81
		Upper Salmon River (above Redfish L.)	1.05	1.14	1.06	1.02	1.01	1.00	1.25	1.31	1.59
		North Fork Salmon River	1.05	1.00	1.06	1.02	1.01	1.00	1.09	1.15	1.39
		Lower Salmon River (below Redfish L.)	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.41
		East Fork Salmon River	1.05	1.01	1.06	1.02	1.01	1.00	1.10	1.16	1.41
		Pahsimeroi River	1.05	1.41	1.06	1.02	1.01	1.00	1.54	1.62	1.97
		Panther - Extirpated									

1 From SCA Hydro Modeling Appendix. Based on differences in average current and prospective smolt-to-adult survival estimates.
2 From CA Chapter 5, Table 5-9.
3 From CA Appendix D, Attachment D-1, Table 6.

4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 No survival changes have been estimated to result from hatchery Prospective Actions – future effects are qualitative.
7 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
8 Same as Footnote 7, except it is calculated from all Prospective Actions, including hydro actions.
9 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier from Table 8.3.3-1.

Table 8.3.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for SR spring/summer Chinook salmon.

ESU	MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.22	1.08	0.98	1.03	Must be HV	All metrics >1, except lambda with HF=1	Currently Moderate Risk	Currently Moderate Risk
		Asotin - Functionally Extirpated								
							Need 1 HV and 3 V:			
	Grande Ronde / Imnaha	Catherine Creek	0.93	1.10	0.96	1.09	1 of these 2 populations must be HV or V	Lambda with HF=0 and BRT trend >1, but lambda with HF=1 and R/S <1, for both populations in this pair	Currently Moderate Risk	Currently Moderate Risk
		Upper Grande Ronde	0.70	1.13	0.97	1.09			Currently High Risk (Loss of occupancy in 1.5 MaSA and 2 MiSA)	Currently Moderate Risk
		Minam River	1.36	1.18	1.10	1.15	1 of these 2 populations must be HV or V	All three metrics >1 for both populations in this pair	Currently Low Risk	Currently Moderate Risk
		Wenaha River	1.28	1.21	1.08	1.21			Currently Low Risk	Currently Moderate Risk
		Lostine/Wallowa Rivers	1.06	1.12	1.03	1.10	HV or V if needed to make 4 total for MPG	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Imnaha River	0.83	1.08	0.92	1.06	HV or V if needed to make 4 total for MPG	Lambda with HF=0 and BRT trend >1, but lambda with HF=1 and R/S <1	Currently Low Risk	Currently Moderate Risk
		Big Sheep Creek - Functionally Extirpated								
		Lookingglass- Functionally Extirpated								
							Need 1 HV and 1 V:			
	South Fork Salmon	South Fork Salmon Mainstem	1.21	1.17	1.07	1.14	HV or V (need 2 of these 3 populations)	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Secesh River	1.68	1.15	1.14	1.13	"Maintained" Population	All three metrics >1	Currently Low Risk	Currently Low Risk
		East Fork S. Fork Salmon (including Johnson)	1.35	1.14	1.13	1.10	HV or V (need 2 of these 3 populations)	All three metrics >1	Currently Low Risk	Currently Low Risk
		Little Salmon River (including Rapid R.)					HV or V (need 2 of these 3 populations)	No Data		
							Need 1 HV and 4 V:			
	Middle Fork Salmon	Big Creek	1.69	1.18	1.18	1.10	Must be HV or V	All three metrics >1	Currently Low Risk	Currently Low Risk
		Bear Valley/Elk Creek	1.88	1.19	1.19	1.13	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
		Marsh Creek	1.32	1.17	1.17	1.08	Must be HV or V	All three metrics >1	Currently Low Risk	Currently Low Risk
		Sulphur Creek	1.35	1.15	1.15	1.10	"Maintained" Population	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Camas Creek	1.10	1.12	1.12	1.07	1 of these 2 populations must be HV or V	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Loon Creek	1.55	1.20	1.20	1.15		All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Chamberlain Creek					Must be HV or V	No Data	Currently Low Risk	Currently Low Risk
		Lower Middle Fork Salmon (below Ind. Cr.)					"Maintained" Population	No Data	Currently Moderate Risk	Currently Moderate Risk
		Upper Middle Fork Salmon (above Ind. Cr.)					"Maintained" Population	No Data		
							Need 1 HV and 4 V:			
	Upper Salmon	Lemhi River	1.61	1.12	1.12	1.07	Must be HV or V	All three metrics >1	Currently High Risk (Loss of occupancy of 2 upstream MaSA and 1 downstream MiSA)	Currently High Risk (Loss of summer-run life history)
		Valley Creek	1.51	1.15	1.15	1.11	Must be HV or V	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Yankee Fork	1.09	1.21	1.21	1.19	"Maintained" Population	All three metrics >1	Currently Moderate Risk	Currently High Risk (Out of population and out of MPG hatchery straying)
		Upper Salmon River (above Redfish L.)	2.40	1.15	1.08	1.11	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
		North Fork Salmon River					"Maintained" Population	No Data	Currently Low Risk	Currently Low Risk
		Lower Salmon River (below Redfish L.)	1.70	1.11	1.11	1.08	"Maintained" Population	All three metrics >1	Currently Low Risk	Currently Low Risk
		East Fork Salmon River	1.50	1.13	1.10	1.09	Must be HV or V	All three metrics >1	Currently Low Risk	Currently High Risk (Genetic diversity and legacy effects of hatchery fish)
		Pahsimeroi River	1.00				Must be HV or V	R/S>1	Currently Moderate Risk	Currently High Risk (High proportion of hatchery fish in multi-year program)
		Panther - Extirpated								

1 Calculated as the base period 20-year R/S productivity from Table 8.3.2-1, multiplied by the total base-to-future survival multiplier in Table 8.3.5-1.
2 Calculated as the base period 20-year mean population growth rate (lambda) from Table 8.3.2-1, multiplied by the total base-to-future survival multiplier in Table 8.3.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.

3 Calculated as the base period 20-year mean BRT abundance trend from Table 8.3.2-1, multiplied by the total base-to-future survival multiplier in Table 8.3.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007a), Attachment 2
5 From Table 8.3.2-2

Table 8.3.6.1-2. Summary of prospective estimates relevant to the survival prong of the jeopardy standard for SR spring/summer Chinook salmon. Numbers represent additional survival improvements (remaining "gaps") to reduce 24-year extinction risk to 5% or less. Numbers less than 1.0 indicate that no additional survival changes are necessary.

			Extinction - Based Only On Current Adjustment - Not Influenced By RPA[1]				Extinction - Based On Current Adjustment and RPA Prospective Actions[2]					
ESU	MPG	Population	24-yr Extinction Risk Gap for ≤5% at QET=1	24-yr Extinction Risk Gap for ≤5% at QET=10	24-yr Extinction Risk Gap for ≤5% at QET=30	24-yr Extinction Risk Gap for ≤5% at QET=50	24-yr Extinction Risk Gap for ≤5% at QET=1	24-yr Extinction Risk Gap for ≤5% at QET=10	24-yr Extinction Risk Gap for ≤5% at QET=30	24-yr Extinction Risk Gap for ≤5% at QET=50	ICTRT MPG Viability Scenario[3]	Survival Prong Notes for Extinction Risk
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.26	0.46	0.69	0.90	0.20	0.34	0.51	0.67	Must be HV	<5% risk at QET=50.
		Asotin - Functionally Extirpated										
											Need 1 HV and 3 V:	
	Grande Ronde / Imnaha	Catherine Creek	0.85	1.45	2.04	2.57	0.60	1.02	1.44	1.82	1 of these 2 populations must be HV or V	<5% risk only expected at low QET, but safety net programs in RPA reduce extinction risk.
		Upper Grande Ronde	0.36	0.73	1.23	1.74	0.26	0.52	0.87	1.23		<5% risk only expected at low QET, but safety net programs in RPA reduce extinction risk.
		Minam River	0.18	0.34	0.54	0.72	0.16	0.29	0.47	0.63	1 of these 2 populations must be HV or V	<5% risk at QET=50 without reliance on immediate RPA actions
		Wenaha River	0.33	0.57	0.82	1.02	0.28	0.49	0.71	0.89		≤5% risk at QET=50 if some prospective actions implemented immediately; otherwise >5% risk
		Lostine/Wallowa Rivers	0.39	0.69	1.01	1.27	0.33	0.59	0.86	1.09	HV or V if needed to make 4 total for MPG	<5% risk only expected at low QET, but safety net programs in RPA reduce extinction risk.
		Imnaha River	0.34	0.57	0.79	0.97	0.29	0.49	0.68	0.83	HV or V if needed to make 4 total for MPG	<5% risk at QET=50 without reliance on immediate RPA actions
		Big Sheep Creek - Functionally Extirpated										
		Lookingglass- Functionally Extirpated										
											Need 1 HV and 1 V:	
	South Fork Salmon	South Fork Salmon Mainstem	0.13	0.22	0.31	0.37	0.11	0.19	0.26	0.32	HV or V (need 2 of these 3 populations)	<5% risk at QET=50 without reliance on immediate RPA actions
		Secesh River	0.26	0.43	0.57	0.70	0.23	0.37	0.49	0.60	"Maintained" Population	<5% risk at QET=50 without reliance on immediate RPA actions
		East Fork S. Fork Salmon (including Johnson)	0.32	0.52	0.67	0.78	0.28	0.45	0.58	0.68	HV or V (need 2 of these 3 populations)	<5% risk at QET=50 without reliance on immediate RPA actions. Safety-net program also reduces short-term extinction risk.
		Little Salmon River (including Rapid R.)									HV or V (need 2 of these 3 populations)	No short-term extinction risk estimates
											Need 1 HV and 4 V:	
	Middle Fork Salmon	Big Creek	0.35	0.79	1.52	2.23	0.30	0.68	1.31	1.92	Must be HV or V	<5% risk only expected at low QET.
		Bear Valley/Elk Creek	0.22	0.44	0.74	1.04	0.19	0.38	0.65	0.91	Must be HV or V	<5% risk at QET=50 with some immediate RPA actions; otherwise, >5% risk
		Marsh Creek	0.74	1.51	2.57	3.54	0.64	1.31	2.24	3.08	Must be HV or V	<5% risk only expected at low QET.
		Sulphur Creek	0.24	0.88	2.20	3.52	0.21	0.76	1.91	3.06	"Maintained" Population	<5% risk only expected at low QET.
		Camas Creek									1 of these 2 populations must be HV or V	No short-term extinction risk estimates
		Loon Creek										No short-term extinction risk estimates
		Chamberlain Creek									Must be HV or V	No short-term extinction risk estimates
		Lower Middle Fork Salmon (below Ind. Cr.)									"Maintained" Population	No short-term extinction risk estimates
		Upper Middle Fork Salmon (above Ind. Cr.)									"Maintained" Population	No short-term extinction risk estimates
											Need 1 HV and 4 V:	
	Upper Salmon	Lemhi River									Must be HV or V	No short-term extinction risk estimates
		Valley Creek	0.26	1.05	2.70	4.42	0.23	0.91	2.33	3.81	Must be HV or V	<5% risk only expected at low QET.
		Yankee Fork									"Maintained" Population	No short-term extinction risk estimates. Captive rearing program in RPA reduces extinction risk.
		Upper Salmon River (above Redfish L.)	0.06	0.17	0.39	0.61	0.04	0.13	0.30	0.46	Must be HV or V	<5% risk at QET=50 without reliance on immediate RPA actions
		North Fork Salmon River									"Maintained" Population	No short-term extinction risk estimates
		Lower Salmon River (below Redfish L.)	0.16	0.47	1.13	1.80	0.13	0.40	0.97	1.55	"Maintained" Population	<5% risk only expected at low QET.
		East Fork Salmon River									Must be HV or V	Safety net programs in RPA reduce extinction risk.
		Pahsimeroi River									Must be HV or V	No short-term extinction risk estimates
		Panther - Extirpated										

1 These estimates assume that only actions that have already occurred can contribute to reducing short-term extinction risk. Calculated as the base period 5% extinction risk gap from Table 8.3.2-4, divided by the total base-to-current survival multiplier in Table 8.3.3-1.
2 These estimates assume that Prospective Actions to be implemented in the next 10 years can contribute to reducing short-term extinction risk. Calculated as the base period 5% extinction risk gap from Table 8.3.2-4, divided by the total base-to-future survival multiplier in Table 8.3.5-1.
3 From ICTRT (2007a), Attachment 2

Figure 8.3.6-1. Summary of prospective mean R/S estimates for SR spring/summer Chinook salmon under the "recent" climate assumption, including 95% confidence limits.

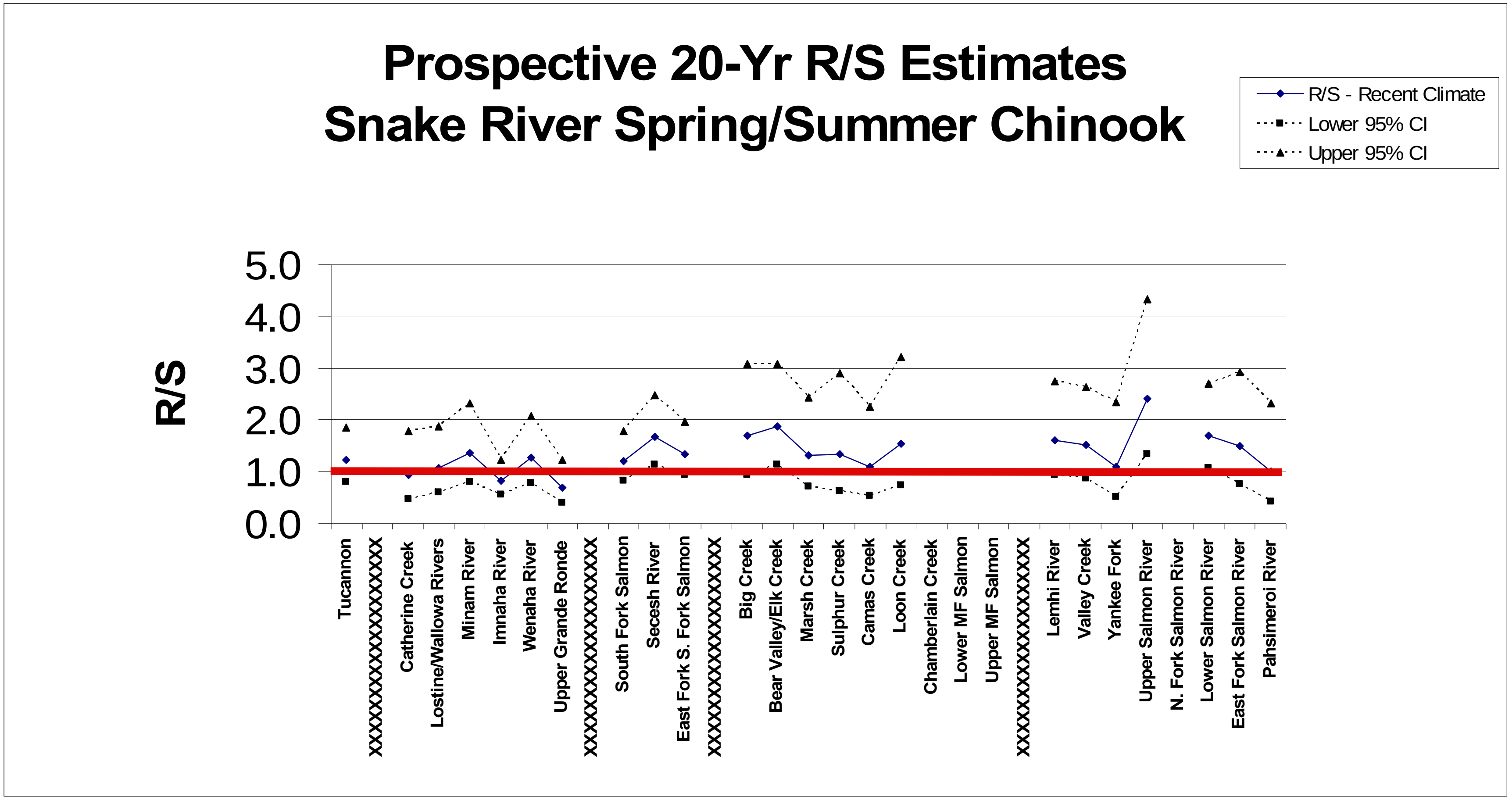


Figure 8.3.6-2. Summary of prospective mean R/S estimates for SR spring/summer Chinook salmon under three climate assumptions.

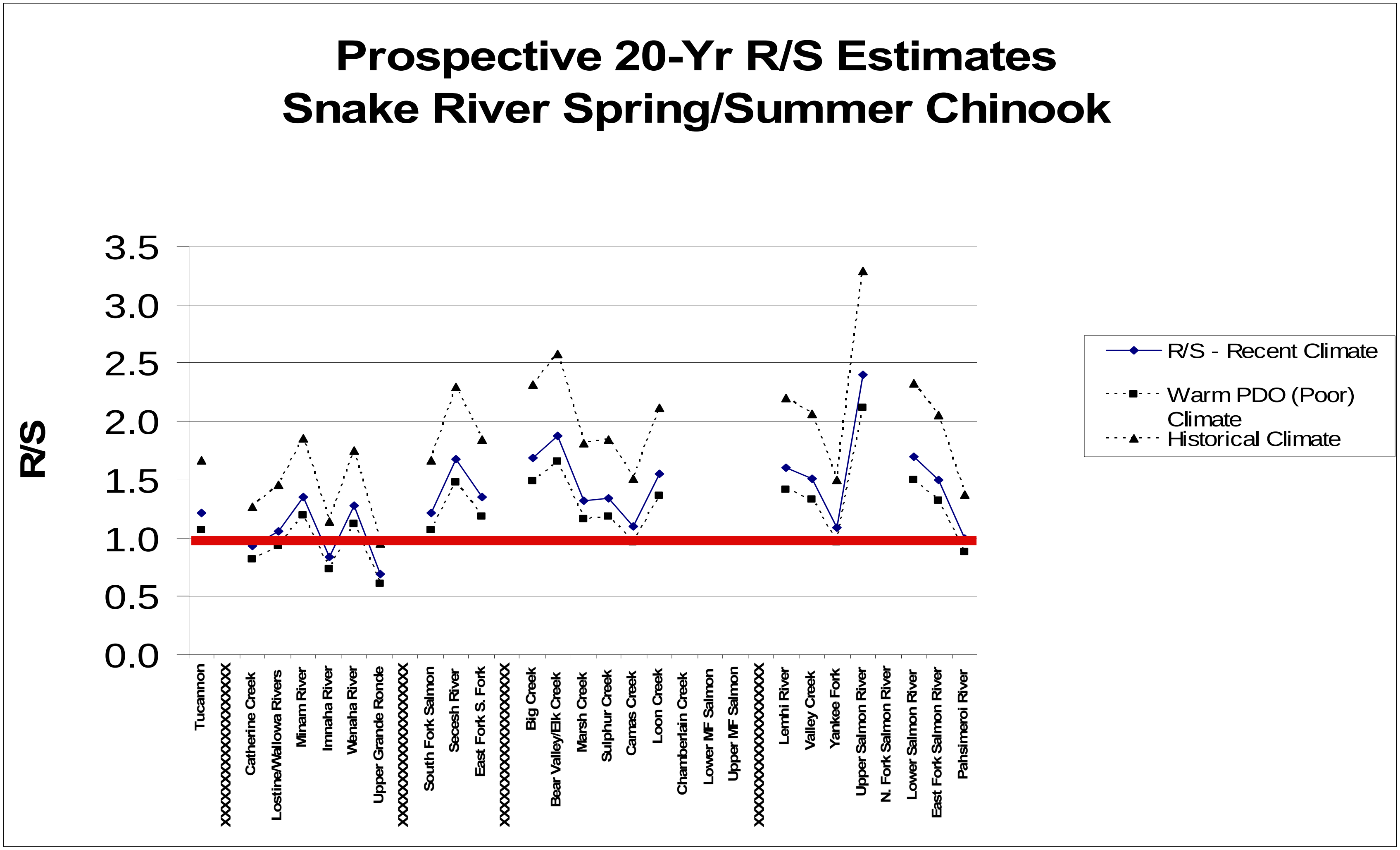


Figure 8.3.6-3. Summary of prospective 5% 24-year extinction risk gap estimates for SR spring/summer Chinook salmon under the "recent" climate assumption, showing effects of three alternative quasi-extinction thresholds (QET).

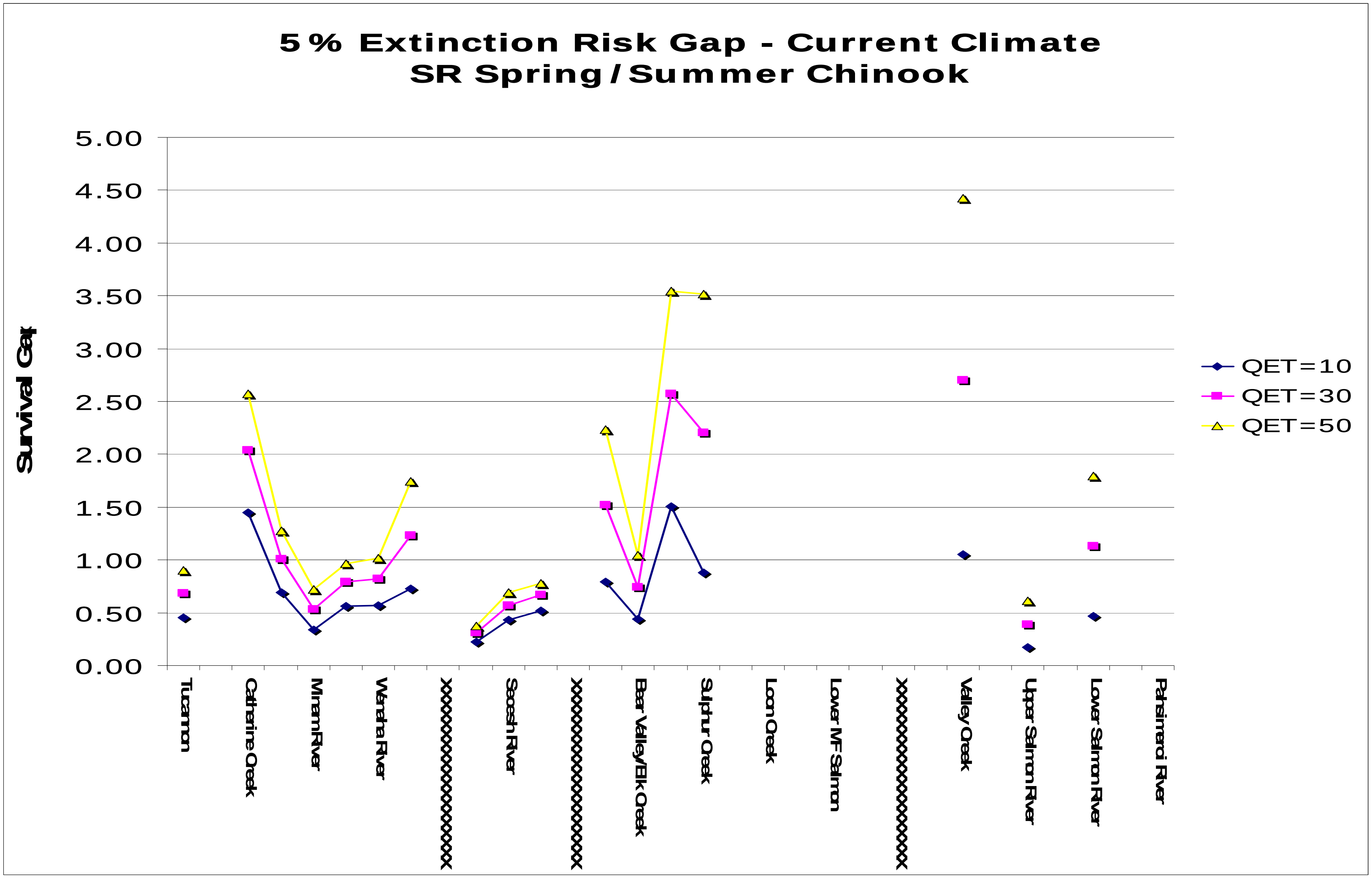
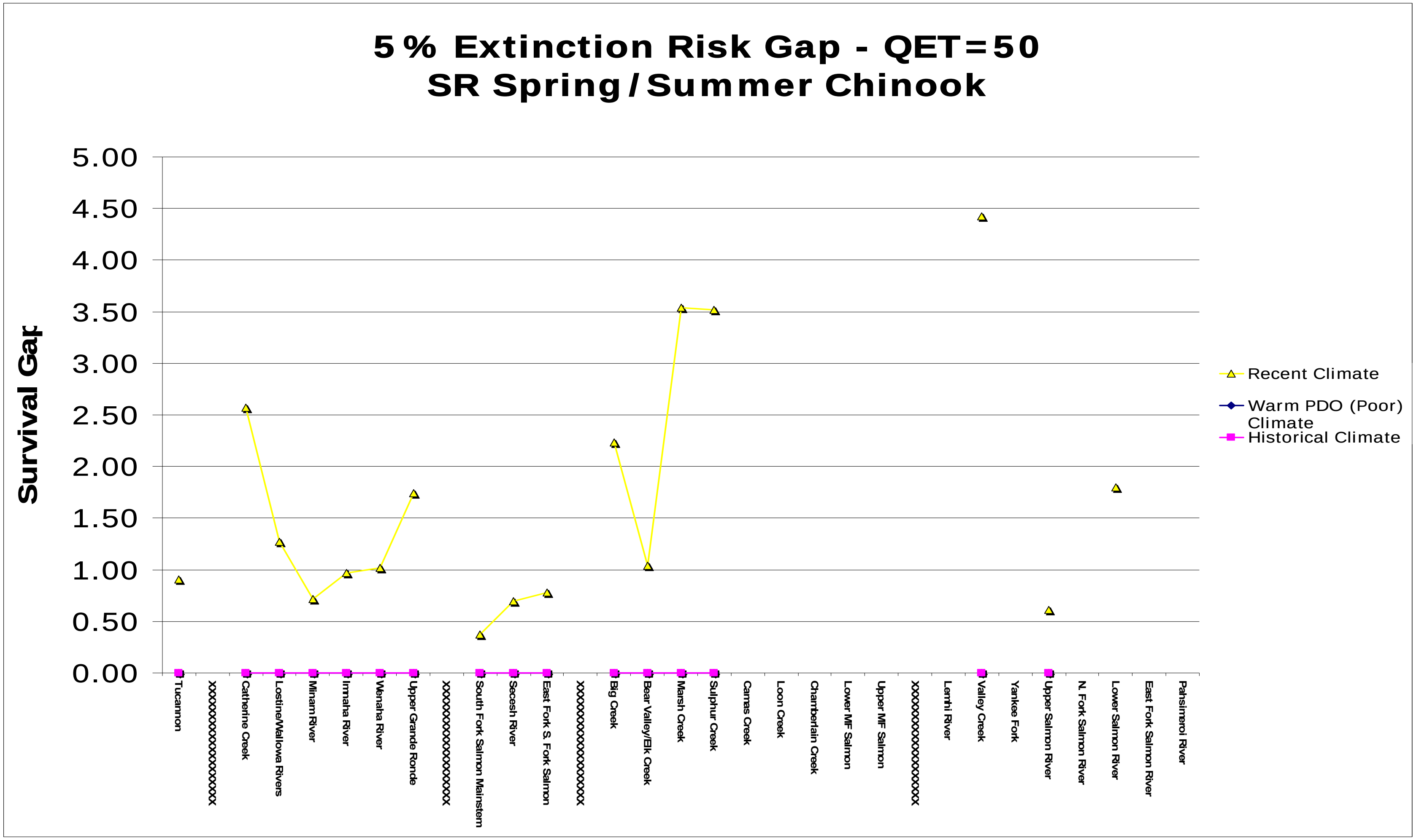
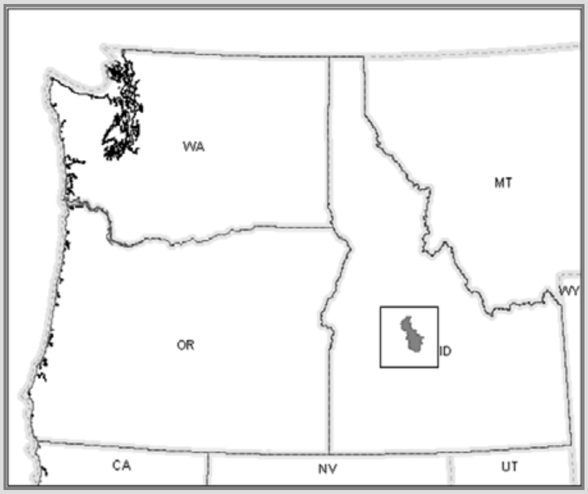
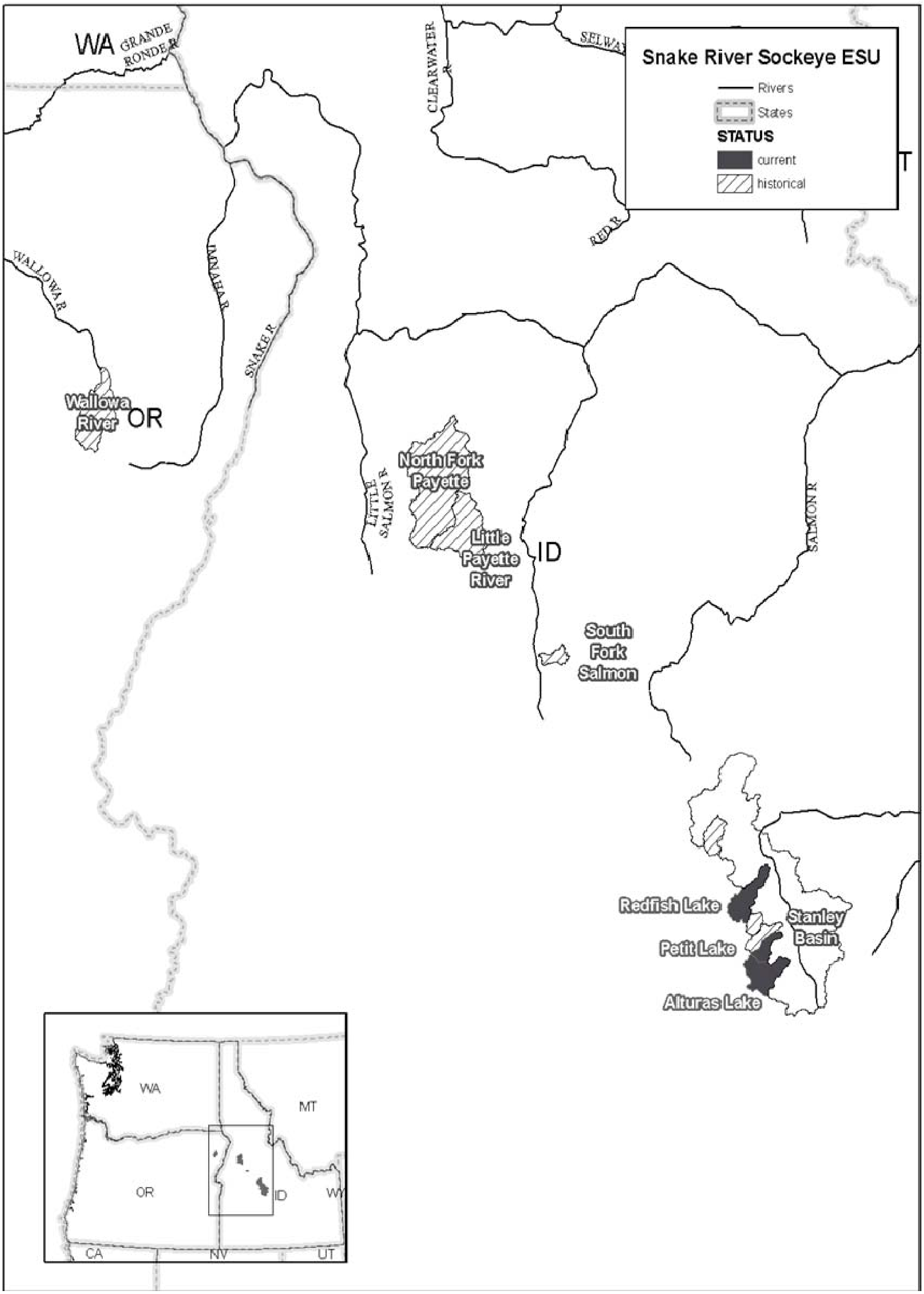


Figure 8.3.6-4. Summary of prospective 5% 24-year extinction risk gap estimates for SR spring/summer Chinook salmon under three climate assumptions.



Section 8.4
Snake River Sockeye Salmon




Snake River Sockeye ESU
Rivers
States
STATUS
current
historical
WA
OR
ID
GRANDE RONDE R
CLEARWATER R
SELWAY
RED R
WALLOWA R
IMNAHA R
SNAKE R
LITTLE SALMON R
SALMON R
Wallowa River
North Fork Payette
Little Payette River
South Fork Salmon
Redfish Lake
Petit Lake
Alturas Lake
Stanley Basin
WA
MT
OR
ID
CA
NV
UT

Section 8.4
Snake River Sockeye Salmon

Species Overview

Background

The Snake River (SR) sockeye salmon ESU includes all anadromous and residual sockeye from the Snake River basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program. Sockeye salmon were historically numerous in many areas of the Snake River basin prior to the European westward expansion. However, intense commercial harvest of sockeye along with other salmon species beginning in the mid-1880s; the existence of Sunbeam Dam as a migration barrier between 1910 and the early 1930s; the eradication of sockeye from Sawtooth Valley lakes in the 1950s and 1960s; the 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 probably combined to reduce the stock to a very small remnant population. Snake River sockeye salmon are now found predominantly in a captive broodstock program associated with Redfish and the other Sawtooth Valley lakes. At the time of listing, one, one, and zero fish had returned to Redfish Lake in the three preceding years, respectively. The Snake River sockeye ESU was listed as endangered in 1991, reaffirmed in 2005.

The designated critical habitat for SR sockeye salmon includes all Columbia River estuarine areas and river reaches upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks); Alturas Lake Creek; and that portion of Valley Creek between Stanley and Lake Creek and the Salmon River.

Current Status & Recent Trends

This species has a very high risk of extinction. 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. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several hundred thousand eggs and juveniles, as well as several hundred adults, for release into the wild. Between 1999 and 2007, more that 355 adults returned from the ocean from captive broodstock releases—almost 20 times the number of wild fish that returned in the 1990s. The program has been successful in its goals of preserving important lineages of Redfish Lake sockeye salmon for genetic variability and in preventing extinction in the near-term. The Stanley Basin Sockeye Technical

Oversight Committee has determined that the next step toward meeting the goal of amplifying the wild population is to increase the number of smolts released.

Limiting Factors and Threats

By the time Snake River Sockeye were listed in 1991, the species had declined to the point that there was no longer a self-sustaining, naturally-spawning anadromous sockeye population. This has been the largest factor limiting the recovery of this ESU, important in terms of both risks due to catastrophic loss and potentially to genetic diversity. It is not yet clear whether the existing population retains sufficient genetic diversity to successfully adapt to the range of variable conditions that occur within its natural habitat. However, unpublished data from geneticists for the Stanley Basin Sockeye Technical Oversight Committee indicate that the captive broodstock has similar levels of haplotype diversity as other sockeye populations in the Pacific Northwest and that the program has been able to maintain rare alleles in the population over time. The broodstock program reduces the risk of domestication by using a spread-the-risk strategy, outplanting prespawning adults and fertilized eyed eggs as well as juveniles raised in the hatchery. The progeny of adults that spawn in the lakes and juveniles that hatch successfully from the eyed eggs are likely to have adapted to the lake environment rather than become “domesticated” to hatchery rearing conditions.

Recent Ocean and Mainstem Harvest

Few sockeye are caught in ocean fisheries. Ocean fishing mortality on Snake River Sockeye is assumed to be zero. Fisheries in the mainstem Columbia River that affect SR sockeye were managed subject to the terms of the *U.S. v. Oregon* Interim Management Agreement for 2005-2007. These fisheries were limited to ensure that the incidental take of ESA-listed SR sockeye does not exceed specified rates. Non-Treaty fisheries in the lower Columbia River were limited to a harvest rate of 1%. Treaty Indian fisheries are limited to a harvest rate of 5 to 7% depending on the run size of upriver sockeye stocks. Harvest rates have ranged from 0 to 0.95%, and 2.8 to 6.1% since 2001, respectively.

8.4.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.4.2.1 Current Rangewide Status of the Species

The Snake River (SR) sockeye salmon ESU includes all anadromous and residual sockeye from the Snake River basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (Table 8.4.2.1-1). Sockeye salmon were historically numerous in many areas of the Snake River basin prior to the European westward expansion. However, intense commercial harvest of sockeye along with other salmon species beginning in the mid-1880s; the existence of Sunbeam Dam as a migration barrier between 1910 and the early 1930s; the eradication of sockeye from Sawtooth Valley lakes in the 1950s and 1960s; the 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 probably combined to reduce the stock to a very small remnant population. Snake River sockeye salmon are now found predominantly in a captive broodstock program associated with Redfish and the other Sawtooth Valley lakes (NMFS 1991a). At the time of listing, one, one, and zero fish had returned to Redfish Lake in the three preceding years, respectively.

Waples et al. (1997) examined the genetics of *0. nerka* from Sawtooth Valley lakes to determine whether the remnant population represented a distinct species or had been diluted by nonnative stocking during the 20th century. Sockeye salmon that returned to Redfish Lake during 1991 to 1993 were genetically distinct from Fishhook Creek kokanee, but were similar to juvenile sockeye outmigrants and a small group of "residual" sockeye salmon discovered in the lake in 1992.[1] This result supports the hypothesis that the original sockeye salmon population had not been extirpated. Populations of *0. nerka* that appear to be native have also been found in Alturas and Stanley lakes. Collectively, the native *0. nerka* from the Stanley Basin form a coherent group that is well separated genetically from all other populations of *0. nerka* in the Pacific Northwest. Therefore, although recent returns had been minimal, NOAA Fisheries' Biological Review Team recommended that the species be listed as Endangered under the ESA "to make a conservative decision in this circumstance" (Waples et al. 1991) and because the ESU might be restored using experimental hatchery programs.

Historically, adult SR 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 fed on plankton for one to three years before migrating to the ocean. Juvenile sockeye generally left the Sawtooth

[1] Residual sockeye salmon are progeny of anadromous or residual fish that remain in freshwater to mature and reproduce. The produce some anadromous offspring (Kline 1994). Residuals are genetically very similar to the anadromous for (Waples et al. 1997) and are ESA-listed along with the anadromous portion of the ESU.

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 migrated through the lower Snake River in May and June, PIT-tagged smolts from Redfish Lake recently passed Lower Granite Dam during mid-May to mid-July. Snake River sockeye spend two to three years in the ocean before returning to their natal lake to spawn.

Table 8.4.2.1-1. Snake River sockeye ESU description. (Sources: NMFS 2005a ; ICTRT 2003; McClure et al. 2005; and Flagg 2007)

ESU Description	
Endangered	Listed under ESA in 1991, reaffirmed in 2005
	Population
	Anadromous sockeye salmon in the Snake River basin and residual sockeye in Redfish Lake [2]
Hatchery programs included in ESU	Captive Broodstock Program – at this time is divided between facilities at Sawtooth and Eagle ID, Burley Creek and Manchester WA, and Oxbow OR

Limiting Factors

By the time Snake River Sockeye were listed in 1991, the species had declined to the point that there was no longer a self-sustaining, naturally-spawning sockeye population. The absence of a functional natural population is the largest factor limiting the recovery of this ESU, important in terms of both risks due to catastrophic loss and potentially to genetic diversity. The population size issue will be directly addressed by the proposed action, which will result in roughly a 10-fold increase in the smolt releases from the current captive broodstock hatchery program. The captive broodstock program has succeeded in maintaining generations of sockeye that are derived from the remnants of the Redfish Lake population. It is now capable of expanding the number of fish produced in subsequent generations and the proposed action will result in the release of up to 1 million smolts per year, a level sufficient to seed Redfish Lake with natural spawners. However, even if the number of natural spawners is much larger, genetic diversity could remain as a significant limiting factor. Before intervention, Snake River Sockeye reached such low numbers that there has been concern that genetic bottlenecks have resulted. It is not yet clear whether the existing population retains sufficient genetic diversity to successfully adapt to the range of variable conditions that occur within its natural habitat. However, unpublished data from geneticists for the Stanley Basin Sockeye Technical Oversight Committee indicate that the captive broodstock has similar levels of haplotype diversity as other sockeye populations in the Pacific Northwest and that the program has been able to maintain rare alleles in the population over time (Flagg 2008). The broodstock program reduces the risk of domestication by using a spread-the-risk strategy, outplanting prespawning adults and fertilized eyed eggs as well as juveniles raised in the hatchery. The progeny of adults that spawn in the lakes and

[2] Progeny of Redfish Lake sockeye have been outplanted to Pettit and Alturas lakes. These fish and their descendants, including residual sockeye salmon in Pettit Lake, are also considered part of the ESU.

juveniles that hatch successfully from the eyed eggs are likely to have adapted to the lake environment rather than become "domesticated" to hatchery rearing conditions.

Mainstem Hydro

Compared to Snake River spring/summer Chinook salmon, there is relatively little route-specific information on the survival of SR sockeye salmon through the FCRPS. Reach survival estimates are imprecise because sample sizes of migrants from the Snake River are small. Williams et al. (2005) used detections of all PIT-tagged sockeye smolts (2000-2003) to the tailrace at Lower Granite Dam for annual estimates of survival between Lower Granite and McNary dams. In 2003, the estimated survival of sockeye smolts was 72.5%, similar to that of yearling Chinook salmon, but in 2000 through 2002, sockeye survival was considerably lower (23.9% to 56.0%). The reason is unclear, but sockeye salmon juveniles appear to be prone to descaling. Williams et al. 2005 reported that between 1990 and 2001, two adults returned from 478 juveniles transported and only one adult returned from 3,925 PIT-tagged fish that migrated in-river (SARs of 0.4% vs. 0.03%, respectively). As with Chinook salmon, most untagged sockeye salmon smolts were transported to below Bonneville Dam. Nonetheless, few adult sockeye salmon returned to Lower Granite Dam in the last decade. The Prospective Action of using the hatchery to increase smolt releases will also increase sample sizes and allow better estimates of juvenile survival through the FCRPS.

Habitat

Chapman and Witty (1993) reviewed the human influences that have resulted in the low numbers of sockeye salmon. Irrigation dams extirpated the anadromous sockeye runs to Wallowa and Payette lakes. Although the residual form of sockeye remains, irrigation withdrawals from Alturas Lake Creek severely reduced the anadromous sockeye salmon population in the watershed in the early 1900s. Sunbeam Dam blocked fish passage on the upper mainstem Salmon River beginning in 1910. Though a fish ladder was built at the dam in 1919, passage remained unlikely until the early 1930s. The IDFG eliminated sockeye from Pettit, Yellow Belly, and Stanley lakes during 1955 to 1965 to manage recreational fisheries for trout. At the time of the initial listing (NMFS 1991a), the greatest habitat problem faced by the ESU was probably the lack of access to any of the lakes but Redfish. The fish barriers on Alturas and Pettit Lake creeks (an irrigation intake and a concrete rough fish barrier, respectively) were modified to facilitate passage of anadromous sockeye into these historical habitats in the early 1990s (Teuscher and Taki 1996, cited in Flagg et al. 2004).

Although access to the spawning and rearing lakes is now considered functional, large portions of the migration corridor in the Salmon River (i.e., between Redfish Lake Creek and Yankee Fork Creek and between Thompson Creek and Squaw Creek) are water quality limited for temperature (IDEQ 2005), which is likely to reduce the survival of adult sockeye returning to the Stanley Basin in late July and August.

The USFS (USDA 2003) recommended the following site-specific measures to improve habitat conditions:

- Reduce lakeshore recreation pressure, particularly in shallow areas where sockeye spawn currently or historically

- Restore or maintain native vegetation that provides naturally resilient and productive shoreline habitats, through management of lakeside recreation and other human development

- Correct causes of listing Salmon River as water-quality limited (sediment and temperature) between the confluence of Redfish Lake Creek and that of Squaw Creek with the upper Salmon River.

The natural hydrological regime in the upper mainstem Salmon has been altered by water withdrawals. The Northwest Power and Conservation Council (NPCC 2004) made the following recommendation in its Salmon Subbasin Management Plan:

- Mimic the shape and timing of the natural hydrograph in the mainstem Salmon River between the East Fork confluence and the headwaters

The NPCC emphasized that the sustainability of base flows will require, in addition to improved water delivery, adequate water storage functions such as wetlands, functional riparian areas, side channels, groundwater recharge, etc. Otherwise, attempts to restore a normative hydrograph will result in more water leaving the system during peak flows and less water available during periods that are critical to sockeye salmon.

Harvest

Few sockeye are caught in ocean fisheries. Ocean fishing mortality on SR sockeye is assumed to be zero. Fisheries in the mainstem Columbia River that affect SR sockeye are currently managed subject to the terms of the *U.S. v. Oregon* Interim Management Agreement for 2005-2007. These fisheries are limited to ensure that the incidental take of ESA-listed SR sockeye does not exceed specified rates. Non-Indian fisheries in the lower Columbia River are limited to a harvest rate of 2%. Treaty Indian fisheries are limited to a harvest rate of 5 to 7%, depending on the run size of upriver sockeye stocks. Actual harvest rates have ranged from 0 to 1.8%, and 2.8 to 7.0%, respectively.

Current Status of the ESU

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. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several hundred thousand eggs and juveniles, as well as several hundred adults, for release into the wild. 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).[3] The program has been successful in its goals of preserving important lineages of Redfish Lake sockeye salmon for genetic variability and in preventing extinction in the near-term. The Stanley Basin Sockeye Technical

[3] Some of these returning adults may have been anadromous progeny of residual sockeye.

Oversight Committee has determined that the next step toward meeting the goal of re-establishing and amplifying the wild population is to increase the number of smolts released.

8.4.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for SR sockeye salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks); Alturas Lake Creek; and that portion of Valley Creek between Stanley Lake Creek and the Salmon River (NMFS 1993). The lower Columbia River corridor is among the areas of high conservation value to the ESU 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. 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 1993). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005b). The status of critical habitat is discussed further in Section 8.4.3.

8.4.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.4.3.1 Recent Hydro Operations and Configuration Improvements

Changes in hydrosystem operations and configuration that have been implemented since 1998 have improved in-river conditions for SR sockeye based on rates of descaling and mortality [see Figures B-4 and B-5 in Martinson et al. 2007]. Changes have included the installation of surface bypass structures, minimum gap turbine runners, and spill deflectors; the relocation of bypass outfalls to avoid areas where predators collect; as well as other operational and structural changes (Appendix A in Corps et al. 2007b). Changes were designed to deflect fish from turbines and attract them to safer passage routes, increase the survival of juveniles that do use the turbine passage route, and reduce dissolved gas concentrations that might otherwise limit spill operations.

Despite these improvements, rates of descaling and mortality are still higher for sockeye than for other species (Martinson et al. 2007). The reasons for this difference are unknown. There are few empirical data on the route-specific survival and behavior of juvenile sockeye salmon under the recent operations and configuration of the FCRPS and Upper Snake Project. Studies with unlisted Upper Columbia River sockeye in the mid-Columbia reach have shown that juvenile sockeye migrate through the system faster than yearling or subyearling Chinook (Steig et al. 2006a, b, and 2007; Timko et al. 2007). In these studies, surface passage routes were similarly or slightly more effective for sockeye salmon than for yearling Chinook. However, data comparing two different surface passage configurations at Rocky Reach Dam indicated that sockeye were highly sensitive to the design and/or location of the surface passage entrance (Steig et al. 2003, 2006a). Because the design and configuration of entrances at the FERC-licensed dams in the mid-Columbia River differ from those at FCRPS projects, specific research is needed to develop strategies for safe passage through the latter.[4]

Based on data for other species of SR salmon and steelhead, recent modifications to FCRPS adult passage facilities, including increased reliability of water supply systems for fish ladders and improved ladder exit conditions to prevent injury and delay (Appendix A in Corps et al. 2007b), probably reduced mortality for this species. NOAA Fisheries estimates that the current survival rate of adult sockeye from Bonneville to Lower Granite dams is 81.1% (about 97.1% per project) based on an expansion of data for adult sockeye bound for Lake Wenatchee and the Okanogan River (SCA Adult Survival Estimates Appendix).

In addition to losses in the lower Columbia and Snake hydrosystem, both juvenile and adult sockeye are lost in the 462-mile migration corridor between Redfish Lake and Lower Granite Dam. Water withdrawals in the Upper Salmon River during juvenile migration are statistically related to decreased juvenile sockeye salmon survival through the reach (approximately a 20% reduction) (Arthaud et al. 2004). Of 614 adults that passed Lower Granite between 1999 and 2007, only 352 (57%) were recovered at Redfish Lake or the Sawtooth Hatchery weir (Kozakiewicz 2007). The factors responsible for these losses have not been established. However, the relatively large run size in 2000 provided an opportunity for a telemetry project to examine the migration behavior and survival of adult Snake River sockeye. Keefer et al. (2007) found that survival decreased as the season progressed and after July 13, none of the sockeye radio-tagged at Lower Granite Dam survived to the spawning grounds. The shift from relatively high survival of migrants that reached Lower Granite before mid-July to 100% loss coincided with the date that the Snake River at Anatone, Washington first reached 21 degrees C, indicating that elevated temperatures played an important role.

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[4] In 2007, the Chelan PUD released acoustic-tagged juvenile sockeye for evaluating the performance of its own systems. Because the ongoing passage study at McNary Dam uses the same technology, researchers obtained three-dimensional passage information (approach and passage behavior as well as fish passage and survival rates) for the fish marked by Chelan PUD. The USGS is currently working on these data and expects to publish preliminary findings by mid-summer (2008).

8.4.3.2 Recent Tributary Habitat Improvements

The Shoshone Bannock Tribes have been supplementing nitrogen and phosphorus and controlling non-native kokanee salmon competitors (i.e., for food resources) in the four Sawtooth Valley lakes (Redfish, Pettit, Alturas, and Stanley) since 1995. Based on water quality and biological sampling described in their annual reports (e.g., Kohler et al. 2007), these management strategies are increasing the carrying capacities of the lakes for rearing juvenile Snake River sockeye salmon. In part because Redfish and the other Sawtooth Valley lakes are naturally oligotrophic systems, nutrient supplementation has stimulated primary productivity and the development of a zooplankton community dominated by *Daphnia* spp. (Selbie et al. 2007). Juvenile *O. nerka* (anadromous and residualized sockeye) fed selectively on the large copepod *Daphnia* in Sawtooth Valley lakes during 2004 and 2006 (i.e., *Daphnia* made up a larger proportion of the diet than would be expected based on its availability in the water column), although the same pattern was not observed in 2005 (Kohler et al. 2005 and 2007, Taki et al. 2006). Also, limiting the number of female kokanee allowed to spawn in Redfish Lake has reduced grazing pressure on shared food resources.

8.4.3.3 Recent Estuary Habitat Improvements

For salmon that use a stream-type life-history strategy, restoration projects in the tidally influenced zone of the estuary between Bonneville Dam and approximately RM 40 are most likely to improve the functioning of the juvenile migration corridor. Projects that protect or restore riparian areas and breach or lower dikes and levees are likely to improve safe passage for this type of juvenile migrant. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

8.4.3.4 Recent Predator Management Improvements

Avian Predation

There are few quantitative data on rates of avian predation on SR sockeye salmon. Ryan et al. (2007) reported the numbers of PIT-tags from in-river juvenile migrants detected at Bonneville Dam and subsequently detected on estuarine bird colonies during 2006. Although the number of sockeye detected was very small compared to steelhead or Chinook, the study indicated that avian predators were consuming some Columbia basin (i.e., potentially Snake River) sockeye salmon. If so, then the Action Agencies' removal of the Caspian tern colony from Rice to East Sand Island in 1999 probably reduced predation rates on listed sockeye salmon to some small degree. PIT-tags from a few juvenile sockeye were also found on cormorant colonies in the estuary (Collis et al. 2001); this potential source of mortality has not been addressed.

Recently, Antolos et al. (2005) quantified predation on juvenile salmonids by Caspian terns nesting on Crescent Island (RM 316) in the mid-Columbia reach. Between 1,000 and 1,300 adult terns were associated with the colony during 2000 and 2001, respectively. These birds consumed approximately 465,000 juvenile salmonids in the first and approximately 679,000 in the second year. Based on PIT-tag recoveries at the colony, these were primarily steelhead from Upper Columbia River stocks. Less than 0.1% of the inriver migrating yearling Chinook from the Snake River and less than 1% of the yearling Chinook from the Upper Columbia were consumed. Presumably, a very small number of sockeye salmon, if any, were included in the “other salmonids” (i.e., not steelhead) category in the samples.

Piscivorous Fish Predation

Although predation of juvenile sockeye undoubtedly occurs, there is little direct evidence that piscivorous fish in the Columbia River consume juvenile sockeye salmon. Presumably, Zimmerman (1999) did not differentiate sockeye from “unidentified species” in the guts of pikeminnows, smallmouth bass, or walleye in the lower Snake and lower Columbia rivers because none or very few were identified. In contrast, Chinook were 29% of the prey of northern pikeminnows in lower Columbia reservoirs, 49% in the lower Snake River, and 64% downstream of Bonneville Dam. However, these observations are likely explained, in large part, by the fact that sockeye smolts make up a very small fraction of the overall number of migrating smolts (Ferguson 2006) in any given year.

8.4.3.5 Recent Hatchery Survival Improvements

The planting of fertilized eyed eggs and the release of prespawn adults for natural spawning has benefited the population through the production of unmarked smolts. Between 1991 and 1997, the number of unmarked smolts emigrating from Redfish Lake declined from levels in excess of 4,000 to only 300 individuals (IDFG 2006). No unmarked smolts were observed to emigrate from Pettit Lake until 1999, but since then, estimate that 23,000 unmarked smolts have done so. Approximately 26,000 unmarked smolts have emigrated from Redfish Lake since 1998. The IDFG estimates that in migration year 2005 alone, approximately 7,870 unmarked smolts out-migrated from Redfish Lake and 7,435 from Pettit Lake. The project sponsors are conducting genetic evaluations to confirm the origins of these fish, but hypothesize that most were derived from the prespawn adults released into Redfish Lake and the eyed-eggs planted in Pettit Lake.

8.4.3.6 Recent Harvest Rates

Non-Indian fisheries in the lower Columbia River are limited to a harvest rate of 1%. Treaty Indian fisheries are limited to a harvest rate of 5 to 7% depending on the run size of upriver sockeye stocks. Actual harvest rates over the last ten years have ranged from 0 to 0.9%, and 2.8 to 6.1%, respectively (TAC 2008, Table 15).

8.4.3.7 Status of Critical Habitat under the Environmental Baseline

A variety of human-caused and natural factors have contributed to the decline of SR sockeye salmon over the past century and have decreased the conservation value of essential features and PCEs of the species’ designated critical habitat. Factors affecting the conservation value of critical habitat include passage barriers (especially high summer temperatures) in the mainstem lower Snake and Salmon rivers, passage mortality at the mainstem FCRPS dams, and high sediment loads in the upper reaches of the mainstem Salmon River. Factors affecting PCEs for spawning and rearing, juvenile and adult migration corridors are described below.

Spawning & Rearing Areas

Most of the historical spawning and rearing areas in Redfish, Pettit, and Alturas lakes lie within nearly pristine areas where habitat conditions are considered functional.

Juvenile & Adult Migration Corridors

Juvenile sockeye migrate from the Sawtooth Valley lakes during late April through May. PIT-tagged smolts from Redfish Lake recently passed Lower Granite Dam during mid-May to mid-July. Adult SR sockeye salmon entered the Columbia River in June and July and migrated upstream through the Snake and Salmon rivers, arriving at Redfish Lake in August and September. Key factors limiting the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Juvenile and adult passage mortality *[hydropower projects in the mainstem lower Snake and Columbia rivers]*

- Juvenile and adult mortality in the lower Snake River above Lower Granite Dam and in the mainstem Salmon River *[water withdrawals, temperature, and degraded riparian conditions]*

Areas for Growth & Development to Adulthood

Although SR sockeye probably spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 1993). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.4.3.8 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the ESU and its designated critical habitat.

The USFS completed consultation on two projects—the Valley Road Fire (emergency consultation) and Whitebark Pine treatment in the Redfish Lake Creek watershed. The Federal Highway Administration (FHWA)/Idaho Department of Transportation (IDT) consulted on repairs at Buckhorn Bridge (Salmon River Mile Post 184).

Projects in Lower Columbia River, Estuary, and Coastal Waters

Federal agencies also completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.14.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

The effects of the habitat restoration projects and tar remediation in the lower Columbia River on the viability of the species will be positive. Other projects, including Whitebark Pine treatment, bridge repairs, dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

The future federal projects that restore habitat in the lower river will have positive effects on water quality. The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

These actions, including those that are likely to have adverse short-term or even long-term adverse effects, were found to meet the ESA standards for avoiding jeopardy and for avoiding any adverse modification of critical habitat.

8.4.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon, Washington, and Idaho provided information on various ongoing and future or expected projects that NOAA Fisheries determined were reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin (see list of projects in Chapter 17 in Corps et al. 2007a). However, neither the State of Idaho nor NOAA Fisheries identified any habitat-related actions and programs by non-federal entities that were expected to benefit SR sockeye salmon.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.4.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in this section. However, the FCRPS and Upper Snake Prospective Actions will ensure that these adverse effects are reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Some habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix and in this section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

The effects of NOAA Fisheries' issuance of a Section 10 juvenile transportation permit on this species are included in the effects of the FCRPS, which is described in Section 8.4.5.1. See Chapter 10 of the FCRPS Biological Opinion for a discussion of this permit.

8.4.5.1 Effects of Hydro Operations & Configuration Prospective Actions

The Prospective Actions include a requirement that the Action Agencies assess the feasibility of using increased PIT-tagging for better estimates of juvenile smolt survival from Redfish Lake to Lower Granite Dam and through the mainstem FCRPS projects (RPA Action 52). This information is needed to optimize in-river passage and transport facilities for juvenile sockeye as well as for Chinook and steelhead. It will also help determine the specific actions that must be taken to address limiting factors in the mainstem Salmon River portion of the juvenile migration corridor.

Until better data are developed, NOAA Fisheries uses information developed for juvenile SR spring/summer Chinook as a surrogate for estimating the effects of the Prospective Actions in the mainstem migration corridor. Based on this information, the survival of juvenile sockeye is likely to increase with the implementation of surface passage routes at Little Goose, Lower Monumental, McNary and John Day dams in concert with training spill (amount and pattern) to provide safe egress (i.e., reduce delay and vulnerability to predators). Installing a long guide wall in The Dalles spillway tailrace will also improve egress conditions. Surface passage routes are designed to reduce juvenile travel time through the forebay of each project where predation rates are often the highest (Section 8.1.1.1). Additional benefits could pertain if faster migrating juveniles are in better condition (e.g., less stressed, greater energy reserves) upon reaching the Bonneville tailrace. Shifting the delivery of a portion of the USBR's flow augmentation water from summer to spring will slightly reduce travel time, susceptibility to predators, and stress.

Hydro Prospective Actions are likely to improve the survival of adult SR sockeye salmon between Bonneville and Lower Granite dams. These include improvements to the collection channel at The Dalles and to the ladders at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite dams and other improvements in section 5.3.3.1 in Corps et al. (2007a). Because temperatures in the Salmon River during late July and August are probably contributing to the loss of adult sockeye between Lower Granite Dam and the Stanley Basin (Section 8.4.3.1), the Prospective Actions also require that the Action Agencies work with appropriate parties to investigate feasibility and potentially develop a plan for ground transport of adult sockeye through this reach. If feasible, transport would provide a short-term solution while specific habitat problems are identified and addressed.

Some of the configuration changes, discussed above, correspond to ISAB recommendations to proactively address the effects of climate change. As described in Section 8.1.3, the installation of surface passage routes and other configuration improvements that reduce delay and exposure to predators also reduce exposure to warm temperatures in project forebays. The regulation of outflow temperatures at Dworshak Dam will reduce summer water temperatures at Lower Granite, and to increasingly lesser extent, at Little Goose, Lower Monumental, and Ice Harbor dams.

Effects on Species Status

The survival of both juvenile and adult SR sockeye is expected to increase under the Prospective Actions due to improvements in the mainstem migration corridor, contributing to increased adult returns to the broodstock program and to the Sawtooth Valley lakes.

Effects on Critical Habitat

The hydro Prospective Actions are expected to increase the functioning of safe passage in the juvenile and adult migration corridors. To the extent that these improvements increase the number of adults returning to spawning areas, the hydro Prospective Actions could improve water quality and forage for juveniles by increasing the return of marine derived nutrients to spawning and rearing areas (Section 8.4.3.2)

8.4.5.2 Effects of Tributary Habitat Prospective Actions

The tributary habitat Prospective Actions do not include specific projects that will improve tributary habitat used by Snake River sockeye. However, the Action Agencies will undertake a study of possible sources and locations of mortality of juvenile sockeye before they reach the Snake River as described above (Section 8.4.5.1). As sockeye smolt production increases (Section 8.4.5.5), the Action Agencies will develop habitat projects to support natural production (Appendix B.2.2 in Corps et al. 2007b).

8.4.5.3 Effects of Estuary Prospective Actions

Juvenile sockeye rear in the natal lakes for one to three years before migrating to the ocean, a stream-type life history. Estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM40, restoring riparian function and access to the floodplain (see Section 5.3.3.3 in Corps et al. 2007a), are likely to improve the survival of juvenile Snake River sockeye.

Effects on Species Status

Restoration projects that are placed along the estuary corridor, with an emphasis on the upper portion of the estuary nearest to Bonneville Dam, are most likely to have a positive influence on life history diversity and spatial structure (Fresh et al 2005).

Effects on Critical Habitat

The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the conservation value of the estuary as critical habitat for this species (section 5.3.3.3 in Corps et al. 2007a). These include restoring riparian function and access to tidal floodplains. Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time.

8.4.5.4 Effects of Predation Prospective Actions

Avian Predation

The Prospective Actions include relocating most of the Caspian terns to sites outside the Columbia basin (RPA Action 54). While this will be beneficial, the available evidence does not indicate that significant numbers of sockeye smolts have fallen prey to Caspian terns. Continued implementation and improvement of avian deterrence at mainstem dams (RPA Action 48) is also likely to increase juvenile sockeye survival by a small amount.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous Fish Predation

There is little evidence that piscivorous fish in the Columbia basin prey on juvenile sockeye salmon (see discussion in Section 8.4.3.4). The best information currently available indicates that continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 43) is not likely to address a limiting factor for this species. Therefore, only a small increase in survival (safe passage in the juvenile migration corridor) is likely to result from decreased predation rates.

Effects on Species Status
The predation Prospective Actions are likely to have small positive effects on the survival of juvenile sockeye salmon.

Effects on Critical Habitat
Small positive effects on survival will correspond to a small improvement in the functioning of safe passage in the juvenile migration corridor.

8.4.5.5 Effects of Hatchery Prospective Actions

The Prospective Actions include two hatchery actions that are expected to benefit Snake River sockeye:

- Continue to fund the safety-net program to achieve the interim goal of annual releases of 150,000 smolts while also continuing to implement other release strategies in nursery lakes, such as fry and parr releases, eyed-egg incubation boxes, and adult releases for volitional spawning

- Fund further expansion of the sockeye program to increase total smolt releases to between 500,000 and 1 million fish

Expanding the number of smolts released is the program's next step toward meeting the goal of amplifying the wild population. The Action Agencies will also continue to fund the other release strategies used to date, because using multiple methods increases the likelihood of success.

Effects on Species Status
The continuing and the expanded smolt releases are expected to result in an increase in the abundance and productivity of the naturally-spawning population.

Effects on Critical Habitat
The smolt releases are not expected to affect PCEs in designated critical habitat.

8.4.5.6 Effects of Harvest Prospective Actions

Management provisions for sockeye in the 2008 *U.S. v. Oregon* agreement have not changed from those in the prior agreement. Non-Indian fisheries in the lower Columbia River will be limited to a harvest rate of 1% and Treaty Indian fisheries to 5 to 7%, depending on the run size of upriver sockeye stocks (Table 8.4.5.6-1)

Table 8.4.5.6-1. Sockeye Harvest Rate Schedule.

River Mouth Sockeye 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 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 and shall submit it to NMFS for consultation under Section 7 of the ESA.

Effects on Species Status

The Prospective harvest rates will continue to have a small negative effect on the numbers of Snake River sockeye returning to the captive broodstock program and to spawn naturally in the Sawtooth Valley lakes.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas.

8.4.5.7 Research, Monitoring & Evaluation Prospective Actions

Please see Section 8.1.4 of this document.

8.4.6 Aggregate Effect of the Environmental Baseline, Prospective Actions, and Cumulative Effects on Snake River Sockeye

This section summarizes the basis for conclusions at the ESU level.

8.4.6.1 Recent Status of the Snake River Sockeye ESU & Critical Habitat

The Snake River sockeye salmon ESU is comprised of a single MPG and single population spawning and rearing in Redfish, Pettit, and Alturas lakes in the Sawtooth Valley, and includes artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program. This population is the last remaining in a group of what were likely to have been independent populations occupying the Sawtooth Valley lakes. The Interior Columbia Basin TRT has designated this species at very high risk. The extremely low number of natural spawners and reliance on a captive Broodstock Program implemented in 1992 illustrates the high degree of risk faced by this population.

Recent annual abundances of natural-origin sockeye salmon to the Stanley Basin have been extremely low. Although residual sockeye salmon have been identified in Redfish and Pettit lakes, the abundance of the ESU is supported by adults produced through the captive propagation program. Recently, the smolt-to-adult survival of sockeye originating from the Sawtooth Valley lakes rarely has been greater than 0.3%. The current average productivity is substantially less than the productivity required for any population to be at Low (1-5%) long-term extinction risk at the minimum abundance threshold. Based on current abundance and productivity information, the Snake River sockeye salmon ESU does not meet the viability criteria for non-negligible risk of extinction over 100-year time period. Short-term extinction risk has been reduced by the captive propagation program; 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. The program has been successful in its goals of preserving important lineages of Redfish Lake sockeye salmon for genetic variability and in preventing extinction in the near-term.

Ocean fishing mortality on Snake River sockeye is assumed to be zero. Non-Indian fisheries in the lower Columbia River are limited to a harvest rate of 1%. Treaty Indian fisheries are limited to a harvest rate of 5 to 7% depending on the run size of upriver sockeye stocks. Actual harvest rates over the last ten years have ranged from 0 to 0.9%, and 2.8 to 6.1%, respectively.

A draft recovery plan containing strategies to address remaining key limiting factors is expected to be completed later in 2008. Given the extremely low levels of Snake River sockeye returns, initial recovery efforts are largely focused on improving survival rates of out-migrant smolts. The Stanley Basin Sockeye Technical Oversight Committee has determined that the next step toward meeting the goal of amplifying the wild population is to increase the number of smolts released.

The major factors limiting the conservation value of critical habitat for Snake River sockeye are the effects on the migration corridor posed by the mainstem lower Snake and Columbia River hydropower system, reduced tributary stream flows and high temperatures experienced by outmigrating smolts and returning adults, and barriers to tributary migration. The Sawtooth Valley lakes lie within nearly pristine areas. The production capacity of these naturally oligotrophic systems is low, but nutrient supplementation in recent years has stimulated primary productivity and the development of a favorable zooplankton forage community. Non-native kokanee salmon directly compete for zooplankton forage in most Sawtooth Valley lakes. Ocean conditions that have affected the status of this ESU generally have been poor since 1977, improving only in the last few years.

8.4.6.2 Effects of the Prospective Actions on Snake River Sockeye & Critical Habitat

Extinction of this ESU has been prevented and the prospects for survival and recovery now depend on expanding the existing safety-net program and increasing juvenile and adult survival. The Prospective Actions are expected to result in an approximately 10-fold increase in the number of sockeye produced by the captive broodstock program, greatly increasing the number of sockeye released to the wild, and thereby increasing the likelihood of higher adult returns. The Action Agencies will continue to fund the existing broodstock program including the continued releases of 150,000 fry and parr, outplanting of eyed-egg incubation boxes, and releases of adults for volitional spawning.

The Prospective Actions include configuration changes at FCRPS dams that are likely to improve the survival of juvenile and adult sockeye salmon, although more species-specific data are needed to ensure that conditions are optimized for this species as well as Chinook and steelhead. The Prospective Actions therefore require that the Action Agencies assess the feasibility of PIT-tag marking smolts for tracking survival of this species through the FCRPS. They will also work with appropriate parties to investigate feasibility and potentially develop a plan for ground transport of adult sockeye from Lower Granite Dam to Redfish Lake to circumvent the habitat problems that are causing losses until they can be addressed.

Management provisions for sockeye in the 2008 Agreement have not changed from those in the prior *U.S. v. Oregon* Agreement. Actual harvest rates over the last ten years have ranged from 0 to 0.9% for the non-Indian and 2.8 to 6.1% for the Treaty Indian fisheries, respectively (Section 8.4.3.6).

In aggregate, the prospective actions are expected to improve the survival of juveniles and adults through the mainstem Salmon and FCRPS migration corridors (safe passage) and together with the expanded smolt release program to increase the likelihood of higher adult returns.

8.4.6.3 Cumulative Effects Relevant to the Snake River Sockeye ESU

The State of Idaho did not identify any habitat-related actions and programs in the action area by non-Federal entities that are expected to address low flows and high temperature in the mainstem Salmon River. The cumulative effects of water withdrawals and land use practices that degrade riparian conditions are likely to continue the significant adverse effects of similar past activities that contributed to the environmental baseline for this ESU.

8.4.6.4 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Snake River Sockeye Salmon ESU

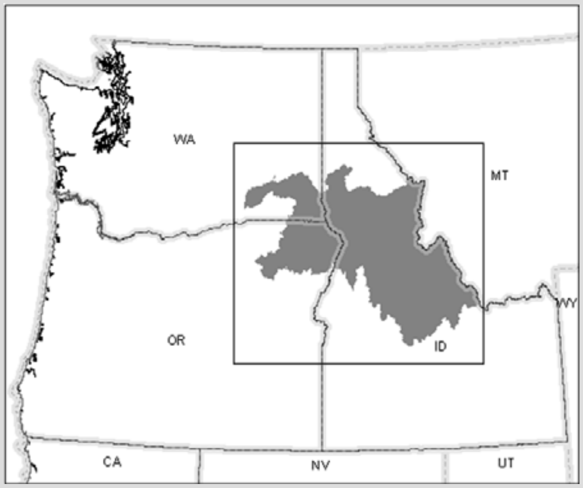
The aggregate effect of the environmental baseline, the Prospective Actions, and cumulative effects will be an improvement in the viability of SR sockeye salmon. Some limiting factors will be addressed by improvements to mainstem hydrosystem passage. The installation of surface passage routes and other configuration changes that will reduce delay and exposure to predators and warm temperatures in forebays, controlling summer water temperatures at Lower Granite by regulating outflow temperatures at Dworshak Dam, also correspond to ISAB recommendations to proactively address the effects of climate change (Section 8.1.3). However, based on an evaluation of future Federal actions that have completed Section 7 consultation and cumulative effects, conditions in the Salmon River portion of the juvenile and adult migration corridors are not expected to improve. If it is feasible to trap adults at Lower Granite Dam and haul them to the Sawtooth Valley, the adverse effects of low flows and high temperatures in the mainstem Salmon can be avoided, at least for this life stage. Management provisions for sockeye in the 2008 Agreement are unchanged from those in the prior *U.S. v. Oregon* Agreement and actual harvest rates are likely to be less than those allowed, as in previous years. Taking into account the obstacles faced, the Prospective Actions provide for the survival of the species with an adequate potential for recovery.

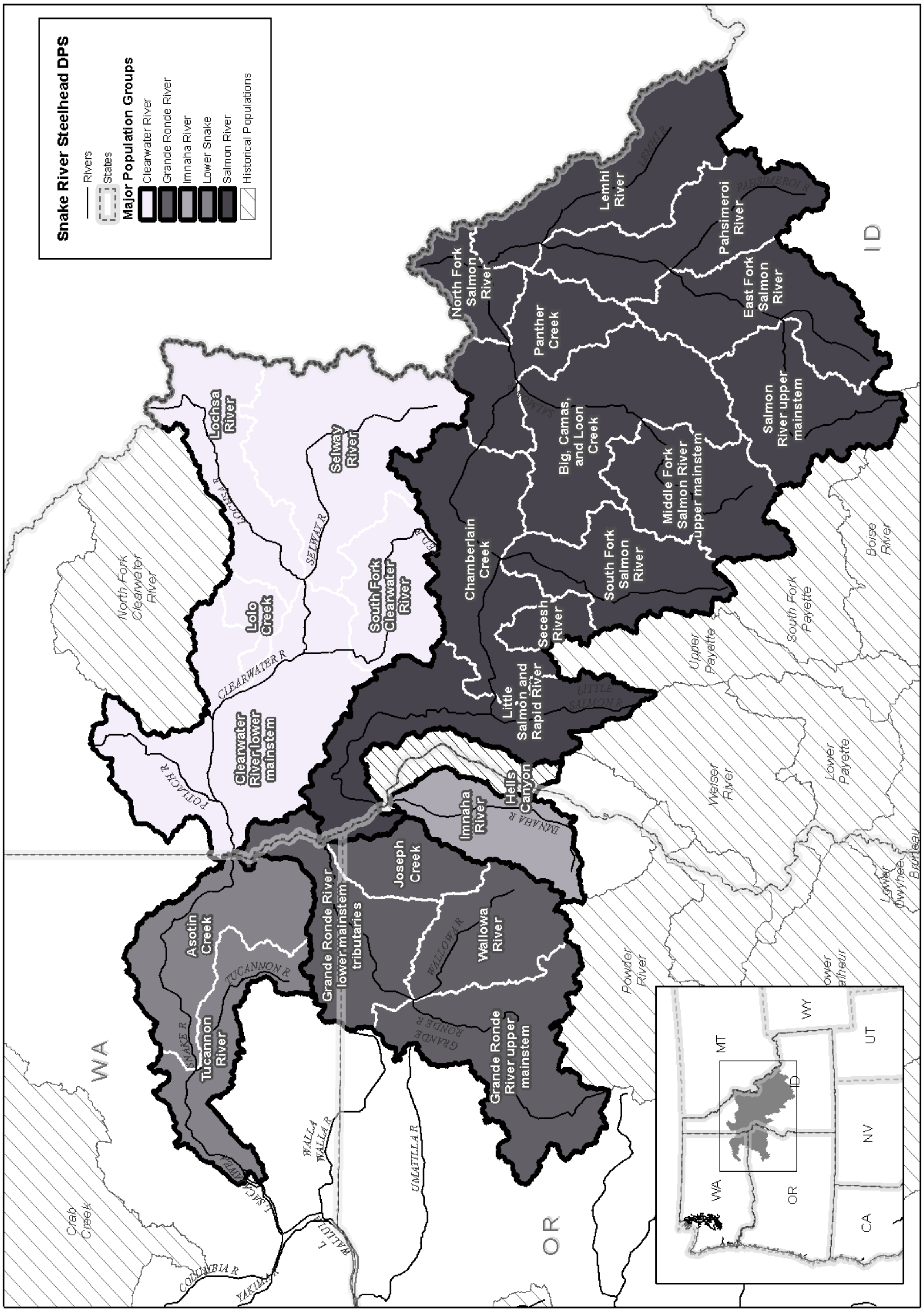
8.4.6.5 Effect of Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for SR sockeye salmon including all Columbia River estuarine areas and river reaches upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes; Alturas Lake Creek; and that portion of Valley Creek between Stanley Lake Creek and the Salmon River. The environmental baseline within the action area, which encompasses these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for SR sockeye salmon. The major factors currently limiting the conservation value of critical habitat are juvenile and adult mortality at mainstem hydro projects in the lower Snake and Columbia rivers and water withdrawals, temperature, and degraded riparian conditions in the lower Snake River above Lower Granite Dam, and in the mainstem Salmon River.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at Little Goose, Lower Monumental, McNary, and John Day dams, in concert with training spill to provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Habitat work in the mainstem Salmon River and in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Section 8.5
Snake River Steelhead




Snake River Steelhead DPS
Rivers
States
Major Population Groups
Clearwater River
Grande Ronde River
Imnaha River
Lower Snake
Salmon River
Historical Populations
Lemhi River
Pahsimeroi River
North Fork Salmon River
East Fork Salmon River
Panther Creek
Salmon River upper mainstem
Big, Camas, and Loon Creek
Middle Fork Salmon River upper mainstem
Lochsa River
Selway River
Chamberlain Creek
South Fork Salmon River
South Fork Clearwater River
Lolo Creek
North Fork Clearwater River
Secesh River
Little Salmon and Rapid River
Clearwater River lower mainstem
Hells Canyon
Imnaha River
Joseph Creek
Grande Ronde River lower mainstem tributaries
Wallowa River
Asotin Creek
Tucannon River
Grande Ronde River upper mainstem
Boise River
South Fork Payette
Upper Payette
Lower Payette
Weiser River
Powder River
Crab Creek
WA
OR
ID
MT
WY
UT
NV
CA

Section 8.5 Snake River Steelhead

Species Overview

Background

The Snake River (SR) steelhead DPS includes all anadromous populations that spawn and rear in the mainstem Snake River and its tributaries between Ice Harbor and the Hells Canyon hydro complex. There are five major population groups with 24 populations. Inland steelhead in the Columbia River Basin are commonly referred to as either A-run or B-run, based on migration timing and differences in age and size at return. A-run steelhead are believed to occur throughout the steelhead streams in the Snake River Basin, and B-run are thought to produce only in the Clearwater and Salmon rivers. This DPS was listed under the ESA as threatened in 1997, reaffirmed in 2006.

Designated critical habitat for SR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in a number of tributary subbasins.

Current Status & Recent Trends

The abundance of SR steelhead has been stable or increasing for most A-run and B-run populations during the last 20 brood cycles. On average, the natural-origin components of the A-run populations have replaced themselves whereas the natural-origin components of the B-run populations have not.

Limiting Factors and Threats

Limiting factors identify the most important biological requirements of the species. Historically, the key limiting factors for the Snake River steelhead include hydropower projects, predation, harvest, hatchery effects, and tributary habitat. Ocean conditions have also affected the status of this DPS. These generally have been poor over at least the last 20 years, improving only in the last few years.

Recent Ocean and Mainstem Harvest

Few steelhead are caught in ocean fisheries. Ocean fishing mortality on Snake River steelhead is assumed to be zero. Fisheries in the Columbia River were limited to ensure that the incidental take of ESA-listed Snake River steelhead does not exceed specified rates. Non-Indian fisheries were subject to a year-round 2% harvest rate limit on A-run and a 2% harvest rate limit for B-run steelhead. Treaty Indian fall season fisheries were subject to a 15% harvest rate limit on B-run steelhead. Incidental harvest rate limits on B-run steelhead, in particular, have reduced access to harvestable stocks in fall season fisheries. Recent harvest rates on Snake River steelhead have generally been lower than what is allowed. The recent harvest rates on A-run steelhead in non-Indian and treaty Indian fisheries range from 1.0% to 1.9%, and 4.1% to 12.4%, respectively. The recent harvest rates on B-run steelhead in non-Treaty and treaty Indian fisheries range from 1.1% to 2.0%, and 3.3% to 15.6%, respectively.

8.5.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point is the scientific analysis of the species' status, which forms the basis for the listing of the species as endangered or threatened.

8.5.2.1 Current Rangewide Status of the Species

SR steelhead is a threatened species composed of 24 extant anadromous populations in five major population groups (MPG). Steelhead are anadromous form of rainbow trout, which are not listed. All populations in this DPS return in the summer and are therefore referred to as "summer-run" in contrast to "winter-run" steelhead in some other DPSs. Key statistics associated with the current status of SR steelhead are summarized in Tables 8.5.2-1 through 8.5.2-4.

Limiting Factors and Threats

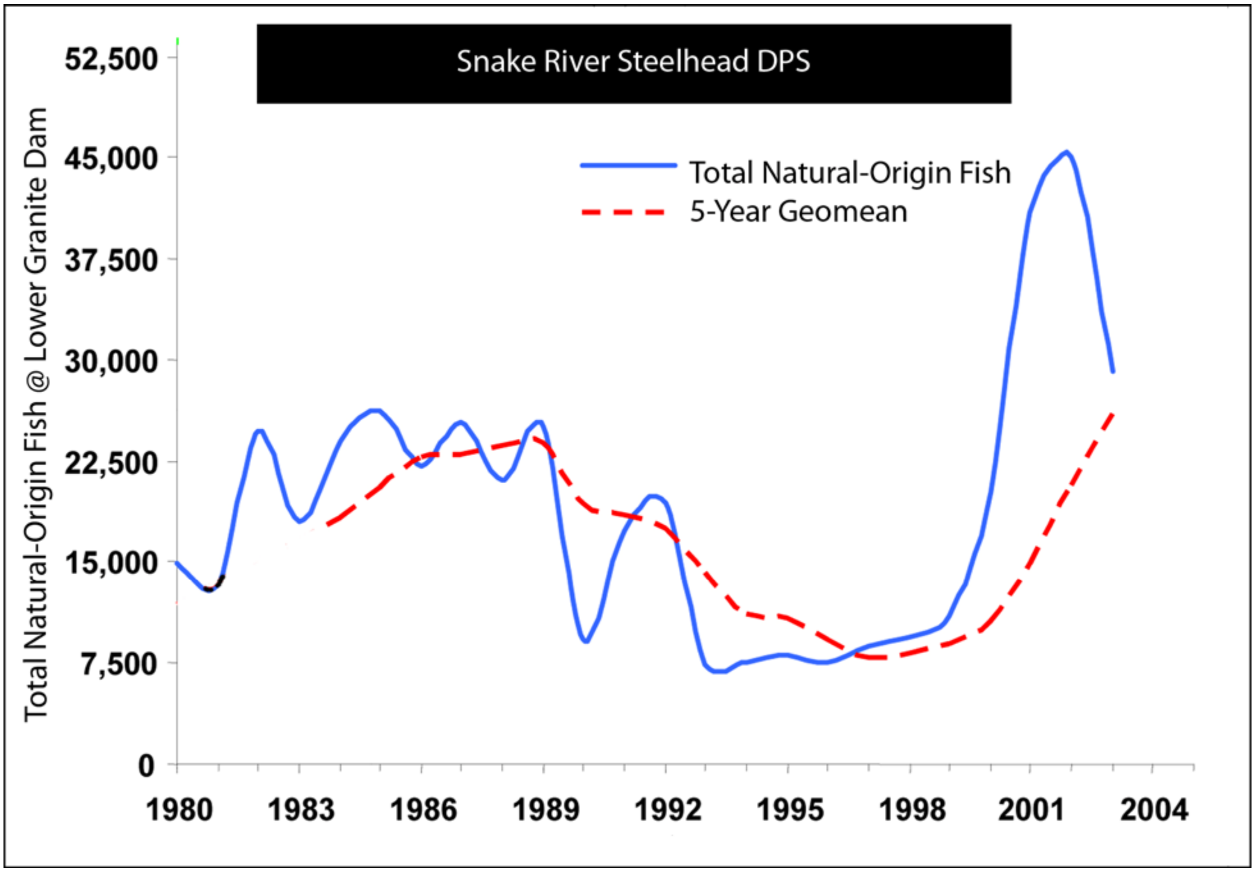
The key limiting factors and threats for Snake River steelhead include hydropower projects, predation, harvest, hatchery effects, and tributary habitat. Ocean conditions generally have been poor for this DPS over the last 20 years (at least), improving only in the last few years. Limiting factors are discussed in more detail in the context of critical habitat in Section 8.5.3.3.

Abundance

Population-specific adult population abundance is generally not available for SR steelhead due to difficulties conducting surveys in much of their range. To supplement the few population-specific estimates, the ICTRT used Lower Granite Dam counts of A-run and B-run steelhead and apportioned those to A- and B-run populations proportional to intrinsic potential habitat (Appendix A of ICTRT 2007c). The ICTRT generated 10-year geometric mean abundance estimates for two populations in the Grande Ronde MPG and reported average A-run and average B-run abundance as an indicator for the other populations. For the two Grande Ronde MPG populations, one recent average abundance exceeds the ICTRT abundance threshold and the second is below the threshold (Table 8.5.2-1). Both the A- and B-run averages are below the average abundance thresholds that the ICTRT identifies as a minimum for low risk. Abundance for Grande Ronde populations, and the average A- and B-run populations, declined to low levels in the mid-1990s, increased to levels at or above the recovery ICTRT abundance thresholds in a few years in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s (Figure 8.5.2.1-1, showing annual abundance of combined populations).

Figure 8.5.2.1-1 shows the 1980 to most recent abundance and 5-year geometric mean trends for the aggregate of all populations above Lower Granite Dam. The 5-year geometric mean increased from 1980, peaking in 1989 and decreasing throughout the 1990s. Aggregate abundance of natural-origin fish peaked in 2002 and the 5-year geometric mean has been increasing since 2000.

Figure 8.5.2.1-1. Snake River Steelhead DPS Abundance and 5-Year Geometric Mean (adopted from Fisher and Hinrichsen 2006)



"Base Period" Productivity

On average over the last 20 full brood year returns (~1980-1999 brood years [BY], including adult returns through ~2004), A-run SR steelhead populations replaced themselves (Table 8.5.2-1) when only natural production is considered (i.e., average R/S has been ≥1.0), while B-run steelhead have not. In order to ensure that the distribution of productivity estimates among MPGs is clearly stated, Table 8.5.2-1 displays the average A- and B-run SR steelhead productivities applied to each individual population. In general, R/S productivity was relatively high during the early 1980s, low during the late 1980s and 1990s, and high again in the most recent brood years (brood year R/S estimates in ICTRT Current Status Summaries [ICTRT 2007d], updated with Cooney [2008a]).

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at ≤5% extinction risk for average A-run and average B-run populations (intrinsic productivity estimates in ICTRT 2007c). However, of the two individual Grande Ronde populations with sufficient data for estimates, one had sufficient intrinsic productivity to meet the ICTRT viability criteria (Joseph Creek) and the other (Upper Grande Ronde) did not.

The base period trend in abundance has been stable or increasing (Table 8.5.2-1) for both A-run and B-run populations, as indicated by median population growth rate (lambda) and BRT trend. The one exception is the Upper Grande Ronde population, which has lambda less than 1.0 (0.99) when estimated under the assumption that effectiveness of hatchery-origin and natural-origin spawners is equal (HF=1).

In summary, abundance has been stable or increasing for A-run SR steelhead over the last 20 brood years, based on R/S, lambda, and BRT trend estimates >1.0. An exception is the Upper Grande Ronde population under one assumption for lambda. For B-run SR steelhead populations, natural survival rates are not sufficient for spawners to replace themselves each generation, as indicated by average R/S estimates <1.0, but abundance has been increasing, as indicated by lambda and BRT trend.

Spatial Structure

The ICTRT characterizes the spatial structure risk of nearly all SR steelhead populations as "very low" or "low" (Table 8.5.2-2). Panther Creek is an exception with "high" risk because only 30% of the historical range is occupied and there is a significant geographical distance between the single major spawning area for this population and the location of the next population. This is largely a result of past mining operations, which are being addressed through other processes, including the EPA Blackbird Mine Superfund Site clean-up.

Diversity

The ICTRT characterizes the diversity risk of all SR steelhead populations as "low" or "moderate" (Table 8.5.2-2).

"Base Period" Extinction Risk

Draft ICTRT Current Status Summaries (ICTRT 2007d) characterize the long-term (100 year) extinction risk, calculated from productivity and natural origin abundance estimates of populations during the "base period" described above for R/S productivity estimates, as "High" (>25% 100-year extinction risk) for all B-run populations and three A-run populations (Tucannon, Asotin, and Chamberlain Creek). The ICTRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50). Most A-run populations are characterized as having "moderate" risk (6-25% 100-year extinction risk). One population (Joseph Creek) is characterized as having a "low" risk of long-term extinction (<5% risk).

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk. It is not possible to evaluate short-term extinction risk for most individual populations or for average B-run populations. Table 8.5.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish) for average A-run populations, average B-run populations, and two individual A-run populations in the Grande Ronde MPG with sufficient data for estimates (Upper Mainstem and Joseph Creek). Short-term extinction risk is zero for the two Grande Ronde populations, 5% for average B-run populations, and >5% for average A-run populations at

QET=50. Risk is also >5% for average A-run populations at other QETs above 1.0. In order to display the distribution of extinction risk among MPGs, Table 8.5.2-3 applies the average A- and B-run extinction risk estimates to individual A- and B-run populations. This short-term extinction risk analysis is also based on the assumption that productivity observed during the "base period" will be unchanged in the future.

Quantitative Survival Gaps

The change in density-independent survival that would be necessary for quantitative indicators of productivity to be greater than 1.0 and for extinction risk to be less than 5% are displayed in Table 8.5.2-4. Mean base period R/S survival gaps range from no needed change for average A-run populations to approximately 25% needed survival improvements for average B-run populations. It is not possible to estimate survival changes necessary to reduce short-term extinction risk to $\leq$5%, as described in Chapter 7.1 and the Aggregate Analysis Appendix.

8.5.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for SR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in the following subbasins: Hells Canyon, Imnaha River, Lower Snake/Asotin, Upper Grande Ronde River, Wallowa River, Lower Grande Ronde, Lower Snake/Tucannon, Lower Snake River, Upper Salmon, Pahsimeroi, Middle Salmon-Panther, Lemhi, Upper Middle Fork Salmon, Lower Middle Fork Salmon, Middle Salmon-Chamberlain, South Fork Salmon, Lower Salmon, Little Salmon, Upper Selway, Lower Selway, Lochsa, Middle Fork Clearwater, South Fork Clearwater, and Clearwater (NMFS 2005b). There are 289 watersheds within the range of this DPS. Fourteen watersheds received a low rating (see Chapter 4 for further detail), 44 received a medium rating, and 231 received a high rating of conservation value to the DPS. The lower Snake/Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified above. This corridor 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. Of the 8,225 miles of habitat areas eligible for designation, 8,049 miles of stream are designated critical habitat. The status of critical habitat is discussed further in Section 8.5.3.3.

8.5.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.5.3.1 "Current" Productivity & Extinction Risk

Because the action area encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section, estimates of productivity and extinction risk are based on performance of populations during a 20-year "base period," ending with the 1999 brood year for average A-run steelhead and 1998 brood year for average B-run steelhead. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone Section 7 consultation and continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity as the riparian area becomes functional).

Quantitative Estimates

Because a number of ongoing human activities have changed over the last 20 years, Table 8.5.3-1 includes estimates of a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Chapter 7 of this document. Results are presented in Table 8.5.3-1.

Briefly, reduction in the average base period harvest rate (estimated at approximately 4% higher survival for both A-run and B-run populations [SCA Quantitative Analysis of Harvest Actions Appendix, based on U.S. v. Oregon estimates]) and estuary habitat projects (less than a 1% survival change, based on CA Appendix D) result in a survival improvement for all SR steelhead populations. Tributary habitat projects result in up to 8.5% survival improvements for specific populations within the DPS (CA Chapter 7, Table 7-6). In contrast, changes in collector dam configurations and transportation timing to benefit other listed species results in a 3% reduction for FCRPS survival, (based on ICTRT base survival and COMPASS analysis of current survival in the SCA Hydro Modeling Appendix) and development of tern colonies in the estuary results in less than a 1% reduction in survival for all populations. There are 16 hatchery programs for Snake River steelhead that operate as partial mitigation for impacts from FCRPS and Hells Canyon dams (Hatchery Effects Appendix). Ten of these hatchery programs, and the vast majority all steelhead hatchery production, operate to make up for lost natural production from hydro impacts. Six steelhead hatchery programs (four A-run and two B-run) add to or supplement natural spawning. These supplementation programs preserve genetic resources, but there is no analysis to show that they have increased natural-origin fish survival.

The net result is that, if these human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to increase 0-9%, depending on the particular population (Table 8.5.3-1). This also means that the survival "gaps," described in Table 8.5.2-4, would be proportionately reduced by this amount (i.e., ["Gap" ÷ 1.00] to ["Gap" ÷ 1.09], depending on the population).

8.5.3.2 Abundance, Spatial Structure, & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section.

8.5.3.3 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as affecting the conservation value of designated critical habitat. The condition of PCEs in spawning and rearing areas and juvenile and adult migration corridors are described below.

Spawning and Rearing Areas

This species spawns in tributaries to the Snake River in southeast Washington, northeast Oregon, and Idaho. Adults enter fresh water from June to October and spawn the following spring from March to June (Thurow 1987). Emergence occurs by early June in low elevation streams and as late as mid-July at higher elevations. Snake River steelhead usually rear in the natal tributaries for two to three years before beginning their seaward migration.

The following are the major factors that limit the functioning and thus the conservation value of habitat used by SR steelhead for these purposes (i.e., spawning and juvenile rearing areas with spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Degraded tributary channel morphology *[bank hardening for roads or other development; livestock on soft riparian soils and streambanks]*
- Physical passage barriers *[culverts; pushup dams; low flows]*
- Excess sediment in gravel *[roads; agricultural and silvicultural practices; livestock on soft riparian soils and streambanks; recreation]*
- Degraded riparian condition *[grazing]*
- Reduced tributary stream flow, which limits usable stream area and alters channel morphology by reducing the likelihood of scouring flows *[water withdrawals]*
- Degraded tributary water quality including elevated summer temperatures *[water withdrawals; groundwater depletion; degraded riparian condition]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions to address limiting factors and threats for this DPS in spawning and rearing areas. Some projects provided immediate benefits and some will result in long-term benefits with survival improvements accruing into the future. These include acquiring water to increase streamflow, installing or improving fish screens at irrigation facilities to prevent entrainment, removing passage barriers and improving access, improving mainstem and channel habitat, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects provided immediate benefits and some will result in long-term benefits with improvements in PCE function accruing into the future.

Juvenile and Adult Migration Corridors

Factors limiting the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers *[push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles]*
- Juvenile and adult passage mortality *[hydropower projects in the mainstem lower Snake and Columbia rivers]*
- Temperature barriers *[timing of adult entry into and migration through the lower Snake River in late summer and early fall is delayed because of elevated mainstem temperatures]*
- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*

In the mainstem FCRPS corridor, the Action Agencies have improved safe passage for juvenile steelhead with the construction and operation of surface bypass routes at Lower Granite, Ice Harbor, and Bonneville dams and other configuration improvements listed in section 7.3.1.1 in Corps et al. (2007a). The safe passage of juvenile steelhead through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown since that time. For steelhead, with a stream-type juvenile life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 7.3.1.3 in Corps et al. 2007a).

Areas for Growth and Development to Adulthood

Although SR steelhead spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the mouth of the Columbia River (NMFS 2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.5.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

Lower Snake MPG

Both of the populations within this MPG were affected by several projects, as described below.

Tucannon River

The USFS consulted on one emergency fire action and two fire salvage/timber sale projects in the Upper Tucannon watershed. The Corps proposed maintenance dredging of a barge slip at the mouth of the Snake River.

Asotin Creek

The BPA consulted on replacing a wood pole transmission line. The FHWA/WSDOT consulted on a project to replace a bridge, removing a channel constriction and thereby increase safe passage.

Grande Ronde River MPG

No Section 7 consultations were completed in the subject timeframe that would affect the Wallowa River population. Projects that affected other populations in this MPG are described below.

Grande Ronde Lower Mainstem

The USFS consulted on two projects in the Grande Ronde River—Mud Creek watershed, construction of an off-highway vehicle (OHV) trail system and a fire salvage timber sale. The USFS also consulted on two habitat restoration projects that were designed to improve conditions in the Grande Ronde River—Mud Creek, Chesnimnus Creek and Upper and Lower Joseph Creek watersheds. In one project, the USFS proposed to plant vegetation in Riparian Habitat Conservation Areas, develop offsite livestock watering facilities, replace 10 culverts identified as passage barriers or unable to withstand the 100-yr flood, maintain roads, harden four vehicle crossings, harden or otherwise protect livestock watering gaps, repair or modify 36 instream structures and remove bridge abutments. These actions were expected to reduce sediment loads, improve temperatures, riparian conditions, improve passage conditions, and to increase habitat complexity. In the second project, USFS would restore riparian habitat associated with a timber sale.

The Corps consulted on construction of a new floating dock at the Port of Clarkston on the lower Snake River.

The BLM consulted on projects to treat noxious weeds and seed riparian flats with native vegetation throughout the Lower Grande Ronde watershed and to maintain ten riparian exclosures protecting five miles of riparian from grazing in the Lower Grande Ronde.

Joseph Creek

The USFS consulted on a fuels reduction project in the Chesnimnus Creek watershed and a rangeland analysis for Joseph Creek. The USFS also consulted on two projects in the Chesnimnus Creek watershed that included habitat restoration elements: 2006 Peavine Noxious Weed Treatment and 2007 Peavine Trail Conservation.

The BLM consulted on a project to improve 100 acres of riparian along eight miles of stream in the Chesnimnus and Upper Joseph Creek watersheds.

Grande Ronde Upper Mainstem

The USFS proposed three fuel reduction projects in the Upper and Lower Catherine Creek watersheds. The USFS also proposed three grazing allotments and a rangeland analysis in the Upper Grande Ronde and Upper Grande Ronde-Five Points Creek watersheds. Additionally, the USFS consulted on a habitat restoration project in the Meadow Creek and Grande Ronde—Beaver Creek watersheds that would improve 200 acres of riparian habitat and maintain cattle exclosures.

The Corps consulted on a culvert replacement project for Oregon Highway 82 at Pierce Slough (Grande Ronde—Five Points Creek watershed). The project was expected to improve fish passage, riparian vegetation, and water quality.

Clearwater River MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that would affect the North Fork Clearwater, Lolo Creek, or Lochsa River populations. Projects that affected other populations in this MPG are described below.

Lower Mainstem Clearwater

The USFS consulted on two projects, the Little Boulder Campground Hazard Tree Removal Project in the Lower Clearwater watershed and the Cottonwood Creek Bridge Repair project. The USFS also consulted on a stream crossing rehabilitation project on Webb Creek in the Lapwai Creek watershed which was designed to provide offsite water for cattle, reducing instream temperatures and improving the condition of spawning gravels.

The FHWA/IDT consulted on a road construction project in Lewiston, ID.

Selway River

The USFS consulted on a project to replace a bridge over Lookout Creek (White Cap Creek watershed).

South Fork Clearwater River

The USFS consulted on one fire salvage and timber sale project in the Red River Watershed. The USFS also proposed two fuels reduction projects that affected the Upper South Fork Clearwater River, Crooked River, and Newsome Creek watersheds which included construction of instream rock and log structures. These were designed to improve instream temperatures and forage for juvenile rearing habitat and increase the number of resting pools for adults. They also included rehabilitation of a portion of Newsome Creek and its floodplain area in the Johns Creek watershed, which was dredge-mined in 1937 to 1940. This project was designed to reduce sediment delivery from roads, remove fish passage impediments and culverts, and treat weeds. On the Red River in the Middle South Fork Clearwater River watershed, the USFS decommissioned 13 miles, improved 20 miles, and abandoned 3 miles of roads; restored soil on 8.5 acres of skid trails and landings; replaced one and removed eight other undersized culverts; and treated noxious weeds.

The Corps consulted on providing an in-water work permit for the Nez Perce County Fishing Pier in the Upper Clearwater River.

The BLM consulted on restoration projects in Johns Creek which would improve access in Telephone Creek and the East Fork American River, increase habitat complexity in summer and winter rearing habitat, increase shading and reduce water temperatures, improve spawning gravels, and improve forage conditions for rearing fish.

Salmon River MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that would affect the South Fork Salmon River; Secesh River; Big, Camas, and Loon Creeks; and Upper or Lower Mainstem Middle Fork Salmon River populations. During the summer of 2007, wildfires burned approximately 310,000 acres of forested habitat within the range of South Fork and Middle Fork Salmon River MPGs. NOAA Fisheries expects that instream habitats will experience increased temperatures, sediment, and large woody debris delivery in the near term. Recovery times to pre-existing conditions will depend on the effects of the fire at each location, which are unknown at this time. Projects that affected other populations in this MPG are described below.

Little Salmon and Rapid Rivers

The USFS consulted on construction of the Rapid River Trailhead in the Upper Little Salmon River watershed. The USFS also proposed to install a fishway at an irrigation diversion dam, which would restore fish access to approximately three miles of Squaw Creek in the Upper Little Salmon River watershed. The project would also consolidate water rights, achieving a net increase in stream flow of 4 cfs, enough to support a low temperature thermal refuge for the Little Salmon River population.

Reclamation consulted on a culvert replacement on Squaw Creek in the Little Salmon River watershed which improved access to four miles of habitat in Squaw Creek and improved habitat complexity in Squaw and Papoose creeks.

Chamberlain Creek

The USFS consulted on a timber salvage project in the Lower South Fork Salmon River watershed and a bank protection (rip-rap) project in the Rock Creek watershed.

Panther Creek

The Corps consulted on a culvert and wetlands fill project in Upper Panther Creek, which would result in the conversion of irrigated agricultural land to low density residential housing. The project was expected to increase safe passage for fish in upper Panther Creek and in the mainstem Salmon River by eliminating rapid drawdowns of irrigation ditches when water was withdrawn for irrigation. The National Resource Conservation Service proposed to rehabilitate stream habitat in Iron Creek (Upper Panther Creek watershed). The BLM consulted on watershed rehabilitation activities associated with managing waste from the abandoned Twin Peaks Mine (Lower Panther Creek).

North Fork Salmon River

The USFS consulted on a culvert replacement project in the North Fork Salmon River, designed to restore both access and the hydraulic processes that transport sediment and large wood.

Lemhi

The FHWA/IDT consulted on the construction of a pedestrian bridge. The USFS consulted on a bank stabilization project at Bog Creek Crossing (Upper Lemhi River watershed) and two projects designed to rehabilitate stream channels and their associated riparian zones in the Middle Salmon River—Carmen Creek, Middle Salmon River—Indian Creek, and Hayden Creek watersheds. NOAA Fisheries consulted with itself on providing funds to screen a water diversion on Kenney Creek (Eighteenmile Creek watershed) and a culvert replacement in Twin Creek (North Fork Salmon River watershed). The latter project was designed to restore access and the hydraulic processes that transport sediment and large woody debris.

Pahsimeroi River

The Corps consulted on a project to prevent a hatchery facility from contaminating the naturally spawning population in the upper Pahsimeroi River (disease). The BLM proposed to rehabilitate Fall Creek and its associated riparian zone (Middle Pahsimeroi River watershed). NOAA Fisheries and USFWS each consulted on projects intended to remove passage barriers by modifying water diversions in the Lower Pahsimeroi River watershed.

East Fork Salmon River

The USFS consulted on a road construction and maintenance project in the Lower East Fork Salmon River watershed, and the FHWA proposed a bridge repair/construction project over the Salmon River (Challis Creek watershed).

Imnaha River MPG

Imnaha River

The USFS consulted on an emergency fire management project in the Salmon River, a harvest/vegetation management project in the Upper Imnaha River watershed, and a bridge replacement project in the Middle Imnaha River. The USFS also consulted on granting a special use permit to private energy companies for operating and maintaining transmission lines in the Upper Imnaha River watershed which included replacing two bridges (relieving channel constrictions) and restoring local floodplain connectivity. The USFS also consulted on a culvert replacement project, also in the Upper Imnaha watershed, designed to restore access to 3.5 miles of rearing habitat.

Projects Affecting Multiple MPGs/Populations

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.5.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration

Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs
Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status
Federal agencies are implementing numerous projects within the range of Snake River steelhead that will improve access to blocked habitat, prevent entrainment into irrigation pipes, increase channel complexity, and create thermal refuges. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of Federal projects, including fire salvage timber sales, maintenance dredging, grazing, bridge repairs, whitebark pine treatment, dock/pier construction, and road construction/maintenance, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat
Future Federal restoration projects will improve the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PCEs. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding in any adverse modification of critical habitat.

8.5.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon, Washington, and Idaho identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin. These are detailed in the lists of projects that appear in Chapter 17 of the FCRPS Action Agencies' Comprehensive Analysis which accompanied their Biological Assessment Corps et al. 2007a). They include tributary habitat actions that will benefit the Little Salmon, Lolo Creek, Lower Clearwater, South Fork Clearwater, and Asotin subbasins as well as actions that should be generally beneficial throughout the DPS. Generally, all of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[1] Many address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve conditions for Snake River steelhead. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing

[1] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.5.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in Sections 8.5.5.1 and 8.5.5.2. The Prospective Actions will ensure that adverse effects of the FCRPS and Upper Snake projects will be reduced from past levels. The Prospective Actions also include habitat improvements, require that all hatchery programs operate under NOAA Fisheries' approved HGMPs, broodstock reform for the Tucannon and East Fork Salmon River hatchery programs, steelhead kelt reconditioning, hatchery safety-net planning and predator reduction actions, which are expected to be beneficial. Flow augmentation from the Upper Snake Projects will also provide benefits. These beneficial effects are described in Sections 8.5.5.3, 8.5.5.4, 8.5.5.7, and 8.5.5.9. Some habitat restoration and RM&E actions may have short-term minor adverse effects, but these will be balanced by short- and long-term beneficial effects, as described in Section 8.5.5.7. The harvest Prospective Action will either reduce survival (A-run steelhead and "allowable" harvest on B-run steelhead) or increase survival ("expected" harvest on B-run steelhead), as described in Section 8.5.5.5.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in Section 8.5.5.4, the Hatchery Effects Appendix of the SCA, and in this section. The Prospective Actions will ensure continuation of the beneficial effects of safety-net hatcheries and will reduce adverse impacts of other hatchery programs.

Effects of NOAA Fisheries' issuance of a Section 10 juvenile transportation permit are discussed in Chapter 10 of the FCRPS Biological Opinion. The expected use of transportation under the permit is included in the effects of the FCRPS Prospective Action, which is described in Section 8.5.5.1.

8.5.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5 of this document) are expected to continue through the duration of the Prospective Actions.

The effects of the Prospective Actions on mainstem flows have been included in the HYDSIM modeling used to create the 70-year water record for input into the COMPASS model (Section 8.1.1.3).. As such, the effect of diminished spring-time flows on juvenile migrants is aggregated in the COMPASS model results used to estimate the effects of the Prospective Actions in the productivity and extinction risk analysis (See Section SCA Sections 7.2.1 and 8.1.1.3).

Based on COMPASS modeling of hydro operations for the 70-year water record, full implementation of the Prospective Actions are expected to increase the in-river survival (from Lower Granite to the

Bonneville tailrace) of SR steelhead from 33.1% (Current) to 38.5% (Prospective), a relative change of 16.4% (SCA Hydro Modeling Appendix). The average proportion of juveniles destined for transportation is expected to drop from 81.7% to 77.1%. However, the proportion of juveniles transported within specific periods of time (in about 80% of the years when expected flows at Lower Granite Dam are expected to exceed 65 kcfs) will change substantially due to altered timing of spill and transportation operations (see RPA Table, Table 3) compared to past operations which did not consider within season variations in the SARs of transported and inriver migrating steelhead. The initial spill and transport operations in the >65 kcfs years will result in (1) no fish – other than what may be needed for research purposes - being collected and transported prior to April 21, (2) high levels (>95% of juveniles) being transported between May 7 and May 20), and (3) intermediate levels of juveniles being transported between April 21 and May 7 and after May 21. Unlike SR spring/summer Chinook salmon (see discussion in Section 8.3.5.1), the smolt-to-adult returns (BON to LGR) of transported SR steelhead are usually equal to, or higher than that of in-river migrating juveniles that survived to below Bonneville Dam throughout the smolt migration period.[2] The Prospective Actions are expected to result in a slight positive (+0.01%) increase in overall LGR to LGR SAR estimates for steelhead even though transport rates are decreasing by about 5.7% (relative to current operations). During the lowest flow years (about 20% of years when spring flows are predicted to be <65 kcfs at Lower Granite Dam), about 90% (71% to 98%) of juvenile steelhead are likely to be transported to below Bonneville Dam.[3]

Implementation of the Prospective Actions addressing hydro operations is expected to slightly reduce the average total system survival (the total percentage of fish arriving at Lower Granite Dam expected to survive to below Bonneville Dam via in-river migration and transportation) from 92.3% to 90.9% (a reduction of about 1.5%). The COMPASS model further estimates that Lower Granite Dam to Lower Granite Dam Smolt to Adult Returns (LGR-to-LGR SARs) will be reduced from about 1.82% to 1.75% (a relative decrease of 3.8%) as a result of the hydro Prospective Actions that govern spill and transport operations and their effect on migration timing to below Bonneville Dam (see discussion above and in Section 8.1).[4]

The Prospective Actions addressing hydro operation and the RM&E program should maintain the high levels of survival currently observed for adult SR steelhead migrating from Bonneville Dam

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[2] These differences do not include the substantial losses of fish migrating inriver to reach the Bonneville Dam tailrace. Including these losses would lower the expected SARs of inriver migrating fish compared to those transported. This is, and will continue to be,

[3] Only three of the 13 years (out of 70) when flows were less than 65 kcfs at Lower Granite Dam had estimated transport rates less than 90%. Closer inspection of these years indicated that the "forecasts" (used to determine the operation to be implemented for a given year in the model) were for flows > 65 kcfs (which would not trigger the "maximum" transport operation). This is a realistic situation that is faced by managers (Regional Forum, Technical Management Team) that must make operational choices based on the forecast information is available at the time.

[4] NOTE: The COMPASS model estimates SARs for in-river and transported migrants separately before combining them (with the estimated percentage of in-river and transported juveniles surviving to below Bonneville Dam) to provide an overall LGR to LGR SAR. Thus, the COMPASS model SAR estimates include (through the transport SAR estimate) the increased stray rates that are often observed for adult fish transported as juveniles (compared to stray rates of those that migrated in-river as juveniles) – a negative effect of transportation.

upstream to Lower Granite Dam. The current PIT tag based survival estimate, taking account of harvest and “natural” stray rates within this reach, is 90.1% (about 98.5% per project). Any delayed mortality of adults (mortality that occurs outside of the Bonneville Dam to Lower Granite Dam migration corridor) that currently exists is not expected to be affected by the Prospective Actions.

The Prospective Hydro Actions are also likely to positively affect the survival of SR steelhead in ways that are not included in the quantitative analysis. NOAA Fisheries considers these expected benefits qualitatively in the remainder of this Section.

The Prospective Actions requiring implementation of surface passage routes at Little Goose, Lower Monumental, McNary and John Day dams, in concert with training spill (amount and pattern) to provide safe egress, should reduce juvenile travel times within the forebays of the individual projects. This is likely to result in survival improvements in the forebays of these projects, where predation rates are currently often the highest. Taken together, surface passage routes should increase juvenile migration rates through the migration corridor, and likely improve overall post-Bonneville survival of in-river migrants. Faster migrating juveniles may be less stressed than is currently the case. Finally, improved tailrace egress conditions should increase the survival of migrating steelhead in tailraces where juvenile mortality rates are relatively high.

Continuing efforts under the NPMP, the program to remove fish predators, and continuing and improved avian deterrence at mainstem dams will also address sources of juvenile mortality. In-river survival from Lower Granite Dam to the tailrace of Bonneville Dam, which is an index of the hydrosystem’s effects on water quality, water quantity, water velocity, project mortality, and predation, will increase to 38.5%. A portion of the 61.5% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that juvenile steelhead would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of juvenile Snake River steelhead in a hypothetical unimpounded Columbia River would be 82%. Therefore, approximately 29% (=18/61.5) of the mortality experienced by in-river migrating juvenile steelhead is probably due to natural factors.

The direct survival rate of adults migrating through the FCRPS is already quite high. The prospective actions include additional passage improvements (to the collection channel at The Dalles and to the ladders at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite dams and other improvements in Corps et al. 2007a). Adult steelhead survival from Bonneville to Lower Granite Dam will be approximately 90.1% under the Prospective Actions. With respect to kelts, the Action Agencies will prepare and implement a Kelt management Plan, including measures to increase in-river survival.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will benefit the juvenile migrants by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor and threat in the lower Columbia River below Bonneville Dam (Section 8.3.3.3).

Effects on Critical Habitat

The Prospective Actions described above will improve the function of safe passage in the juvenile and adult migration corridors by addressing water quantity, water velocity, project mortality, and exposure to predators. To the extent that the hydro Prospective Actions result in more adults returning to spawning areas, water quality and forage for juveniles could be affected by the increase in marine-derived nutrients. This was identified as a limiting factor for the Lochsa and South Fork Clearwater populations by the Remand Collaboration Habitat Technical Subgroup (Habitat Technical Subgroup 2007 a, b).

8.5.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

The population-specific effects of the tributary habitat Prospective Actions on survival for all populations, except the Lower Middle Fork Tributaries population, are listed in CA Chapter 7, Table 7-8, p. 7-16. Although CA Table 7-8 indicates that the Prospective Actions will improve habitat quality for the Lower Middle Fork Tributaries population by 7%, a more realistic estimate is a 2% improvement (Table 8.5.5-1). This is because the Prospective Actions target actions only in the Big Creek watershed, which affect only a subpopulation of the entire Lower Middle Fork Tributary population. The Big Creek Watershed encompasses approximately 29% of the intrinsic potential for the Lower Middle Fork Tributaries Population. Therefore, the actions in Big Creek will result in a lower survival increase when spread over the entire population, or approximately 2% (7% X 0.291= 2%). In summary, for targeted populations in this DPS, the effect is a <1 - 16% expected increase in egg-smolt survival, depending on population. This is a result of implementing tributary habitat projects that improve habitat function quality by addressing limiting factors and threats.[5] For example, roads in the Sesech and South Fork Salmon watersheds contribute fine sediment to stream gravels and inadequate culverts at stream crossings create passage barriers. As part of their implementation of the RPA (Action 34), the Action Agencies will address this limiting factor by providing funds for decommissioning and/or improving roads and for removing and/or replacing culverts on Forest Service lands to the Nez Perce Tribe.

Effects on Critical Habitat

As described above, the tributary habitat Prospective Actions will address factors that have limited the functioning and conservation value of habitat that this species uses for spawning and rearing. PCEs expected to be improved are water quality, water quantity, cover/shelter, food, riparian vegetation, space, and safe passage/access. Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts

[5] The Action Agencies identify the projects that will improve these PCEs and that they will fund by 2009 in Tables 3b; 4a; and 5a,b in Attachment B.2.2-2 to Corps et al. (2007b).

will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.5.5.3 Effects of Estuary Prospective Actions

Effects on Species Status

The estimated survival benefit for Snake River steelhead (stream-type life history) associated with the specific actions to be implemented from 2007-2010 is 1.4%. The survival benefit for Snake River steelhead (stream-type life history), associated with actions to be implemented from 2010 through 2018, is 4.3%. The total survival benefit for Snake River steelhead, as a result of Prospective Actions implemented to address estuary habitat limiting factors and threats, is approximately 5.7% (Corps et al. 2007a Chapt.7.3.3.3). Estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM 40 will address factors that have limited the functioning of PCEs used by juvenile steelhead migrants from the Snake River. The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the value of the estuary as habitat for this species (section 7.3.3.3 in Corps et al. 2007a). These include restoring riparian function and access to tidal floodplains.

Effects on Critical Habitat

The estuary habitat Prospective Actions will address factors that have limited the functioning of PCEs needed by juvenile steelhead from the Snake River. Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction (Section 8.5.5.2) are expected to be minor, occur only at the project scale, and persist for a short time.

8.5.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Hatchery programs preserve genetic resources in the Tucannon, North Fork Clearwater, Pahsimeroi, and East Fork Salmon. On the other hand, hatchery programs in the Little Salmon River, mainstem Salmon River, Lemhi River, Upper Salmon River, Wallowa River, Lower Grande Ronde River, and Hells Canyon pose risks to the diversity and productivity of many populations in the DPS (SCA Hatchery Effects Appendix).

Prospective Actions include continued funding of hatcheries and the adoption of programmatic criteria, or Best Management Practices (BMPs), for operating salmon and steelhead hatchery programs. More than thirty hatchery programs in the Snake River Basin require ESA consultation and NOAA Fisheries has scheduled these consultations to follow scientific reviews by the congressionally mandated Hatchery Scientific Review Group and the United States Fish and Wildlife Service Hatchery Review Team. Hatchery reforms will be implemented in new ESA consultations informed by new science, new Hatchery and Genetic Management Plans for each program, and NOAA Fisheries guidance (see Artificial Propagation for Pacific Salmon Appendix) has established a schedule for completing new ESA consultations on more than thirty hatchery programs in the Snake River Basin and will consult on the operation of existing or new programs when Hatchery and Genetic

Management Plans (HGMPs) for each program are updated. The Action Agencies intend to adopt these programmatic criteria. Site-specific application of BMPs will be defined in HGMPs, and consultations with NOAA Fisheries will be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies (FCRPS Biological Assessment, Corps et al. 2007b, Page 2-44). Consultation with the Action Agencies will be initiated by February of 2010 and completed by August of 2010.

Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.5.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

There are three stock groups of summer steelhead used for harvest management including the lower river Skamania stock, upriver A-run stock, and upriver B-run stock. SR steelhead populations are designated as both A-run and B-run.

Prospective non-Treaty fisheries, pursuant to the 2008 *U.S. v. Oregon* Agreement, will be managed subject to DPS-specific harvest rate limits. Winter, spring, and summer fisheries are subject to a 2% harvest rate limit on wild steelhead from each steelhead DPS. Non-Treaty fall season fisheries are likewise subject to a 2% harvest rate limit for each steelhead DPS. The total annual harvest rate limit for A-run steelhead, for example, is 4%. This is consistent with the ESA-related management constraints that have been in place in recent years. The expected harvest impacts on non-Treaty fisheries are less than those proposed (TAC 2008). The yearly incidental catch of A-run steelhead in non-Treaty fisheries has averaged 1.6 since 1999 (Table 8.5.5.5-1). Harvest rates for non-Treaty fisheries are not expected to change over the course of this Agreement (TAC 2008).

The harvest rate on A-run steelhead in tribal spring season fisheries has averaged0.2% since 1985 (Table 8.5.5.5-1). The harvest rate in summer season fisheries averaged 2.3% since 1985 (Table 8.5.2.1.1-1). The harvest rate in fall season fisheries averaged 9.6% since 1985 and 4.2% since 1998 (Table 8.5.5.5-1). Impacts resulting from treaty-Indian fall season fisheries during this agreement are similar to the 1998-2006 average of 4.2%.

With respect to spring and summer season fisheries, increases in harvest beyond those observed in recent years are unlikely. The spring season extends through June 15. The harvest rate of A-run steelhead has been consistent and low, at approximately 0.2%, since 1985 (Table 8.5.5.5-1).

No changes in the fishery are proposed or anticipated that would lead to changes in the expected catch of steelhead.

Summer season fisheries extend through July 31. Snake River steelhead are caught regularly in ceremonial and subsistence fisheries (primarily the platform fishery), as well as in commercial fisheries targeting summer Chinook (summer Chinook that are targeted in the fishery are part of the UCR summer/fall ESU and are not listed under the ESA.). Summer Chinook were chronically depressed for decades until returns began to increase in 2001. Higher runs provided more fishing opportunity as of 2002. However, there is no evidence of an associated increase in the catch of listed steelhead. The harvest rate of summer Chinook in the tribal fishery averaged 1.5% from 1989 to 2001 and 10.9% from 2002 to 2006 (TAC 2008). During those same years, the harvest rate of steelhead averaged 2.3% and 2.4% (Table 8.5.5.5-1). As with the spring fisheries, no further changes in future fisheries are expected, as a result of the Prospective Action, that would lead to changes in the expected catch of steelhead. However, there is recent information regarding adult conversion rates from analysis of PIT-tag data, indicating that more UCR steelhead than SR steelhead are lost in upstream passage. These greater losses may be due to differential harvest rates that are not currently detectable. The losses may also be due to timing differences, passage conditions, or another combination of factors. If new evidence develops related to the catch of steelhead in the summer season, these conclusions will be reviewed.

Prospective treaty-Indian fall season fisheries will be managed using the abundance based harvest rate schedule for B-run steelhead, as contained in the 2008 Agreement (Table 8.5.5.5-2). From 1998 to 2007 treaty-Indian fall season fisheries were managed subject to a 15% harvest rate limit on B-run steelhead. Under the abundance based harvest rate schedule, harvest may vary up or down from the status quo of 15%, depending on the abundance of B-run steelhead. The harvest rate allowed under the prospective schedule is also limited by the abundance of upriver fall Chinook. The purpose of this provision is to recognize that impacts to B-run steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook, is higher and remain consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-run steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right, to harvest 50% of the harvestable surplus of fall Chinook, in years when conditions are generally favorable. Even with these provisions, it is unlikely that the treaty right for Chinook or steelhead can be fully satisfied. The harvest rate in tribal fall season fisheries may range from 13 to 20%. As indicated above, the non-Treaty fall season fishery harvest rate would remain fixed at 2%.

Table 8.5.5.5-1. Harvest rates of A-run steelhead in spring, summer, and fall season fisheries expressed as a proportion of the Skamania and A-run steelhead run size (TAC 2008).

Treaty Indian					Non-Indian			
Year	**Spring Season**	**Summer Season**	**Fall Season**	**Total**	**Spring Season**	**Summer Season**	**Fall Season**	**Total**
1985	0.15%	NA	19.40%	19.50%				
1986	0.08%	NA	12.60%	12.70%				
1987	0.05%	NA	14.70%	14.80%				
1988	0.18%	NA	16.10%	16.20%				
1989	0.04%	4.00%	14.90%	18.90%				
1990	0.44%	3.50%	14.10%	18.00%				
1991	0.15%	1.90%	14.40%	16.40%				
1992	0.49%	2.00%	15.20%	17.60%				
1993	0.14%	1.40%	14.60%	16.20%				
1994	0.16%	1.10%	9.70%	10.90%				
1995	0.06%	2.20%	10.00%	12.20%				
1996	0.66%	2.30%	8.40%	11.40%				
1997	0.10%	2.70%	10.10%	12.80%				
1998	0.11%	3.80%	8.40%	12.40%				
1999	0.05%	2.10%	5.20%	7.40%	0.10%	0.30%	0.60%	1.00%
2000	0.11%	1.00%	4.00%	5.10%	0.10%	0.60%	1.00%	1.70%
2001	0.09%	2.10%	3.80%	6.00%	0.10%	0.40%	0.60%	1.10%
2002	0.09%	2.10%	2.40%	4.60%	0.40%	0.40%	0.80%	1.60%
2003	0.12%	2.80%	2.50%	5.40%	0.60%	0.30%	1.00%	1.90%
2004	0.13%	3.90%	3.00%	7.00%	0.40%	0.40%	1.00%	1.80%
2005	0.05%	2.30%	3.60%	5.90%	0.40%	0.40%	0.90%	1.70%
2006	0.13%	0.80%	5.00%	6.00%	0.30%	0.40%	1.20%	1.90%
2007					0.30%	0.30%	0.80%	1.40%
1985-06 average	0.16%	2.33%	9.64%	11.70%				
1989-06 average	0.17%	2.33%	8.29%	10.79%				

Treaty Indian					Non-Indian			
Year	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
1998-06 average	0.10%	2.32%	4.21%	6.64%	0.30%	0.40%	0.89%	1.59%

Table 8.5.5.5-2. Abundance Based Harvest Rate Schedule for B-run Steelhead (TAC 2008).

Upriver Summer Steelhead Total B Harvest Rate Schedule				
Forecast Bonneville Total B Steelhead Run Size	River Mouth URB Run Size	Treaty Total B Harvest Rate	Non-Treaty wild B Harvest Rate	Total Harvest Rate
20,000	Any	13%	2.0%	15.0%
20,000	Any	15%	2.0%	17.0%
35,000	>200,000	20%	2.0%	22.0%

B-run steelhead will be used as the primary steelhead related harvest constraint for tribal fall season fisheries and are thus the indicator stock used for management purposes. Generally, the status of B-run steelhead is worse than that of A-run steelhead. B-run steelhead are subject to higher harvest rates because they are larger and thus more susceptible to catch in gillnets. Harvest impacts on B-run steelhead generally are also higher because their timing coincides with the return of fall Chinook, the primary target of this fishery. A-run steelhead typically return a few weeks earlier and thus are less susceptible to catch. Consequently, there are no specific management constraints in tribal fisheries for A-run steelhead. Since 1998, when the 15% harvest rate limit was first implemented for B-run steelhead, the harvest rate on A-run steelhead in fall season treaty-Indian fisheries has averaged 4.2% and ranged from 5.4 to 12.4% (Table 8.5.5.5-1).

The abundance based harvest rate schedule allows the tribal harvest rate on B-run steelhead to vary from the fixed rate of 15% that has been in place since 1998, depending on the abundance of B-run steelhead and upriver fall Chinook. By evaluating historical run size, a determination can be made as to how often fisheries would be subject to the 13%, 15%, or 20% level. This retrospective analysis suggests that the annual harvest rate limit will be 15% or less 12 out of 22 years, and 20% 10 out of 22 years, and 20% 10 out of 22 years. The average allowable harvest rate on B-run steelhead from this retrospective analysis is 17.1% (Table 8.5.5.5-3).

Table 8.5.5.5-3. Retrospective analysis of allowable harvest rates for B-run steelhead in the tribal fall season fisheries.

Year	Upriver Fall Chinook Run Size	B-run Steelhead Run Size	Allowable Harvest Rate in Tribal Fall Fisheries
1985	196,500	40,870	15%
1986	281,500	64,016	20%
1987	420,600	44,959	20%
1988	340,000	81,643	20%
1989	261,300	77,604	20%
1990	153,600	47,174	15%
1991	103,300	28,265	15%
1992	81,000	57,438	15%
1993	102,900	36,169	15%
1994	132,800	27,463	15%
1995	106,500	13,221	13%
1996	143,200	18,693	13%
1997	161,700	36,663	15%
1998	142,300	40,241	15%
1999	166,100	22,137	15%
2000	155,700	40,909	15%
2001	232,600	86,426	20%
2002	276,900	129,882	20%
2003	373,200	37,229	20%
2004	367,858	37,398	20%
2005	268,744	48,967	20%
2006	230,388	74,127	20%
1985-06 average			17.10%

Although the prospective harvest rate schedule will allow for harvest in tribal fall season fisheries to increase in some years, the observed harvest rates in both the non-Treaty and treaty-Indian fisheries have generally been lower than allowed. Since 1998, fall season fisheries have been subject to a combined 17% harvest rate limit for B-run steelhead. From 1998 to 2006 the observed harvest rate averaged 12.7% (TAC 2008).

For fall season fisheries it is also necessary to consider whether there will be an increase in the harvest of A-run steelhead associated with the Prospective Action. As discussed above, B-run steelhead are used as the indicator stock for steelhead. This is done in order to limit fishery impacts in fall season fisheries. The retrospective analysis suggests that harvest rates on B-run steelhead in the treaty Indian fall season fisheries may be higher than 15% approximately half of the time. The average of the allowable harvest rate limits from the retrospective analysis is 17.1% (Table 8.5.5.5-3). This represents a 14% increase over the current harvest rate limit of 15% (17.1/15.0 = 1.14). The harvest rates on A-run steelhead will not necessarily increase, but A-run and B-run harvest rates are correlated. It is therefore reasonable to assume that A-run harvest rates will increase in proportion to B-run harvest rates. Table 8.5.5.5-1 shows the tribal fishery harvest rates for A-run steelhead in spring, summer, and fall season fisheries. Since 1998, when the current ESA limits were applied, fall season harvest rate averaged 4.2%, while the total harvest rate averaged 6.6%. Under the assumption that fall season harvest rates will increase by 14% in proportion to the expected increase for B-run steelhead, the anticipated future fall season and total harvest rates will be 4.8% (0.042 * 1.140 = 0.48) and 7.2%.

The net result for A-run populations of SR steelhead will be a small increase in the current harvest rate (from 6.6% to 7.2%), which will result in approximately a 1% reduction in survival (Harvest Appendix, based on US v Oregon memorandum). Therefore, a 0.99 current-to-future survival adjustment is applied to the prospective harvest action for A-run populations.

The net result for B-run populations of SR steelhead ranges from a 3% reduction in survival, based on the allowable harvest rate, to a 2% increase in survival, based on the expected harvest rate. Therefore, a 0.97-1.02 current-to-future survival adjustment is applied to the prospective harvest action for B-run populations.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas. This was identified as a limiting factor for the Lochsa and South Fork Clearwater populations by the remand collaboration Habitat Workgroup (Habitat Technical Subgroup 2007a, b).

8.5.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to Snake River steelhead from reduction in Caspian tern nesting habitat on East Sand Island and subsequent relocation of most of the terns to sites outside the Columbia River Basin (RPA Action 45) is 3.4% (Corps et al. 2007a Attachment F-2, Table 4).

Compensatory mortality may occur but based on the discussion in Section 8.3.5.6 it is unlikely to significantly affect the results of the action.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 43) should further reduce consumption rates of juvenile salmon and steelhead. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (CA, Corps et al. 2007a Appendix F, Attachment F-1: Benefits of Predation Management on Northern Pikeminnow). Implementation and further improvement of avian deterrence at all lower Snake and Columbia dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces (RPA Action 48).

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island, continued implementation of the base Northern Pikeminnow Management Program, continuation of the increased reward structure in the sport-reward fishery implementation and further improvement of avian deterrence at mainstem dams are expected to improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.5.5.7 Effects of Research and Monitoring Prospective Actions

See Section 8.1.4 of this document.

8.5.5.8 Effects of Kelt Reconditioning

Effects on Species Status

Prospective Actions implementing passage improvements for juvenile salmon and steelhead, including surface passage such as RSWs and sluiceways, are likely to also benefit downstream migrating kelts. This should lead to improved survival through the FCRPS. Reduced forebay residence times, which lead to a reduction in total travel time, may also contribute to an improvement in kelt return rates. It is not possible to calculate the precise amount of improvement expected, because the interactions between improved surface passage and improved kelt survival and return rates are not fully known. However, some improvement is likely.

The Prospective Actions implementing reconditioning and transport of steelhead kelts potentially represent a much greater improvement in both outmigration survival and return rates. Reconditioning programs capture kelts and hold them in tanks where they are fed and medicated to enhance survival. Current programs either hold kelts for 3-5 weeks and release them below Bonneville or hold kelts until they are ready to spawn and release them into their natal streams. Short-term reconditioning efforts have produced average survival rates of 82% and kelt returns of 4% to the Yakima River (Hatch et al. 2006). Long-term reconditioning has produced average survival rates of 35.6%, all of which are returned to their natal stream for spawning (Hatch et al. 2006).

There is some concern over the viability of the offspring from long-term reconditioned kelts. Laboratory studies found high rates of post hatching mortality (Branstetter et al. 2006), and studies using DNA analysis to identify the parentage of outmigrating steelhead smolts (Stephenson et al. 2007) have failed to identify any offspring of reconditioned kelts among the juvenile steelhead collected from streams where reconditioned kelts were released. These studies suggest that long-term reconditioning may reduce gamete viability. It is not known if short-term reconditioned kelts may have the same problems with offspring viability; however, because they feed and mature under natural conditions it seems less likely.

Transportation of kelts involves capturing kelts, transporting them to a point downstream of Bonneville dam, and releasing them. Kelt transportation studies in the Snake River found that there was not only an improvement in FCRPS survival from 4-33% to approximately 98% in transported kelts, but transported kelts returned to Lower Granite dam at a rate of 1.7% versus in-river migrating kelts which returned at a rate of 0.5% (Boggs and Peery, 2004).

Both transportation and reconditioning of kelts require capture of downstream migrating kelts. Given kelt preference for surface passage and the potential for future implementation of surface passage routes, the number of kelts that can be collected is limited. Upper and Mid-Columbia DPSs present significant challenges to successfully collecting kelts. Existing bypass systems and transportation facilities on the Snake River dams make successful collection of Snake River steelhead more likely. An analysis by Dygert (2007) estimated that 7% (during spill) to 22% (no spill) of the upstream steelhead run could be captured at LGR as downstream migrating kelts. The Prospective Actions would employ collection at both LGR and LGS. Our analysis of the Prospective Actions (SCA Hydro Modeling Appendix) suggests that employing a combination of transportation, reconditioning, and in-stream passage improvements could increase kelt returns enough to increase the number of Snake River B-run steelhead spawners by about 6% (SCA steelhead Kelt Appendix). If logistical difficulties associated with capture of upper Columbia River steelhead kelts can be overcome, similar benefits could be expected for that DPS as well.

Effects on Critical Habitat

NOAA Fisheries will analyze any effects of the kelt reconditioning action on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.5.5.9 Summary: Quantitative Survival Changes Expected From All Prospective Actions

Expected changes in productivity and quantitative extinction risk are calculated as survival improvements in a manner identical to estimation of the base-to-current survival improvements. The estimates of "prospective" expected survival changes resulting from the Prospective Actions are described in Sections 8.5.5.1 through 8.5.5.9 and are summarized in Table 8.5.5-1. Estuary habitat improvement projects, kelt reconditioning, and further reductions in bird and fish predation are expected to increase survival above current levels for all populations in the DPS. Tributary habitat improvement projects are expected to increase survival for selected populations. The net effect, which varies by population, is 10-39% increased survival, compared to the "current" condition, and 11-40% increased survival, compared to the "base" condition.

8.5.5.10 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Tables 8.5.6-1 and 8.5.6-2 and in Figures 8.5.6-1 and 8.5.6-2. In addition to these summary tables and figures, the SCA Life Cycle Modeling Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007 Draft Biological Opinion. Additional qualitative considerations that generally apply to multiple populations are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions at the MPG and DPS level. Also, because quantitative short-term extinction risk gaps cannot be calculated for this species, future short-term extinction risk is discussed qualitatively in subsequent sections.

8.5.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects, Summarized by Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared with the importance of each population to MPG and DPS viability. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Lower Snake River MPG

This MPG consists of two extant populations (Tucannon and Asotin), one of which must be viable and the other highly viable to achieve the ICTRT's suggested MPG viability scenario. Both are A-run populations. Please see Section 7.3 for a discussion of these MPG viability scenarios.

As discussed previously, population-specific estimates are not available for populations in this MPG, so productivity and extinction risk are inferred from average A-run population estimates, coupled with Prospective Actions that are specific to each population. The estimated productivity (based on all three metrics: R/S, lambda, and BRT trend) is expected to be greater than 1.0 for both populations (Table 8.5.6-1; Figure 8.5.6-1). This means that with implementation of the Prospective Actions survival is expected to be sufficient for these populations to grow and for the abundance of spawners to trend upward. There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix) and the application of average A-run estimates to these specific populations. This suggests that other qualitative information should also be considered:

- Life-stage specific survival rates are expected to improve for estuarine survival, as well as in both tributaries as a result of the Prospective Actions, as described in Sections 8.5.5.1 through 8.5.5.6. These actions address limiting factors and threats. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity greater than 1.0 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "low" to "moderate," as defined by the ICTRT (Table 8.5.2-2). The MPG can achieve the ICTRT suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity sufficiently increase to levels exceeding minimum thresholds.

- The productivity estimates described above are based on mean results of analyses that assume future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under both "Warm PDO" (poor) and "historical" ocean scenarios both populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.5.6-2).

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

- Quantitative estimates of *base period* extinction risk indicate 21% risk at QET=50 for average A-run populations (Table 8.5.2-3). As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Base period extinction risk is estimated to be 5% risk at QET=1 and greater than 5% at all higher QETs. These estimates do not take into account current survival rates or the effects of Prospective Actions that will be implemented quickly. Survival changes necessary to reduce short-term extinction risk to 5% cannot be estimated for this species. Base-to-current survival improvements range from 7 to 9%, depending on the population. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 14 to 16% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk.

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for A-Run base period extinction risk ranges from 0 to 50%; Table 8.5.2-3). This suggests that other qualitative information should also be considered:

- There is no safety-net hatchery program for these populations. There is a hatchery supplementation program for the Tucannon that preserves genetic resources and reduces extinction risk in the short-term.

- The recent 10-year geometric mean abundance is unknown, but average A-run abundance was estimated by the ICTRT to be 456 fish, which is well above the 50 fish QET (Table 8.5.2-1). No years in the average A-Run data set are below 50 fish (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Clearwater MPG

This MPG consists of five extant populations. The ICTRT recommends that four of these populations be viable or highly viable for this MPG. Key populations within this MPG include the Lower Clearwater (the only extant "large" population), Lolo Creek (the only population with both the A-run and B-run life histories), and the Selway, Lochsa, and South Fork Clearwater populations (all of which are "intermediate" sized populations). The Lower Clearwater is an A-run population, Lolo Creek has both A-run and B-run life histories, and the other extant populations are B-run. Please see Section 7.3 for a discussion of these MPG viability scenarios.

As discussed previously, population-specific estimates are not available for populations in this MPG, so productivity and extinction risk are inferred from average A-run and average B-run population estimates, coupled with Prospective Actions that are specific to each population. Estimated productivity (based on R/S) is expected to be greater than 1.0 for 3-4 populations and less than 1.0 for 1-2 populations, depending upon assumption for prospective harvest, with implementation of the Prospective Actions (Table 8.5.6-1). The Selway River population is expected to be less than 1.0 under both harvest assumptions while the Lolo Creek results depend upon prospective harvest assumption (0.99 with allowable harvest and 1.04 with expected harvest). This means that with implementation of the Prospective Actions, survival for 3-4 of the five populations is expected to be sufficient for them to grow. Lambda and the BRT abundance trend are expected to be greater than 1.0 for all five populations. This means that all populations in this MPG are expected to increase in abundance.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix; Figure 8.). For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for estuarine survival and survival in tributaries as a result of the Prospective Actions, as described in Sections 8.5.5.1 through 8.5.5.6. These actions address limiting factors and threats. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for these populations are not solely determined by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "very low" to "moderate," as defined by the ICTRT (Table 8.5.2-2). The MPG can achieve the ICTRT-suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- The productivity estimates described above are based on mean results of analyses that assume future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the ICTRT "historical" ocean scenario, all populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix). Under the ICTRT "Warm PDO" (poor) climate scenario, the results are nearly identical to results under recent climate conditions.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

- Quantitative estimates of *base period* extinction risk indicate 21% risk at QET=50 for average A-run populations (Table 8.5.2-3). As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Base period extinction risk is estimated to be 5% risk at QET=1 and greater than 5% at all higher QETs. Base period B-run extinction risk is estimated to be 5% at QET=50 and less than 5% at lower QET levels.

- These estimates do not take into account current survival rates or the effects of Prospective Actions that will be implemented quickly. Survival changes necessary to reduce short-term extinction risk to 5% could not be estimated for this species. Base-to-current survival improvements range from 1-3%, depending on population. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 10-39% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk of both A-run and B-run populations.

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for A-Run base period extinction risk ranges from 0 to 50%; Table 8.5.2-3). This suggests that other qualitative information should also be considered:

- There is no safety-net hatchery program for these populations.

- The recent 10-year geometric mean abundance for these populations is unknown. However, the ICTRT estimated average A-run abundance (applicable to the Lower Clearwater population) at 456 fish and average B-run abundance at 272 fish (Table 8.5.2-1), both of which are well above the 50 fish QET. No years in either the average A-Run or average B-run data sets are below 50 fish (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Grande Ronde MPG
This MPG consists of four extant populations. The ICTRT recommends that two of these populations be viable or highly viable for MPG viability. Key populations within this MPG include the Grande Ronde Upper Mainstem (essential, since it is the only "large" population in this MPG), Joseph Creek (least influenced by hatcheries and contributes to spatial structure in the lower portion of the MPG), and the Lower Grande Ronde Mainstem (also contributes to spatial structure in the lower portion of the MPG). The ICTRT suggests a choice among Joseph Creek and the Lower Mainstem. All four populations are A-run. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Population-specific productivity estimates are available for the Upper Grande Ronde, Wallowa, and Joseph Creek populations. Population-specific estimates are not available for the Lower Grande Ronde population, so productivity and extinction risk are inferred from average A-run population estimates, coupled with Prospective Actions that are specific to this population. The estimated productivity based on all three metrics (R/S, lambda, and BRT trend) is expected to be greater than 1.0 for three of the four populations (Table 8.5.6-1; Figure 8.5.6-1). This means that with implementation of the Prospective Actions survival is expected to be sufficient for these populations to grow and for the abundance of spawners to trend upward. For the Upper Mainstem populations, all metrics except lambda, calculated with the assumption that hatchery-origin and natural-origin spawners are equally effective (HF=1), are greater than 1.0. The lambda HF=1 estimate for the Upper Mainstem is 0.99.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix; Figure 8.6.6-1). For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for estuarine survival and survival in tributaries as a result of the Prospective Actions, as described in Sections 8.5.5.1 through 8.5.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for this population are not solely driven by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "very low" to "moderate," as defined by the ICTRT (Table 8.5.2-2). As long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds, the MPG can achieve the ICTRT suggested viability scenario with moderate risk for these factors.

- The productivity estimates described above are based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario all populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.5.6-2). Under the ICTRT "Warm PDO" (poor) climate scenario, the results are nearly identical to results under recent climate conditions.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of base period short-term extinction risk indicate 21% risk at QET=50 for average A-run populations (indicative of the Lower Mainstem and Wallowa populations) and 0% extinction risk for the Joseph Creek and Upper Mainstem populations, which were estimated directly (Table 8.5.2-3).

As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Base period extinction risk for average A-run populations is estimated to be 5% risk at QET=1 and greater than 5% at all higher QETs (Table 8.5.2-3). These estimates do not take into account current survival rates or the effects of Prospective Actions that will be implemented quickly. Survival changes necessary to reduce short-term extinction risk to 5% could not be estimated for this species. Base-to-current survival improvements range from 1-2%, depending on population. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 11-14% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk for the populations in this MPG.

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for base period extinction risk range from 0 to 50% for these populations; Table 8.5.2-3). For this reason, other qualitative information is also considered:

- There is no safety-net hatchery program for these populations.

- The recent 10-year geometric mean abundance is 1226 spawners for the Upper Mainstem and 2132 spawners for Joseph Creek, both of which are far above the 50 fish QET (Table 8.5.2-1).

Abundance of the Lower Mainstem and Wallowa populations is unknown, but average A-run abundance was estimated by the ICTRT to be 456 fish, which is above the 50 fish QET. No years in the average A-Run data set are below 50 fish (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Imnaha River MPG

This MPG consists of one population (Imnaha River), which must be highly viable to achieve the ICTRT suggested MPG viability scenario. The Imnaha population exhibits the A-run life history pattern. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Population-specific productivity estimates are available for this population. Estimated productivity (based on all three metrics: R/S, lambda, and BRT trend) is expected to be greater than 1.0 for the Imnaha population (Table 8.5.6-1; Figure 8.5.6-1). This means that with implementation of the Prospective Actions, survival is expected to be sufficient for this population to grow and for the abundance of spawners to trend upward.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix; Figure 8.5.6-1). For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for estuarine survival and survival in the Imnaha River as a result of the Prospective Actions, as described in Sections 8.5.5.1 through 8.5.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for this population are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is “very low” to “moderate,” as defined by the ICTRT (Table 8.5.2-2). The MPG can achieve the ICTRT-suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- The productivity estimates described above are based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under “historical” and “Warm PDO” (poor) ocean scenarios this population is expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.5.6-2).

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Population-specific extinction risk is not available for the Imnaha population, so it is inferred from average A-run population estimates, coupled with Prospective Actions that are specific to this population. Quantitative estimates of *base period* extinction risk indicate 21% risk at QET=50 for average A-run populations (Table 8.5.2-3). As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Base period extinction risk for average A-run populations is estimated to be 5% risk at QET=1 and greater than 5% at all higher QETs (Table 8.5.2-3). These estimates do not take into account current survival rates or the effects of Prospective Actions that will be implemented quickly. Survival changes necessary to reduce short-term extinction risk to 5% cannot be estimated for this species. Base-to-current survival improvements are estimated to be 1% for this population. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 10% current-to-prospective survival change for this population). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk.

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for base period extinction risk range from 0 to 50% for average A-run populations; Table 8.5.2-3; Figure 8.5.6-1). For this reason, other qualitative information is also considered:

- There is no safety-net hatchery program for this population, but a supplementation hatchery program does preserves genetic resources.

- The recent 10-year geometric mean abundance for the Imnaha population is unknown, but average A-run abundance was estimated by the ICTRT to be 456 fish, which is above the 50 fish QET (Table 8.5.2-1). No years in the average A-Run data set are below 50 fish (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Salmon River MPG

This MPG consists of 12 extant populations. The ICTRT recommends that six of these populations be viable or highly viable for MPG viability. Eight of the populations are A-run and four of the populations are B-run. Key populations within this MPG include the South Fork Salmon (only "intermediate"-sized B-run population), the Upper Middle Fork Salmon (one of two "large" B-run populations; no history of hatchery influence), and Chamberlain Creek ("basic" sized A-run population with no history of hatchery influence). The ICTRT also suggests that two of the remaining six "intermediate"-sized populations be viable or highly viable (Lower Middle Fork, Little Salmon/Rapid River, Lemhi, Pahsimeroi, East Fork Salmon, and Upper Mainstem). Additionally, the ICTRT recommends that one additional population of any size be viable or highly viable. Please see Section 7.3 for a discussion of these MPG viability scenarios.

As discussed previously, population-specific estimates are not available for populations in this MPG, so productivity and extinction risk are inferred from average A-run and average B-run population estimates, coupled with Prospective Actions that are specific to each population. Estimated productivity (based on R/S) is expected to be greater than 1.0 for 8-9 populations, depending on prospective harvest assumptions (Table 8.5.6-1; Figure 8.5.6-1). This means that survival for 8-9 populations will be sufficient for the populations to grow. The Upper Middle Fork, Lower Middle Fork, South Fork, and (under one harvest assumption) the Secesh populations are expected to have R/S <1.0. All four of these populations are B-run and it would be necessary for two of them to be viable to achieve the TRT viability scenario. All 12 populations are expected to have lambda and BRT trend greater than 1.0, meaning that abundance of spawners is expected to increase.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix; Figure 8.5.6-1). This suggests that other qualitative information should also be considered:

- Life-stage specific survival rates are expected to improve for estuarine survival and survival in tributaries as a result of the Prospective Actions, as described in Sections 8.5.5.1 through 8.5.5.6. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "very low" to "moderate," as defined by the ICTRT, for all but one population (the Pahsimeroi; Table 8.5.2-2). For the remaining populations, the MPG can achieve the ICTRT-suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- The Pahsimeroi population currently has a "high" risk, as defined by the ICTRT, for spatial structure. This risk is due to the population occupying only 30% of its historical range and because of the geographic distance between its single major spawning area and the nearest adjacent population.

- The productivity estimates described above are based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. . Under the ICTRT "historical" ocean scenario, all populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix). Under the ICTRT "Warm PDO" (poor) climate assumption, results are nearly identical to those based on recent climate conditions.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Population-specific extinction risk is not available for the populations in this MPG, so it is inferred from average A-run and average B-run population estimates, coupled with Prospective Actions that are specific to each population. Quantitative estimates of *base period* extinction risk indicate 21% risk at QET=50 for average A-run populations and 5% for average B-run populations (Table 8.5.2.3). As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Base period extinction risk for average A-run populations is estimated to be 5% risk at QET=1 and greater than 5% at all higher QETs. These estimates do not take into account current survival rates or the effects of Prospective Actions that will be implemented quickly. Survival changes necessary to reduce short-term extinction risk to 5% could not be estimated for this species. Base-to-current survival improvements range from 0-7%, depending on population. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 10-27% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk of both A-run and B-run populations

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for A-Run base period extinction risk ranges from 0 to 50%; Table 8.5.2-3). For this reason, other qualitative information is also considered:

- There is no safety-net hatchery program for any of these populations, except the East Fork Salmon A-run population. This program increases the number of natural spawners and reduces extinction risk in the short-term.

- The recent 10-year geometric mean abundance for these populations is unknown. However, the ICTRT estimated average A-run abundance at 456 fish and average B-run abundance at 272 fish (Table 8.5.2-1), both of which are above the 50 fish QET. No years in either the average A-Run or average B-run data set are below 50 fish (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

8.5.7 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Snake River Steelhead DPS

This section summarizes the basis for conclusions at the DPS level.

8.5.7.1 Potential For Recovery

The future status of all populations and MPGs of SR steelhead will be improved compared to their current status through the implementation of Prospective Actions with beneficial effects, as described in Sections 8.5.5, 8.5.6, and 8.5.7.2. These actions include reduction of avian and fish predation, estuary habitat improvements, kelt reconditioning of B-run steelhead, and tributary habitat improvements for most populations. These beneficial actions also completely offset the slightly decreased A-run population survival associated with the harvest Prospective Action. For B-run populations, the harvest Prospective Action may represent decreased survival, which is offset by the beneficial actions if the "allowable" harvest rate is implemented. Conversely, it may represent increased B-run steelhead survival if the "expected" harvest rate is implemented (Section 8.5.5.5). Hydro actions are expected to remain at current survival levels. Therefore, the status of the DPS as a whole is expected to improve compared to its current condition and to move closer to a recovered condition. This conclusion takes into account some short-term adverse effects of Prospective Actions related to habitat improvements (Section 8.5.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this DPS.

The Prospective Actions described above address limiting factors and threats and will reduce their negative effects. As described in Section 8.5.1, key limiting factors and threats affecting the current status of this species (abundance, productivity, spatial structure, and diversity) include: hydropower development, predation, harvest, hatchery programs, and degradation of tributary and estuary habitat. The high spatial structure risk for the Panther Creek population is largely a result of past mining operations, which are being addressed through other processes including the EPA Blackbird Mine Superfund Site cleanup. In addition to Prospective Actions, Federal actions in the environmental baseline and non-Federal actions appropriately considered cumulative effects and also address limiting factors and threats. The ICTRT has indicated that the longer some hatchery programs continue, the more likely their effects will limit recovery potential. As described in Section 8.5.5.4, several ongoing hatchery programs that affect this DPS pose risks to diversity and natural productivity. The Prospective Actions include measures to ensure that hatchery management changes that have been implemented in recent years will continue, that safety-net hatchery programs will continue, and that further hatchery improvements will be implemented to reduce the likelihood of longer-term problems associated with continuing hatchery programs although subject to future hatchery-specific consultations after which these benefits may be realized.

The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays. Tributary habitat projects include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat, which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Some of the problems limiting recovery of SR steelhead, such as genetic diversity concerns, will probably take longer than 10 years to correct. However, actions included in the Prospective Actions represent significant improvements that reasonably can be implemented within the next 10 years.

Additionally, the Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In sum, these qualitative considerations suggest that the SR steelhead DPS will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of metrics indicating a trend toward recovery also support this conclusion. However, quantitative information is extremely limited for the Snake River steelhead DPS because of the difficulty of counting redds or fish during the spring and early summer spawning period. The ICTRT was able to estimate trends for only four populations in the Grande Ronde and Imnaha MPGs and abundance for only two populations. All other population estimates are inferred from average A-run and B-run estimates of base productivity, which are derived from dam counts and assumptions about the distribution of spawners within the DPS. These average base period estimates were then coupled with population-specific improvements in the Prospective Actions to derive population-specific estimates of prospective effects.

Return-per-spawner (R/S) estimates are indicative of natural survival rates (i.e., the estimates assume no future effects of hatchery supplementation). As such, they are somewhat conservative for populations with ongoing supplementation programs, 11 of which are described in Section 8.5.5.4, but R/S may be the best indicator of the ability of populations to be self-sustaining. R/S estimates incorporate many variables, including age structure and fraction of hatchery-origin spawners by year. The availability and quality of this information varies, so in some cases R/S estimates are less certain than lambda and BRT trend metrics.

As described in Section 8.5.6, with implementation of the Prospective Actions, R/S, lambda, and the BRT trend are expected to be greater than 1.0 for three of the four of the populations in the Imnaha and Grande Ronde MPGs for which the ICTRT developed population-specific base period estimates (Table 8.5.6-1 and Figure 8.5.6-1). For the fourth population, Grande Ronde Upper Mainstem, estimates were either greater than 1.0 or were very close (0.99). A-run populations and 2-4 of the eight B-run populations (depending on prospective harvest assumptions) are expected to have R/S greater than 1.0, based on average A- and B-run base productivity. This equates to R/S greater than 1.0 for 18-20 of the 24 populations with estimates. The 4-6 populations with estimates less than 1.0 are all composed of B-run steelhead and are components of the Clearwater and Salmon River MPGs. R/S is expected to be greater than 1.0 for all of the important populations identified by the ICTRT in the other three MPGs in this DPS.

Populations for which R/S is expected to be greater than 1.0 generally have estimates that are considerably greater than 1.0 (mean approximately 1.20). By providing additional benefits to stronger populations, the Prospective Actions help offset problems with poorly performing populations, supporting the viability of the DPS as a whole.

Some important caveats that apply to all three quantitative estimates are as follows:

- As described above, population-specific productivity is available for only four populations in the MPG – the remaining population estimates are extrapolations of average A- and B-run estimates from the ICTRT.

- Not all beneficial effects of the Prospective Actions could be quantified (e.g., habitat improvements that accrue over longer than a 10-year period), so quantitative estimates of prospective R/S and BRT trend may be low.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario, all populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.5.6-2). Under the ICTRT "Warm PDO" (poor) climate assumption, results are nearly identical to the results under the recent climate assumption.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

- The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, R/S and the BRT trend are expected to be greater than 1.0 at the upper 95% confidence limits for all populations and R/S and the BRT trend are expected to be less than 1.0 for all populations at the lower 95% confidence limits (SCA Aggregate Analysis Appendix; Figure 8.5.6-2). This uncertainty indicates that it is important to also consider qualitative factors in reaching conclusions.

Taken together, the combination of all the qualitative and quantitative factors discussed above indicates that the DPS as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. All populations are expected to increase in abundance in the future, based on lambda and BRT trends. NOAA Fisheries cannot demonstrate quantitatively by R/S >1.0, that all populations (including important populations in two MPGs) will have natural productivity sufficient to replace themselves and grow as a result of the actions considered in the aggregate analysis. However, the great majority of populations are likely to increase in abundance and enough populations are likely to be increasing to conclude that the DPS as a whole will be trending toward recovery.

This does not mean that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes in the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the DPS being on a trend toward recovery.

8.5.7.2 Short-Term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through net survival improvements resulting from the Prospective Actions and a continuation of other current management actions, as described above and in Sections 8.5.3 and 8.5.5.

As described above and in Section 8.5.6, abundance is expected to be increasing for all populations and natural productivity (R/S) is expected to be sufficient for most populations to grow (Table 8.5.6-1). Recent abundance levels for average A-run and B-run populations are estimated to be 456 and 272 spawners, respectively, which is well above the QET levels under consideration (Table 8.5.2-1). These factors also indicate a decreasing risk of extinction.

Hatchery supplementation programs preserve genetic resources and reduce short-term extinction risk by increasing abundance of four A-run and two B-run populations in the Tucannon, North Fork Clearwater, Pahsimeroi, and East Fork Salmon rivers. These programs insure that the affected populations will not go extinct in the short-term, although as described above they would increase diversity risk to the DPS if continued over a long time period.

The Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24-year) extinction risk also support this conclusion.

As described in Section 8.2.6, short-term extinction risk derived from performance during the base period is 0% at QET=50 for the two populations in this DPS for which population-specific estimates are available (Upper Grande Ronde and Joseph Creek; Table 8.5.2-3). For all other A-run populations, base period-derived short-term extinction risk is based on the A-run average: 21% at QET=50 and 5% at QET=1. As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. B-run base extinction risk was estimated to be 5% at QET=50. These estimates assume no continued supplementation.

It was not possible to determine the survival improvements needed to reduce extinction risk to 5% or less for any populations except those already below 5% during recent years. Base-to-current survival improvements range from 0-9%, depending on population. Some additional improvements will also accrue from Prospective Actions that are likely to be implemented immediately (an unknown proportion of the 10-39% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they will reduce the base period extinction risk of both A-run and B-run populations.

Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change were considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

The mean base period short-term extinction risk estimates represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While we do not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from near 0% to 50% for average A-run populations (Table 8.5.2-3). This uncertainty indicates that it is important also to consider qualitative factors in reaching conclusions.

Taken together, the combination of all the factors above indicates that the DPS as a whole is likely to have a low risk of short-term extinction when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements result in lower short-term extinction risk than in recent years. NOAA Fisheries cannot demonstrate quantitatively that all populations or all MPGs will have a low risk, primarily because of data limitations and significant uncertainty in the estimates for base period performance. However, the combination of recent abundance estimates for average populations, expected survival improvements, expected positive trends for most populations, and supplementation programs that reduce short-term risk for some populations, indicate that enough populations are likely to have a low enough risk to conclude that the DPS, as a whole, will have a low risk of short-term extinction.

8.5.7.3 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for SR steelhead including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in the following subbasins: Hells Canyon, Imnaha River, Lower

Snake/Asotin, Upper Grande Ronde River, Wallowa River, Lower Grande Ronde, Lower Snake/Tucannon, Lower Snake River, Upper Salmon, Pahsimeroi, Middle Salmon-Panther, Lemhi, Upper Middle Fork Salmon, Lower Middle Fork Salmon, Middle Salmon-Chamberlain, South Fork Salmon, Lower Salmon, Little Salmon, Upper Selway, Lower Selway, Lochsa, Middle Fork Clearwater, South Fork Clearwater, and Clearwater. The environmental baseline within the action area, which encompasses all of these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for SR steelhead. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Snake and Columbia rivers; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, excess sediment in gravel, and high summer temperatures in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at Little Goose, Lower Monumental, McNary, and John Day dams, in concert with training spill to provide safe egress (i.e., avoid predators), will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles. Habitat work in tributaries used for spawning and rearing and in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.5.2-1. Status of SR steelhead with respect to abundance and productivity VSP factors. Productivity is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY). Italicized estimates represent application of average A-run and B-run estimates to individual A-run and B-run populations lacking population-specific estimates.

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	**MPG**	**Population**	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: 20-yr non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope: 1980 - Current[4]	Lower 95% CI	Upper 95% CI
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		456	1995-2004	1000	1.09	0.56	2.12	1.05	0.50	2.23	1.05	0.50	2.23	1.01	0.94	1.22
	Average "B-Run" Populations (only 13 years)		272	1995-2004	1000	0.80	0.52	1.22	1.00	0.63	1.58	1.00	0.63	1.58	0.96	0.90	1.10
	Lower Snake	Tucannon (A, but below LGR)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Asotin (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
	Imnaha River	Imnaha R. (A)			1000	1.45	0.94	2.24	1.06	0.82	1.37	1.06	0.82	1.37	1.03	0.99	1.14
	Grande Ronde	Upper Mainstem (A)	1226	1997-2006	1500	0.93	0.65	1.33	0.99	0.83	1.17	0.96	0.81	1.13	0.99	0.95	1.07
		Lower Mainstem (A)			*1000*	*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Joseph Cr. (A)	2132	1996-2005	500	1.26	0.84	1.89	1.05	0.82	1.35	1.05	0.82	1.35	1.01	0.97	1.11
		Wallowa R. (A)			1000	1.28	0.94	1.75	1.05	0.82	1.34	1.04	0.81	1.34	1.03	0.99	1.20
	Clearwater River	Lower Mainstem (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Lolo Creek (A & B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		Lochsa River (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		Selway River (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		South Fork (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Chamberlain Cr. (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Secesh River (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		South Fork Salmon (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		Panther Creek (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Lower Middle Fork Tribs (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		Upper Middle Fork Tribs (B)				*0.80*	*0.52*	*1.22*	*1.00*	*0.63*	*1.58*	*1.00*	*0.63*	*1.58*	*0.96*	*0.90*	*1.10*
		North Fork (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Lemhi River (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Pahsimeroi River (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		East Fork Salmon (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*
		Upper Mainstem (A)				*1.09*	*0.56*	*2.12*	*1.05*	*0.50*	*2.23*	*1.05*	*0.50*	*2.23*	*1.01*	*0.94*	*1.22*

1 Most recent year for 10-year geometric mean abundance is 2003-2005, depending upon the population. ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from the ICTRT (2007c).
2 Mean returns-per-spawner are estimated from the most recent period of approximately 20 years (Upper Grande Ronde,Imnaha River, Wallowa River, and Joseph Creek) or 13-14 years (average A- and B-run), as described in Cooney (2008a).
3 Median population growth rate (lambda) during the most recent period of approximately 20 years from Cooney (2008b). Actual years in estimates vary by population.
4 Biological Review Team (Good et al. 2005) trend estimates and 95% confidence limits updated for recent years in Cooney (2008b).

Table 8.5.2-2. Status of SR steelhead with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	ICTRT Current Risk For Spatial Structure[1]	ICTRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Snake River Steelhead	Average "A-Run" Populations (only 14 years)				
	Average "B-Run" Populations (only 13 years)				
	Lower Snake	Tucannon (A, but below LGR)	Currently Low Risk	Currently Moderate Risk	
		Asotin (A)	Currently Low Risk	Currently Moderate Risk	
	Imnaha River	Imnaha R. (A)	Currently Very Low Risk	Currently Moderate Risk	1.00
	Grande Ronde	Upper Mainstem (A)	Currently Very Low Risk	Currently Moderate Risk	0.86
		Lower Mainstem (A)	N/A	N/A	
		Joseph Cr. (A)	Currently Very Low Risk	Currently Low Risk	1.00
		Wallowa R. (A)	Currently Very Low Risk	Currently Low Risk	1.00
	Clearwater River	Lower Mainstem (A)	Currently Very Low Risk	Currently Low Risk	
		Lolo Creek (A & B)	Currently Low Risk	Currently Moderate Risk	
		Lochsa River (B)	Currently Very Low Risk	Currently Low Risk	
		Selway River (B)	Currently Very Low Risk	Currently Low Risk	
		South Fork (B)	Currently Low Risk	Currently Moderate Risk	
		North Fork - (Extirpated)			
	Salmon River	Little Salmon/Rapid (A)	Currently Very Low Risk	Currently Low Risk	
		Chamberlain Cr. (A)	Currently Low Risk	Currently Low Risk	
		Secesh River (B)	Currently Very Low Risk	Currently Low Risk	
		South Fork Salmon (B)	Currently Low Risk	Currently Low Risk	
		Panther Creek (A)	Currently High Risk (Only occupy 30% of historic range, gap between single MaSA and adjacent pops)	Currently Moderate Risk	
		Lower Middle Fork Tribs (B)	Currently Low Risk	Currently Moderate Risk	
		Upper Middle Fork Tribs (B)	Currently Very Low Risk	Currently Low Risk	
		North Fork (A)	Currently Low Risk	Currently Moderate Risk	
		Lemhi River (A)	Currently Low Risk	Currently Moderate Risk	
		Pahsimeroi River (A)	Currently Moderate Risk	Currently Moderate Risk	
		East Fork Salmon (A)	Currently Very Low Risk	Currently Moderate Risk	
		Upper Mainstem (A)	Currently Very Low Risk	Currently Moderate Risk	

1 ICTRT conclusions for Snake River steelhead are from draft versions of ICTRT Current Status Summaries (ICTRT 2007d)
2 Average fractions of natural-origin natural spawners are from the ICTRT (2007c).

Table 8.5.2-3. Status of SR steelhead with respect to extinction risk. Extinction risk is estimated from performance during the "base period" of the approximately 20 most recent brood years. Italicized estimates represent application of average A-run and B-run estimates to individual A-run and B-run populations lacking population-specific estimates.

			24-Year Extinction Risk											
ESU	MPG	Population	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
	Average "B-Run" Populations (only 13 years)		0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
	Lower Snake	Tucannon (A, but below LGR)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Asotin (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
	Imnaha River	Imnaha R. (A)	*0.05*	*0.00*	*0.28*	*0.10*	*0.00*	*0.37*	*0.16*	*0.00*	*0.44*	*0.21*	*0.00*	*0.49*
	Grande Ronde	Upper Mainstem (A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
		Lower Mainstem (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Joseph Cr. (A)	0.00	0.00	0.03	0.00	0.00	0.10	0.00	0.00	0.15	0.00	0.00	0.19
		Wallowa R. (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
	Clearwater River	Lower Mainstem (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Lolo Creek (A & B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		Lochsa River (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		Selway River (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		South Fork (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		North Fork - (Extirpated)												
	Salmon River	Little Salmon/Rapid (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Chamberlain Cr. (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Secesh River (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		South Fork Salmon (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		Panther Creek (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Lower Middle Fork Tribs (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		Upper Middle Fork Tribs (B)	0.00	0.00	0.18	0.02	0.00	0.29	0.03	0.00	0.36	0.05	0.00	0.41
		North Fork (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Lemhi River (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Pahsimeroi River (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		East Fork Salmon (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49
		Upper Mainstem (A)	0.05	0.00	0.28	0.10	0.00	0.37	0.16	0.00	0.44	0.21	0.00	0.49

1 Short-term (24-year) extinction risk and 95% confidence limits from Hinrichsen (2008), in the SCA Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.5.2-4. Changes in density-independent survival of SR steelhead ("gaps") necessary for indices of productivity equal to 1.0 and estimates of extinction risk no higher than 5% for SR steelhead. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated "gaps" are based on population performance during the "base period" of approximately the last 20 brood years or spawning years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%. Italicized estimates represent application of average A-run and B-run estimates to individual A-run and B-run populations lacking population-specific estimates.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 1980-current BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.92	1.80	0.47	0.79	>10	0.03	0.79	>10	0.03	0.94	1.35	0.41				
	Average "B-Run" Populations (only 13 years)		1.25	1.91	0.82	1.00	7.88	0.13	1.00	7.88	0.13	1.21	1.60	0.66				
	Lower Snake	Tucannon (A, but below LGR)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Asotin (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
	Imnaha River	Imnaha R. (A)	*0.69*	*1.07*	*0.45*	0.77	2.50	0.24	0.77	2.50	0.24	*0.89*	*1.07*	*0.56*				
	Grande Ronde	Upper Mainstem (A)	1.08	1.55	0.75	1.07	2.28	0.50	1.23	2.65	0.57	1.07	1.24	0.75				
		Lower Mainstem (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Joseph Cr. (A)	0.79	1.19	0.53	0.81	2.50	0.26	0.81	2.50	0.26	0.94	1.12	0.62				
		Wallowa R. (A)	*0.78*	*1.07*	*0.57*	0.82	2.46	0.27	0.83	2.54	0.27	*0.89*	*1.04*	*0.44*				
	Clearwater River	Lower Mainstem (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Lolo Creek (A & B)-assume B	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		Lochsa River (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		Selway River (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		South Fork (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		North Fork - (Extirpated)																
	Salmon River	Little Salmon/Rapid (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Chamberlain Cr. (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Secesh River (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		South Fork Salmon (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		Panther Creek (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Lower Middle Fork Tribs (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		Upper Middle Fork Tribs (B)	*1.25*	*1.91*	*0.82*	1.00	7.88	0.13	1.00	7.88	0.13	*1.21*	*1.60*	*0.66*				
		North Fork (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Lemhi River (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Pahsimeroi River (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		East Fork Salmon (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				
		Upper Mainstem (A)	*0.92*	*1.80*	*0.47*	0.79	>10	0.03	0.79	>10	0.03	*0.94*	*1.35*	*0.41*				

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.5.2-1.
2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.5.2-1) ^ Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.5.2-1) ^ Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
4 Extinction risk survival gap could not be calculated for this species.

Table 8.5.3-1. Proportional changes in SR steelhead average base period survival expected from completed actions and current human activities that are likely to continue into the future. Factors greater than one result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average).

			Base-to-Current Adjustment (Divisor)							
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Marine Mammal Predation[5]	Harvest[6]	Hatcheries[7]	Total[8]
Snake River Steelhead	Average "A-Run" Populations (only 14 years)									
	Average "B-Run" Populations (only 13 years)									
	Lower Snake	Tucannon (A, but below LGR)	0.966	1.065	1.003	0.996	1.000	1.041	1.00	1.07
		Asotin (A)	0.966	1.085	1.003	0.996	1.000	1.041	1.00	1.09
	Imnaha River	Imnaha R. (A)	0.966	1.001	1.003	0.996	1.000	1.041	1.00	1.01
	Grande Ronde	Upper Mainstem (A)	0.966	1.020	1.003	0.996	1.000	1.041	1.00	1.02
		Lower Mainstem (A)	0.966	1.001	1.003	0.996	1.000	1.041	1.00	1.01
		Joseph Cr. (A)	0.966	1.020	1.003	0.996	1.000	1.041	1.00	1.02
		Wallowa R. (A)	0.966	1.020	1.003	0.996	1.000	1.041	1.00	1.02
	Clearwater River	Lower Mainstem (A)	0.966	1.025	1.003	0.996	1.000	1.041	1.00	1.03
		Lolo Creek (A & B)	0.966	1.005	1.003	0.996	1.000	1.040	1.00	1.01
		Lochsa River (B)	0.966	1.005	1.003	0.996	1.000	1.040	1.00	1.01
		Selway River (B)	0.966	1.007	1.003	0.996	1.000	1.040	1.00	1.01
		South Fork (B)	0.966	1.015	1.003	0.996	1.000	1.040	1.00	1.02
		North Fork - (Extirpated)								
	Salmon River	Little Salmon/Rapid (A)	0.966	1.005	1.003	0.996	1.000	1.041	1.00	1.01
		Chamberlain Cr. (A)	0.966	1.000	1.003	0.996	1.000	1.041	1.00	1.00
		Secesh River (B)	0.966	1.000	1.003	0.996	1.000	1.040	1.00	1.00
		South Fork Salmon (B)	0.966	1.000	1.003	0.996	1.000	1.040	1.00	1.00
		Panther Creek (A)	0.966	1.000	1.003	0.996	1.000	1.041	1.00	1.00
		Lower Middle Fork Tribs (B)	0.966	1.000	1.003	0.996	1.000	1.040	1.00	1.00
		Upper Middle Fork Tribs (B)	0.966	1.000	1.003	0.996	1.000	1.040	1.00	1.00
		North Fork (A)	0.966	1.000	1.003	0.996	1.000	1.041	1.00	1.00
		Lemhi River (A)	0.966	1.005	1.003	0.996	1.000	1.041	1.00	1.01
		Pahsimeroi River (A)	0.966	1.065	1.003	0.996	1.000	1.041	1.00	1.07
		East Fork Salmon (A)	0.966	1.005	1.003	0.996	1.000	1.041	1.00	1.01
		Upper Mainstem (A)	0.966	1.005	1.003	0.996	1.000	1.041	1.00	1.01

1 From SCA Hydro Modeling Appendix Based on differences in average base and current smolt-to-adult survival estimates.
2 From CA Chapter 7, Table 7-6.

3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Current 2 S/Baseline 2 S" approach, as described in Attachment F-2.
5 From SCA Marine Mammal Appendix. No populations in this DPS are winter-run.
6 From SCA Quantitative Analysis of Harvest Actions Appendix). Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup, modified to reflect the current maximum harvest rate for B-run steelhead.
7 Hatchery changes are discussed qualitatively.
8 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column.

Table 8.5.5-1. Proportional changes in SR steelhead survival expected from the Prospective Actions. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Divisor)									
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2] (2007-2017)	Estuary Habitat[3]	Bird Predation[4]	Pike-minnow Predation[5]	Kelt Reconditioning[6]	Marine Mammal[7]	Allowable Harvest8	Expected Harvest[8]	Hatcheries9
Snake River Steelhead	Average "A-Run" Populations (only 14 years)											
	Average "B-Run" Populations (only 13 years)											
	Lower Snake	Tucannon (A, but below LGR)	1.00	1.05	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Asotin (A)	1.00	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
	Imnaha River	Imnaha R. (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
	Grande Ronde	Upper Mainstem (A)	1.00	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Lower Mainstem (A)	1.00	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Joseph Cr. (A)	1.00	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Wallowa R. (A)	1.00	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
	Clearwater River	Lower Mainstem (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Lolo Creek (A & B)	1.00	1.08	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		Lochsa River (B)	1.00	1.16	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		Selway River (B)	1.00	1.01	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		South Fork (B)	1.00	1.14	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		North Fork - (Extirpated)										
	Salmon River	Little Salmon/Rapid (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Chamberlain Cr. (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Secesh River (B)	1.00	1.06	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		South Fork Salmon (B)	1.00	1.01	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		Panther Creek (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Lower Middle Fork Tribs (B)	1.00	1.02	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		Upper Middle Fork Tribs (B)	1.00	1.00	1.06	1.03	1.01	1.06	1.00	0.97	1.02	1.00
		North Fork (A)	1.00	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Lemhi River (A)	1.00	1.03	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Pahsimeroi River (A)	1.00	1.09	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		East Fork Salmon (A)	1.00	1.02	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Upper Mainstem (A)	1.00	1.06	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00

Table 8.5.5-1. Continued.

			Current-to-Future Adjustment (Divisor)					High	Low
ESU	MPG	Population	Non-Hydro With Allowable Harvest[10]	Non-Hydro With Expected Harvest[10]	Total (Allowable Harvest)[11]	Total (Expected Harvest)[11]		Total Base-Current and Current-Future[12]	Total Base-Current and Current-Future[12]
	Average "A-Run" Populations (only 14 years)								
	Average "B-Run" Populations (only 13 years)								
	Lower Snake	Tucannon (A, but below LGR)	1.15	1.15	1.16	1.16		1.24	1.24
		Asotin (A)	1.14	1.14	1.14	1.14		1.25	1.25
	Imnaha River	Imnaha R. (A)	1.10	1.10	1.10	1.10		1.11	1.11
	Grande Ronde	Upper Mainstem (A)	1.14	1.14	1.14	1.14		1.17	1.17
		Lower Mainstem (A)	1.11	1.11	1.11	1.11		1.12	1.12
		Joseph Cr. (A)	1.14	1.14	1.14	1.14		1.17	1.17
		Wallowa R. (A)	1.11	1.11	1.11	1.11		1.13	1.13
Snake River Steelhead	Clearwater River	Lower Mainstem (A)	1.10	1.10	1.10	1.10		1.13	1.13
		Lolo Creek (A & B)	1.23	1.29	1.23	1.29		1.24	1.30
		Lochsa River (B)	1.32	1.39	1.32	1.39		1.33	1.40
		Selway River (B)	1.15	1.21	1.15	1.21		1.16	1.22
		South Fork (B)	1.30	1.36	1.30	1.36		1.32	1.39
		North Fork - (Extirpated)							
	Salmon River	Little Salmon/Rapid (A)	1.10	1.10	1.10	1.10		1.11	1.11
		Chamberlain Cr. (A)	1.10	1.10	1.10	1.10		1.11	1.11
		Secesh River (B)	1.21	1.27	1.21	1.27		1.21	1.27
		South Fork Salmon (B)	1.14	1.20	1.15	1.20		1.15	1.21
		Panther Creek (A)	1.10	1.10	1.10	1.10		1.11	1.11
		Lower Middle Fork Tribs (B)	1.16	1.22	1.16	1.22		1.17	1.23
		Upper Middle Fork Tribs (B)	1.14	1.20	1.14	1.20		1.14	1.20
		North Fork (A)	1.10	1.10	1.10	1.10		1.11	1.11
		Lemhi River (A)	1.13	1.13	1.13	1.13		1.14	1.14
		Pahsimeroi River (A)	1.20	1.20	1.20	1.20		1.28	1.28
		East Fork Salmon (A)	1.12	1.12	1.12	1.12		1.13	1.13
		Upper Mainstem (A)	1.17	1.17	1.17	1.17		1.18	1.18

1 From SCA Hydro Modeling Appendix. Based on differences in average current and prospective smolt-to-adult survival estimates.
2 From CA Chapter 7, Table 7-6.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 From SCA Steelhead Kelt Appendix
7 From Supplemental Comprehensive Analysis, SCA Marine Mammal Appendix. No populations in this DPS are winter-run.
8 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
9No quantitative survival changes have been estimated to result from hatchery Prospective Actions – future effects are qualitative.

10 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
11 Same as Footnote 8, except it is calculated from all Prospective Actions, including hydro actions.
12 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier from Table 8.8.3-1.

Table 8.5.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for SR steelhead.

Expected Harvest Assumption:										
ESU	**MPG**	**Population**	**20-Yr R/S Recent Climate[1]**	**20-yr lambda Recent Climate @ HF=0[2]**	**20-yr lambda Recent Climate @ HF=1[3]**	**1980-Current BRT Trend Recent Climate[3]**	**ICTRT MPG Viability Scenario[4]**	**Recovery Prong Notes for Abundance/Productivity**	**Recovery Prong Notes for Spatial Structure[5]**	**Recovery Prong Notes for Diversity[5]**
Snake River Steelhead	Average "A-Run" Populations (only 14 years)									
	Average "B-Run" Populations (only 13 years)									
							Need 1 HV and 1 V:			
	Lower Snake	Tucannon (A, but below LGR)	*1.34*	*1.10*	*1.10*	*1.25*	Must be HV or V	All three metrics >1. Estimates assume average A run base productivity.	Currently Low Risk	Currently Moderate Risk
		Asotin (A)	*1.36*	*1.11*	*1.11*	*1.27*	Must be HV or V	All three metrics >1. Estimates assume average A run base productivity.	Currently Low Risk	Currently Moderate Risk
	Imnaha River	Imnaha R. (A)	1.60	1.08	1.08	1.14	Must be HV	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
							Need 1 HV and 1 V:			
	Grande Ronde	Upper Mainstem (A)	1.09	1.02	0.99	1.16	Must be HV or V	Three metrics >1, but lambda with HF=1 assumption is 0.99.	Currently Very Low Risk	Currently Moderate Risk
		Lower Mainstem (A)	*1.22*	*1.08*	*1.08*	*1.13*	1 of these 2 populations must be HV or V	All three metrics >1. Estimates assume average A run base productivity. Both populations in this group meet criteria.	N/A	N/A
		Joseph Cr. (A)	1.48	1.09	1.09	1.19		All three metrics >1. Both populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		Wallowa R. (A)	1.45	1.07	1.07	1.16	"Maintained" Population	All three metrics >1	Currently Very Low Risk	Currently Low Risk
							Need 1 HV and 3 V:			
	Clearwater River	Lower Mainstem (A)	*1.23*	*1.08*	*1.08*	*1.15*	Must be HV or V	All three metrics >1. Estimates assume average A run base productivity.	Currently Very Low Risk	Currently Low Risk
		Lolo Creek (A & B)	*1.04*	*1.06*	*1.06*	*1.25*	Must be HV or V	All three metrics >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Moderate Risk
		Lochsa River (B)	*1.12*	*1.08*	*1.08*	*1.34*	2 of these 3 populations must be HV or V	All three metrics >1. Estimates assume average B-run base productivity. Two of three populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		Selway River (B)	*0.98*	*1.05*	*1.05*	*1.17*		R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Low Risk
		South Fork (B)	*1.11*	*1.08*	*1.08*	*1.33*		All three metrics >1. Estimates assume average B-run base productivity. Two of three populations in this group meet criteria.	Currently Very Low Risk	Currently Moderate Risk
		North Fork - (Extirpated)								
							Need 1 HV and 5 V:			
	Salmon River	Upper Middle Fork Tribs (B)	*0.96*	*1.04*	*1.04*	*1.15*	Must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Low Risk
		Chamberlain Cr. (A)	*1.20*	*1.08*	*1.08*	*1.12*	Must be HV or V	All three metrics >1. Estimates assume average A run base productivity.	Currently Low Risk	Currently Low Risk
		South Fork Salmon (B)	*0.97*	*1.04*	*1.04*	*1.16*	Must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Low Risk	Currently Low Risk
		Panther Creek (A)	*1.20*	*1.08*	*1.08*	*1.12*	1 of these 3 populations must be HV or V	All three metrics >1. Estimates assume average A run base productivity. All three populations in this group meet criteria.	Currently High Risk (Only occupy 30% of historic range, gap between single MaSA and adjacent pops)	Currently Moderate Risk
		Secesh River (B)	*1.02*	*1.06*	*1.06*	*1.22*		All three metrics >1. Estimates assume average B-run base productivity. All three populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		North Fork (A)	*1.20*	*1.08*	*1.08*	*1.12*		All three metrics >1. Estimates assume average A run base productivity. All three populations in this group meet criteria.	Currently Low Risk	Currently Moderate Risk
		Lower Middle Fork Tribs (B)	*0.98*	*1.05*	*1.05*	*1.17*	2 of these 6 populations must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Low Risk	Currently Moderate Risk
		Little Salmon/Rapid (A)	*1.21*	*1.08*	*1.08*	*1.13*		All three metrics >1. Estimates assume average A run base productivity. Four of 5 populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		Lemhi River (A)	*1.24*	*1.09*	*1.09*	*1.16*		All three metrics >1. Estimates assume average A run base productivity. Four of 5 populations in this group meet criteria.	Currently Low Risk	Currently Moderate Risk
		Pahsimeroi River (A)	*1.40*	*1.11*	*1.11*	*1.30*		All three metrics >1. Estimates assume average A run base productivity. Four of 5 populations in this group meet criteria.	Currently Moderate Risk	Currently Moderate Risk
		East Fork Salmon (A)	*1.23*	*1.08*	*1.08*	*1.15*		All three metrics >1. Estimates assume average A run base productivity. Four of 5 populations in this group meet criteria.	Currently Very Low Risk	Currently Moderate Risk
		Upper Mainstem (A)	*1.28*	*1.09*	*1.09*	*1.19*		All three metrics >1. Estimates assume average A run base productivity. Four of 5 populations in this group meet criteria.	Currently Very Low Risk	Currently Moderate Risk

Table 8.5.6.1-1. Continued.

Allowable Harvest Assumption:

ESU	MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Snake River Steelhead	Average "A-Run" Populations (only 14 years)									
	Average "B-Run" Populations (only 13 years)									
							Need 1 HV and 1 V:			
	Lower Snake	Tucannon (A, but below LGR)	1.34	1.10	1.10	1.25	Must be HV or V	All three metrics >1. Estimates assume average A-run base productivity.	Currently Low Risk	Currently Moderate Risk
		Asotin (A)	1.36	1.11	1.11	1.27	Must be HV or V	All three metrics >1. Estimates assume average A-run base productivity.	Currently Low Risk	Currently Moderate Risk
	Imnaha River	Imnaha R. (A)	1.60	1.08	1.08	1.14	Must be HV	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
							Need 1 HV and 1 V:			
	Grande Ronde	Upper Mainstem (A)	1.09	1.02	0.99	1.16	Must be HV or V	Three metrics >1, but lambda with HF=1 assumption is 0.99.	Currently Very Low Risk	Currently Moderate Risk
		Lower Mainstem (A)	1.22	1.08	1.08	1.13	1 of these 2 populations must be HV or V	All three metrics >1. Estimates assume average A-run base productivity. Both populations in this group meet criteria.	N/A	N/A
		Joseph Cr. (A)	1.48	1.09	1.09	1.19		All three metrics >1. Both populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		Wallowa R. (A)	1.45	1.07	1.07	1.16	"Maintained" Population	All three metrics >1	Currently Very Low Risk	Currently Low Risk
							Need 1 HV and 3 V:			
	Clearwater River	Lower Mainstem (A)	1.23	1.08	1.08	1.15	Must be HV or V	All three metrics >1. Estimates assume average A-run base productivity.	Currently Very Low Risk	Currently Low Risk
		Lolo Creek (A & B)	0.99	1.05	1.05	1.19	Must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Low Risk	Currently Moderate Risk
		Lochsa River (B)	1.07	1.07	1.07	1.28	2 of these 3 populations must be HV or V	All three metrics >1. Estimates assume average B-run base productivity. One of two populations in this group to meet criteria.	Currently Very Low Risk	Currently Low Risk
		Selway River (B)	0.93	1.03	1.03	1.11		R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Low Risk
		South Fork (B)	1.06	1.06	1.06	1.27		All three metrics >1. Estimates assume average B-run base productivity. Two of three populations in this group meet criteria.	Currently Low Risk	Currently Moderate Risk
		North Fork - (Extirpated)								
							Need 1 HV and 5 V:			
	Salmon River	Upper Middle Fork Tribs (B)	0.91	1.03	1.03	1.10	Must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Low Risk
		Chamberlain Cr. (A)	1.20	1.08	1.08	1.12	Must be HV or V	All three metrics >1. Estimates assume average A-run base productivity.	Currently Low Risk	Currently Low Risk
		South Fork Salmon (B)	0.92	1.03	1.03	1.10	Must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Low Risk	Currently Low Risk
		Panther Creek (A)	1.20	1.08	1.08	1.12	1 of these 3 populations must be HV or V	All three metrics >1. Estimates assume average A-run base productivity. Two of three populations in this group to meet criteria.	Currently High Risk (Only occupy 30% of historic range, gap between single MaSA and adjacent pops)	Currently Moderate Risk
		Secesh River (B)	0.97	1.04	1.04	1.16		R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Very Low Risk	Currently Low Risk
		North Fork (A)	1.20	1.08	1.08	1.12		All three metrics >1. Estimates assume average A-run base productivity. Two of three populations in this group to meet criteria.	Currently Low Risk	Currently Moderate Risk
		Lower Middle Fork Tribs (B)	0.93	1.03	1.03	1.12	2 of these 6 populations must be HV or V	R/S <1 but lambda and BRT trend >1. Estimates assume average B-run base productivity.	Currently Low Risk	Currently Moderate Risk
		Little Salmon/Rapid (A)	1.21	1.08	1.08	1.13		All three metrics >1. Estimates assume average A-run base productivity. Four of five populations in this group meet criteria.	Currently Very Low Risk	Currently Low Risk
		Lemhi River (A)	1.24	1.09	1.09	1.16		All three metrics >1. Estimates assume average A-run base productivity. Four of five populations in this group meet criteria.	Currently Low Risk	Currently Moderate Risk
		Pahsimeroi River (A)	1.40	1.11	1.11	1.30		All three metrics >1. Estimates assume average A-run base productivity. Four of five populations in this group meet criteria.	Currently Moderate Risk	Currently Moderate Risk
		East Fork Salmon (A)	1.23	1.08	1.08	1.15		All three metrics >1. Estimates assume average A-run base productivity. Four of five populations in this group meet criteria.	Currently Very Low Risk	Currently Moderate Risk
		Upper Mainstem (A)	1.28	1.09	1.09	1.19		All three metrics >1. Estimates assume average A-run base productivity. Four of five populations in this group meet criteria.	Currently Very Low Risk	Currently Moderate Risk

1 Calculated as the base period 20-year R/S productivity from Table 8.5.2-1, multiplied by the total base-to-future survival multiplier in Table 8.5.5-1.
2 Calculated as the base period 20-year mean population growth rate (lambda) from Table 8.5.2-1, multiplied by the total base-to-future survival multiplier in Table 8.5.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
3 Calculated as the base period 20-year mean BRT abundance trend from Table 8.5.2-1, multiplied by the total base-to-future survival multiplier in Table 8.5.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007c), Attachment 2
5 From Table 8.5.2-2.

Figure 8.5.6-1. Summary of prospective mean R/S estimates for SR steelhead under the "recent" climate assumption, including 95% confidence limits.

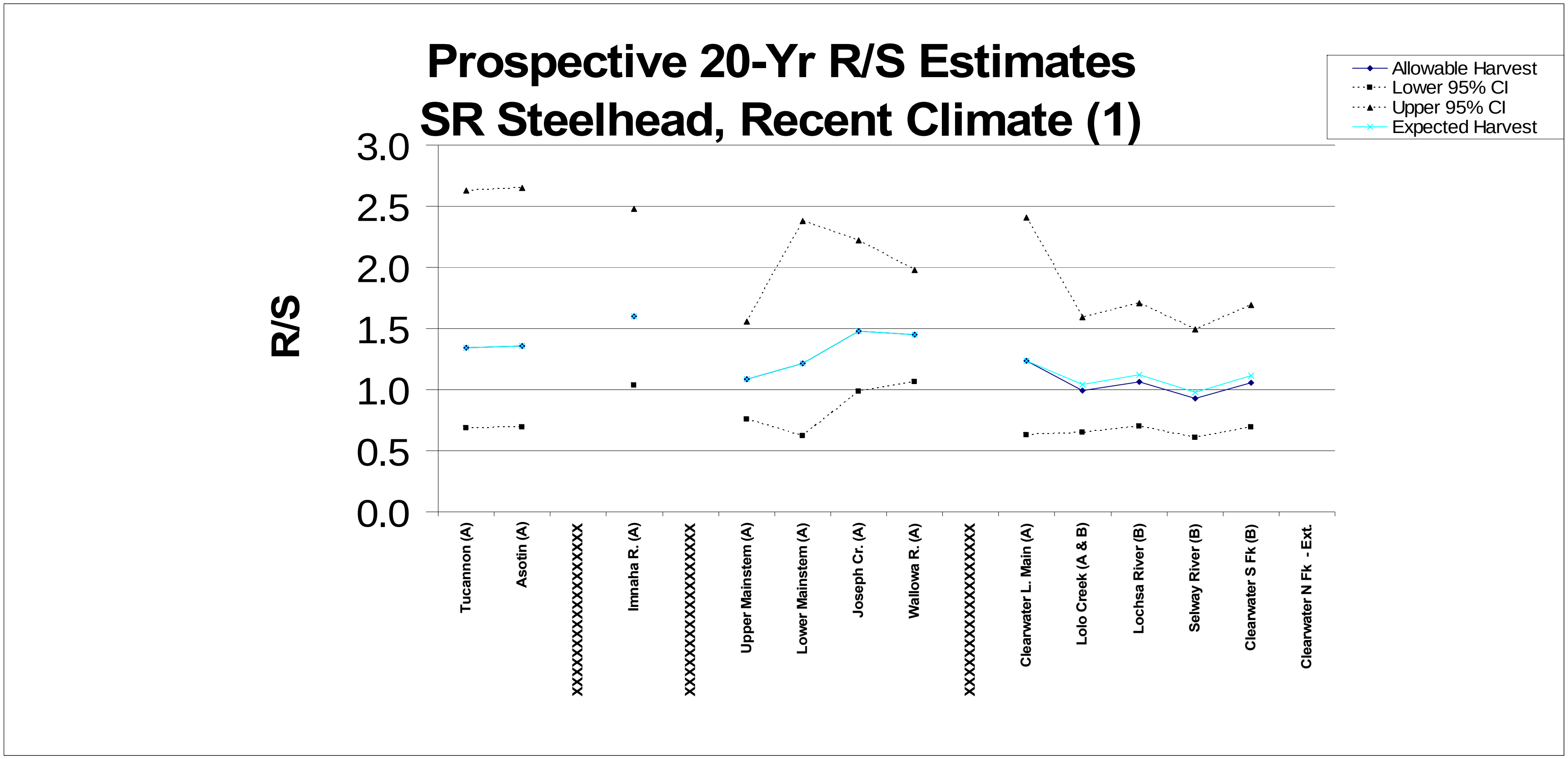


Figure 8.5.6-1. Continued.

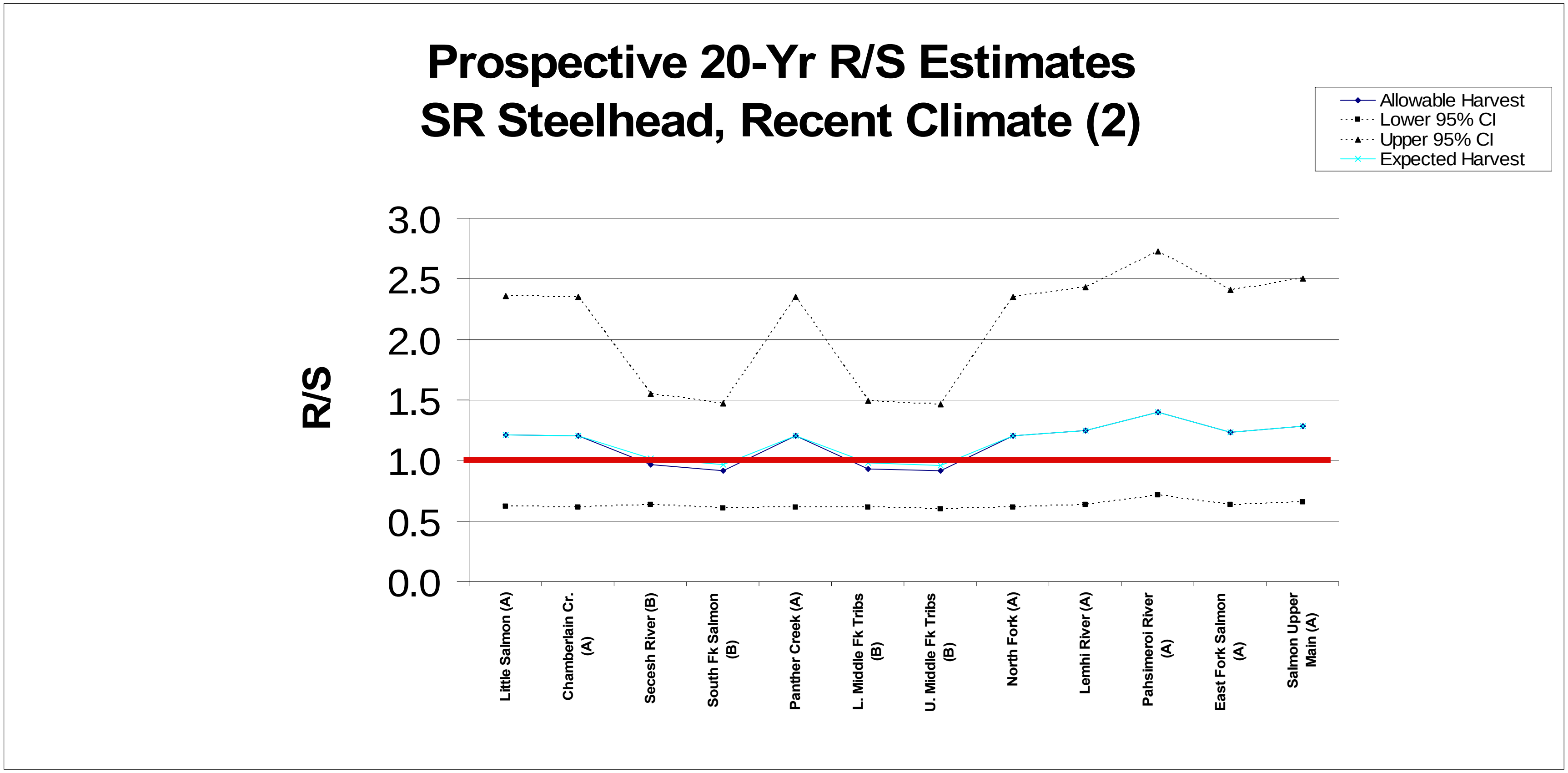


Figure 8.5.6-2. Summary of prospective mean R/S estimates for SR steelhead under three climate assumptions.

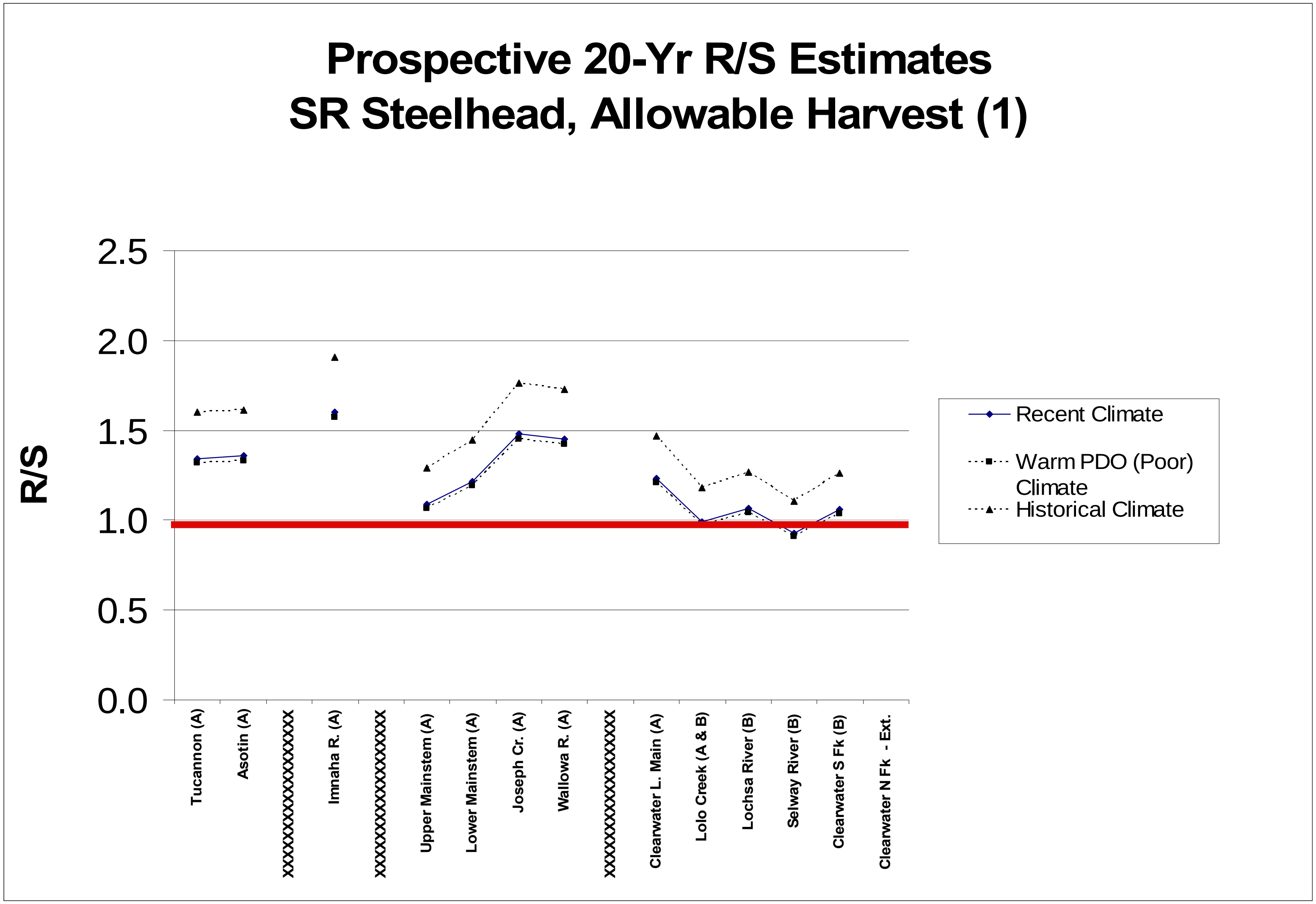
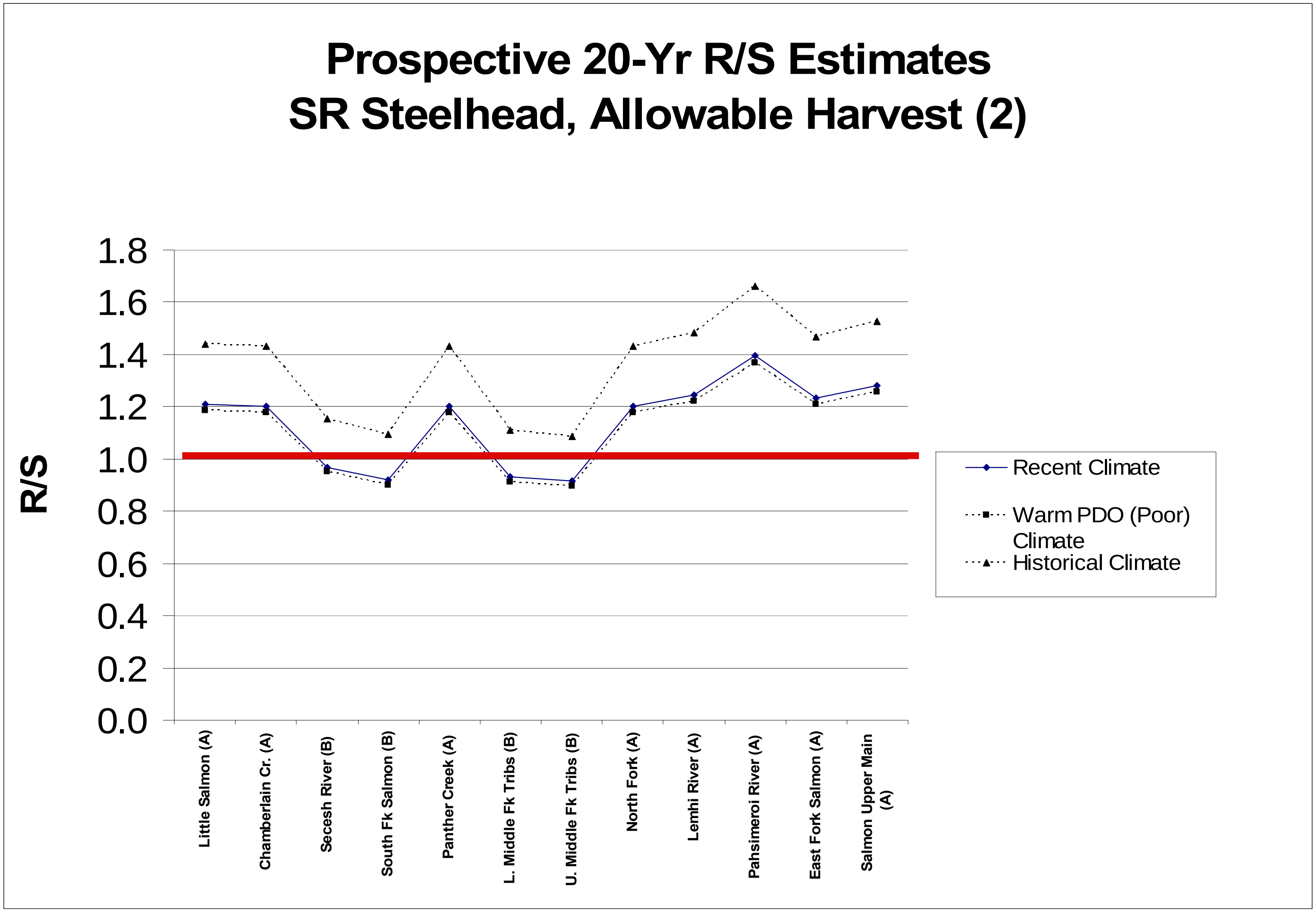


Figure 8.5.6-2. Continued.



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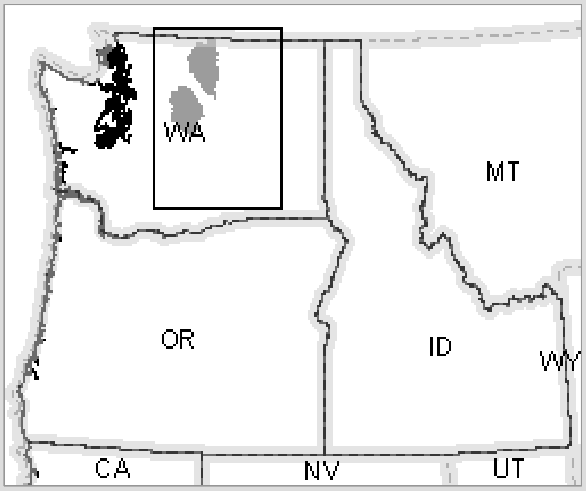
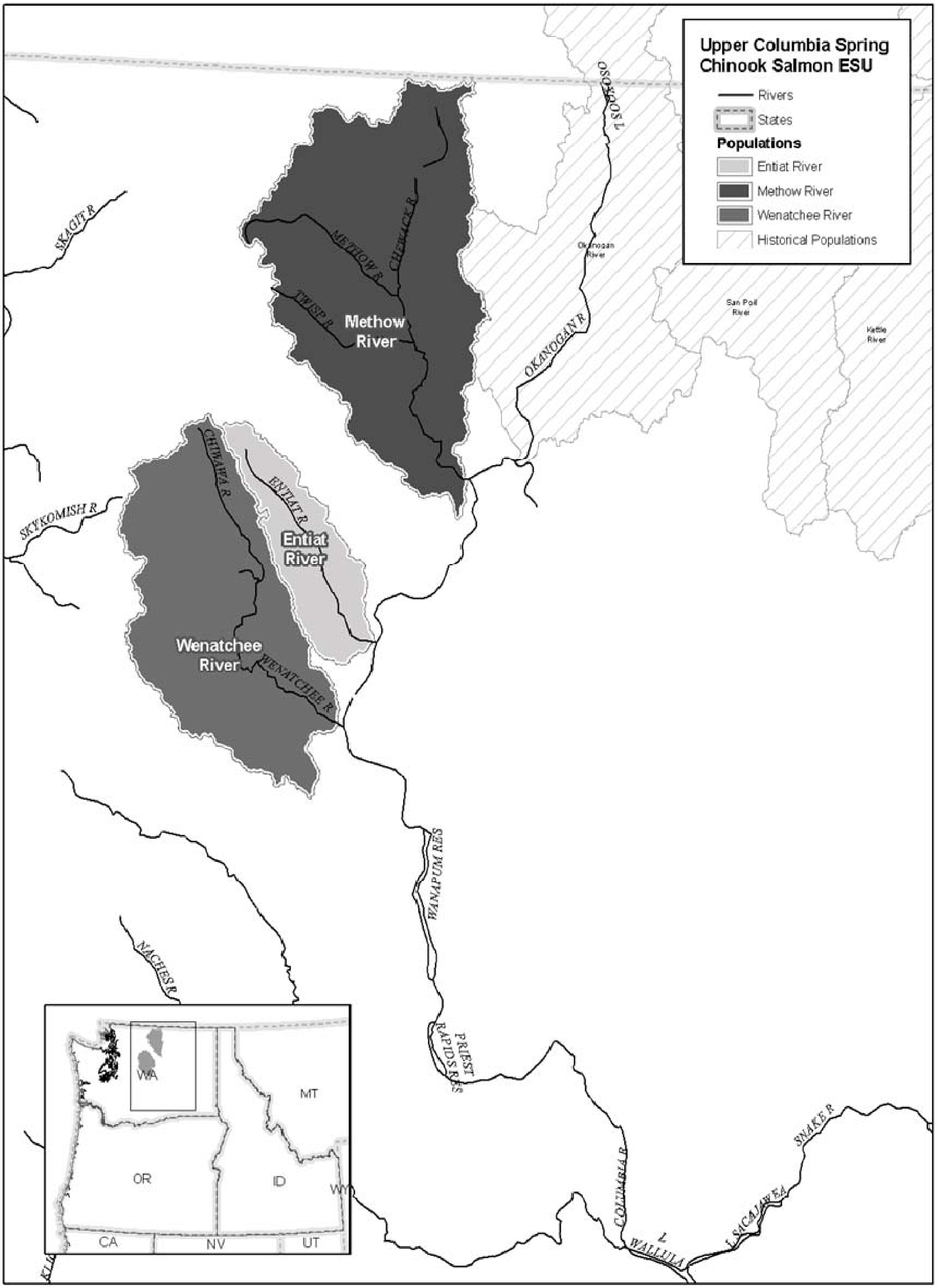
Section 8.6
Upper Columbia River Spring Chinook Salmon




Upper Columbia Spring Chinook Salmon ESU
Rivers
States
Populations
Entiat River
Methow River
Wenatchee River
Historical Populations
Methow River
Entiat River
Wenatchee River
METHOW R
CHEWACK R
TWISP R
OSOYOOS L
OKANOGAN R
Okanogan River
San Poil River
Kettle River
SKAGIT R
SKYKOMISH R
CHIWAWA R
ENTIAT R
WENATCHEE R
WANAPUM RES
NACHES R
PRIEST RAPIDS RES
COLUMBIA R
L WALLULA
L SACAJAWEA
SNAKE R
WA
MT
OR
ID
WY
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Section 8.6
Upper Columbia River Spring Chinook Salmon

Species Overview

Background

The Upper Columbia River (UCR) spring Chinook salmon ESU consists of one major population group (MPG) composed of three existing and one extinct population. These fish spawn and rear in the mainstem Columbia River and its tributaries between Rock Island and Chief Joseph dams. The latter, completed in 1961, now blocks the upriver migration of this species. For 20 years prior to that, migration was blocked by Grand Coulee Dam. Upper Columbia River spring Chinook were listed as endangered under the ESA in 1999, reaffirmed in 2005.

Designated critical habitat for UCR spring Chinook includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam and several tributary subbasins.

Current Status & Recent Trends

Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels above (Wenatchee and Methow) or near (Entiat) the recovery abundance thresholds in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s. Jack counts in 2007, an indicator of future adult returns, were at the highest level since 1977.

Limiting Factors and Threats

The key limiting factors and threats for the UCR spring Chinook include hydropower projects, predation, harvest, hatchery effects, degraded estuary habitat, and degraded tributary habitat. Ocean conditions, which have also affected the status of this ESU generally have been poor over the last 20 years, improving only recently.

Recent Ocean and Mainstem Harvest

The ocean fishery mortality affecting Upper Columbia River spring Chinook is low, and for practical purposes, assumed to be zero. Incidental take occurs in spring season fisheries in the mainstem Columbia River, which are intended to target harvestable hatchery and natural-origin stocks. The fisheries were limited to assure that incidental take does not exceed a rate of 5.5 to 17%. The average take in recent years, however, has been 10.7%.

8.6.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point is with the scientific analysis of species' status, which forms the basis for the listing of the species as endangered or threatened.

8.6.2.1 Current Rangewide Status of the Species

UCR spring Chinook is an endangered species composed of three extant populations in one major population group (MPG). All three populations must be viable to achieve the delisting criteria in the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007). Key statistics associated with the current status of UCR spring Chinook salmon are summarized in Tables 8.6.2-1 through 8.6.2-4.

Limiting Factors & Threats

The key limiting factors and threats for the UCR spring Chinook include hydropower projects, predation, harvest, hatchery effects, degraded estuary habitat, and degraded tributary habitat. Ocean conditions have also affected the status of this ESU and generally have been poor for this ESU over the last 20 years, improving only in the last few years. Limiting factors are discussed in detail in the context of the conservation value of critical habitat in Section 8.6.3.3.

Abundance

For all populations, average abundance over the recent 10-year period is below the average abundance thresholds that the ICTRT identifies as a minimum for low risk (Table 8.6.2-1).[1] Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels above (Wenatchee and Methow) or near (Entiat) the recovery abundance thresholds in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s (Figure 8.6.1.1-1), which shows annual abundance of combined populations. The 5y-year geometric mean peaked in 1987, and continuously decreased until 1999 (Figure 8.6.1.1-1). The 5-year geometric mean remains low as of 2003 (Figure 8.6.1.1-1). Recently, 2007 UCR spring Chinook jack counts, an indicator of future adult returns, have increased to their highest level since 1977.

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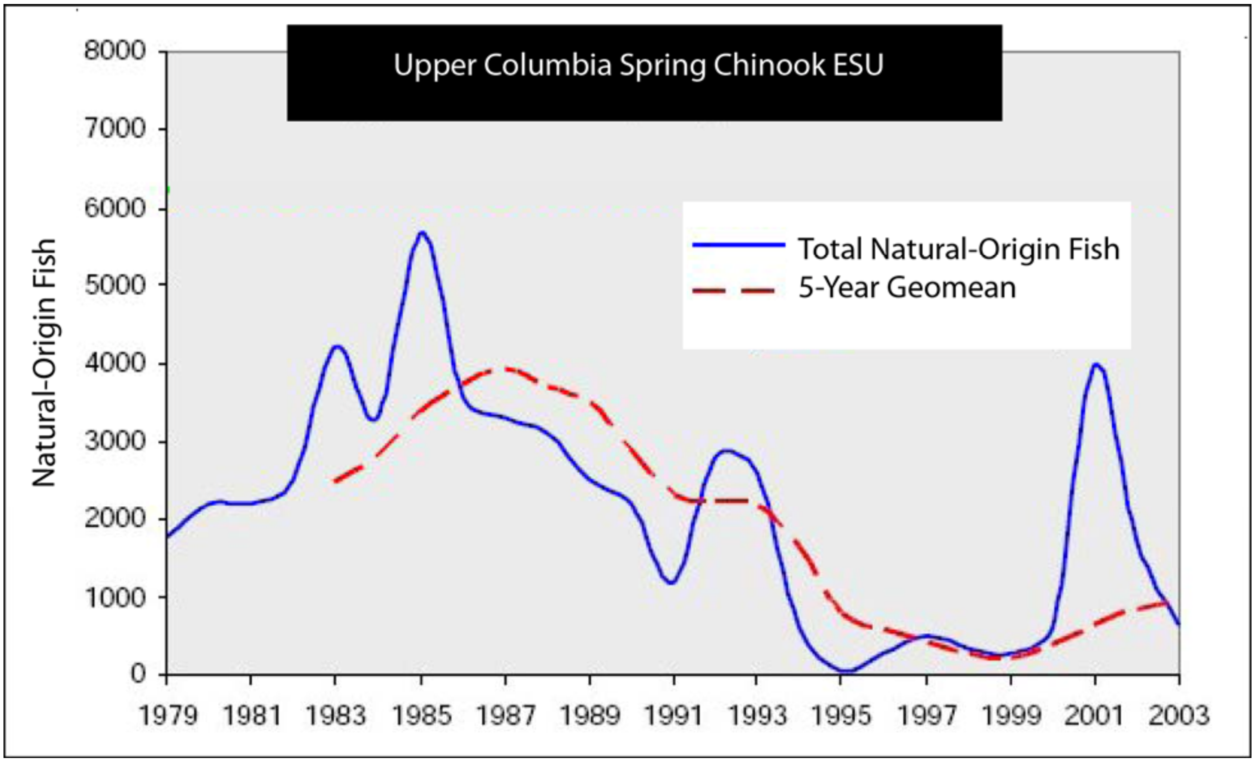
[1] BRT and ICTRT products were developed as primary sources of information for the development of delisting or long-term recovery goals. They were not intended as the basis for setting goals for "no jeopardy" determinations. Although NOAA Fisheries considers the information in the BRT and ICTRT documents in this consultation, its jeopardy determinations are made in a manner consistent with the Lohn memos dated July 12, and September 6, 2006 (NMFS 2006h, i).

Figure 8.6.1.1-1. Upper Columbia River Spring Chinook Abundance Trends (Corps et al. 2007a, Chapter 8, Figure 8.2 showing annual abundance of combined populations).



"Base Period" Productivity

On average over the last 20 full brood year returns (1979-1998 brood years [BY], including adult returns through 2003), UCR spring Chinook populations have not replaced themselves (Table 8.6.2-1). This is true when only natural production is considered (i.e., average R/S has been less than 1.0). In general, R/S productivity was relatively high during the early 1980s, low during the late 1980s and 1990s, and high again in the most recent brood years (brood year R/S estimates in ICTRT Current Status Summaries [ICTRT 2007d], updated with Cooney [2007b]).

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at $\leq$5% extinction risk (ICTRT 2007c).

The BRT trend in abundance and median population growth rate (lambda) calculated with HF=1 also indicates a decline during this period for all three populations (Table 8.6.2-1). Lambda, when calculated with the HF=0 assumption, does indicate an increasing trend for the Methow population, but not for the Wenatchee and Entiat populations (Table 8.6.2-1). The HF=1 and the HF=0 lambda calculation assumptions are alternatives regarding the effectiveness of hatchery-origin natural spawners, relative to natural-origin natural spawners, as discussed in Section 7.1.1.2.

Spatial Structure

The ICTRT characterizes the spatial structure risk to UCR spring Chinook populations as "low" or "moderate" (Table 8.6.2-2).

Diversity

The ICTRT characterizes the diversity risk to all UCR spring Chinook populations as "high" (Table 8.6.2-2). The high risk is a result of reduced genetic diversity from homogenization of populations that occurred under the Grand Coulee Fish Maintenance Project in 1939-1943. In recent years, straying hatchery fish, compositing fish for broodstock, low proportion of natural-origin fish in some broodstocks and a high proportion of hatchery fish on the spawning grounds have contributed to the high genetic diversity risk. Discontinuation of the Entiat hatchery program in 2007 addresses a major limiting factor and is expected to benefit Entiat Chinook productivity and diversity.

"Base Period" Extinction Risk

The ICTRT Current Status Summaries (ICTRT 2007d) characterizes the long-term (100 year) extinction risk, calculated from productivity and natural origin abundance estimates of populations during the "base period" described above for R/S productivity estimates, as "High" (>25% 100-year extinction risk) for all three UCR spring Chinook populations. The ICTRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50).

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk. Table 8.6.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish) for the Wenatchee and Entiat populations. It is not possible to estimate short-term extinction risk for the Methow population using the methods employed in this analysis. This short-term extinction risk analysis is based also on the assumption that productivity observed during the "base period" will be unchanged in the future. At QET=50, the Wenatchee population has approximately a 2% risk while the Entiat population has greater than a 5% risk of extinction. Confidence limits on these estimates are extremely high, ranging from 0 to over 80% risk of extinction.

A QET of less than 50 may also be considered a reasonable indicator of short-term risk, as discussed in Section 7.1.1.1. At QET levels below 50 spawners, the results are more optimistic. The Entiat population has less than 5% risk of short-term extinction when QET=10 or less.

The short-term and ICTRT long-term extinction risk analyses assume that all hatchery supplementation ceases immediately. As described in Section 7.1.1.1, this assumption is not representative of hatchery management under the Prospective Actions. A more realistic assessment of short-term extinction risk will take hatchery programs into consideration, either qualitatively or quantitatively. When hatchery supplementation is assumed to continue at current levels for those populations affected by hatchery programs, short-term extinction risk is lower as evidenced by analyses for SR spring/summer Chinook, SR fall Chinook, and UCR steelhead (Hinrichsen 2008, included as Attachment 1 in the Aggregate Analysis Appendix).

Quantitative Survival Gaps

The change in density-independent survival (See Table 7.4.1) necessary for quantitative indicators of productivity to be greater than 1.0 and for extinction risk to be less than 5% are displayed in Table 8.6.2-4. Mean base period R/S survival gaps range from 34-40%, lambda survival gaps range from no needed change to 54% needed survival improvement, and BRT trend survival gaps range from 37-69%. Because short-term extinction risk is <5% for the Wenatchee population, there is no extinction risk gap at QET=50. However, survival would have to improve approximately 47% for the Entiat population to have <5% risk at QET=50 and survival would have to improve 4% at QET=30.

8.6.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for UCR spring Chinook includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Methow, Upper Columbia/Entiat, and Wenatchee (NMFS 2005b). There are 31 watersheds within the range of this ESU. Five watersheds received a medium rating and 26 received a high rating of conservation value to the ESU (see Chapter 4 for more detail). The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified above. This corridor 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. Of the 1,002 miles of habitat areas eligible for designation, 974 miles of stream are designated critical habitat. The status of critical habitat is discussed further in Section 8.6.3.3.

8.6.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.6.3.1 "Current" Productivity & Extinction Risk under the Environmental Baseline

Because the action area as described in Chapter 5 encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section, estimates of productivity and extinction risk are based on performance of populations during a 20-year "base period," ending with the 1998 brood year. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone

Section 7 consultation and continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity as the riparian area becomes functional).

Quantitative Estimates

Because a number of ongoing human activities have changed over the last 20 years, and since 1998, the Comprehensive Analysis includes estimates of a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Chapter 7 of this document. Results are presented in this document, in Table 8.6.3-1.

Briefly, reduction in the average base period harvest rate (estimated to result in a 4% survival increase [SCA Harvest Appendix, based on *U.S. v. Oregon* estimates]), improvements in both FCRPS and Public Utility District (PUD) dam configuration and operation (approximately a 24-43% survival increase, based on ICTRT base survival and COMPASS analysis of current survival in SCA Hydro Modeling Appendix), and estuary habitat projects (a less than 1% survival change, based on CA Appendix D) result in a survival improvement for all UCR spring Chinook populations. Tributary habitat projects and changes in hatchery operations result in approximately a 2% survival improvement for all three populations (Corps et al. 2007a Chapter 8, Table 8-5). In contrast, the development of tern colonies in the estuary in recent years results in less than 1% reduction in survival for all populations. Additionally, increased adult Chinook predation by marine mammals (primarily California sea lions) in the Columbia River immediately downstream of Bonneville Dam has resulted in approximately a 3% reduction in survival for UCR spring Chinook salmon populations (SCA Marine Mammal Appendix).

Hatchery programs have been operated in each of the three ESU populations, but their effect on the base-to-current status of each of these populations has varied. For more information, see the Salmonid Hatchery Inventory and Effects Evaluation Report (NMFS 2004b). Over the base period, hatchery programs in the Wenatchee have reduced short-term extinction risk on the one hand and have imposed hybridization and the loss of genetic variation on the other. In the Entiat, genetic studies have shown that the natural population has been subject to outbreeding depression because the Entiat National Fish Hatchery (NFH) used Carson stock fish for broodstock. This program was discontinued in 2007 and adult returns from the last juvenile releases in 2006 will cease after 2010. For the Methow, the threat of outbreeding depression has been reduced since the phasing-out of Carson broodstock beginning in 2001. The PUD-funded hatchery program in the Methow basin started in 1992, using local fish for broodstock. Over the base period, this program has reduced short-term extinction risk while it has imposed hybridization and the loss of genetic variation.

The CA (Corps et al. 2007a) assumes a 1% survival change for the Methow population, based on the Winthrop NFH transition from Carson stock to a local Methow stock. Although this is an improvement, it fails to fully complete the transition in broodstock practices for two reasons. First, both the NFH and the PUD programs still rely on a high percentage of hatchery-origin fish for broodstock, and second, they use a composite stock (i.e., a combination of Methow and Chewuch River fish). This practice homogenizes Methow Chinook, breaking down genetic differentiation and posing a continued risk to the fitness of the natural population. Therefore, the 1% survival benefit assumed in the CA/BA is not anticipated in the SCA.

The net result of all base-to-current changes is that, if these human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to increase 28-47%, depending on the particular population (Table 8.6.3-1). This also implies that the survival "gaps" described in Table 8.6.2-4 would be reduced proportionally by this amount (i.e., ["Gap" ÷ 1.28] to ["Gap" ÷ 1.47], depending on the population).

8.6.3.2 Abundance, Spatial Structure & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section. For further detail please see the Rangewide Status section of this Chapter.

8.6.3.3 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as reducing the conservation value of essential features and PCEs of designated critical habitat. Tributary habitat conditions vary widely among the various drainages occupied by UCR spring Chinook salmon. Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and forest management continue to threaten the conservation value of critical habitat for this species in some locations in the upper Columbia basin.

Spawning & Rearing Areas

UCR spring Chinook spawn and rear in the major tributaries to the Columbia River between Rock Island and Chief Joseph dams. Adults reach the spawning areas from April through July and hold in tributaries until late summer. Spawning peaks in mid- to late-August (UCSRB 2007). The majority of juvenile spring Chinook rear in their natal tributaries, although a significant proportion (30-40%) emigrate downstream to the Wenatchee mainstem to complete freshwater rearing (ICTRT 2007d). Juvenile spring Chinook spend a year in freshwater before migrating to salt water in the spring of their second year of life. The following are the major factors that have limited the functioning and thus the conservation value of habitat used by UCR spring Chinook salmon for these purposes (i.e., spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that help ensure their survival):

- Physical passage barriers [*mortality at hydroelectric projects in the mainstem Columbia River; water withdrawals and unscreened diversions*]

- Excess sediment in spawning gravels and in substrates that support forage organisms [*land and water management activities*]

- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures [*degraded riparian and channel function*]

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions to address limiting factors for this ESU in spawning and rearing areas. These include acquiring water to increase streamflow, installing or improving fish screens at irrigation facilities to prevent entrainment, removing passage barriers and improving access, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects provided immediate benefits and some will result in long-term benefits with improvements in PCE function accruing into the future.

Juvenile & Adult Migration Corridors

Adults begin to return from the ocean in early spring and enter upper Columbia tributaries during April through July. Juvenile spring Chinook migrate to salt water in the spring of their second year of life. Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers [*push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles*]

- Juvenile and adult passage mortality [*hydropower projects in the mainstem Columbia River*]

- Pinniped predation on adults due to habitat changes in the lower river [*existence and operation of Bonneville Dam*]

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators [*Caspian terns and double-crested cormorants*]

In the mainstem FCRPS migration corridor, the Action Agencies have improved safe passage through the hydrosystem for yearling Chinook with the construction and operation of surface bypass routes at Lower Granite, Ice Harbor, and Bonneville dams and other configuration improvements listed in section 5.3.1.1 in Corps et al. (2007a). NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the absolute survival of spring-run Chinook by 5.5%. Thus, the continuing negative impact of sea lions will likely be approximately a 3% reduction from base period survival for spring Chinook populations.

The safe passage of yearling Chinook through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown since that time. For these salmon, with a stream-type juvenile life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 8.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood

Although UCR spring Chinook spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat NOAA Fisheries designated critical habitat no farther west than the mouth of the Columbia River NMFS (2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.6.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

Mainstem Mid-Columbia Hydroelectric Projects

NOAA Fisheries completed ESA Section 7(a)(2) consultations on its issuance of incidental take permits to Douglas and Chelan County Public Utility Districts in support of the proposed Anadromous Fish Agreements and Habitat Conservation Plans (HCPs) for the Wells, Rocky Reach, and Rock Island hydroelectric projects in the mid-Columbia reach on August 12, 2003. Under the HCPs, Douglas and Chelan County PUDs agreed to use a long-term adaptive management process to achieve a 91% combined adult and juvenile survival standard for each salmon and steelhead ESU migrating through each project. In addition, compensation for up to 9% unavoidable project mortality is provided through hatchery and tributary programs, with compensation for up to 7% mortality provided through hatchery programs and compensation for up to 2% provided through tributary habitat improvement programs.

In May 2004, NOAA Fisheries also completed an ESA Section 7 consultation on FERC's proposed amendment to the existing license for the Grant County PUD's Priest Rapids Hydroelectric Project, which permitted implementation of an interim protection plan, including interim operations for Wanapum and Priest Rapids dams. Under this biological opinion and incidental take statement, NOAA Fisheries expects that project-related mortalities (i.e., direct, indirect, and delayed mortality resulting from project effects) for both hydro projects combined will not exceed 24.5% for juvenile UCR spring Chinook salmon. NOAA Fisheries also expects that implementation of the interim protection plan will result in mortality rates of no more than 2% per project or 4% combined for adult UCR spring Chinook salmon.

Thus, NOAA Fisheries expects the cumulative mortality through the mid-Columbia reach of juvenile UCR spring Chinook to be 18% for the Wenatchee population; 24% for the Entiat population; and 27% for the Methow population. The total mortality rates (natural and project-related) of adult UCR spring Chinook salmon are expected to be 2% for adult spring Chinook returning to the Wenatchee and Entiat rivers and 3% for fish returning to the Methow.

Wenatchee River

A number of forest management activities relevant to this consultation have also undergone consultation and are included in the baseline. The USFS proposed fuels reduction projects in the White River – Little Wenatchee and Wenatchee River – Nason Creek watersheds, respectively, and a fire salvage timber sale in the Lower Wenatchee River watershed. The USFS also proposed a habitat restoration project in the Natapoc Ridge Forest (Wenatchee River – Nason Creek and Chiwawa River watersheds). The USFS' project to relocate White River Road and stabilize the streambank used large woody debris to increase habitat complexity (White River – Little Wenatchee River watershed). Another USFS project, replacing three culverts along Sand and Little Camas creeks (Lower Wenatchee River watershed), improved passage and partially restored natural channel-forming processes. The USFS completed one project 2007 under its programmatic consultation (19 Aquatic Habitat Restoration Activities in Oregon, Washington, Idaho, and California): a road decommissioning to improve riparian habitat and the connection to the floodplain along one mile of Clear Creek in the Chiwawa River watershed.

The FHWA/WSDOT consulted on a road construction project in the Wenatchee River – Icicle Creek watershed and a culvert replacement along Mill Creek (Wenatchee River – Nason Creek) to improve fish passage.

In the Lower Wenatchee watershed, NOAA Fisheries consulted on the restoration of off-channel habitat; the USFWS funded the installation of a fishway on Peshastin Creek, designed to provide access to spawning and rearing habitat; and the Corps consulted on a fish passage enhancement project. The Corps also proposed 20 projects to build or maintain docks, piers, launches, boat lifts, moorage basins, and swimming beaches along the shores of Lake Entiat, Columbia River – Lynch Coulee, and Columbia River – Sand Hollow mainstem reaches (juvenile and adult migration corridors). The Department of the Army consulted on construction at the Yakima Training Center (Columbia River – Lynch Coulee and Columbia River – Sand Hollow mainstem reaches).

As part of the Grant PUD interim protection plan, NOAA Fisheries consulted with itself on the issuance of an ESA Section 10 permit issued jointly to Grant PUD, WDFW, and The Confederated Tribes and Bands of the Yakama Nation on the implementation of an artificial propagation (hatchery) program to supplement the spring Chinook salmon spawning aggregate in the White River.[2]

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[2] Five major spawning areas contribute to the Wenatchee spring Chinook population. These are the White River, Chiwawa River, Nason Creek, Little Wenatchee River, and upper Wenatchee River spawning aggregates.

As part of the Chelan and Douglas PUD's HCPs described above, NOAA Fisheries consulted on the issuance of an ESA Section 10 permit jointly to Chelan and Douglas PUDs and WDFW on the implementation of an artificial propagation program to supplement the spawning aggregate in the Chiwawa River. NOAA Fisheries conducted two separate consultations on hatchery programs of unlisted summer Chinook salmon and sockeye salmon and endangered steelhead in the Wenatchee basin, which could have effects on natural-origin spring Chinook, resulting in issuance of an ESA Section 10 permits. Inclusive with these consultations were actions to monitor and evaluate the effects of the hatchery programs on the natural salmon and steelhead populations in the Wenatchee basin.

The USFW consulted on the implementation of a hatchery program rearing out-of-ESU Carson stock spring Chinook salmon at Leavenworth NFH to provide fish for terminal-area harvest. The BPA consulted on funding the Yakama Nation Tribes' hatchery program to reintroduce coho salmon to the Wenatchee basin. BPA underwent a separate consultation on the operation of a juvenile fish trap to monitor all salmonid species in Nason Creek.

Entiat River

The USFS proposed a campground and summer home vegetation management project in the lower Entiat River watershed and habitat restoration activities in the Columbia River – Lynch Coulee portion of the mainstem Columbia River. NOAA Fisheries consulted with itself on funding for a project in the lower Entiat River watershed that included building an overflow structure in an existing irrigation canal to improve fish passage; adding boulders and large wood to increase habitat complexity in a side channel; reconnecting the river and its floodplain; and enhancing the recruitment of spawning gravels.

The FHWA/WSDOT proposed road maintenance along State Route 28 (Sunset Highway), Eastside Corridor, East Wenatchee (Lake Entiat mainstem reach).

The Corps proposed 20 projects to build or maintain docks, piers, launches, boat lifts, moorage basins, and swimming beaches along the shores of Lake Entiat, Columbia River – Lynch Coulee, and Columbia River – Sand Hollow mainstem reaches (juvenile and adult migration corridors). The Department of the Army consulted on construction at the Yakima Training Center (Columbia River – Lynch Coulee and Columbia River – Sand Hollow mainstem reaches).

Methow River

The USFS consulted on a total of three timber sales in the Upper and Lower Chewuch and Twisp River watersheds; a grazing allotment plan for the Lower Chewuch and Middle Methow River watersheds; and a vegetation management plan for the Lower Methow River watershed. The USFS also consulted on projects to restore habitat damaged by grazing in the Lower Chewuch River watershed, improve passage (by replacing a diversion dam) into seven miles of Little Bridge Creek (Twisp River watershed), and modify an irrigation ditch for access to nine miles of habitat in a wilderness area (Middle Methow River watershed). The USFS completed two projects during 2007 under its programmatic consultation with NOAA Fisheries (19 Aquatic Habitat Restoration Activities in Oregon, Washington, Idaho, and California): decommissioning and relocating the Twisp

River/North Creek Trail to improve five acres of riparian habitat and installing a culvert in Reynolds Creek to allow access to four miles of stream.

Reclamation consulted on leasing water from the Chewuch Canal Company (Lower Chewuch River watershed) to improve instream flows. The FHWA/WSDOT proposed a bridge rehabilitation project on Buttermilk Creek Road in the Twisp River watershed.

The FERC consulted on a license amendment for the Wells hydroelectric project—land easements for 11 irrigation diversions from Lake Entiat with new or improved fish screens.

As part of the Chelan and Douglas PUD's HCPs described above, NOAA Fisheries consulted on the issuance of an ESA Section 10 permit jointly to Chelan and Douglas PUDs and WDFW on the implementation of an artificial propagation program to supplement the spawning aggregates in the Methow, Chewuch, and Twisp Rivers. NOAA Fisheries conducted two separate consultations on hatchery programs of unlisted summer Chinook salmon, and endangered steelhead in the Methow basin, which could have effects on natural-origin spring Chinook. These consultations resulted in the issuance of an ESA Section 10 permit. Inclusive with these consultations were actions to monitor and evaluate the effects of the hatchery programs on the natural salmon and steelhead populations in the Methow basin.

The USFWS consulted on the implementation of a supplementation hatchery program rearing listed spring Chinook salmon at Winthrop NFH. They also consulted on the implementation of a hatchery program rearing listed UCR steelhead at Winthrop NFH.

The BPA consulted on funding the Yakama Nation Tribes' hatchery program to reintroduce Coho salmon to the Methow basin. Reintroduction could effect the natural population of spring Chinook salmon in the basin.

Projects Affecting Multiple Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.6.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

Federal agencies are implementing numerous projects within the range of UCR spring Chinook salmon that will improve access to blocked habitat, prevent entrainment into irrigation pipes, increase channel complexity, and increase instream flows. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of Federal projects such as hydroelectric generation (including the FERC-licensed hydro projects in the mid-Columbia River), forest thinning, road construction/maintenance, dock and pier construction, hatchery programs, and grazing will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Future Federal restoration projects will improve the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PCEs. However, all of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.6.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect one or more of the listed species or associated critical habitat in the Columbia Basin. These are detailed in the lists of projects that appear in Chapter 17 of the FCRPS Action Agencies' Comprehensive Analysis which accompanied their Biological Assessment Corps et al. 2007a). They include tributary habitat actions that will benefit the Entiat, Methow, and Wenatchee populations as well as actions that should be generally beneficial throughout the ESU. Generally, all of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[3] Many address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to significantly improve conditions for Upper Columbia River spring Chinook. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

[3] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

8.6.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in Sections 8.6.5.1, 8.6.5.2, and 8.6.5.5. The Prospective Actions will ensure that adverse effects of the FCRPS and Upper Snake projects will be reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions, which are expected to be beneficial. Some habitat restoration and RM&E actions may have short-term minor adverse effects, but these will be balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in this section. There are no Federal safety-net hatchery programs for UCR spring Chinook salmon.

8.6.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5) are expected to continue through the duration of the Prospective Actions.

The effects of the Prospective Actions on mainstem flows have been included in the HYDSIM modeling used to create the 70-year water record for input into the COMPASS model (Section 8.1.1.3). As such, the effect of diminished spring-time flows on juvenile migrants is aggregated in the COMPASS model results used to estimate the Prospective Actions effects in the productivity and extinction risk analysis (See SCA Sections 7.2.1 and 8.1.1.3)

Based on COMPASS modeling of hydro operations for the 70-year water record, full implementation of the Prospective Actions is expected to increase the in-river survival (McNary to the Bonneville tailrace) of UCR spring Chinook salmon from 66.7% (Current) to 72.6% (Prospective), a relative change of 8.8% (SCA Hydro Modeling Appendix).[4] Transportation at McNary Dam is only expected to occur in 1 of 70 years, < 2% of the time, when flows at McNary are less than 125 kcfs. In this unlikely circumstance, about 70.6% of the juveniles arriving at McNary Dam would be transported (see Table 11.7 of the FCRPS Biological Opinion). Based on the very positive benefits observed from transportation study results from the Snake River during the extremely low flow conditions of 2001, NOAA Fisheries anticipates a similar, albeit somewhat smaller benefit, would exist from transportation at McNary Dam.

The COMPASS model estimates, combined with in-river migrant survivals through the non-Federal mainstem projects and smolt-to-adult returns (McNary Dam to the ocean and back to Rock Island Dam (assuming SR spring/summer Chinook salmon post-Bonneville survival relationships as a surrogate) will likely increase from about 0.58 to 0.63% (a relative improvement of 8.5%) for

[4] For UCR spring Chinook salmon, the in-river survival estimate and total system survival estimate are virtually identical because fish are not likely to be transported in 69 out of 70 years (>98% of the time) in the 70-year water record.

Wenatchee River fish; 0.53 to 0.58% (a relative improvement of 9.6%) for Entiat River fish; and 0.51 to 0.56% (a relative improvement of 9.7%) for Methow and Okanogan River fish. These increases are a result of the Prospective Actions and mid-Columbia PUD actions being implemented.

This improvement, combined with the expected survival improvements resulting from actions being implemented as a result of the completed biological opinions on the existence and operation of the five mid-Columbia mainstem projects (NMFS 2006e and SCA Hydro Modeling Appendix,) are expected to increase the relative survival of in-river migrants to the Bonneville tailrace by 8.8% (Wenatchee population) and 10.0% (Entiat, Methow, and Okanogan populations).

The Prospective Actions addressing hydro operation and the RM&E program should maintain the high levels of survival currently observed for adult UCR spring Chinook salmon migrating from Bonneville Dam upstream to McNary Dam. The current PIT tag based survival estimate, taking account of harvest and "natural" stray rates within this reach, is 90.1% (about 96.6% per project) (BA Table 2.1). Any delayed mortality of adults (mortality that occurs outside of the Bonneville Dam to McNary Dam migration corridor) that currently exists is not expected to be affected by the Prospective Actions.

The Prospective Hydro Actions are also likely to positively affect the survival of UCR spring Chinook salmon, as a result of the construction of gas abatement structures at Chief Joseph Dam (reduction of future total dissolved gas levels), in ways that are not included in the quantitative analysis. NOAA Fisheries considers these expected benefits, but has not been able to quantify these effects.

The Prospective Actions requiring implementation of surface passage routes at McNary and John Day dams, in concert with training spill (amount and pattern) to provide safe egress, should reduce juvenile travel times within the forebays of the individual projects. This is likely to result in survival improvements in the forebays of these projects, where predation rates often are currently the highest (see Section 8.1.1). Taken together, surface passage routes should increase juvenile migration rates through the migration corridor, and likely improve overall post-Bonneville survival of in-river migrants. Faster migrating juveniles may be less stressed than is currently the case.

Continuing efforts under the NPMP and continuing and improved avian deterrence at mainstem dams will also address sources of juvenile mortality. In-river survival from McNary Dam to the tailrace of Bonneville Dam, which is an index of the hydrosystem's effects on water quality, water quantity, water velocity, project injury and mortality, and predation, will increase to 72.6%. A portion of the 27.4% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that yearling Chinook would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of yearling UCR spring Chinook in a hypothetical, unimpounded Columbia River from McNary Dam to Bonneville Dam would be 89.5%. Therefore, approximately 38.3% (10.5%/27.4%) of the mortality experienced by in-river migrating juvenile Chinook salmon is probably due to natural factors.

The direct survival rate of adults through the FCRPS is already relatively high. The prospective actions include additional passage improvements (to the ladders at John Day and McNary dams and other improvements. Adult spring Chinook survival from Bonneville to Priest Rapids Dam will be approximately 90.1% under the Prospective Actions.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. Shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit the yearling migrants in the lower Columbia River, reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.6.3.3).

Effects on Critical Habitat

The Prospective Actions described above will improve the functioning of safe passage in the juvenile and adult migration corridors by addressing water quantity, water velocity, project mortality, and exposure to predators. To the extent that the hydro Prospective Actions result in more adults returning to spawning areas, water quality and forage for juveniles could be affected by the increase in marine-derived nutrients. This was identified as a limiting factor for the Wenatchee population by the Remand Collaboration Habitat Technical Subgroup (Habitat Technical Subgroup 2006b).

8.6.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

The population-specific effects of the tributary habitat Prospective Actions on survival are listed in CA Chapter 8, Table 8-7, p. 8-12. For targeted populations in this ESU the effect is a 3 to 22% expected increase in low density egg-smolt survival, depending on population, as a result of implementing tributary habitat Prospective Actions that improve habitat function by addressing significant limiting factors and threats.[5] For example, the Action Agencies will address limiting factors by replacing barrier culverts and screen irrigation pumps in the Wenatchee, Entiat, and Methow subbasins (Table 1-b in Attachment B.2.2-2 to Corps et al. 2007b). These passage projects in many instances will enable juvenile spring-run Chinook to access rearing habitat in tributaries that are too small to support spawning, but are generally more productive per unit area for rearing than are mainstem settings. The Action Agencies will also fund channel complexity projects and restore streamflows. Channel complexity projects include reconnecting oxbows that were isolated by highway and railroad construction in the Upper Wenatchee (Nason Creek in particular) and reconnecting small side channel habitats in the Methow and Entiat that have been stranded as a consequence of mainstem channel incision.

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[5] The Action Agencies identified the projects that will improve these PCEs and that they will fund by 2009 in Tables 1a and 5a,b in Attachment B.2.2-2 to Corps et al. (2007b).

Effects on Critical Habitat

As described above, the tributary habitat Prospective Actions will address factors that have limited the functioning and conservation value of habitat that this species uses for spawning and rearing. PCEs expected to be improved are water quality, water quantity, cover/shelter, food, riparian vegetation, space, and safe passage/access.

Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.6.5.3 Effects of Estuary Prospective Actions

Effects on Species Status

The estimated survival benefit for Upper Columbia River Spring-run Chinook (stream-type life history) associated with the specific Prospective Actions to be implemented from 2007-2010 is 1.4%. The survival benefit for Upper Columbia River Spring-run Chinook (stream-type life history) associated with actions to be implemented from 2010 through 2018 is 4.3%. The total survival benefit for Upper Columbia River Spring-run Chinook as a result of Prospective Actions implemented to address estuary habitat limiting factors and threats is approximately 5.7% (Chapter 8.3.3.3 in Corps et al. 2007a). Estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM 40 will provide habitats needed by yearling Chinook migrants from the upper Columbia River to increase life history diversity and spatial structure. The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the conservation value of the estuary as habitat for this species (Section 8.3.3.3 in Corps et at. 2007a). These include restoring riparian function and access to tidal floodplains.

Effects on Critical Habitat

The estuary habitat Prospective Actions will address factors that have limited the functioning of PCEs in the estuary needed by yearling Chinook from the upper Columbia River. Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (Section 8.6.5.2).

8.6.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

A qualitative assessment of the Prospective Actions was provided in Section 8.3.3.5, page 8-15, of the CA. The hatchery Prospective Actions consist of continued funding of hatcheries as well as reforms to current federally funded programs that will be identified in future ESA consultations (see Tier 2 actions in the BA).

The Prospective Actions require the adoption of programmatic criteria or BMPs for operating salmon and steelhead hatchery programs (see Appendix E of Corps et al. 2007a and SCA Artificial Propagation for Pacific Salmon Appendix) NOAA Fisheries cannot consult on the operation of existing or new programs until Hatchery and Genetic Management Plans are updated and consultation is initiated (consultations will be initiated and submitted to NOAA Fisheries by January 2009 and completed by July 2009). The FCRPS Action Agencies intend to adopt this programmatic criteria for funding decisions on future mitigation programs for the FCRPS that incorporate BMPs, and site specific application of BMPs, will be defined in ESA Section 7, Section 10, and Section 4(d) limits with NOAA Fisheries to be initiated and conducted by hatchery operators with the FCRPS Action Agencies as cooperating agencies (FCRPS Biological Assessment, page 2-44). Available information, principles, and guidance for operating hatchery programs are described in Appendix E of the CA and Artificial Propagation for Pacific Salmon Appendix. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPS are expected to: 1) integrate hatchery mitigation and conservation objectives; 2) preserve genetic resources; and 3) accelerate trends toward recovery as limiting factors and threats are fixed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.6.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

Under the Prospective Action the harvest of UCR spring Chinook will vary from year-to-year depending on an abundance-based harvest rate schedule (Table 8.6.5.5-1). Harvest will depend on the total abundance of upriver spring, natural-origin SR spring/summer Chinook, and may be further limited by natural-origin Upper Columbia River spring Chinook (see Table 8.6.5.5-1 footnote 4). The allowable harvest rate will range from 5.5 to 17%. As indicated in Table 8.6.5.5-1, most of the prospective harvest will occur in treaty Indian fisheries.

Table 8.6.5.1-1. Abundance-based harvest rate schedule for upriver spring Chinook and Snake River spring/summer Chinook in spring management period fisheries (TAC 2008).

Harvest Rate Schedule for Chinook in Spring Management Period					
Total Upriver Spring and Snake River Summer Chinook Run Size	**Snake River Natural Spring/Summer Chinook Run Size[1]**	**Treaty Zone 6 Total Harvest Rate [2,5]**	**Non-Treaty Natural Harvest Rate [3]**	**Total Natural Harvest Rate[4]**	**Non-Treaty Natural Limited Harvest Rate[4]**
<27,000	<2,700	5.0%	<0.5%	<5.5%	0.5%
27,000	2,700	5.0%	0.5%	5.5%	0.5%
33,000	3,300	5.0%	1.0%	6.0%	0.5%
44,000	4,400	6.0%	1.0%	7.0%	0.5%
55,000	5,500	7.0%	1.5%	8.5%	1.0%
82,000	8,200	7.4%	1.6%	9.0%	1.5%
109,000	10,900	8.3%	1.7%	10.0%	
141,000	14,100	9.1%	1.9%	11.0%	
217,000	21,700	10.0%	2.0%	12.0%	
271,000	27,100	10.8%	2.2%	13.0%	
326,000	32,600	11.7%	2.3%	14.0%	
380,000	38,000	12.5%	2.5%	15.0%	
434,000	43,400	13.4%	2.6%	16.0%	
488,000	48,800	14.3%	2.7%	17.0%	

1. If the Snake River natural spring/summer forecast is less than 10% of the total upriver run size, the allowable mortality rate will be based on the Snake River natural spring/summer Chinook run size. In the event the total forecast is less than 27,000 or the Snake River natural spring/summer forecast is less than 2,700, Oregon and Washington would keep their mortality rate below 0.5% and attempt to keep actual mortalities as close to zero as possible while maintaining minimal fisheries targeting other harvestable runs.
2. Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from January 1-June 15. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.
3. Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the Hwy 395 Bridge in the Tri-Cities and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from January 1-June 15; Wanapum tribal fisheries, and Snake River mainstem recreational fisheries upstream to the Washington-Idaho border from April through June. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.
4. If the Upper Columbia River natural spring Chinook forecast is less than 1,000, then the total allowable mortality for treaty and non-treaty fisheries combined would be restricted to 9% or less. Whenever Upper Columbia River natural fish restrict the total allowable mortality rate to 9% or less, then non-treaty fisheries would transfer 0.5% harvest rate to treaty fisheries. In no event would non-treaty fisheries go below 0.5%

harvest rate.
5. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.

The prospective harvest schedule is similar to that used in 2001, as well as in the most recent 2005 to 2007 Agreement. Since 2001, the allowable harvest rates ranged from 5.5 to 17%. The 2001 schedule did not include SR summer Chinook as part of the abundance indicator. The 2005 schedule was modified to included SR summer Chinook, but the abundance levels were adjusted accordingly to provide a comparable level of harvest for the adjusted run size. The harvest rate schedule proposed for use in 2008 and beyond differs from the 2005 schedule only in that it adjusts the allocations between the treaty-Indian and non-treaty fisheries.

Harvest rates under the Prospective Actions will be the same as they have been in recent years. Therefore, no additional current-to-future survival adjustment is necessary for the prospective harvest action for this species.

It is also pertinent to consider the potential effects of conservative management. Fisheries directed at upriver spring Chinook can be managed with relative precision. Catch is tracked on a daily basis, and runsize estimates can be adjusted in-season using counts at Bonneville dam. Since 2001, actual harvest rates have ranged between 1.1 and 2.6% less then those allowed (Table 8.3.5.5-2). Any analysis that assumes that the allowed harvest rates will always be fully used would therefore be conservative.

Table 8.6.5.5-2. Actual harvest rate on UCR spring Chinook, and those allowed under the applicable abundance based harvest rate schedule (Actual HR from TAC 2008).

Year	Actual HR (%)	Allowed HR (%)	Difference (%)
2001	14.6	16.0	1.4
2002	12.7	14.0	1.3
2003	9.4	12.0	2.6
2004	10.8	12.0	1.2
2005	7.9	9.0	1.1
2006	8.0	10.0	2.0

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, identified as a limiting factor for the Wenatchee population (Habitat Technical Subgroup 2006b).

8.6.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to Upper Columbia River spring-run Chinook from reduction in Caspian tern nesting habitat on East Sand Island and relocation of most of the terns to sites outside the Columbia River Basin (RPA Action 45) is 2.1% (CA Attachment F-2, Table 4). Compensatory mortality may occur, but based on the discussion in 8.3.5.6, it is unlikely to significantly affect the results of the action.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 43) should further reduce consumption rates of juvenile salmon by northern pikeminnow. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (Corps et al. 2007a Appendix F). Continued implementation and improvement of avian deterrence at all lower Columbia River dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces (RPA Action 48).

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island will further reduce predation on yearling Chinook, improving the status of safe passage in the juvenile migration corridor. These fish migrate over the deep water channel adjacent to the East Sand Island colony, which has made them especially vulnerable to predation. The benefit of this action will be long term.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery, and continued implementation and improvement of avian deterrence at mainstem dams are expected to improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.6.5.7 Effects of Research & Monitoring Prospective Actions

See Section 8.1.4 of this document.

8.6.5.8 Summary: Quantitative Survival Changes Expected From All Prospective Actions

Expected changes in productivity and quantitative extinction risk are calculated as survival improvements in a manner identical to the estimation of base-to-current survival improvements. The estimates of "prospective" expected survival changes resulting from the action are described in Sections 8.6.5.1 through 8.6.5.8 and are summarized in Table 8.6.5-1. Improvements in hydro operation and configuration, estuary habitat improvement projects, and further reductions in bird and fish predation are expected to increase survival above current levels for all populations in the ESU. Tributary habitat improvement projects are also expected to increase survival for all three populations. The net effect, which varies by population, is 22-46% increased survival, compared to the "current" condition, and 56-99% increased survival, compared to the "base" condition.

8.6.5.9 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Tables 8.6.6-1 and 8.6.6-2 and in Figures 8.6.6-1 through 8.6.6-4. In addition to these summary tables and figures, the SCA Life Cycle Modeling Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007 Draft Biological Opinion. Additional qualitative considerations that generally apply to multiple populations are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions at the MPG and ESU level.

8.6.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects, Summarized by Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared to the importance of each population to MPG and ESU viability. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

The Eastern Cascades MPG is the only MPG within the Upper Columbia River Spring Chinook ESU. Because there is only one MPG, Section 8.6.7 applies to both the Eastern Cascades MPG and the entire Upper Columbia River Spring Chinook ESU. As described in Section 8.6.2.1, all three populations must be viable to achieve the delisting criteria in the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007).

8.6.7 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Upper Columbia River Spring Chinook ESU

This section summarizes the basis for conclusions at the ESU level.

8.6.7.1 Potential for Recovery

It is likely that the Upper Columbia River Chinook ESU will trend toward recovery.

The future status of all three extant populations and the single MPG of UCR Chinook will be improved compared to their current status. This will be done through a reduction of adverse effects of the FCRPS and Upper Snake projects, as well as the implementation of Prospective Actions with beneficial effects, as described in Sections 8.6.5, 8.6.6, and 8.6.7.2. These beneficial actions include reduction of avian and fish predation, estuary habitat improvements, hatchery reform and tributary habitat improvements for each population. Therefore, the status of the ESU as a whole is expected to improve compared to its current condition and to move closer to a recovered condition. This expectation takes into account some short-term adverse effects of Prospective Actions related to habitat improvements (Section 8.6.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this ESU.

The Prospective Actions described above address limiting factors and threats and will reduce their negative effects. As described in Section 8.6.1, key limiting factors and threats affecting the current status of this species (abundance, productivity, spatial structure, and diversity) include: hydropower development, predation, harvest, hatcheries, and degradation of tributary and estuary habitat. The ICTRT has indicated concerns for all three populations relative to high diversity risk, including legacy effects of historical hatchery practices. The Prospective Actions include measures to ensure that hatchery management changes that have been implemented in recent years will continue, that safety-net hatchery programs will continue, and that further hatchery improvements will be implemented to reduce the likelihood of longer-term problems associated with continuing hatchery programs although subject to future hatchery-specific consultations after which these benefits may be realized. In addition to Prospective Actions, Federal actions in the environmental baseline and non-Federal actions appropriately considered cumulative effects also address limiting factors and threats. The harvest Prospective Action is to implement a *U.S. v. Oregon* harvest rate schedule that is expected to result in no change from the current harvest rates in the environmental baseline.

Some of the problems limiting recovery of UCR Chinook, such as the effects of legacy hatchery practices, will probably take longer than 10 years to correct. However, actions included in the Prospective Actions represent significant improvements that reasonably can be implemented within the next 10 years.

Additionally, the Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

In sum, these qualitative considerations suggest that the UCR Chinook ESU will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of some of the metrics indicating a trend toward recovery also support this conclusion.

Return-per-spawner (R/S) estimates are indicative of natural survival rates (i.e., the estimates assume no future effects of supplementation). As such, they are somewhat conservative for populations with ongoing supplementation programs, such as those affecting all three extant UCR Chinook populations (Section 8.6.5.4), but R/S may be the best indicator of the ability of populations to be self-sustaining. R/S calculations incorporate many variables, including age structure and fraction of hatchery-origin spawners by year. The availability and quality of this information varies, so in some cases R/S estimates are less certain than lambda and BRT trend metrics.

R/S is expected to be greater than 1.0 for all three UCR Chinook populations after implementation of the Prospective Actions (Table 8.6.6.1-1, Figure 8.6.6-1).

Population growth rate (lambda) and BRT trend estimates are indicative of abundance trends of natural-origin and combined-origin spawners, assuming that current supplementation programs continue. These estimates require fewer assumptions and less data than R/S estimates, but may also be limited by data quality. All three populations in this ESU are expected to have lambda greater than 1.0 and two of three populations are expected to have a BRT trend greater than 1.0 (Table 8.6.6-1). This indicates that in general these populations are expected to continue to increase in abundance in the future. In contrast to R/S estimates, the lambda and BRT trend estimates are at least partially explained by second generation hatchery progeny (F_2 generation) spawning naturally.

Some important caveats that apply to all three quantitative estimates are as follows:

- Not all beneficial effects of the Prospective Actions could be quantified (e.g., habitat improvements that accrue over a longer than 10-year period), so quantitative estimates of prospective R/S, lambda, and BRT trend may be low.
- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate and its effects on early ocean survival will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the ICTRT "historical" scenario, all three metrics are expected to be greater than 1.0 for all three populations (SCA Aggregate Analysis Appendix; Figure 8.6.6-2). With the "Warm PDO" (poor) ocean scenario, all three populations are expected to have R/S greater than 1.0, two of three populations are expected to have BRT trend and lambda (HF=0) greater than 1.0, and no populations are expected to have lambda greater than 1.0 if hatchery-origin spawners are assumed equally as effective as natural-origin spawners.
- The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, all three metrics are expected to be less than 1.0 at the lower 95% confidence limit and greater than 1.0 at the upper 95% confidence limit for all populations (SCA Aggregate Analysis Appendix; Figure 8.6.6-1). These results suggest that it also is important to consider qualitative factors in reaching conclusions.

Taken together, the combination of all the qualitative and quantitative factors indicates that the ESU as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements.

Quantitative estimates indicate that all UCR Chinook populations will be increasing (indicated by R/S) as a result of the actions considered in the aggregate analysis. It is also likely that abundance will increase given the aggregate effects, including a continuing supplementation program (indicated by BRT trend and lambda).

This does not mean that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes in the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the ESU being on a trend toward recovery.

8.6.7.2 Short-term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through survival improvements resulting from the Prospective Action and a continuation of other current management actions, as described above and in Section 8.6.5.

As described above and in Section 8.6.7.1, abundance is expected to be stable or increasing and populations are expected to grow as indicated by R/S, lambda, and two of three BRT trend estimates. Recent abundance levels are estimated between 59 and 222 spawners, depending on population, which is above the QET levels under consideration (Table 8.6.2-1). These factors also indicate a decreasing risk of extinction.

Continuing hatchery reforms will likely contribute to reduced risk and improving viability for all three Chinook populations in this ESU through hatchery reform generally will be analyzed in future consultations, as described above. However, some important changes are already taking place (e.g., discontinued use of Carson stock in the Entiat). For the Wenatchee population, the White River spawning area is one of the only locations with any evidence of genetic differentiation from other areas in the entire Upper Columbia ESU (ICTRT 2007b), and investments in the White River program are expected to decrease extinction risks associated with spatial distribution and diversity and buffer the Wenatchee population against environmental variability. For the Entiat, the hatchery program using incompatible Carson stock fish was discontinued in 2007. This was identified as a major limiting factor for Entiat spring Chinook. Adult returns from juvenile releases prior to 2007 should cease after 2010 and the fitness of Entiat spring Chinook is expected to improve as hatchery returns and outbreeding depression declines. For the Methow, the threat of outbreeding depression and reduced fitness is declining since the phasing-out of Carson broodstock beginning in 2001. Additional reforms would reduce threats to genetic diversity within the Methow population that can buffer the population from fluctuations in environmental conditions and to fitness reductions when a high proportion of the natural spawners are of hatchery-origin. New ESA consultations for Action Agency funded hatchery programs leading to the implementation of more hatchery reform are to be completed by June 2009 and NOAA Fisheries guidance (Artificial Propagation for Pacific Salmon Appendix) is expected to help shape those consultations.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

The Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24 year) extinction risk also support this conclusion.

Quantitative estimates of extinction risk indicate <5% risk at QET=50 for the Wenatchee population, regardless of the schedule for implementing the Prospective Actions (Table 8.6.1-2; Figure 8.6.6-3). No quantitative estimates are available for the Methow population, but because its abundance and trend are similar to that of the Wenatchee population, it is likely to have similar extinction risk. For the Entiat, estimated short-term extinction risk is <5% at QET=50, if all Prospective Actions are assumed to occur immediately, and >5% if no Prospective Actions occur immediately (Table 8.6.6.1-2). An additional 8% survival change is needed to reduce extinction risk to <5% under the latter assumption. Implementation of all Prospective Actions is expected to result in an additional 46% survival improvement for this population (Table 8.6.5-1).

These estimates assume no continued supplementation and assume that the population will be extinct if it falls below 50 fish for four years in a row (QET=50). It is likely that short-term extinction risk is lower than that calculated above when continued supplementation is considered (see, for example, the UCR steelhead analysis in Section 8.7.7 and Hinrichsen 2008, which is Attachment 1 to the Aggregate Analysis Appendix), but such an analysis was not conducted for this ESU. Similarly, as discussed in Section 7.1.1, QET levels less than 50 may be relevant to short-term extinction risk, particularly for smaller populations like the Entiat. Short-term extinction risk for the Entiat under continuing current management conditions is expected to be less than 5% at QET levels of 30 spawners or less (Table 8.6.5-1; Figure 8.6.6-3).

The mean base period short-term extinction risk estimates represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While NOAA Fisheries does not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from near 0% to approximately 80% at QET=50 (Table 8.6.2-3). This uncertainty indicates that it is important to also consider qualitative factors in reaching conclusions.

This summary of quantitative extinction risk estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the “historical” ocean scenario both populations are expected to have ≤ 5% risk at QET=50 (Aggregate Analysis Appendix; Figure 8.6.6-4). Under the ICTRT "Warm PDO" climate scenario, in which all years are anomalously warm, the results are very similar to those under the "recent" climate scenario, as described above.

Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change were considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

Taken together, the combination of all the factors above indicates that the ESU as a whole is likely to have a low risk of short-term extinction when the environmental baseline and cumulative effects are considered, along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements result in a lower short-term extinction risk than in recent years. Quantitative estimates available for two populations indicate that UCR Chinook from the Wenatchee population will have a low risk even without implementation of any Prospective Actions, while some improvements would need to occur quickly for the Entiat population to have low risk at QET=50. Only about one-sixth of the survival improvement expected from the Prospective Action would need to occur quickly, which is a reasonable expectation given the nature of several of the actions. No Prospective Actions would be needed for low short-term risk of the Entiat population at QET=30. Because of similar abundance and trends, the Methow population likely has similar extinction risk as the Wenatchee population. Additionally, it is likely that short-term extinction risk in the Methow and Wenatchee is low given continuation of current supplementation programs. The combination of recent abundance estimates, expected survival improvements, expected positive trends for these populations, and supplementation programs that reduce short-term risk indicate the three populations in this ESU are likely to have a low enough risk of extinction to conclude that the ESU as a whole will have a low risk of short-term extinction.

8.6.7.3 Effect of Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for UCR spring Chinook salmon including all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Methow, Upper Columbia/Entiat, and Wenatchee. The environmental baseline within the action area, which encompasses all of these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for UCR spring Chinook. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Columbia River; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, and excess sediment in gravel in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at McNary and John Day dams, in concert with training spill to provide safe egress provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles and the removal of sea lions known to eat spring Chinook in the tailrace of Bonneville Dam will do the same for adults. Habitat work in tributaries used for spawning and rearing and in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.6.2-1. Status of UCR spring Chinook salmon with respect to abundance and productivity VSP factors. Productivity is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	**MPG**	**Population**	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: 20-yr non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope: 1980 - Current[4]	Lower 95% CI	Upper 95% CI
Upper Columbia Spring Chinook Salmon	**Eastern Cascades**	Wenatchee R.	222	1994-2003	2000	0.75	0.46	1.22	0.96	0.61	1.51	0.91	0.61	1.36	0.89	0.83	0.95
		Methow R.	180	1994-2003	2000	0.73	0.42	1.27	1.02	0.59	1.78	0.94	0.58	1.53	0.90	0.80	1.01
		Entiat R.	59	1994-2003	500	0.72	0.49	1.05	0.97	0.72	1.31	0.92	0.71	1.21	0.93	0.89	0.98
		Okanogan R. (extirpated)															

1 Most recent year for 10-year geometric mean abundance is 2003. ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from ICTRT (2007c).
2 Mean returns-per-spawner are estimated from the most recent period of approximately 20 brood years in Cooney (2007). Actual years in average vary by population.
3 Median population growth rate (lambda) during the most recent period of approximately 20 years. Actual years in estimate vary by population. Lambda estimates are from Cooney (2008c).
4 Biological Review Team (Good et al. 2005) trend estimates and 95% confidence limits updated for recent years in Cooney (2008c).

Table 8.6.2-2. Status of UCR spring Chinook salmon with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	ICTRT Current Risk For Spatial Structure[1]	ICTRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Upper Columbia Spring Chinook Salmon	Eastern Cascades	Wenatchee R.	Currently Low Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops hatchery straying; high proportion hatchery fish)	0.62
		Methow R.	Currently Low Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops hatchery straying; high proportion hatchery fish)	0.52
		Entiat R.	Currently Moderate Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops hatchery straying; high proportion hatchery fish)	0.69
		Okanogan R. (extirpated)			

1 ICTRT conclusions for UCR spring Chinook are from ICTRT Current Status Summaries (ICTRT 2007d)
2 Average fractions of natural-origin natural spawners are from ICTRT (2007c).

Table 8.6.2-3. Status of UCR spring Chinook salmon with respect to extinction risk. Extinction risk is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			24-Year Extinction Risk											
ESU	**MPG**	**Population**	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Upper Columbia Spring Chinook Salmon	**Eastern Cascades**	Wenatchee R.	0.00	0.00	0.42	0.00	0.00	0.64	0.01	0.00	0.78	0.02	0.00	0.82
		Methow R.												
		Entiat R.	0.00	0.00	0.18	0.01	0.00	0.42	0.07	0.00	0.69	0.19	0.00	0.82
		Okanogan R. (extirpated)												

1 Short-term (24-year) extinction risk and 95% confidence limits from Hinrichsen (2008), in the Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.6.2-4. Changes in density-independent survival ("gaps") necessary for indices of productivity equal to 1.0 and estimates of extinction risk no higher than 5% for UCR spring Chinook salmon. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated "gaps" are based on population performance during the "base period" of approximately the last 20 brood years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 1980-current BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Upper Columbia Spring Chinook Salmon	Eastern Cascades	Wenatchee R.	1.34	2.17	0.82	1.23	9.60	0.16	1.54	9.53	0.87	1.69	2.28	1.26	0.13	0.29	0.49	0.65
		Methow R.	1.37	2.40	0.79	0.90	10.91	0.07	1.30	11.34	1.00	1.63	2.75	0.96				
		Entiat R.	1.40	2.05	0.95	1.13	4.33	0.30	1.43	4.73	0.90	1.37	1.72	1.10	0.32	0.63	1.04	1.47
		Okanogan R. (extirpated)																

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.6.2-1.
2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.6.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.6.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
4 Extinction risk survival gap is calculated as the exponent of a Beverton-Holt "a" value from a production function that would result in 5% risk, divided by the exponent of the base period Beverton-Holt "a" value. Estimates are from Hinrichsen (2008), in the Aggregate Analysis Appendix.

Table 8.6.3-1. Proportional changes in average base period survival of UCR Chinook salmon expected from completed actions and current human activities that are likely to continue into the future. Factors greater than one result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average).

			Base-to-Current Adjustment (Survival Multiplier)							
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Marine Mammal Predation[5]	Harvest[6]	Hatcheries[7]	Total Base-to-Current Survival Multiplier[8]
Upper Columbia Spring Chinook Salmon	Eastern Cascades	Wenatchee R.	1.25	1.02	1.00	1.00	0.97	1.04	1.00	1.28
		Methow R.	1.43	1.02	1.00	1.00	0.97	1.04	1.00	1.47
		Entiat R.	1.32	1.02	1.00	1.00	0.97	1.04	1.00	1.36
		Okanogan R. (extirpated)								

1 From SCA Hydro Appendix. Based on differences in average base and current smolt-to-adult survival estimates for both FCRPS and PUD dams.
2 From CA Chapter 8, Table 8-7.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Current 2 S/Baseline 2 S" approach, as described in Attachment F-2.
5 From SCA Marine Mammal Appendix
6 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
7 No quantitative hatchery effects.
8 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column.

Table 8.6.5-1. Proportional changes in survival of UCR spring Chinook salmon expected from the Prospective Actions. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Survival Multiplier)									
ESU	**MPG**	**Population**	**Hydro[1]**	**Tributary Habitat[2] (2007-2017)**	**Estuary Habitat[3]**	**Bird Predation[4]**	**Pike-minnow Predation[5]**	**Hatcheries[6]**	**Non-Hydro Current-to-Future Survival Multiplier[7]**	**Total Current-to-Future Survival Multiplier[8]**		**Total Base-to-Future Survival Multiplier[9]**
Upper Columbia Spring Chinook Salmon	**Eastern Cascades**	Wenatchee R.	1.09	1.03	1.06	1.02	1.01	1.00	1.13	1.22		1.56
		Methow R.	1.10	1.06	1.06	1.02	1.01	1.00	1.16	1.27		1.86
		Entiat R.	1.10	1.22	1.06	1.02	1.01	1.00	1.33	1.46		1.99
		Okanogan R. (extirpated)										

1 From SCA Hydro Modeling Appendix. Based on differences in average current and prospective smolt-to-adult survival estimates for both FCRPS and PUD dams.
2 From CA Chapter 8, Table 8-9.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 No quantitative survival changes have been estimated to result from hatchery Prospective Actions – future effects are qualitative.
7 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
8 Same as Footnote 7, except it is calculated from all Prospective Actions, including hydro actions.
9 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier from Table 8.6.3-1.

Table 8.6.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for UCR spring Chinook.

ESU	MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Upper Columbia Spring Chinook Salmon	Eastern Cascades	Wenatchee R.	1.17	1.05	1.00	0.98	Must be HV or V	R/S and lambda >1; BRT trend <1	Currently Low Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops, hatchery straying; high proportion hatchery fish)
		Methow R.	1.36	1.17	1.08	1.03	Must be HV or V	All three metrics >1	Currently Low Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops, hatchery straying; high proportion hatchery fish)
		Entiat R.	1.42	1.13	1.08	1.09	Must be HV or V	All three metrics >1	Currently Moderate Risk	Currently High Risk (Reduced genetic diversity from homogenization of pops, hatchery straying; high proportion hatchery fish)
		Okanogan R. (extirpated)								

1 Calculated as the base period 20-year R/S productivity from Table 8.6.2-1, multiplied by the total base-to-future survival multiplier in Table 8.6.5-1.
2 Calculated as the base period 20-year mean population growth rate (lambda) from Table 8.6.2-1, multiplied by the total base-to-future survival multiplier in Table 8.6.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
3 Calculated as the base period 20-year mean BRT abundance trend from Table 8.6.2-1, multiplied by the total base-to-future survival multiplier in Table 8.6.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007a), Attachment 2
5 From Table 8.6.2-2

Table 8.6.6.1-2. Summary of prospective estimates relevant to the survival prong of the jeopardy standard for UCR spring Chinook. Numbers represent additional survival improvements (remaining "gaps") to reduce 24-year extinction risk to 5% or less. Numbers less than 1.0 indicate that no additional survival changes are necessary.

			Extinction - Based Only On Current Adjustment - Not Influenced By RPA[1]				Extinction - Based On Current Adjustment and RPA Prospective Actions[2]					
ESU	MPG	Population	24-yr Extinction Risk Gap for ≤5% at QET=1	24-yr Extinction Risk Gap for ≤5% at QET=10	24-yr Extinction Risk Gap for ≤5% at QET=30	24-yr Extinction Risk Gap for ≤5% at QET=50	24-yr Extinction Risk Gap for ≤5% at QET=1	24-yr Extinction Risk Gap for ≤5% at QET=10	24-yr Extinction Risk Gap for ≤5% at QET=30	24-yr Extinction Risk Gap for ≤5% at QET=50	ICTRT MPG Viability Scenario	Survival Prong Notes for Extinction Risk
Upper Columbia Spring Chinook Salmon	Eastern Cascades	Wenatchee R.	0.10	0.23	0.38	0.51	0.08	0.19	0.31	0.42	Must be HV or V	<5% risk at QET=50 without reliance on immediate RPA actions
		Methow R.									Must be HV or V	No short-term extinction risk estimates
		Entiat R.	0.24	0.46	0.76	1.08	0.16	0.32	0.52	0.74	Must be HV or V	<5% risk at QET=50 if some Prospective Actions implemented immediately; otherwise, >5% risk
		Okanogan R. (extirpated)										

1 These estimates assume that only actions that have already occurred can contribute to reducing short-term extinction risk. Calculated as the base period 5% extinction risk gap from Table 8.6.2-4, divided by the total base-to-current survival multiplier in Table 8.6.3-1.
2 These estimates assume that the Prospective Actions to be implemented in the next 10 years can contribute to reducing short-term extinction risk. Calculated as the base period 5% extinction risk gap from Table 8.6.2-4, divided by the total base-to-future survival multiplier in Table 8.6.5-1.
3 From ICTRT (2007a), Attachment 2

Figure 8.6.6-1. Summary of prospective mean R/S estimates for UCR spring Chinook salmon under the "recent" climate assumption, including 95% confidence limits.

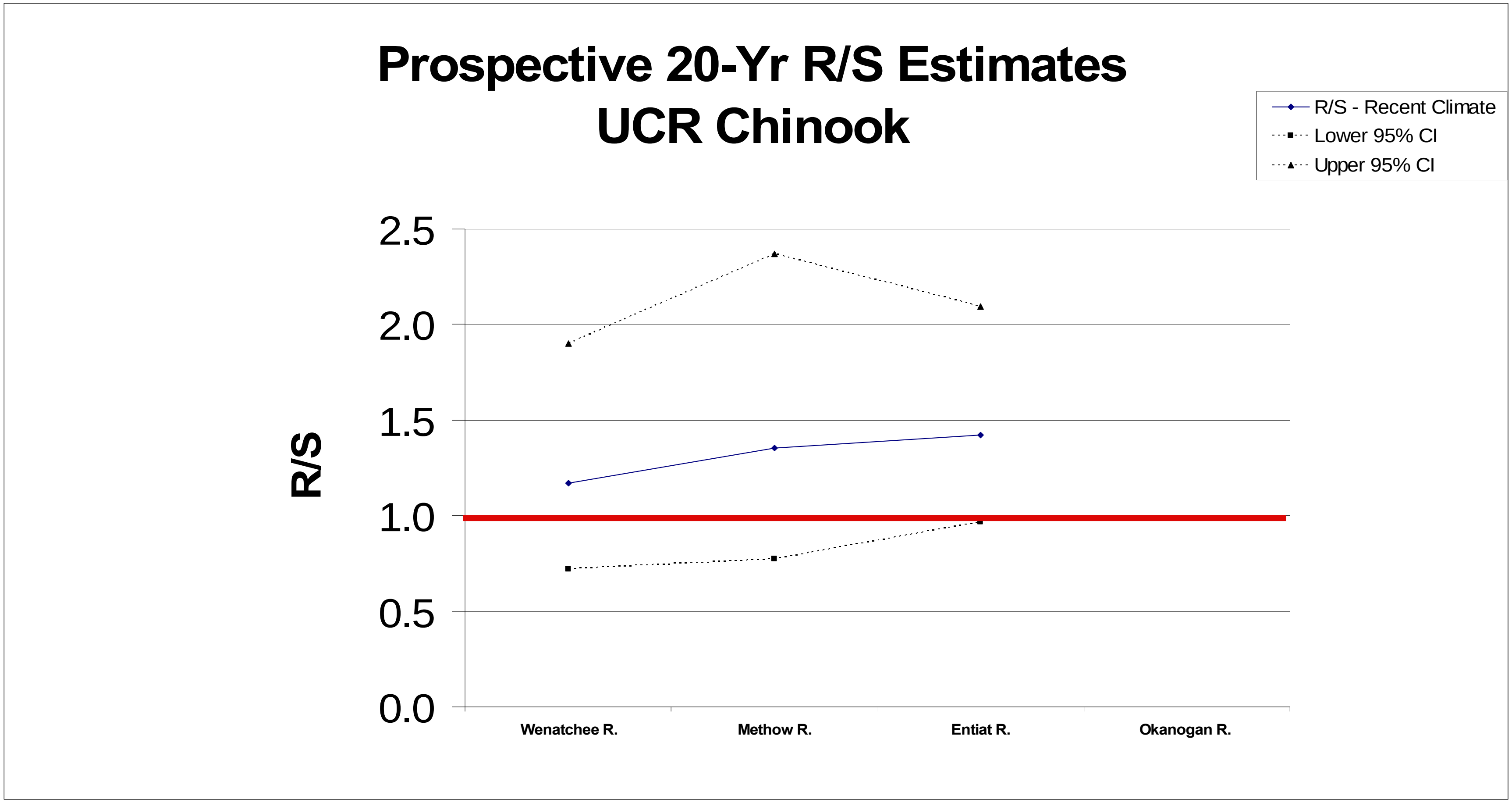


Figure 8.6.6-2. Summary of prospective mean R/S estimates for UCR Spring Chinook salmon under three climate assumptions.

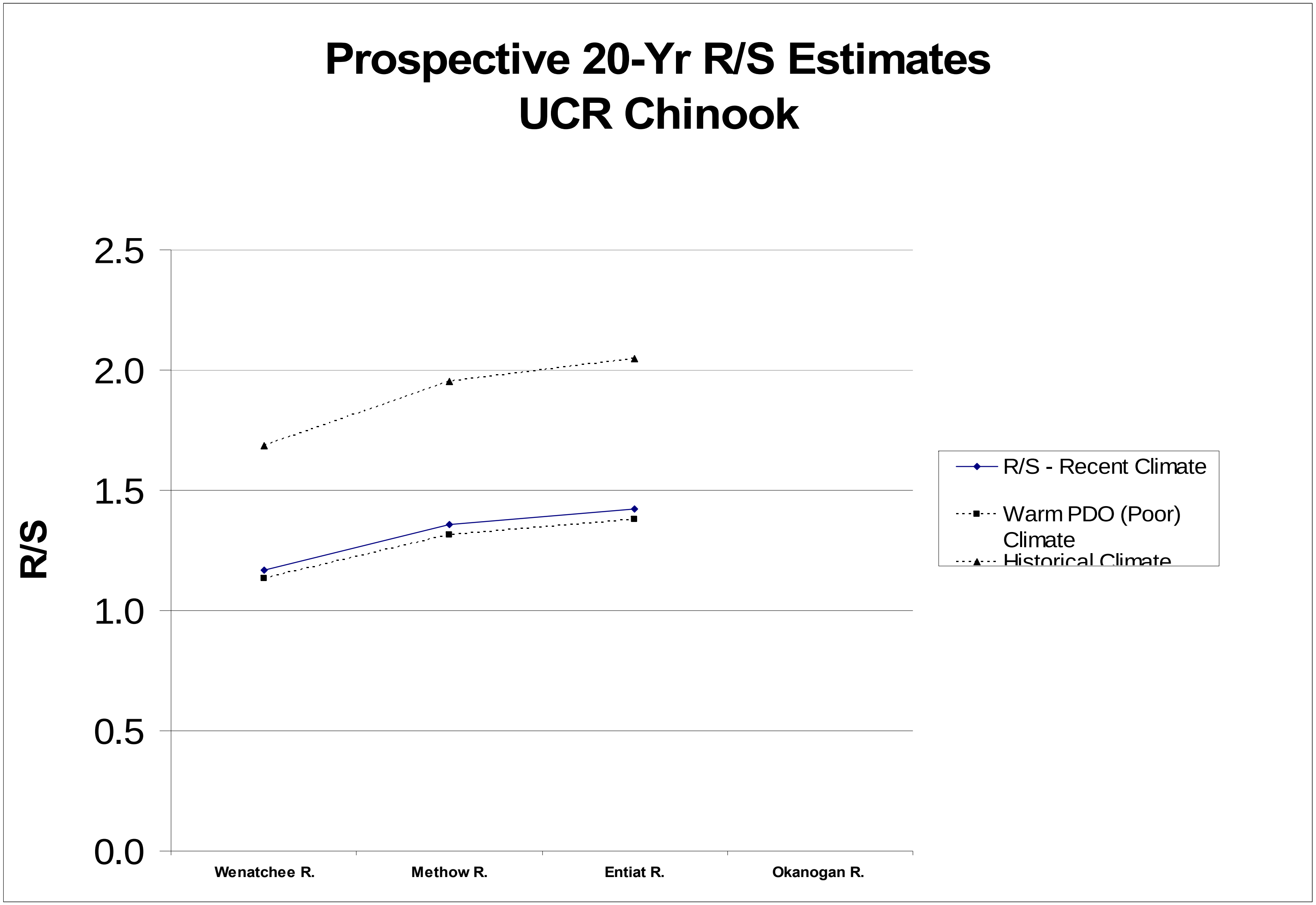


Figure 8.6.6-3. Summary of prospective 5% 24-year extinction risk gap estimates for UCR spring Chinook salmon under the "recent" climate assumption, showing effects of three alternative quasi-extinction thresholds (QET).

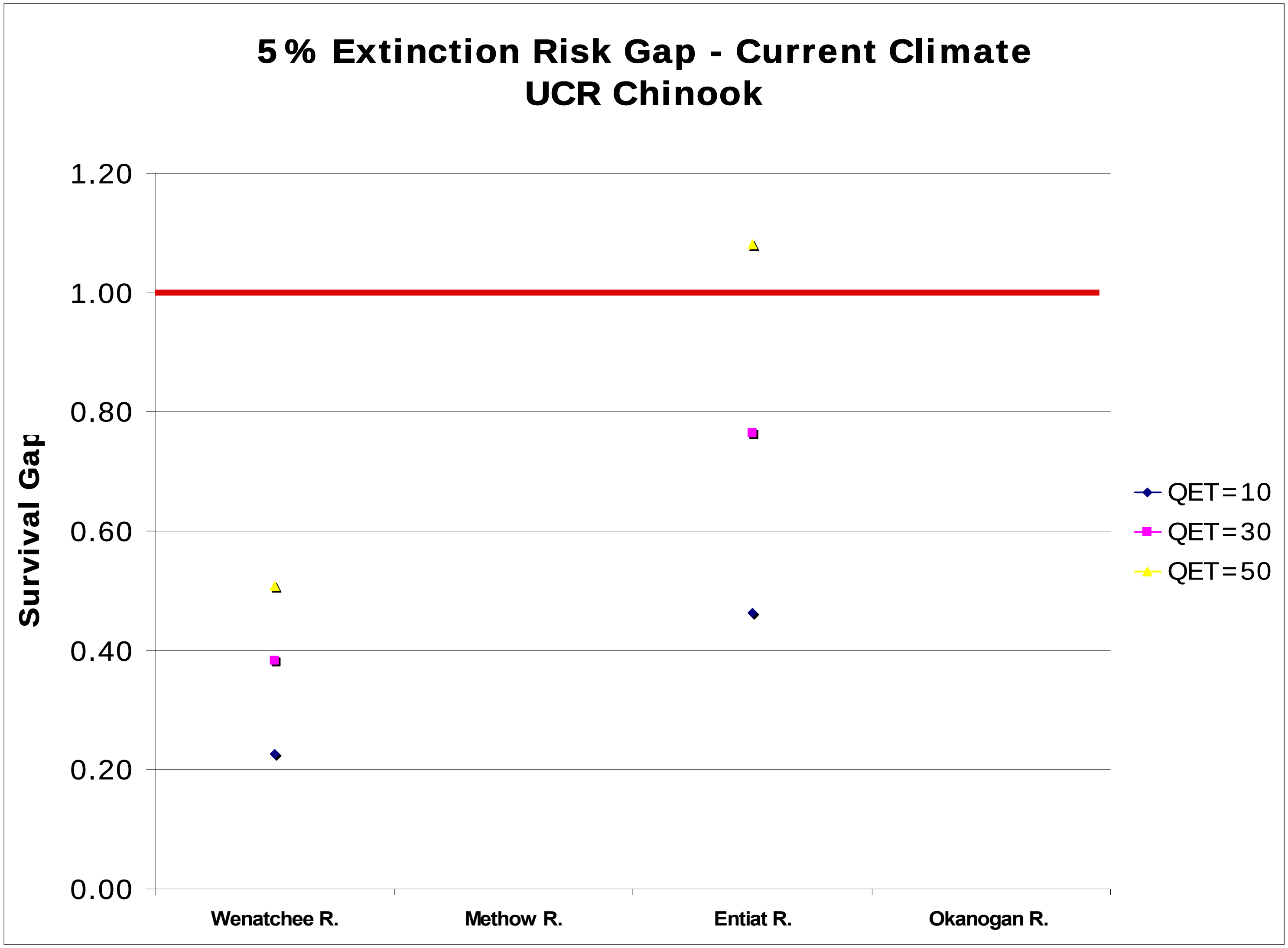
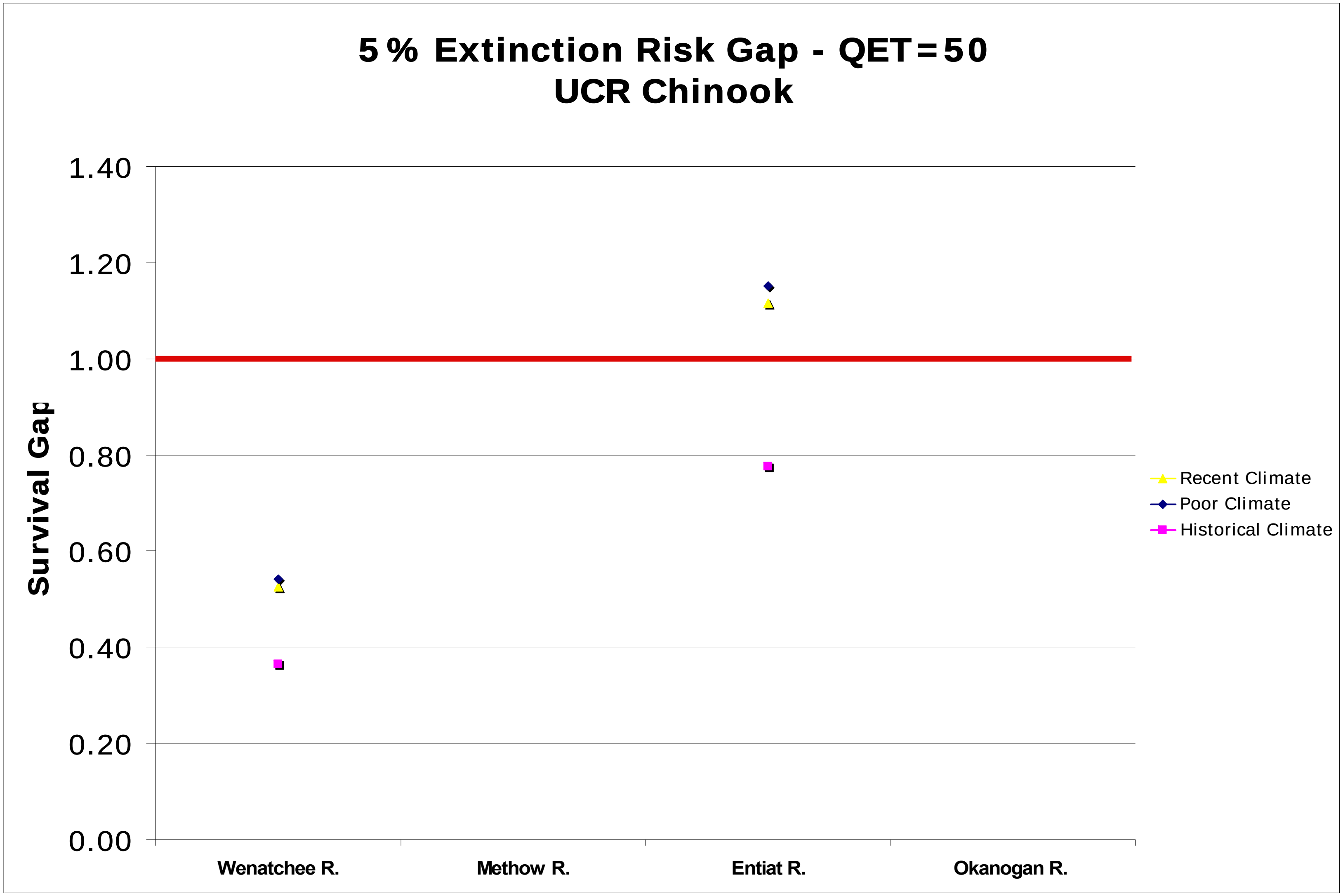


Figure 8.6.6-4. Summary of prospective 5% 24-year extinction risk gap estimates for UCR spring Chinook salmon under three climate assumptions.



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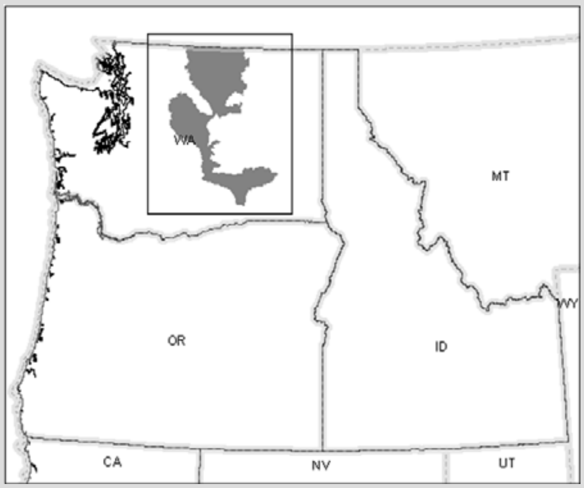
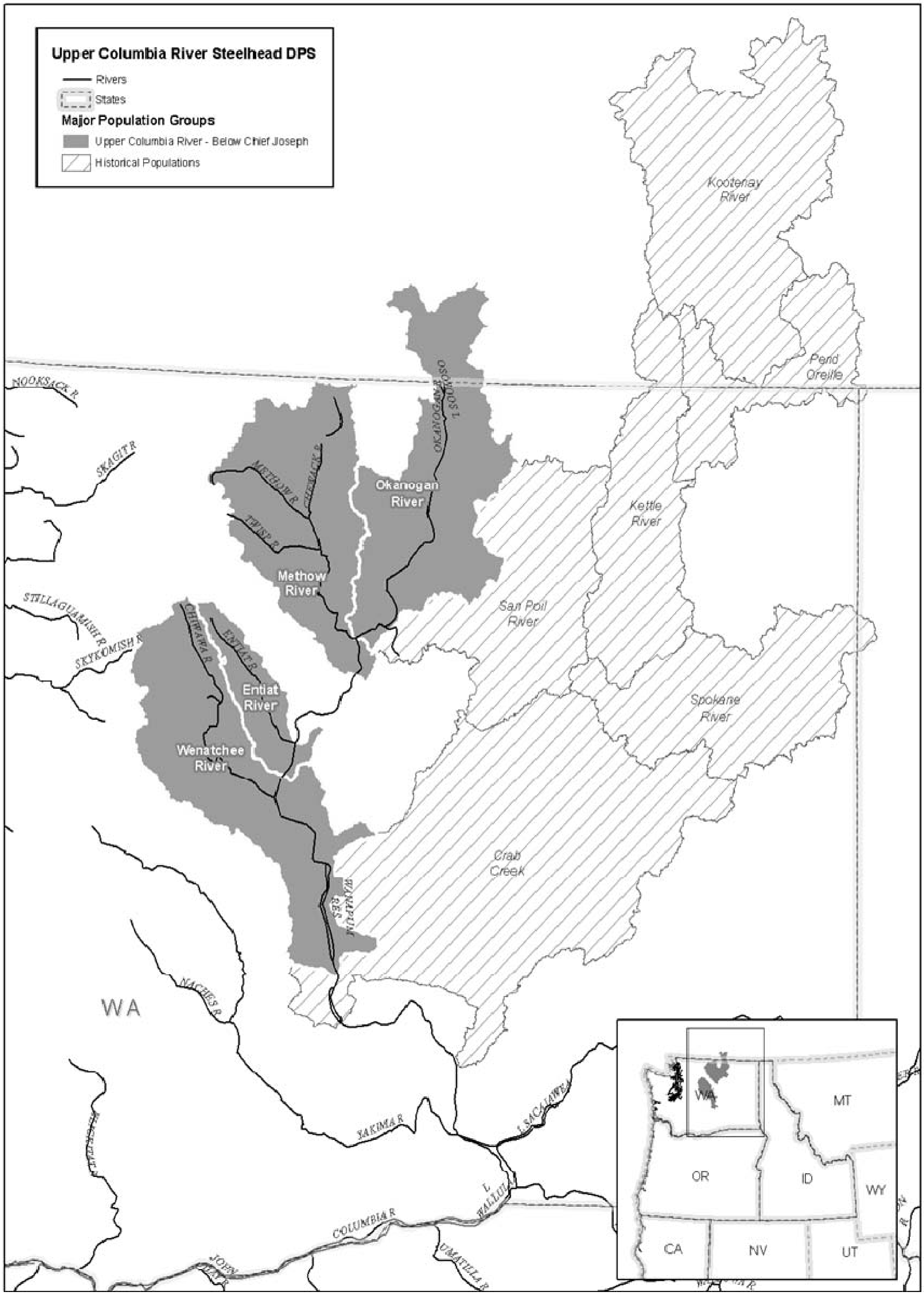
Section 8.7
Upper Columbia River Steelhead




Upper Columbia River Steelhead DPS
Rivers
States
Major Population Groups
Upper Columbia River - Below Chief Joseph
Historical Populations
Kootenay River
Pend Oreille
Kettle River
San Poil River
Spokane River
Crab Creek
Okanogan River
Methow River
Entiat River
Wenatchee River
WA
MT
OR
ID
WY
CA
NV
UT

Section 8.7
Upper Columbia River Steelhead

Species Overview

Background

The Upper Columbia River (UCR) steelhead DPS includes all anadromous populations that spawn and rear in the middle reaches of the rivers and tributaries draining the eastern slope of the Cascade Mountains upstream of Rock Island Dam. There are four populations in a single major population group. The Upper Columbia River steelhead DPS was listed under the ESA as endangered in 1997.

Hatchery steelhead have been released into the Methow and Okanogan since the late 1960s and into the Wenatchee and Entiat systems since the 1970s. Through the 1980s, operations were designed to accommodate harvest and there was no attempt to limit introgression of hatchery fish into the native populations. In many cases, the hatchery broodstock originated from outside the upper Columbia area. Naturally spawning hatchery fish were not adapted to local conditions, which most likely limited their effectiveness and depressed the production of the population as a whole. While there is no precise means to measure the full effect of these practices, they likely contributed substantially to the current low recruits-per-spawner (R/S) productivities for naturally spawning fish.

Since the early 1990s, hatchery programs that operate in the Wenatchee, Methow, and Okanogan basins have implemented reforms to support steelhead conservation and recovery. No hatchery fish are released into the Entiat and the hatchery broodstocks in other watersheds are now composed exclusively of steelhead from the Upper Columbia DPS. The hatchery programs are managed to preserve natural genetic resources.

Designated critical habitat for UCR steelhead includes all Columbia River estuarine areas and river reaches upstream to Chief Joseph Dam and several tributary subbasins.

Current Status & Recent Trends

Upper Columbia River (UCR) steelhead is an endangered species composed of the anadromous *O. mykiss* in four extant populations in one major population group (MPG). For all populations, abundance over the most recent 10-year period is below the thresholds that the ICTRT has identified as a minimum for recovery. Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels above or near the recovery abundance thresholds (all populations except the Okanogan) in a few years in the early 2000s, and is now at levels intermediate to those of the mid-1990s and early 2000s. Abundance since 2001 has substantially increased for the DPS as a whole.

Limiting Factors and Threats

The key limiting factors and threats for UCR steelhead include hydropower projects, predation, harvest, hatchery effects, degraded tributary habitat and degraded estuary habitat. Ocean conditions generally have been poor for this DPS over the last 20 years, improving only in the last few years.

Recent Ocean and Mainstem Harvest

Few steelhead are caught in ocean fisheries. Ocean fishing mortality on UCR steelhead is assumed to be zero. Upriver summer steelhead, which include UCR steelhead, are categorized as A-run or B-run based on run timing and age and size characteristics. UCR are all A-run fish.

Fisheries in the Columbia River are limited to assure that the incidental take of ESA-listed Upper Columbia River steelhead does not exceed specified rates. Non-Treaty fisheries are subject to a 2% harvest rate limit on A-run steelhead. Treaty Indian fall season fisheries are subject to a 15% harvest rate limit on B-run steelhead, but were not subject to a particular A-run harvest rate constraint since B-run steelhead are generally more limiting. Recent harvest rates on Upper Columbia River steelhead in non-Treaty and treaty Indian fisheries ranged from 1.0% to 1.9%, and 4.1% to 12.4%, respectively.

8.7.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point is the scientific analysis of species' status, which forms the basis for the listing of the species as endangered or threatened.

8.7.2.1 Current Rangewide Status of the Species

Upper Columbia River (UCR) steelhead is an endangered species composed of the anadromous *O. mykiss* in four extant populations in one major population group (MPG). All four populations must be viable to achieve the delisting criteria in the Upper Columbia River Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007). Key statistics associated with the current status of UCR steelhead are summarized in Tables 8.7.2-1 through 8.7.2-4. Upriver summer steelhead, which include UCR steelhead, are categorized as A-run or B-run based on run timing and age and size characteristics. UCR steelhead are all A-run fish.

Limiting Factors & Threats

The key limiting factors and threats for UCR steelhead include hydropower projects, predation, harvest, hatchery effects, degraded tributary habitat and degraded estuary habitat. Ocean conditions generally have been poor for this DPS over the last 20 years, improving only in the last few years. Limiting factors are discussed in detail in the context of critical habitat in Section 8.7.3.3.

Abundance

For all populations, average abundance over the most recent 10-year period is below the average abundance thresholds that the ICTRT has identified as a minimum for low risk (Table 8.7.2-1).[1] Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels above or near the recovery abundance thresholds (all populations except the Okanogan) in a few years in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s (Figure 8.7.2.1-1, showing annual abundance of combined populations).

Aggregate abundance of the four populations and a rolling 5-year geometric mean of abundance for the DPS are shown in Figure 8.7.2.1-1. Geometric mean abundance since 2001 has substantially increased for the DPS as a whole. Geomean abundance of natural-origin fish for the 2001 to 2003 period was 3,643 compared to 1,146 for the 1996 to 2000 period, a 218 percent improvement (Fisher and Hinrichsen 2006). The recent geomean abundance was influenced by exceptional returns in 2002, yet returns of natural-origin adults have been well above the 1996 to 2000 geomean in years since 2000.

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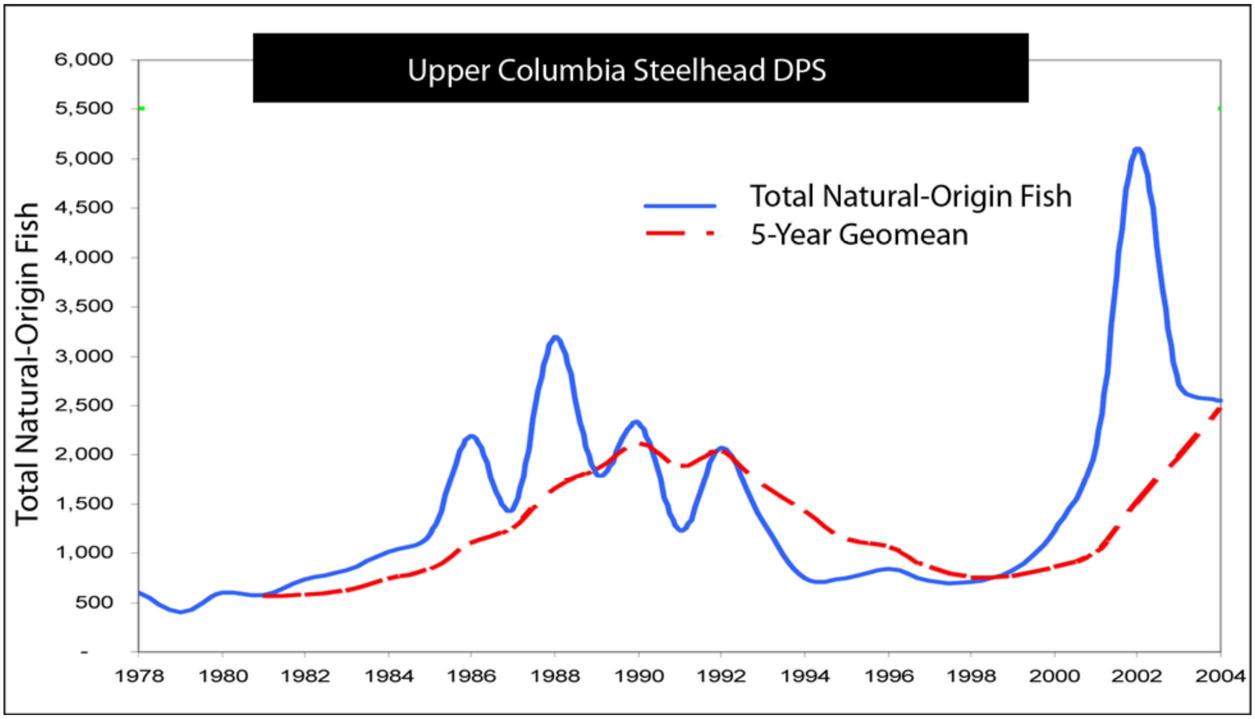
[1] BRT and ICTRT products were developed as primary sources of information for the development of delisting or long-term recovery goals. They were not intended as the basis for setting goals for "no jeopardy" determinations. Although NOAA Fisheries considers the information in the BRT and ICTRT documents in this consultation, its jeopardy determinations are made in a manner consistent with the Lohn memos dated July 12, and September 6, 2006 (NMFS 2006h, i).

Figure 8.7.2.1-1. Upper Columbia River Steelhead Population Trends, 1978 to 2004 (adopted from Fisher and Hinrichsen 2006)



"Base Period" Productivity

On average over the last 20 full brood year returns (1980/81 through 1999/2000 brood years [BY], including adult returns through 2004-2005), UCR steelhead populations have not replaced themselves (Table 8.7.2-1) when only natural production is considered (i.e., average R/S has been less than 1.0). In general, R/S productivity was relatively high during the early 1980s, low during the late 1980s and 1990s, and high again in the most recent brood years (brood year R/S estimates in ICTRT Current Status Summaries [ICTRT 2007d] updated with Cooney [2008a]).

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at <5% extinction risk (ICTRT 2007c).

The BRT trend in abundance and median population growth rate (lambda) calculated with an assumption that hatchery-origin natural spawners are not successful (HF=0) indicates an increase in abundance during this period for all three populations for which trend can be estimated (Table 8.7.2-1). Lambda, when calculated with an assumption that hatchery-origin and natural-origin natural spawners are equally effective (HF=1), indicated a declining trend similar to that of R/S (Table 8.7.2-1).

Spatial Structure

The ICTRT has characterized the spatial structure risk to UCR steelhead populations as "low" for the Wenatchee and Methow, "moderate" for the Entiat, and "high" for the Okanogan (Table 8.7.2-2). The ICTRT considers the risk high for the Okanogan population because only the lower of two major spawning areas in the United States is occupied.

Diversity

The ICTRT has characterized the diversity risk to all UCR steelhead populations as "high" (Table 8.7.2-2). The high risk is a result of reduced genetic diversity from homogenization of populations that occurred during the Grand Coulee Fish Maintenance Project from 1939-1943 and then again from 1960 to as recently as 1981 (Chapman et al. 1994). Additionally, the Methow and Okanogan populations have particularly high proportions of hatchery-origin spawners, and recent monitoring data suggests that hatchery fish may be straying into non-target areas, likely contributing to the continued homogenization of the populations.

"Base Period" Extinction Risk

The draft ICTRT Current Status Summaries (ICTRT 2007d) have characterized the long-term (100 year) extinction risk, calculated from productivity of populations during the "base period" described above for R/S productivity estimates, as "High" (>25% 100-year extinction risk) for all four UCR steelhead populations. The ICTRT defined the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50).

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk. Table 8.7.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish) for each population. This short-term extinction risk analysis is also based on the assumption that productivity observed during the "base period" will be unchanged in the future. At QET=50 all populations have >5% risk of short-term extinction. Confidence limits on these estimates are extremely wide, ranging from 0 to 100% risk of extinction.

A QET of less than 50 may also be considered a reasonable indicator of short-term risk, as discussed in Section 7.1.1.1. At QET=30 and QET=10 all populations have >5% risk of short-term extinction.

The short-term and ICTRT long-term extinction risk analyses assume that all hatchery supplementation ceases immediately. As described in Section 7.1.1.1, this assumption is not representative of hatchery management under the Prospective Actions. A more realistic assessment of short-term extinction risk will take hatchery programs into consideration, either qualitatively or quantitatively. If hatchery supplementation is assumed to continue at current levels for those populations affected by hatchery programs, short-term extinction risk is lower (Hinrichsen 2008, included as attachment 1 of the SCA Aggregate Analysis Appendix). This analysis indicates that short-term extinction risk at QET=50 is at or near 0% if continued supplementation is assumed for all except the Entiat population. However, dependence on hatcheries for more than three or four generations (9-16 years for UCR Steelhead), poses an increased risk to population diversity (ICTRT 2007d).

Quantitative Survival Gaps

The change in density-independent survival that would be necessary for quantitative indicators of productivity to be greater than 1.0 are displayed in Table 8.7.2-4. Mean base period R/S survival gaps range from 20% to over 700%, Under the HF=0 assumption, there is no survival gap for lambda, nor is there a survival gap for BRT trend. However, under the HF=1 assumption, the lambda gap ranges from 160% to nearly 500%.

Survival gaps for 24-year extinction risk could not be calculated using the methods employed in this analysis. However, based on the high base period risk it is likely that these gaps would be very large. An analysis that assumed that hatchery supplementation would continue indicated close to 0% risk of short-term extinction for all but the Entiat population (see above), so there would be no extinction risk gap for three populations if continued supplementation is assumed.

8.7.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for UCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Okanogan, Similkameen, Methow, Upper Columbia/Entiat, Wenatchee, Lower Crab, and Upper Columbia/Priest Rapids (NMFS 2005b). There are 42 watersheds within the range of this DPS. Three watersheds received a low rating, 8 received a medium rating, and 31 received a high rating of conservation value to the DPS (see Chapter 4 for more detail). The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 11 of the high value watersheds identified above. This corridor 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. Of the 1,332 miles of habitat areas eligible for designation, 1,262 miles of stream are designated critical habitat. The status of critical habitat is discussed further in Section 8.7.3.3.

8.7.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.7.3.1 "Current" Productivity & Extinction Risk

Because the action area encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section, estimates of productivity and extinction risk were based on performance of populations during a 20-year "base period," ending with the 1999 or 2000 brood year. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone Section 7 consultation and the continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity as the riparian area becomes functional).

Quantitative Estimates

Because a number of ongoing human activities have changed over the last 20 years, the CA includes estimates of a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Chapter 7.1 of this document. Results are presented in Table 8.7.3-1.

Briefly, reduction in the average base period harvest rate of natural origin fish (estimated at approximately a 4% survival change [SCA Harvest Appendix, based on *U.S. v. Oregon* estimates]), improvements in both FCRPS and Public Utility District (PUD) dam configuration and operation (approximately a 8% to 25% survival change, based on ICTRT base survival and COMPASS analysis of current survival in CA Appendix B), and estuary habitat projects (a less than 1% survival change, based on CA Appendix D) result in a survival improvement for all UCR steelhead populations. Tributary habitat projects result in approximately 2-6% survival improvements, depending on population (CA Chapter 9, Table 9-7). In contrast, development of tern colonies in the estuary in recent years results in less than a 1% reduction in survival for all populations.

NOAA Fisheries reviewed hatchery information for the period 1936 to present, including the origin, number and location of hatchery origin fish (HOF) releases. In 1998, the goal of all the hatchery programs in the UCR steelhead DPS changed from providing fish for harvest to also conserving the genetic resources and reducing short-term extinction risk and increasing HOF fitness or effectiveness. Before 1998, all hatchery programs fell into Category 1 (HOF<30% as effective as natural origin fish [NOF]) and HOF were planted in areas to accommodate fisheries, not promote HOF effectiveness (i.e., the majority of releases were not in prime steelhead production areas). After 1998, hatchery program reforms were initiated for each of the four steelhead populations. Additionally, starting in 1998 tributary fisheries were curtailed until a plan was developed that addressed impacts on ESA listed fish. Currently, ESA Section 10 permit #1395 authorizes steelhead fisheries targeting surplus hatchery fish in the Wenatchee, Methow, and Okanogan when natural-origin fish returns meet criteria established in the steelhead management plan.

The CA suggests a range of 52 to 113% survival improvement to the Wenatchee population from hatchery reforms that began in 1998 (CA Table 9-7). Hatchery reforms of PUD-funded programs in the Wenatchee basin include using broodstock collected only from the Wenatchee River, with a substantially increased proportion of natural-origin fish in the broodstock; released fish in primary steelhead production areas (to promote effectiveness); and mechanisms to manage hatchery returns on spawning grounds in years of high survival. Future reforms, called for in the 50-year Habitat Conservation Plan, include increased rearing and acclimation on Wenatchee basin surface water to improve survival and homing fidelity. PUD-funded RM&E actions are also called for and are anticipated to reduce risk associated with the hatchery program.

The “low” hatchery effectiveness estimate for the Wenatchee population used in Table 9-4 of the CA (1.52) is reasonable. When re-calculated with updated historical hatchery fractions from the ICTRT (Cooney 2008a), the estimate changes to 1.60 (SCA Quantitative Analysis of Hatchery Actions Appendix). Available information does not support effectiveness estimates greater than 0.3 for HOF before 1998. HOF effectiveness was likely lower than 0.3 based on historical release practices and absent estimates of HOF straying into primary steelhead production areas.

The CA suggests a range of 56 to 150% survival improvement to the Entiat population based on hatchery reforms in place since 1998 (CA Table 9-7). Releases of hatchery steelhead from the PUD funded program in the Entiat River ended in 1997 as a hatchery reform measure. Based on limited telemetry studies, the Entiat population may have continued to be affected by hatchery steelhead from other programs, particularly the Wenatchee program, that stray into the Entiat River. The reform measure to increase rearing and acclimation of the hatchery program in the Wenatchee basin is expected to benefit Entiat population productivity and diversity by increasing homing fidelity to the Wenatchee and thus reducing Wenatchee hatchery steelhead straying into the Entiat. Estimates of prospective productivity improvements are disadvantaged by lack of spawner composition data and uncertainties over the implementation and effectiveness of reforms to reduce straying.

The proportion of natural spawners made up of hatchery-origin fish is an important variable in estimating productivity changes. The FCRPS Action Agencies use ICTRT estimates of natural spawner composition for the Entiat, and these estimates are based on very limited data. Data for the Entiat is the least robust of any escapement data for basins in the upper Columbia because they are based only on dam count and tributary turn-off estimates. The last HOF releases into the Entiat were in 1999, and it is reasonable to assume that HOF on the spawning grounds declined after 2002. After 2002, the only HOF spawning in the Entiat were strays. Most strays are thought to be hatchery steelhead from the Wenatchee. Facilities have not been built to acclimate them to Wenatchee water before they are released to migrate to the ocean. Therefore, they are expected to stray more when they return as adults. Less than 10% HOF strays spawning naturally in the Entiat is a reasonable goal, but it will take time before improvements are operational (e.g., the construction of acclimation ponds in the Wenatchee) and the effectiveness of these improvements can be established. Based on the termination of hatchery steelhead releases in the Entiat (the last returns from hatchery releases were in 2004), NOAA Fisheries assumes a future hatchery fraction of 0.22 to 0.50.

For the period prior to hatchery program termination, available information does not support effectiveness estimates >0.3. After termination, stray HOF in the Entiat originate from Category 1 hatchery programs, but since these fish are not from the Entiat, the effectiveness of stray HOF would be < 0.3. Considering all this information, NOAA Fisheries estimates a survival change of 0-18% to +56% for the Entiat, based on hatchery management changes (SCA Quantitative Analysis of Hatchery Actions Appendix).

The Methow population has a PUD funded program at Wells Hatchery and an Action Agency funded program at Winthrop NFH. In 1998, the goals of both programs changed from primarily providing fish for harvest to conserving genetic resources and increasing hatchery fish fitness or effectiveness. Both programs use broodstock collected at Wells Dam, which combines fish returning to the Methow and Okanogan basins. The Federal program at Winthrop NFH releases steelhead from the hatchery facility. The PUD funded program uses tank trucks to release steelhead at multiple locations in the Methow basin. The Winthrop NFH receives eyed eggs from the PUD funded program that are progeny of hatchery-by-hatchery fish crosses, while the PUD program maximizes and retains progeny of hatchery-by-natural fish crosses.

Before 1998, the programs fell into Category 1 (HOF<30% as effective as NOF) and HOF were planted in areas to accommodate fisheries, not promote HOF effectiveness (i.e., the majority of releases were not in prime steelhead production areas). After 1998, the broodstock included some NOF (Category 3) and the PUD funded program altered release locations to include steelhead production areas (to promote effectiveness). In recent years, NOF in broodstock have increased to about 30% in the PUD funded program. However, this program continues to be a composite of the Methow and Okanogan populations (not an optimum practice for a hatchery program intended to promote genetic diversity and improve natural survival). A further reform has been the transfer of eggs from earliest maturing broodstock, which are always hatchery-origin fish (this is thought to be a legacy effect of historical hatchery operation protocols that selected for early maturing fish in the broodstock) to the Ringold Program in the Middle Columbia River. Redd surveys in the Methow River have not found a difference in spawn timing between HOF and HOR (Snow and Humling 2006).

For the Methow population, available information would not support effectiveness estimates greater than 0.3 for HOF before 1998. HOF effectiveness was likely lower than 0.3 based on release practices and the reliance on HOF for broodstock (i.e., hatchery domestication effects). After 1998, HOF effectiveness may be incrementally increasing over time, but still is likely to be quite low in the 0.30 to 0.45 range (the upper end of the Araki et al. 2007b range for a Category 3 program). This results in survival multipliers between 17 and 55% for the Methow population (SCA Quantitative Analysis of Hatchery Actions Appendix).

The Okanogan population is supplemented by two hatchery programs, the PUD funded Wells program and a relatively new program operated by the Colville Tribes. Similar to the situation in the Methow, prior to 1998 the program fell into Category 1 (HOF<30% as effective as NOF) and HOF were planted in areas to accommodate fisheries, not to promote HOF effectiveness (i.e., the majority of juvenile releases were not in prime steelhead production areas). After 1998, the steelhead program at Wells Hatchery has increased the use of NOF for broodstock. This is beneficial except that the broodstock is a composite of different spawning aggregates and different populations (not an optimum practice for a hatchery program intended to conserve genetic resources and increase HOF fitness or effectiveness).

The Colville Tribes have begun a relatively small hatchery program in Omak Creek to promote local adaptation in the Okanogan Basin. This program uses broodstock collected from Omak Creek or the Okanogan River. Overall, these hatchery reforms are beneficial, but for the Okanogan basin in particular, increases in natural productivity will depend on improvements in spawning and rearing habitat conditions. The available information does not support effectiveness estimates greater than 0.3 for HOF before 1998. HOF effectiveness was likely lower than 0.3 based on release practices and the propagation of multiple generations of HOF. Since 1998, HOF effectiveness may be incrementally increasing over time, but is still likely to be quite low, in the 0.30 to 0.45 range (the upper end of the Araki et al. range for a Category 3 program). Supplementation levels and spawner composition data provided in Table 9-5 are used for this analysis except that “post-1998” relative effectiveness should be up to 0.45, not 0.5. This results in survival multipliers between 34 and 88% for the Okanogan population (SCA Quantitative Analysis of Hatchery Actions Appendix).

Another important parameter in estimating natural productivity and assessing risk is the composition of natural spawners (i.e., the proportion of natural spawners composed of HOF and NOF). In this analysis for the Wenatchee, Methow and Okanogan basins, NOAA Fisheries uses available data from supplementation levels over the “most recent 10 years” (Table 8.7.2-1). Assumptions in Table 9-4 of the CA that supplementation will be “significantly reduced from recent averages” and that the proportion of natural spawners composed of HOF will decline dramatically, depend on the increased abundance of natural-origin natural spawners in each basin and on future Hatchery and Genetic Management Plans that reduce the proportion of natural spawners composed of HOF as the abundance of natural-origin fish increases.

The net result is that, if these human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to increase 83 to 159% for the Wenatchee, Methow, and Okanogan populations (Table 8.2.3-1). This also means that the survival "gaps" described in Table 8.2.2-4 would be proportionately reduced by this amount (i.e., ["Gap" ÷ 1.83] to ["Gap" ÷ 2.59], depending on the population and the hatchery effectiveness assumption). For the Entiat population, survival changes would be expected to range from a 2% decline to a 55% increase

8.7.3.2 Abundance, Spatial Structure & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section.

8.7.3.3 Status of Critical Habitat Under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. Tributary habitat conditions vary widely among the various drainages occupied by UCR steelhead. Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and forest management continue to threaten the conservation value of critical habitat for this species in some locations in the upper Columbia basin.

Spawning & Rearing Areas

UCR steelhead spawn and rear in the major tributaries to the Columbia River between Rock Island and Chief Joseph dams. Adults reach spawning areas in late spring. Newly emerged fry move about considerably as they seek suitable rearing habitat, moving downstream in the fall in search of suitable overwintering habitat (Chapman et al. 1994). Fry use stream margins and cascades and larger juvenile life stages use progressively deeper and faster water, sheltering behind boulders in the highest gradient riffles and cascades. Most juvenile steelhead spend two or three years in freshwater before migrating to salt water. The following are the major factors that have limited the functioning and thus the conservation value of habitat used by UCR steelhead for these purposes (i.e., spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that help ensure their survival):

- Physical passage barriers *[mortality at hydroelectric projects in the mainstem Columbia River; water withdrawals and unscreened diversions]*

- Excess sediment in spawning gravels and in substrates that support forage organisms *[land and water management activities]*

- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures *[degraded riparian and channel function]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions to address limiting factors and threats for this DPS in spawning and rearing areas. These include acquiring water to increase streamflow, installing or improving fish screens at irrigation facilities to prevent entrainment, removing passage barriers and improving access, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects provided immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

Juvenile & Adult Migration Corridors
Adults begin to return from the ocean in early spring and enter upper Columbia tributaries during April through July. Juvenile steelhead migrate to salt water in the spring of their second year of life. Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers *[push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles]*

- Juvenile and adult passage mortality *[hydropower projects in the mainstem Columbia River]*

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*

In the mainstem FCRPS corridor, the Action Agencies have improved safe passage for juvenile steelhead with the construction and operation of surface bypass routes at Bonneville Dam and other configuration improvements listed in Section 5.3.1.1 in Corps et al. (2007a).

The safe passage of juvenile steelhead through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown since that time. For these salmonids, with a stream-type juvenile life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 9.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood

Although UCR steelhead spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the mouth of the Columbia River NMFS (2005b). Therefore, the effects of the Prospective Actions on PCEs in areas for growth and development to adulthood are not considered further in this consultation.

8.7.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

Mainstem Mid-Columbia Hydroelectric Projects

NOAA Fisheries completed ESA Section 7(a)(2) consultations on its issuance of incidental take permits to Douglas and Chelan County Public Utility Districts in support of the proposed Anadromous Fish Agreements and Habitat Conservation Plans (HCPs) for the Wells, Rocky Reach, and Rock Island hydroelectric projects in the mid-Columbia reach on August 12, 2003. Under the HCPs, Douglas and Chelan County PUDs agreed to use a long-term adaptive management process to achieve a 91% combined adult and juvenile survival standard for each salmon and steelhead DPS migrating through each project. In addition, compensation for up to 9% unavoidable project mortality is provided through hatchery and tributary programs, with compensation for up to 7% mortality provided through hatchery programs and compensation for up to 2% provided through tributary habitat improvement programs.

In May 2004, NOAA Fisheries also completed an ESA Section 7 consultation on FERC's proposed amendment to the existing license for the Grant County PUD's Priest Rapids Hydroelectric Project, which permitted implementation of an interim protection plan, including interim operations for Wanapum and Priest Rapids dams. Under this biological opinion and incidental take statement, NOAA Fisheries expects that project-related mortalities (i.e., direct, indirect, and delayed mortality resulting from project effects) for both hydro projects combined will not exceed 23.2% for juvenile UCR steelhead. NOAA Fisheries also expects that implementation of the interim protection plan will result in mortality rates of no more than 3% per project or 6% combined for adult UCR steelhead.

Thus, NOAA Fisheries expects the cumulative mortality through the mid-Columbia reach of juvenile UCR steelhead will be 19% for the Wenatchee population; 22% for the Entiat population; and 25% for the Methow population. The total mortality rates (natural and project-related) of adult UCR steelhead are expected to be 4% for adult steelhead returning to the Wenatchee River, 5% for those returning to the Entiat, and 6% for those returning to the Methow.

Wenatchee River

The USFS proposed fuels reduction projects in the White River–Little Wenatchee and Wenatchee River – Nason Creek watersheds, respectively, as well as a fire salvage timber sale in the Lower Wenatchee River watershed. The USFS also proposed a habitat restoration project in the Natapoc Ridge Forest (Wenatchee River–Nason Creek and Chiwawa River watersheds). The USFS' project to relocate White River Road and stabilize the streambank used large woody debris to increase habitat complexity (White River–Little Wenatchee River watershed). Another USFS project, replacing three culverts along Sand and Little Camas creeks (Lower Wenatchee River watershed), improved passage and partially restored natural channel-forming processes. The USFS completed one project in 2007 under its programmatic consultation (19 Aquatic Habitat Restoration Activities in Oregon, Washington, Idaho, and California): a road decommissioning to improve riparian habitat and the connection to the floodplain along one mile of Clear Creek in the Chiwawa River watershed.

The FHWA/WSDOT consulted on a road construction project in the Wenatchee River–Icicle Creek watershed and a culvert replacement along Mill Creek (Wenatchee River–Nason Creek) to improve fish passage.

In the Lower Wenatchee watershed, NOAA Fisheries consulted on the restoration of off-channel habitat; the USFWS funded the installation of a fishway on Peshastin Creek, designed to provide access to spawning and rearing habitat; and the Corps consulted on a fish passage enhancement project. The Corps also proposed 20 projects to build or maintain docks, piers, launches, boat lifts, moorage basins, and swimming beaches along the shores of Lake Entiat, Columbia River-Lynch Coulee, and Columbia River–Sand Hollow mainstem reaches (juvenile and adult migration corridors). The Department of the Army consulted on construction at the Yakima Training Center (Columbia River–Lynch Coulee and Columbia River–Sand Hollow mainstem reaches).

As part of the Chelan and Douglas PUD's HCPs described above, NOAA Fisheries consulted on the issuance of an ESA Section 10 permit jointly to Chelan and Douglas PUDs and WDFW on the implementation of an artificial propagation program to supplement the UCR steelhead population in the Wenatchee basin. NOAA Fisheries conducted two separate consultations on hatchery programs of unlisted summer Chinook salmon, sockeye salmon, and endangered spring Chinook salmon in the Wenatchee basin, which could have effects on natural-origin steelhead, resulting in the issuance of ESA Section 10 permits. Inclusive with these consultations were actions to monitor and evaluate the effects of the hatchery programs on the natural salmon and steelhead populations in the Wenatchee basin.

The BPA consulted on funding the Yakama Nation Tribes' hatchery program to reintroduce Coho salmon to the Wenatchee basin, which could affect natural-origin steelhead in the Wenatchee basin.

Entiat River

The USFS proposed a campground and summer home vegetation management project in the lower Entiat River watershed and habitat restoration activities in the Columbia River – Lynch Coulee portion of the mainstem Columbia River. NOAA Fisheries consulted with itself on funding for a project in the lower Entiat River watershed that included building an overflow structure in an existing irrigation canal to improve fish passage; adding boulders and large wood to increase habitat complexity in a side channel; reconnecting the river and its floodplain; and enhancing the recruitment of spawning gravels.

The FHWA/WSDOT proposed road maintenance along State Route 28 (Sunset Highway), Eastside Corridor, East Wenatchee (Lake Entiat mainstem reach).

The Corps proposed 20 projects to build or maintain docks, piers, launches, boat lifts, moorage basins, and swimming beaches along the shores of Lake Entiat, Columbia River–Lynch Coulee, and Columbia River–Sand Hollow mainstem reaches (juvenile and adult migration corridors). The Department of the Army consulted on construction at the Yakima Training Center (Columbia River–Lynch Coulee and Columbia River–Sand Hollow mainstem reaches).

Methow River

The USFS consulted on a total of three timber sales in the Upper and Lower Chewuch and Twisp River watersheds; a grazing allotment plan for the Lower Chewuch and Middle Methow River watersheds; and a vegetation management plan for the Lower Methow River watershed. The USFS also consulted on projects to restore habitat damaged by grazing in the Lower Chewuch River watershed, improve passage (by replacing a diversion dam) into seven miles of Little Bridge Creek (Twisp River watershed), and modify an irrigation ditch for access to nine miles of habitat in a wilderness area (Middle Methow River watershed). The USFS completed two projects during 2007 under its programmatic consultation with NOAA Fisheries (19 Aquatic Habitat Restoration Activities in Oregon, Washington, Idaho, and California): decommissioning and relocating the Twisp River/North Creek Trail to improve five acres of riparian habitat and installing a culvert in Reynolds Creek to allow access to four miles of stream.

Reclamation consulted on leasing water from the Chewuch Canal Company (Lower Chewuch River watershed) to improve instream flows. The FHWA/WSDOT proposed a bridge rehabilitation project on Buttermilk Creek Road in the Twisp River watershed.

The Corps proposed 20 projects to build or maintain docks, piers, launches, boat lifts, moorage basins, and swimming beaches along the shores of Lake Entiat, Columbia River–Lynch Coulee, and Columbia River–Sand Hollow mainstem reaches (juvenile and adult migration corridors). The Department of the Army consulted on construction at the Yakima Training Center (Columbia River–Lynch Coulee and Columbia River–Sand Hollow mainstem reaches).

The FERC consulted on a license amendment for the Wells hydroelectric project—land easements for 11 irrigation diversions from Lake Entiat with new or improved fish screens.

As part of the Chelan and Douglas PUD's HCPs described above, NOAA Fisheries consulted on the issuance of an ESA Section 10 permit jointly to Chelan and Douglas PUDs and WDFW on the implementation of an artificial propagation program to supplement the UCR steelhead population in the Methow basin. NOAA Fisheries conducted two separate consultations on hatchery programs of unlisted summer Chinook salmon and endangered spring Chinook salmon in the Methow basin that could have effects on natural-origin steelhead. These resulted in the issuance of ESA Section 10 permits. Included in these consultations were actions to monitor and evaluate the effects of the hatchery programs on the natural salmon and steelhead populations in the Methow basin.

The USFW consulted on the implementation of a hatchery program rearing listed steelhead at Winthrop NFH. They also consulted on the implementation of a hatchery program rearing listed spring Chinook salmon at Winthrop NFH.

The BPA consulted on funding the Yakama Nation Tribes' hatchery program to reintroduce coho salmon to the Methow basin that could affect natural-origin steelhead in the Methow basin.

Okanogan

The Corps consulted on a project to install a boat ramp on the Okanogan River (Upper Okanogan River watershed). The FHWA/WSDOT consulted on projects to improve the road between Loomis and Oroville (Upper Okanogan River) and to replace the Salmon Creek Bridge (Salmon Creek watershed).

As part of the Chelan and Douglas PUD's HCPs described, NOAA Fisheries consulted on the issuance of an ESA Section 10 permit jointly to Chelan and Douglas PUDs and WDFW on the implementation of an artificial propagation program to supplement the UCR steelhead population in the Okanogan basin. NOAA Fisheries also conducted a separate consultation on a hatchery program of unlisted summer Chinook salmon in the Okanogan basin that could affect the natural population of steelhead. Included in these consultations were actions to monitor and evaluate the effects of the hatchery programs on the natural salmon and steelhead populations in the Okanogan basin.

The Bureau of Indian Affairs (BIA) consulted on funding the Colville Tribe's hatchery supplementation program in Omak Creek.

Projects Affecting Multiple Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.7.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

Federal agencies are implementing numerous projects within the range of UCR steelhead that will improve access to blocked habitat, prevent entrainment into irrigation pipes, increase channel complexity, and increase instream flows. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of Federal projects, including hydroelectric generation, forest thinning, road construction/maintenance, dock and pier construction, hatchery programs, and grazing will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Other types of Federal projects such as hydroelectric generation (including the FERC-licensed hydro projects in the mid-Columbia River), forest thinning, road construction/maintenance, dock and pier construction, hatchery programs, and grazing will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modifications of critical habitat.

8.7.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Washington and Idaho identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin. These are detailed in the lists of projects that appear in Chapter 17 of the FCRPS Action Agencies' Comprehensive Analysis which accompanied their Biological Assessment Corps et al. 2007a). They include tributary habitat actions that will benefit the Entiat, Methow, Okanagan, and Wenatchee populations as well as actions that will be generally beneficial throughout the DPS. Generally, all of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[2] Many address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to significantly improve conditions for the Upper Columbia River steelhead. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of

[2] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.7.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in Sections 8.7.5.1, 8.7.5.2, and 8.7.5.5. The Prospective Actions will ensure that adverse effects of the FCRPS and Upper Snake projects will be reduced from past levels. The Prospective Actions also include habitat improvements and predator reduction actions, which are expected to be beneficial. Some habitat restoration and RM&E actions may have short-term minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the Hatchery Effects Appendix of the SCA and in this section.

8.7.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5) are expected to continue through the duration of the Prospective Actions.

The effects of the Prospective Actions projects are also included in this analysis. These effects on mainstem flows have been included in the HYDSIM modeling used to create the 70-year water record for input into the COMPASS model (Section 8.1.1.3). As such, the effect of diminished spring-time flows on juvenile migrants is aggregated in the COMPASS model results used to estimate the effects of the effects in the productivity and extinction risk analysis (See SCA Sections 7.2.1 and 8.8.1.3).

Based on COMPASS modeling of hydro operations for the 70-year water record, full implementation of the Prospective Actions is expected to increase the in-river survival (from McNary to the Bonneville tailrace) of UCR steelhead from 47.9% (Current) to 52.8% (Prospective), a relative change of 10.2%. Transportation at McNary Dam is expected to occur only in 1 of 70 years, < 2% of the time, when flows at McNary are less than 125 kcfs). In this unlikely circumstance, about 75.7% of the juveniles arriving at McNary Dam would likely be transported (see Table 11.7 of the FCRPS Biological Opinion). Based on the very positive benefits observed from transportation study results from the Snake River during the extremely low flow conditions of 2001, NOAA Fisheries anticipates a similar, albeit somewhat smaller, benefit would exist from transportation at McNary Dam.

The COMPASS model estimates that (combined with in-river migrant survivals through the non-Federal mainstem projects) smolt-to-adult returns (McNary Dam to the ocean and back to Rock Island Dam - assuming SR steelhead post-Bonneville survival relationships as a surrogate) will likely increase from 0.58% to 0.63% for Wenatchee River fish (a relative improvement of about 8.5%); 0.53% to 0.58% (a relative improvement of 9.6%) for Entiat River fish; and 0.51% to 0.56% (a relative improvement of 9.7%) for Methow and Okanogan River fish.

These increases are a result of the Prospective Actions and the expected survival improvement from actions implemented as a result of completed biological opinions on the existence and operation of the five mid-Columbia mainstem hydro projects (NMFS 2006e; SCA Hydro Modeling Appendix). These actions are expected to increase the relative survival of in-river migrants to the Bonneville tailrace by approximately 23.5% for the four populations.

The Prospective Hydro Actions addressing hydro operation and the RM&E program should maintain or improve the levels of survival currently observed for adult UCR steelhead migrating from Bonneville Dam upstream to McNary Dam. The current PIT tag based survival estimate, taking account of harvest and “natural” stray rates within this reach, is 84.5% (about 94.5% per project). Any delayed mortality of adults (mortality that occurs outside of the Bonneville Dam to McNary Dam migration corridor) that currently exists is not expected to be affected by the Prospective Actions.

The hydro Prospective Actions also are likely to positively affect the survival of UCR steelhead in ways that are not included in the quantitative analysis. To be clear, NOAA Fisheries considers these expected benefits, but has not been able to quantify these effects.

The Prospective Actions requiring implementation of surface passage routes at McNary and John Day dams in concert with training spill (amount and pattern) to provide safe egress should reduce juvenile travel times within the forebays of the individual projects, where predation rates are currently often the highest (see Section 8.1). This is likely to result in survival improvements. Taken together, surface passage routes should increase juvenile migration rates through the migration corridor, and likely improve overall post-Bonneville survival of in-river migrants. Faster migrating juveniles may be less stressed than is currently the case. Finally, improved tailrace egress conditions should increase the survival of migrating steelhead smolts in tailraces where juvenile mortality rates are relatively high.

Prospective Actions implementing passage improvements for juvenile salmon and steelhead, including surface passage such as RSWs and sluiceways, also are likely to benefit downstream migrating kelts. This should lead to improved survival through the FCRPS. Reduced forebay residence times, which lead to a reduction in total travel time, may also contribute to an improvement in kelt return rates. It is not possible to calculate the precise amount of improvement expected, because the interactions between improved surface passage and improved kelt survival and return rates is not well known. However, some improvement is likely.

The Prospective Actions governing reconditioning and transport of steelhead kelts potentially represent a much greater improvement in both outmigration survival and return rates. Reconditioning programs capture kelts and hold them in tanks, where they are fed and medicated to enhance survival. Current programs either hold kelts for 3 to 5 weeks and release them below Bonneville, or hold kelts until they are ready to spawn and release them into their natal streams. Short-term reconditioning efforts have produced average survival rates of 82% and kelt returns of 4% to the Yakima River (Hatch et al. 2006). Long-term reconditioning has produced average survival rates of 35.6%, all of which are returned to their natal stream for spawning (Hatch et al. 2006).

There is some concern over the viability of the offspring from long-term reconditioned kelts. Laboratory studies found high rates of post hatching mortality (Branstetter et al. 2006), and studies using DNA analysis to identify the parentage of outmigrating steelhead smolts (Stephenson et al. 2007) have failed to identify any offspring of reconditioned kelts among the juvenile steelhead collected from streams where reconditioned kelts were released. These studies suggest that long-term reconditioning may reduce gamete viability. It is not known if short-term reconditioned kelts may have the same problems with offspring viability; however, because they feed and mature under natural conditions it seems less likely.

Transportation of kelts involves capturing kelts, transporting them to a point downstream of Bonneville dam, and releasing them. Kelt transportation studies in the Snake River found that not only was there an improvement in FCRPS survival of between 4-33% to actual survival of approximately 98% in transported kelts, but also transported kelts returned to Lower Granite dam at a rate of 1.7% versus in-river migrating kelts, which returned at a rate of 0.5% (Boggs and Peery, 2004).

Both transportation and reconditioning of kelts require capture of downstream migrating kelts. Given kelt preference for surface passage and the potential for future implementation of surface passage routes, the number of kelts that can be collected is limited. Upper and Mid-Columbia DPSs present significant challenges to successfully collecting kelts. Existing bypass systems and transportation facilities on the Snake River dams make successful collection of Snake River steelhead more likely. An analysis by Dygert (2007) estimated that 7% (during spill) to 22% (no spill) of the upstream steelhead run could be captured at LGR as downstream migrating kelts. The hydro Prospective Actions would employ collection at both LGR and LGS. NOAA Fisheries analysis of the Prospective Actions suggests that employing a combination of transportation, reconditioning, and in-stream passage improvements could increase kelt returns enough to increase the number of Snake River B-run steelhead spawners by approximately 6%. If logistical difficulties associated with capture of Upper Columbia River steelhead kelts can be overcome, similar benefits could be expected for that DPS as well.

Continuing efforts under the NPMP and continuing and improved avian deterrence at mainstem dams will also address sources of juvenile mortality. In-river survival from McNary Dam to the tailrace of Bonneville Dam, which is an index of the hydrosystem's effects on water quality, water quantity, water velocity, project mortality, and predation, will increase to 52.8%. A portion of the 47.2% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that juvenile steelhead would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of UCR steelhead in a hypothetical, unimpounded Columbia River would be 90.6%. Therefore, approximately 20% (9.4%/47.2%) of the expected mortality experienced by in-river migrating juvenile steelhead is probably due to natural factors.

The direct survival rate of adults through the FCRPS is already relatively high. The prospective actions include additional passage improvements (e.g., to the ladders at John Day and McNary dams). Adult steelhead survival from Bonneville to Priest Rapids Dam will be approximately 84.5% under the Prospective Actions. With respect to kelts, the Action Agencies will prepare and implement a Kelt management Plan, including measures to increase in-river survival.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit to yearling migrants in the lower Columbia River by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.7.3.3).

Effects on Critical Habitat

The Prospective Actions described above will improve the function of safe passage in the juvenile and adult migration corridors by addressing water quantity, water velocity, project mortality, and exposure to predators. To the extent that the hydro Prospective Actions result in more adults returning to spawning areas, water quality and forage for juveniles could be affected by the increase in marine-derived nutrients. This was identified as a limiting factor for the Wenatchee population by the Remand Collaboration Habitat Technical Subgroup (Habitat Technical Subgroup 2006b).

8.7.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

The population-specific effects of the tributary habitat Prospective Actions on survival are listed in CA Table 9-9, p. 9-14. For targeted populations in this DPS the effect is a 4-14% expected increase in egg-smolt survival, depending on population, as a result of implementing the Prospective Actions tributary habitat projects, which improve habitat function by addressing significant limiting factors and threats.[3] Based on the ICTRT population-level criteria (ICTRT 2007a), projects that restore the number of, or improve the size, quality or access to, major and minor spawning areas could have a beneficial effect on population spatial structure. The Action Agencies will address limiting factors by replacing barrier culverts and screen irrigation pumps in the Wenatchee, Entiat, and Methow subbasins (Table 1-b in Attachment B.2.2-2 to Corps et al. 2007b). These passage projects in many instances will enable juvenile steelhead to access rearing habitat in tributaries that are too small to support spawning, but are generally more productive per unit area for rearing than are mainstem settings. The Action Agencies will also fund channel complexity projects and restore streamflows. Channel complexity projects include reconnecting oxbows that were isolated by highway and railroad construction in the Upper Wenatchee (Nason Creek in particular) and reconnecting small side channel habitats in the Methow and Entiat that have been stranded as a consequence of mainstem channel incision.

Effects on Critical Habitat

As describe above, the tributary habitat Prospective Actions will address factors that have limited the functioning and conservation value of habitat that this species uses for spawning and rearing. PCEs expected to be improved are water quality, water quantity, cover/shelter, food, riparian vegetation, space and safe passage/access.

Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.7.5.3 Effects of Estuary Prospective Actions

Effects on Species Status

The estimated survival benefit for Upper Columbia River steelhead (stream-type life history) associated with the specific Prospective Actions to be implemented from 2007 to 2010 is 1.4%. The survival benefit for Upper Columbia River steelhead (stream-type life history) associated with actions to be implemented from 2010 through 2018 is 4.3%. The total survival benefit for Upper Columbia River steelhead as a result of Prospective Actions implemented to address estuary habitat limiting factors and threats is approximately 5.7% (CA Section 9.3.3.3). Estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM 40 will provide habitats used by juvenile steelhead migrants from the upper

[3] The Action Agencies identified the projects that will improve these PCEs and that they will fund by 2009 in Tables 1a; 4c; and 5a,b in Attachment B.2.2-2 to Corps et al. (2007b).

Columbia River to increase life history, diversity and spatial structure. The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the value of the estuary as critical habitat for this species (section 9.3.3.3 in Corps et al. 2007c). These include restoring riparian function and access to tidal floodplains.

Effects on Critical Habitat

The estuary habitat Prospective Actions will address factors that have limited the functioning of PCEs in the estuary needed by juvenile steelhead from the Upper Columbia River. Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (Section 8.7.5.2). The estuary Prospective Actions will address factors that have limited the functioning of PCEs in the estuary needed by juvenile steelhead from the upper Columbia River

8.7.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Qualitative assessment of the Prospective Actions was provided in Section 9.3.3.5, page 9-18, of the CA. The hatchery Prospective Actions consist of continued funding of hatcheries as well as a new hatchery program in the Okanogan basin and a new kelt reconditioning program for the Wenatchee, Entiat, and Methow populations. Each of these programs will be subject to ESA consultation based on an HGMP developed through BMPs.

The Prospective Actions include the continued funding of hatcheries and the adoption of programmatic criteria or BMPs for operating salmon and steelhead hatchery programs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated. The Action Agencies intend to adopt these programmatic criteria for funding decisions on future mitigation programs for the FCRPS that incorporate BMPs. Site-specific application of BMPs will be defined in ESA Section 7, Section 10, and Section 4(d) limits with NOAA Fisheries to be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies (FCRPS Biological Assessment, page 2-44). Available information, principles, and guidance for operating hatchery programs are described in Appendix E of the CA and the SCA Artificial Propagation for Pacific Salmon Appendix. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

The Federal hatchery program in the Upper Columbia preserves genetic resources and reduces short-term extinction risk (SCA Hatchery Effects Appendix). Increasing dependence on the hatchery poses longer-term risk to population diversity and productivity. NOAA Fisheries expects that hatchery reform measures will include a plan for reducing the dependence on hatchery fish to spawn naturally as the abundance of natural-origin fish increases.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.7.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

There are three stock groups of summer steelhead used for management including the lower river Skamania stock, upriver A-run stock, and upriver B-run stock. All UCR steelhead populations are designated A-run steelhead.

Prospective non-Treaty fisheries, pursuant to the 2008 *U.S. v. Oregon* Agreement, will be managed subject to DPS-specific harvest rate limits. Winter, spring, and summer fisheries are subject to a 2% harvest rate limit on wild steelhead from each steelhead DPS. Non-Treaty fall season fisheries are likewise subject to a 2% harvest rate limit for each steelhead DPS. The total annual harvest rate limit for A-run steelhead, for example, is 4%. This is consistent with ESA-related management. The expected harvest impacts on non-Treaty fisheries are less than those proposed. The yearly incidental catch of A-run steelhead in non-Treaty fisheries has averaged 1.6 since 1999 (Table 8.7.5.5-1). Harvest rates for A-run steelhead in non-Treaty fisheries are not expected to change over the course of this Agreement (TAC 2008).

There are no specific harvest rate limits for tribal fisheries on steelhead during the spring or summer seasons which extend through July 31. Some impacts, however, do occur. The harvest rate on A-run steelhead in tribal spring season fisheries has averaged 0.2% from 1985 (Table 8.7.5.5-1). The harvest rate in summer season fisheries averaged 2.3% since 1985 (Table 8.7.5.5-1). The harvest rate in fall season fisheries averaged 9.6% since 1985 and 4.2% since 1998 (Table 8.7.5.5-1). Impacts resulting from treaty-Indian fall season fisheries during this agreement are likely similar to the 1998-2006 average of 4.2%.

With respect to spring and summer season fisheries, increases in harvest beyond those observed in recent years are unlikely. The spring season extends through June 15. The harvest rate of A-run steelhead has been consistent and low, at approximately 0.2% since 1985 (Table 8.7.5.5-1). No changes in the fishery are proposed or anticipated that would lead to changes in the expected catch of steelhead.

Summer season fisheries extend through July 31. Steelhead are caught regularly in ceremonial and subsistence fisheries (primarily the platform fishery), as well as in commercial fisheries targeting summer Chinook (summer Chinook that are targeted in the fishery are part of the UCR summer/fall ESU and are not listed under the ESA). Summer

Chinook were chronically depressed for decades until returns began to increase in 2001. As of 2002, higher runs provided more fishing opportunity. However, there is no evidence of an associated increase in the catch of listed steelhead. The harvest rate of summer Chinook in the tribal fishery averaged 1.5% from 1989 to 2001, and 10.9% from 2002 to 2006 (TAC 2008). During those same years, the harvest rate of steelhead averaged 2.3% to 2.4% (Table 8.7.5.5-1). As with spring fisheries, no further changes in future fisheries are expected as a result of the Prospective Action that would lead to changes in the expected catch of steelhead. However, as a result of PIT-tag data, there is recent information regarding adult conversion rates that indicate that more UCR steelhead than SR steelhead are lost in upstream passage. The greater losses may be due to differential harvest rates that currently are not detectable. It is also plausible that the losses are due to timing differences, passage conditions, or some combination of factors. If new evidence develops related to the catch of steelhead in the summer season, these conclusions will be reviewed.

Table 8.7.5.5-1. Harvest rates of A-run steelhead in spring, summer, and fall season fisheries expressed as a proportion of the Skamania and A-run steelhead run size (TAC 2008).

Year	Treaty Indian				Non-Indian			
	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
1985	0.15%	NA	19.40%	19.50%				
1986	0.08%	NA	12.60%	12.70%				
1987	0.05%	NA	14.70%	14.80%				
1988	0.18%	NA	16.10%	16.20%				
1989	0.04%	4.00%	14.90%	18.90%				
1990	0.44%	3.50%	14.10%	18.00%				
1991	0.15%	1.90%	14.40%	16.40%				
1992	0.49%	2.00%	15.20%	17.60%				
1993	0.14%	1.40%	14.60%	16.20%				
1994	0.16%	1.10%	9.70%	10.90%				
1995	0.06%	2.20%	10.00%	12.20%				
1996	0.66%	2.30%	8.40%	11.40%				
1997	0.10%	2.70%	10.10%	12.80%				
1998	0.11%	3.80%	8.40%	12.40%				
1999	0.05%	2.10%	5.20%	7.40%	0.10%	0.30%	0.60%	1.00%
2000	0.11%	1.00%	4.00%	5.10%	0.10%	0.60%	1.00%	1.70%
2001	0.09%	2.10%	3.80%	6.00%	0.10%	0.40%	0.60%	1.10%
2002	0.09%	2.10%	2.40%	4.60%	0.40%	0.40%	0.80%	1.60%
2003	0.12%	2.80%	2.50%	5.40%	0.60%	0.30%	1.00%	1.90%
2004	0.13%	3.90%	3.00%	7.00%	0.40%	0.40%	1.00%	1.80%
2005	0.05%	2.30%	3.60%	5.90%	0.40%	0.40%	0.90%	1.70%
2006	0.13%	0.80%	5.00%	6.00%	0.30%	0.40%	1.20%	1.90%
2007					0.30%	0.30%	0.80%	1.40%
1985-06 average	0.16%	2.33%	9.64%	11.70%				
1989-06 average	0.17%	2.33%	8.29%	10.79%				
1998-06 average	0.10%	2.32%	4.21%	6.64%	0.30%	0.40%	0.89%	1.59%

Prospective treaty-Indian fall season fisheries will be managed using the abundance based harvest rate schedule for B-run steelhead contained in the 2008 Agreement (Table 8.7.5.5-2). From 1998 to 2007 treaty-Indian fall season fisheries were managed subject to a 15% harvest rate limit on B-run steelhead. Under the abundance-based harvest rate schedule, harvest may vary from the status quo of 15%, depending on the abundance of B-run steelhead. The harvest rate allowed under the prospective schedule is also limited by the abundance of upriver fall Chinook. The purpose of this provision is to recognize that impacts on B-run steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook, is higher and remain consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-run steelhead is also greater than 35,000. This provision is designed to provide the tribes with greater opportunity to satisfy their treaty right to harvest 50% of the harvestable surplus of fall Chinook in years when conditions are favorable. Even with these provisions, it is unlikely that the treaty right for Chinook steelhead can be fully satisfied. The harvest rate in tribal fall season fisheries may range from 13 to 20%. As indicated above, the non-Treaty fall season fishery harvest rate will remain fixed at 2%.

8.7.5.5-2. Abundance Based Harvest Rate Schedule for B-run Steelhead (TAC 2008).

Upriver Summer Steelhead Total B Harvest Rate Schedule				
Forecast Bonneville Total B Steelhead Run Size	**River Mouth URB Run Size**	**Treaty Total B Harvest Rate**	**Non-Treaty wild B Harvest Rate**	**Total Harvest Rate**
20,000	Any	13%	2.0%	15.0%
20,000	Any	15%	2.0%	17.0%
35,000	>200,000	20%	2.0%	22.0%

B-run steelhead will be used as the primary steelhead related harvest constraint for tribal fall season fisheries, and thus are the indicator stock used for management purposes. Generally, the status of B-run steelhead is poorer than that of A-run steelhead. B-run steelhead are subject to higher harvest rates because they are larger and thus more susceptible to catch in gillnets. Harvest impacts on B-run steelhead typically are higher because their timing coincides with the return of fall Chinook. A-run steelhead generally return a few weeks earlier, resulting in less susceptibility to catch. Consequently, there are no specific management constraints in tribal fisheries for A-run steelhead. Since 1998, when the 15% harvest rate limit was first implemented for B-run steelhead, the harvest rate on A-run steelhead in fall season treaty-Indian fisheries has averaged 4.2% and ranged from 5.4 to 12.4% (Table 8.7.5.5-1).

The abundance-based harvest rate schedule allows tribal harvest rate on B-run steelhead to vary from the fixed rate of 15% that has been in place since 1998, depending on the abundance of B-run steelhead and upriver fall Chinook. By evaluating historical run size data, a determination can be made as to how often fisheries would be subject to the 13%, 15%, or 20% level. This retrospective analysis suggests that the annual harvest rate limit will be 15% or less 12 out of 22 years, and 20% 10 out of 22 years. The primary limiting constraint from this retrospective analysis is the abundance of upriver fall Chinook. The average allowable harvest rate on B-run steelhead from this retrospective analysis is 17.1% (Table 8.7.5.5-3).

Table 8.7.5.5-3. Retrospective analysis of allowable harvest rates for B-run steelhead in the tribal fall season fisheries (Upriver fall Chinook run size from TAC 2008, Table 7; B-run Steelhead run size from TAC 2008, Table 12).

Year	Upriver Fall Chinook Run Size	B-run Steelhead Run Size	Allowable Harvest Rate in Tribal Fall Fisheries
1985	196,500	40,870	15%
1986	281,500	64,016	20%
1987	420,600	44,959	20%
1988	340,000	81,643	20%
1989	261,300	77,604	20%
1990	153,600	47,174	15%
1991	103,300	28,265	15%
1992	81,000	57,438	15%
1993	102,900	36,169	15%
1994	132,800	27,463	15%
1995	106,500	13,221	13%
1996	143,200	18,693	13%
1997	161,700	36,663	15%
1998	142,300	40,241	15%
1999	166,100	22,137	15%
2000	155,700	40,909	15%
2001	232,600	86,426	20%
2002	276,900	129,882	20%

Year	Upriver Fall Chinook Run Size	B-run Steelhead Run Size	Allowable Harvest Rate in Tribal Fall Fisheries
2003	373,200	37,229	20%
2004	367,858	37,398	20%
2005	268,744	48,967	20%
2006	230,388	74,127	20%
1985-06 average			17.1%

Although the prospective harvest rate schedule will allow the harvest in tribal fall season fisheries to increase in some years, the observed harvest rates in both the non-Treaty and treaty- Indian fisheries have been lower than the allowed rates. Since 1998, the fall season fisheries have been subject to a combined 17% harvest rate limit on B-run steelhead. From 1998 to 2006 the observed harvest rate has averaged 12.7% (TAC 2008).

For fall season fisheries it is necessary to consider whether there will be an increase in the harvest of A-run steelhead associated with the Prospective Action. As discussed above, B-run steelhead are used as the indicator stock for steelhead. This is done in order to limit fishery impacts in fall season fisheries. The retrospective analysis suggests that harvest rates on B-run steelhead in the treaty-Indian fall season fisheries may be higher than 15% approximately half of the time. The average of the allowable harvest rate limits from the retrospective analysis is 17.1% (Table 8.7.5.5-3). This represents a 14% increase over the current harvest rate limit of 15% (17.1/15.0 = 1.14). Harvest rates on A-run steelhead will not necessarily increase, but A-run and B-run harvest rates are correlated. It is therefore reasonable to assume that A-run harvest rates will increase in proportion to B-run harvest rates. Table 8.7.5.5-1 shows the tribal fishery harvest rates for A-run steelhead in spring, summer, and fall season fisheries. Since 1998 when the current ESA limits were applied, the fall season harvest rate averaged 4.2% while the total harvest rate averaged 6.6%. Under the assumption that fall season harvest rates will increase by 14% in proportion to the expected increase for B-run steelhead, the anticipated future fall season and total harvest rates will be 4.8% (0.042 * 1.140 = 0.48) and 7.2%.

The net result will be a small increase in the current harvest rate (from 6.6% to 7.2%), which will result in approximately a 1% reduction in survival (Harvest Appendix, based on *U.S. v. Oregon* memorandum). Therefore, a 0.99 current-to-future survival adjustment is applied to the prospective harvest action for this species.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, identified as a limiting factor for the Wenatchee population (see Habitat Technical Work Group 2006b).

8.7.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to Upper Columbia River steelhead from reduction in Caspian tern nesting habitat on East Sand Island and relocation of most of the terns to sites outside the Columbia River Basin (RPA Action 45) is 3.4 % (CA Attachment F-2, Table 4). Compensatory mortality may occur, but based on the discussion in 8.3.5.6, it is unlikely to significantly affect the results of the action.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 43) should further reduce consumption rates of juvenile salmon and steelhead by northern pikeminnow. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (CA Appendix F, Attachment F-1: Benefits of Predation Management on Northern Pikeminnow). Continued implementation and improvement of avian deterrence at all lower Columbia dams will continue to reduce the number of smolts taken by birds in project forebays and tail races (RPA Action 48).

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island, continued implementation of the base Northern Pikeminnow Management Program, continuation of the increased reward structure in the sport-reward fishery, and continued implementation and improvement of avian deterrence at mainstem dams are expected to improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.7.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of this document.

8.7.5.8 Summary: Quantitative Survival Changes Expected From All Prospective Actions

Expected changes in productivity and quantitative extinction risk are calculated as survival improvements in a manner identical to estimation of the base-to-current survival improvements. The estimates of "prospective" expected survival changes resulting from the Prospective Actions are described in Sections 8.7.5.1 through 8.7.5.8 and are summarized in Table 8.7.5-1. Improvements in hydro operation and configuration, estuary habitat improvement projects, and further reductions in bird and fish predation are expected to increase survival above current levels for all populations in the DPS. Tributary habitat improvement projects are also expected to increase survival for all three populations. The net effect, which varies by population, is 36 to 54% increased survival, compared to the "current" condition, and 43 to 299% increased survival, compared to the "base" condition.

8.7.5.9 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Tables 8.7.6-1 and 8.7.6-2 and in Figures 8.7.6-1 and 8.7.6-2. In addition to these summary tables and figures, the SCA Aggregate Analysis Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007 Draft Biological Opinion. Additional qualitative considerations that generally apply to multiple populations are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions at the MPG and DPS level. Additionally, because quantitative short-term extinction risk gaps could not be calculated for this species, future short-term extinction risk is discussed qualitatively in subsequent sections.

8.7.6 Aggregate Effect of the Environmental Baseline, Prospective Actions, & Cumulative Effects, Summarized By Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared to the importance of each population to MPG and DPS viability. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

The Eastern Cascades MPG is the only MPG within the Upper Columbia River steelhead DPS. Because there is only one MPG, Section 8.7.7 applies to both the Eastern Cascades MPG and the entire Upper Columbia River steelhead DPS. All four populations must be viable to achieve the delisting criteria in the Upper Columbia River Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007).

8.7.7 Aggregate Effect of the Environmental Baseline, Prospective Actions, & Cumulative Effects on the Upper Columbia River Steelhead DPS

This section summarizes the basis for conclusions at the DPS level.

8.7.7.1 Potential For Recovery

It is likely that the Upper Columbia River steelhead DPS will trend toward recovery.

The future status of all four populations in the single MPG of UCR steelhead will be improved compared to their current status. It will be improved through a reduction of adverse effects associated with FCRPS and Upper Snake Projects and the implementation of Prospective Actions with beneficial effects, as described in Sections 8.7.5, 8.7.6, and 8.7.7.2. These actions include reduction of avian and fish predation, estuary habitat improvements, kelt reconditioning, and tributary habitat improvements for each population. These beneficial actions also completely offset the slightly decreased survival associated with the harvest Prospective Action. Therefore, the status of the DPS as a whole is expected to improve compared to its current condition and move closer toward a recovered condition. This expectation takes into account some short-term adverse effects of Prospective Actions related to habitat improvements (Section 8.5.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this DPS.

The Prospective Actions described above address limiting factors and threats and will reduce their negative effects. As described in Section 8.7.1, key limiting factors and threats affecting the current status of this species (abundance, productivity, spatial structure, and diversity) include: hydropower development, predation, harvest, hatcheries, and degradation of tributary and estuary habitat. Prospective habitat improvements will initiate and at least partially correct ICTRT concerns regarding high spatial structure risk for the Okanogan population. The ICTRT has indicated concerns for all four populations relative to high diversity risk, including legacy effects of historical hatchery practices. In addition to Prospective Actions, Federal actions in the environmental baseline and non-Federal actions that are appropriately considered cumulative effects also address limiting factors and threats. The harvest Prospective Action is to implement a *U.S. v. Oregon* harvest rate schedule that is expected to result in only a very small change from the current harvest rates in the environmental baseline.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Some of the problems limiting recovery of UCR steelhead, such as the effects of legacy hatchery practices, will probably take longer than 10 years to correct. However, actions included in the Prospective Actions represent significant improvements to address these factors and they can be reasonably implemented within the next 10 years.

Additionally, the Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. This includes a new steelhead study in the Methow to determine hatchery fish effectiveness compared to natural-origin fish and to determine the effects of hatchery fish on population productivity. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In sum, these qualitative considerations suggest that the UCR steelhead DPS will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of some of the metrics indicating a trend toward recovery, discussed below, also support this conclusion.

Return-per-spawner (R/S) estimates are indicative of natural survival rates (i.e., the estimates assume no future effects of hatchery supplementation). As such, they are somewhat conservative for populations with ongoing supplementation programs, such as those affecting all four UCR steelhead populations (Section 8.7.5.4), but R/S may be the best indicator of the ability of populations to be self-sustaining without hatchery supplementation. R/S calculations incorporate many variables, including age structure and fraction of hatchery-origin spawners by year. The availability and quality of this information varies, so in some cases R/S estimates are less certain than lambda and BRT trend metrics.

R/S is expected to be less than 1.0 for all four populations after implementation of the Prospective Actions, except under the high base-to-current hatchery assumption for the Entiat population (Table 8.7.6.1-1; Figure 8.7.6-1). Additional management actions would have to more than double the average survival rate to achieve mean R/S greater than 1.0 for the Okanogan and Methow populations.

This result takes into account the range of base-to-current survival improvements estimated to result from changes in hatchery practices that have already been implemented. However, if the percentage of natural-origin fish on the spawning grounds increases, then it is likely that further increases in productivity, as reflected in the R/S estimates, would occur.

The present analysis does not include any assumptions about future reductions in the hatchery-origin fraction of natural spawners, although such improvements are likely as a result of future changes in Federal and non-Federal hatchery practices. The CA included such an analysis, which demonstrated that if hatchery fractions were to be reduced sufficiently in the future, R/S estimates could be greater than 1.0 for three of the four populations. NOAA Fisheries acknowledges the potential that R/S could be greater than 1.0 for these populations when the natural-origin abundance increases and dependence on hatcheries can be reduced. Since some of the changes are outside the authority of the Action Agencies, and have not yet been fully consulted upon, the potential benefits from such changes have not been included here.

It is, however, important to recognize that the Action Agencies have made substantial progress, within their control, in addressing the factors affecting this DPS. The estimate of juvenile survival through Federal dams in the lower Columbia River under the Prospective Actions is 53% and the estimate of survival through a free-flowing river of equal length is 88% (Section 8.7.5.1). Since achieving a R/S rate of greater than 1.0 will require doubling the survival of the natural spawners for some populations, it is apparent that additional Federal hydropower management actions alone cannot bring this DPS to recovery. It is a reasonable hypothesis that productivity in this DPS is being limited by reduced quality and quantity of spawning and rearing habitat and the residual effects of past Federal and non-Federal hatchery practices using non-native broodstock. The corrective measures already adopted in hatchery practices, together with additional reforms to increase the percentage of natural-origin fish on the spawning grounds and improved hatchery broodstock practices, are likely to reduce these residual effects and increase productivity. However, multiple generations of these better hatchery practices may be required before productivity improves to an adequate level.

Population growth rate (lambda) and BRT trend estimates, as calculated in this analysis, are indicative of abundance trends of natural-origin and combined-origin spawners, assuming that current supplementation programs continue. These estimates require fewer assumptions and less data than R/S estimates, but may also be limited by data quality. Because of the hatchery assumptions these metrics may be less indicative of a trend toward recovery than R/S for populations significantly influenced by hatchery programs, since recovery implies self-sustaining populations absent continuing hatchery supplementation. In particular, lambda as calculated in this analysis has limited utility since the UCR steelhead populations are so heavily supplemented.

All three populations in this DPS for which estimates were possible have lambda (HF=0) and BRT trends that are expected to be greater than 1.0 with implementation of the Prospective Actions (Table 8.7.6.1-1). This indicates that these populations are expected to continue to increase in abundance in the future, but the contrast in R/S and these trend estimates suggests that the future increase is at least partially explained by second generation hatchery progeny (F_2 generation) spawning naturally. Lambda estimates that assume that the effectiveness of hatchery-origin spawners is equal to that of hatchery-origin spawners (HF=1) results in estimates similar to R/S estimates, with all populations less than 1.0.

Some important caveats that apply to all three quantitative estimates are as follows:

- Not all beneficial effects of the Prospective Actions could be quantified (e.g., habitat improvements that accrue over a longer than 10-year period), so quantitative estimates of prospective R/S, lambda, and BRT trend may be low.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the "historical" ocean scenario, 1-2 of the four populations are expected to have R/S trend greater than 1.0, depending upon hatchery base-to-current assumption, compared to all four less than 1.0 under the recent ocean climate scenario (SCA Aggregate Analysis Appendix; Figure 8.7.6-2). Under the ICTRT "Warm PDO" (poor) results are very similar to results based on the current climate scenario, described above.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

- The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, R/S is expected to be less than 1.0 at the lower 95% confidence limit and greater than 1.0 at the upper 95% confidence limit for two of the four populations (SCA Aggregate Analysis Appendix; Figure 8.7.6-1). Confidence limits for lambda and BRT trend are variable, but also generally include a range above and below 1.0. These results suggest that it also is important to consider qualitative factors in reaching conclusions.

Taken together, the combination of all the qualitative and quantitative factors discussed above indicates that the DPS as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements.

NOAA Fisheries cannot demonstrate quantitatively that UCR steelhead populations will be increasing without hatchery supplementation (indicated by R/S and lambda with HF=1) as a result of the actions considered in the aggregate analysis, but it is likely that abundance will increase given the aggregate effects, including a continuing supplementation program (indicated by BRT trend and lambda with HF=0). The impact from historic hatchery practices on this species has likely been significant, as has mortality associated with Federal and non-Federal hydropower projects in the mainstem Columbia River. However, the difference in current status between Upper Columbia River Spring Chinook Salmon and Upper Columbia River steelhead populations is telling. Listed fish from both species pass through the same hydrosystem. Both occupy habitat that has been similarly impacted by human activity. Biological differences between the species generally do not account for the great discrepancy in their status in the Upper Columbia River, as evidenced by the similar status of SR spring/summer Chinook salmon and SR steelhead. The status of Upper Columbia River steelhead, as evidenced by recruit-per-spawner productivity and other base period biological indicators, is generally much worse than the status of Upper Columbia River Spring Chinook Salmon. Three factors that distinguish steelhead from spring Chinook salmon populations in the Upper Columbia River are harvest rates between 50-90% until the early 1980s, the extremely high proportion of hatchery fish in historical steelhead spawning populations, and the homogenization of hatchery broodstock due to past and present (for the Methow population) broodstock collection practices. To the extent that hatchery practices have contributed to current low productivities for the Wenatchee, Entiat, Methow, and Okanogan populations, hatchery reforms already underway in the Wenatchee (i.e., the use of Wenatchee steelhead for broodstock and reforms to reduce straying into the Entiat) and Prospective Actions to develop a local broodstock for the Methow and Okanogan are expected to improve the situation for the Wenatchee, Entiat, Methow and Okanogan populations. Substantial reduction in the homogenization of the Methow population will require reforms at Winthrop NFH and in the Wells Hatchery program (a hatchery program not funded by the Action Agencies).

It will take a considerable time before legacy hatchery effects are resolved and diversity risk is reduced. Similarly, it will take some time for habitat and other improvements to take effect, which will be necessary before managers conclude that dependence on hatcheries can be reduced. When survival increases and natural-origin abundance grows, dependence on the hatcheries to supplement natural spawning can be reduced (i.e., the fraction of hatchery-origin fish on the spawning grounds can be reduced), in which case it appears that the natural productivity as indicated by R/S will be positive. In the meantime, the current supplementation program, as indicated by expected BRT trend greater than 1.0, suggests that the DPS will be increasing in abundance and trending toward recovery.

This does not mean that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes in the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the DPS being on a trend toward recovery.

8.7.7.2 Short-Term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through survival improvements resulting from the Prospective Actions and a continuation of other current management actions in the environmental baseline, as described above and in Sections 8.7.3 and 8.7.5.

As described above, abundance is expected to be stable or increasing and populations are expected to grow as indicated by lambda and the BRT trend. Recent abundance levels are estimated between 94 and 900 spawners, depending on the population, which is well above the QET levels under consideration (Table 8.7.2-1). These factors also indicate a decreasing risk of extinction.

A well-run conservation hatchery program in the Wenatchee reduces short-term extinction risk for the Wenatchee steelhead population. There is no hatchery program for the Entiat. Hatchery programs in the Methow and Okanogan use a composite of listed fish and preserve genetic resources, but they do not currently follow optimum broodstock practices for improving diversity for the Methow and Okanogan populations. The Prospective Actions address only one hatchery program in the Methow basin at Winthrop NFH. Reforms of this program are expected as an outcome of several hatchery program review processes.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

The Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. These include a new hatchery effectiveness and effects study in the Methow. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24 year) extinction risk also support this conclusion.

As described in Section 8.2.6, extinction risk after implementing the Prospective Actions cannot be estimated quantitatively. However, because base period extinction risk (assuming no future supplementation) is extremely high, it is likely that short-term extinction risk under the Prospective Actions would also be high if calculated in the same manner. These estimates assume that all hatchery supplementation ceases, which is not a reasonable assumption. Because hatchery supplementation programs now in place will preserve genetic resources into the future, short-term extinction risk is negligible. The sensitivity analysis of Hinrichsen (2008), included as Attachment 1 of the SCA Aggregate Analysis Appendix, indicates that there is 0% chance of short-term extinction risk at QET=50 under continued supplementation for three of the four populations if supplementation programs continue under current management plans. Short-term extinction risk for the Entiat population would be greatly reduced, but would still be greater than 5%.

The mean base period short-term extinction risk estimates represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While we do not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from near 0% to near 100% for some populations (Table 8.7.2-3). This uncertainty indicates that it is important to also consider qualitative factors in reaching conclusions.

Taken together, the combination of all the factors above indicates that the DPS as a whole is likely to have a low risk of short-term extinction when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements result in lower short-term extinction risk than in recent years. NOAA Fisheries cannot demonstrate quantitatively that UCR steelhead will have a low risk if all supplementation ceases. However, both qualitative considerations and quantitative sensitivity analyses indicate that short-term extinction risk is low given continuation of current supplementation programs. The combination of recent abundance estimates for average populations, expected survival improvements, expected positive trends for most populations, and supplementation programs that reduce short-term risk indicate that these populations are likely to have a low enough risk of extinction to conclude that the DPS as a whole will have a low risk of short-term extinction.

8.7.7.3 Aggregate Effect of the Environmental Baseline, Prospective Actions, & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for UCR steelhead including all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Okanogan, Similkameen, Methow, Upper Columbia/Entiat, Wenatchee, Lower Crab, and Upper Columbia/Priest Rapids. The environmental baseline within the action area, which encompasses all of these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for UCR steelhead. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Columbia River; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, excess sediment in gravel, and high summer temperatures in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem, tributary and estuary land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established to serve the intended conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at McNary and John Day dams, in concert with training spill to provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles. Habitat work in tributaries used for spawning and rearing and in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.7.2-1. Status of UCR steelhead with respect to abundance and productivity VSP factors. Productivity is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	MPG	Population	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: 20-yr non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope: 1980 - Current[4]	Lower 95% CI	Upper 95% CI
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee (Summer A)	900	1997-2006	1000	0.35	0.22	0.55	1.07	0.83	1.38	0.80	0.62	1.03	1.04	1.00	1.11
		Methow (Summer A)	281	1997-2006	1000	0.21	0.15	0.30	1.09	0.83	1.43	0.67	0.56	0.81	1.07	1.03	1.14
		Entiat (Summer A)	94	1997-2006	500	0.52	0.37	0.73	1.05	0.82	1.36	0.81	0.67	0.97	1.04	1.01	1.12
		Okanogan (Summer A)	104	1997-2006	1000	0.08	0.06	0.11									

1 Most recent year for 10-year geometric mean abundance is 2004-2005, depending upon population. ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from ICTRT (2007c).
2 Mean returns-per-spawner are estimated from the most recent period of approximately 20 years in Cooney (2008a). Actual years in average vary by population.
3 Median population growth rate (lambda) during the most recent period of approximately 20 years. Actual years in estimate vary by population. Lambda estimates are from Cooney (2008b).
4 Biological Review Team (Good et al. 2005) trend estimates and 95% confidence limits updated for recent years in Cooney (2008b).

Table 8.7.2-2. Status of UCR steelhead with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	ICTRT Current Risk For Spatial Structure[1]	ICTRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee (Summer A)	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)	0.40
		Methow (Summer A)	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)	0.10
		Entiat (Summer A)	Currently Moderate Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)	0.20
		Okanogan (Summer A)	Currently High Risk (Only occupy lower halves of 2 US MaSAs)	Currently High Risk (Homogenization of historical populations and high hatchery %)	0.06

1 ICTRT conclusions for UCR steelhead are from draft ICTRT Current Status Summaries (ICTRT 2007d).
2 Average fractions of natural-origin natural spawners are from the ICTRT (2007c).

Table 8.7.2-3. Status of UCR steelhead with respect to extinction risk. Extinction risk is estimated from performance during the "base period" of the 20 most recent brood years (approximately 1980 BY – 1999 BY).

			24-Year Extinction Risk											
ESU	MPG	Population	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - (Summer A)	0.01	0.00	0.38	0.06	0.00	0.59	0.19	0.00	0.84	0.27	0.00	0.92
		Methow (Summer A)	0.00	0.00	0.82	0.07	0.00	0.99	0.28	0.00	1.00	0.47	0.02	1.00
		Entiat (Summer A)	0.53	0.00	0.67	0.80	0.00	0.95	0.95	0.01	1.00	0.99	0.10	1.00
		Okanogan (Summer A)	0.93	0.18	1.00	1.00	0.56	1.00	1.00	0.71	1.00	1.00	0.77	1.00

1 Short-term (24-year) extinction risk and 95% confidence limits from Hinrichsen (2008), in the SCA Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.7.2-4. Changes in density-independent survival of UCR steelhead ("gaps") necessary for indices of productivity equal to 1.0 and estimates of extinction risk no higher than 5% for UCR steelhead. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated "gaps" are based on population performance during the "base period" of approximately the last 20 brood years or spawning years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 1980-current BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee (Summer A)	2.85	4.45	1.83	0.75	2.34	0.24	2.76	8.78	0.86	0.85	0.99	0.63				
		Methow (Summer A)	4.68	6.63	3.30	0.69	2.33	0.20	5.90	>10	2.60	0.75	0.88	0.56				
		Entiat (Summer A)	1.93	2.71	1.38	0.80	2.50	0.25	2.60	5.90	1.14	0.84	0.97	0.61				
		Okanogan (Summer A)	12.65	18.17	8.81													

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.7.2-1.
2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.7.2-1) ^ Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.7.2-1) ^ Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
4 Extinction risk survival gap could not be calculated for this species (see Aggregate Analysis Appendix).

Table 8.7.3-1. Proportional changes in average base period survival of UCR steelhead expected from completed actions and current human activities that are likely to continue into the future. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average).

			Base-to-Current Adjustment (Divisor)									
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Marine Mammal Predation[5]	Harvest[6]	"Low" Hatcheries[7]	"High" Hatcheries[7]	Total (Low Hatchery)[8]	Total (High Hatchery)[9]
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee (Summer A)	1.08	1.02	1.00	1.00	1.00	1.04	1.60	1.60	1.83	1.83
		Methow (Summer A)	1.25	1.02	1.00	1.00	1.00	1.04	1.17	1.55	1.55	2.06
		Entiat (Summer A)	1.13	1.02	1.00	1.00	1.00	1.04	0.82	1.30	0.98	1.55
		Okanogan (Summer A)	1.25	1.06	1.00	1.00	1.00	1.04	1.34	1.88	1.85	2.59

1 From SCA hydro appendix. Based on differences in average base and current smolt-to-adult survival estimates for both FCRPS and PUD dams.
2 From CA Chapter 9, Table 9-7.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the
"Current 2 S/Baseline 2 S" approach, as described in Attachment F-2.
5 SCA Marine Mammal Appendix. No populations in this DPS are winter-run.
6 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
6 From SCA Quantitative Analysis of Hatchery Actions Appendix
8 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column, except for the high hatchery estimate.
9 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column, except for the low hatchery estimate.

Table 8.7.5-1. Proportional changes in survival of UCR steelhead expected from the Prospective Actions. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Divisor)									
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2] (2007-2017)	Estuary Habitat[3]	Bird Predation[4]	Pike-minnow Predation[5]	Kelt Reconditioning[6]	Marine Mammal[7]	Allowable Harvest8	Expected Harvest[8]	Hatcheries9
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.23	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Methow (Summer A)	1.23	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Entiat (Summer A)	1.23	1.08	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Okanogan (Summer A)	1.23	1.14	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00

			Current-to-Future Adjustment (Divisor)					High	Low
ESU	MPG	Population	Non-Hydro With Allowable Harvest[10]	Non-Hydro With Expected Harvest[10]	Total (Allowable Harvest)[11]	Total (Expected Harvest)[11]		Total Base-Current and Current-Future[12]	Total Base-Current and Current-Future[12]
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.14	1.14	1.41	1.41		2.58	2.58
		Methow (Summer A)	1.14	1.14	1.41	1.41		2.18	2.89
		Entiat (Summer A)	1.19	1.19	1.46	1.46		1.43	2.26
		Okanogan (Summer A)	1.25	1.25	1.54	1.54		2.85	3.99

1 From SCA Hydro Modeling Appendix. Based on differences in average current and prospective smolt-to-adult survival estimates for both FCRPS and PUD dams.
2 From CA Chapter 9, Table 9-9.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 SCA Kelt Reconditioning Appendix
7 SCA Marine Mammal Appendix. No populations in this DPS are winter-run.
8 From SCA Harvest Appendix. Primary source: memorandum from US v. Oregon ad hoc technical workgroup.
9 No quantitative survival changes have been estimated to result from hatchery Prospective Actions – future effects are qualitative .
10 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
11 Same as Footnote 10, except it is calculated from all Prospective Actions, including hydro actions.
12 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multipliers (with high and low hatchery estimates) from Table 8.7.3-1.

Table 8.7.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for UCR steelhead. Low and high productivity estimates are a result of the range of changes in hatchery-origin spawner effectiveness from the base to the current conditions, as described in Section 8.7.3.1 and CA Section 9.3.1.5.

Low Base-to-Current Hatchery Adjustment

		Low Base-to-Current Hatchery Adjustment							
MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	0.90	1.32	0.98	2.67	Two must be HV and 1 must be V	Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <1	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
	Methow (Summer A)	0.47	1.29	0.80	2.32		Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <3	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
	Entiat (Summer A)	0.74	1.14	0.88	1.48		Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <4	Currently Moderate Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
	Okanogan (Summer A)	0.23					R/S<1	Currently High Risk (Only occupy lower halves of 2 US MaSAs)	Currently High Risk (Homogenization of historical populations and high hatchery %)

High Base-to-Current Hatchery Adjustment

			High Base-to-Current Hatchery Adjustment							
ESU	MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	0.90	1.32	0.98	2.67	Two must be HV and 1 must be V	Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <3	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
		Methow (Summer A)	0.62	1.38	0.85	3.08		Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <5	Currently Low Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
		Entiat (Summer A)	1.17	1.26	0.97	2.35		Lambda HF=0 and BRT trend >1, but R/S and Lambda HF=1 <6	Currently Moderate Risk	Currently High Risk (Homogenization of historical populations and high hatchery %)
		Okanogan (Summer A)	0.32					R/S<1	Currently High Risk (Only occupy lower halves of 2 US MaSAs)	Currently High Risk (Homogenization of historical populations and high hatchery %)

1 Calculated as the base period 20-year R/S productivity from Table 8.7.2-1, multiplied by the total base-to-future survival multiplier in Table 8.7.5-1.
2 Calculated as the base period 20-year mean population growth rate (lambda) from Table 8.7.2-1, multiplied by the total base-to-future survival multiplier in Table 8.7.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
3 Calculated as the base period 20-year mean BRT abundance trend from Table 8.7.2-1, multiplied by the total base-to-future survival multiplier in Table 8.7.5-1, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007c), Attachment 2
5 From Table 8.7.2-2

Figure 8.7.6-1. Summary of prospective mean R/S estimates for UCR steelhead under the "recent" climate assumption, including 95% confidence limits.

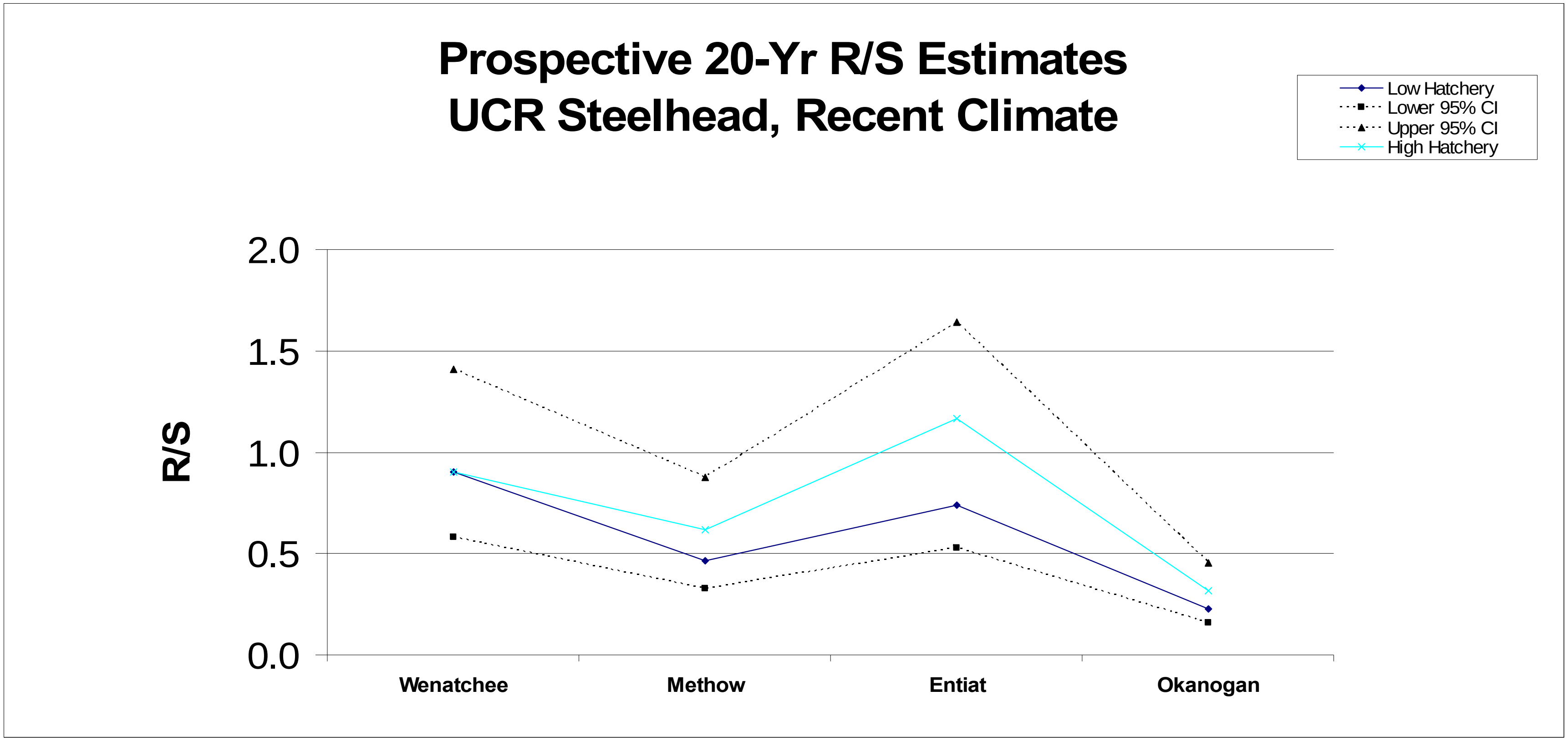
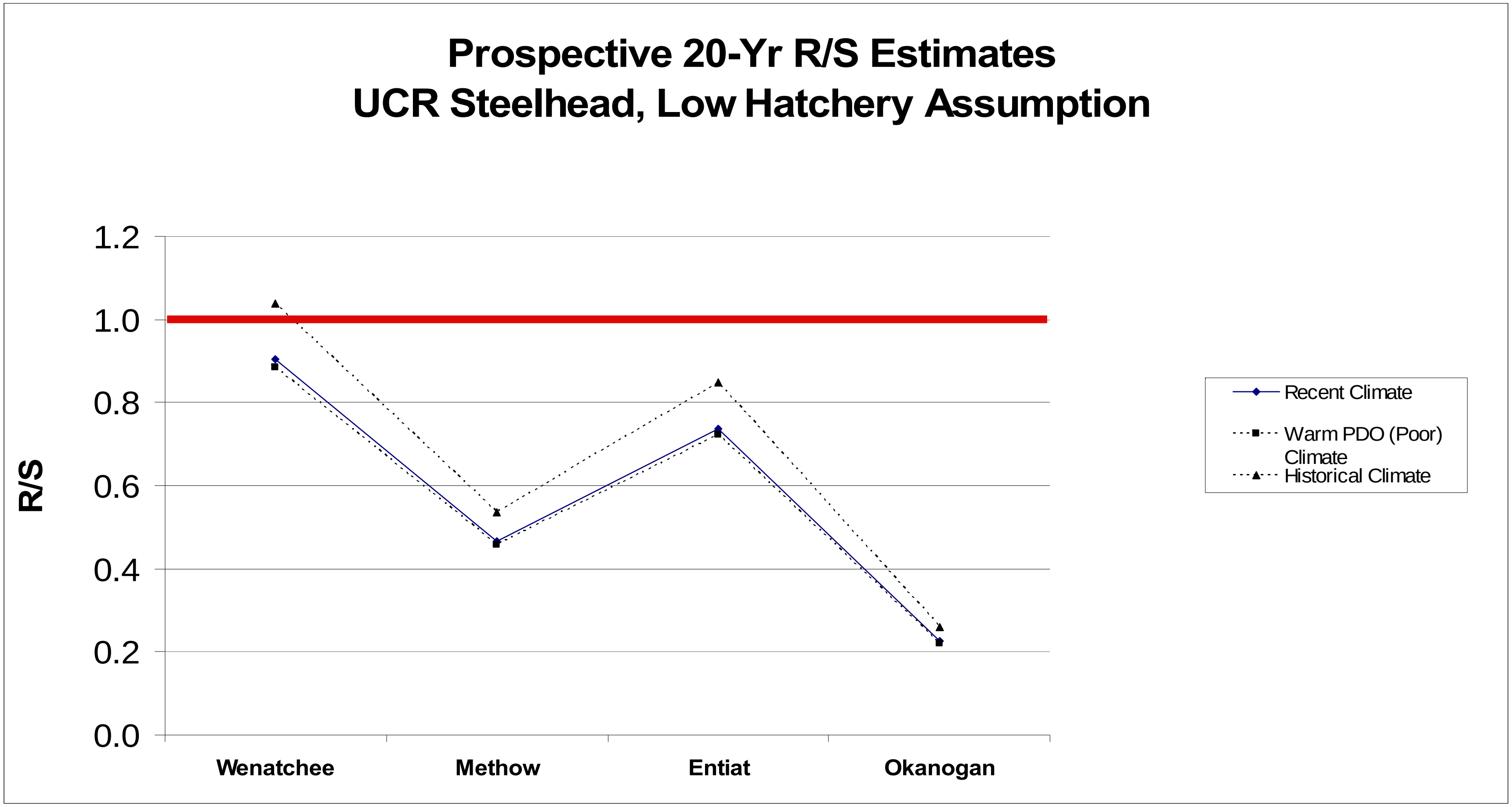


Figure 8.7.6-2. Summary of prospective mean R/S estimates for UCR steelhead under three climate assumptions.



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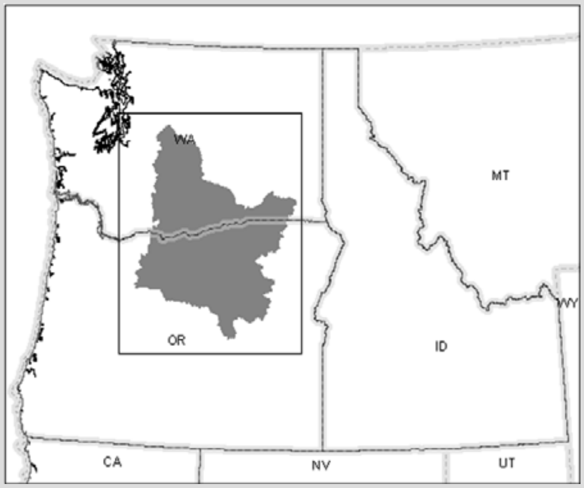
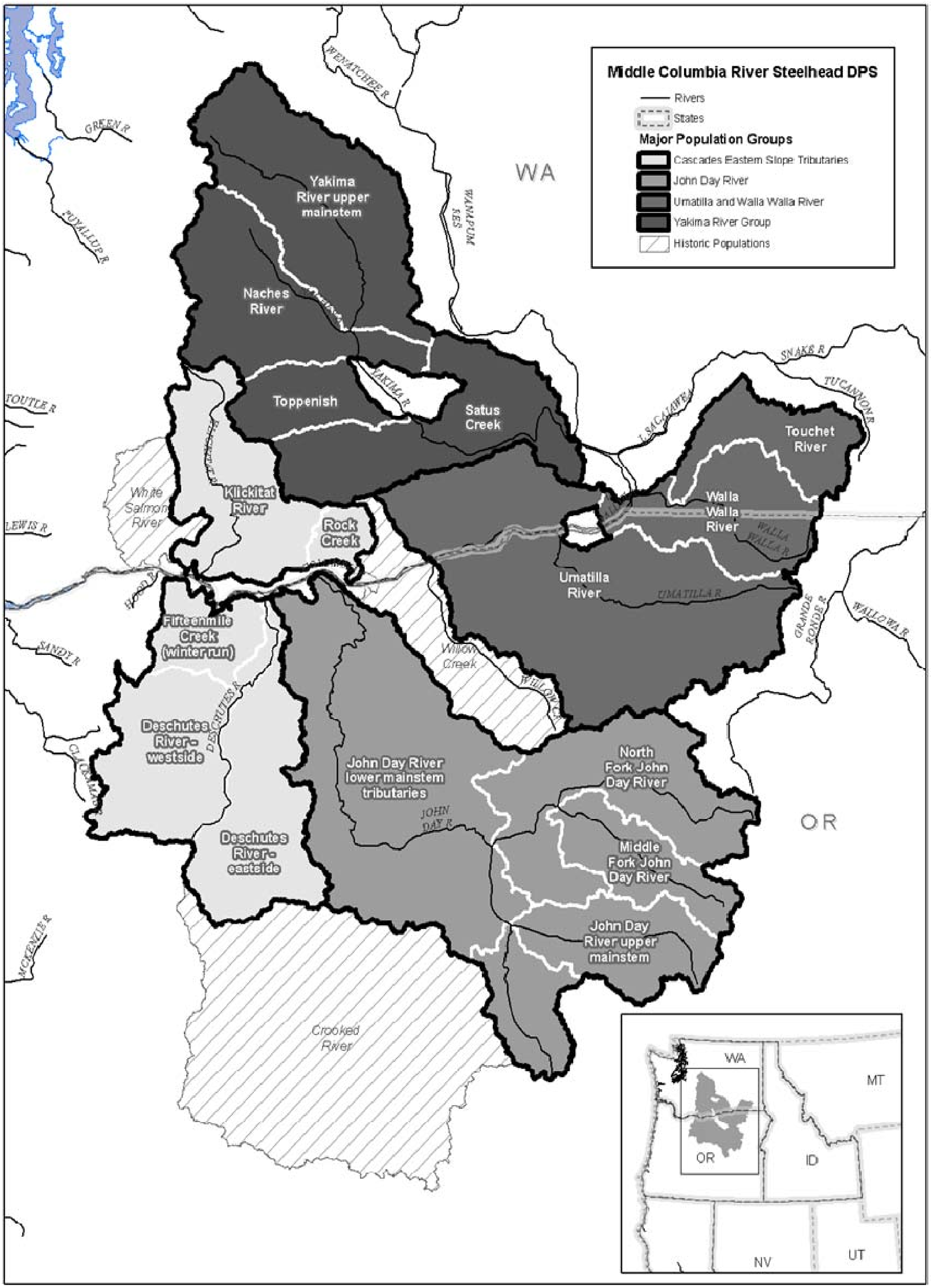
Middle Columbia River Steelhead




Middle Columbia River Steelhead DPS
Rivers
States
Major Population Groups
Cascades Eastern Slope Tributaries
John Day River
Umatilla and Walla Walla River
Yakima River Group
Historic Populations
WA
OR
Yakima River upper mainstem
Naches River
Toppenish
Satus Creek
Touchet River
Walla Walla River
Umatilla River
Klickitat River
Rock Creek
White Salmon River
Fifteenmile Creek (winter run)
Deschutes River - westside
Deschutes River - eastside
John Day River lower mainstem tributaries
North Fork John Day River
Middle Fork John Day River
John Day River upper mainstem
Willow Creek
Crooked River
WENATCHEE R
GREEN R
PUYALLUP R
WANAPUM SES
SNAKE R
TUCANNON R
TOUTLE R
LEWIS R
HOOD R
SANDY R
CLACKAMAS R
MCKENZIE R
DESCHUTES R
YAKIMA R
WALLA WALLA R
UMATILLA R
GRANDE RONDE R
WALLOWA R
WILLOW CR
JOHN DAY R
MT
ID
NV
UT

Section 8.8
Middle Columbia River Steelhead

Species Overview

Background

The Middle Columbia River (MCR) Steelhead DPS includes anadromous populations in Oregon and Washington subbasins upstream of the Hood and Wind River systems to and including the Yakima River. There are four major population groups with 17 populations in this DPS. Almost all populations are summer-run fish; two winter-run populations return to the Klickitat and Fifteenmile Creek watersheds. Blockages have prevented access to sizable historical production areas in the Deschutes, White Salmon, and White Salmon rivers. The Middle Columbia River Steelhead DPS was listed under the ESA as threatened in 1999, reaffirmed in 2006.

Designated critical habitat for MCR steelhead includes all Columbia River estuarine and river reaches proceeding upstream to the confluence of the Yakima River and a number of tributary subbasins.

Current Status & Recent Trends

During the most recent 10-year period for which trends in abundance could be estimated, they were positive for approximately half of the populations and negative for the remainder. On average, when only natural production is considered, most of the MCR steelhead populations have replaced themselves.

Limiting Factors and Threats

Historically, the key limiting factors for MCR steelhead include mainstem hydropower projects, tributary habitat and hydropower, water storage projects, predation, hatchery effects, harvest, and estuary conditions. Ocean conditions have been generally poor over most of the last 20 years, improving only in the last few years.

Recent Ocean and Mainstem Harvest

Few steelhead are caught in ocean fisheries. Ocean fishing mortality on Middle Columbia River steelhead is assumed to be zero. The MCR steelhead DPS is made up of mostly summer run populations, although there are a few populations with winter run timing. The summer run populations are all categorized as A-run based on run timing and age and size characteristics.

Fisheries in the Columbia River are limited to assure that the incidental take of ESA-listed Middle Columbia River steelhead does not exceed specified rates. Non-Treaty fisheries were subject to a 2% harvest rate limit on A-run steelhead. Treaty Indian fall season fisheries were subject to a 15% harvest rate limit on B-run steelhead, but were not subject to a particular A-run harvest rate constraint since B-run steelhead are generally more limiting. Recent harvest rates on Middle Columbia River A-run steelhead in non-Treaty and treaty Indian fisheries ranged from 1.0% to 1.9%, and 4.1% to 12.4%, respectively.

The yearly incidental catch of winter-run steelhead populations in non-Treaty fisheries has averaged 1.9% and has ranged from 0.2 to 9.3% since 2001. The high harvest rate observed in 2002 (i.e. 9.3%) was due to a lack of proper in-season management guidelines. These guidelines were subsequently corrected in 2003 and have been in place since that time. The yearly incidental take of winter-run steelhead populations in tribal fisheries, which is limited to winter populations above Bonneville Dam, has averaged 2.2% and has ranged from 0.8 to 5.8% since 2001.

8.8.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point is the scientific analysis of species' status, which forms the basis for the listing of the species as endangered or threatened.

8.8.2.1 Current Rangewide Status of the Species

Middle Columbia River (MCR) steelhead is a threatened species composed of 17 extant anadromous populations in four major population groups (MPG). Key statistics associated with the current status of MCR steelhead are summarized in Tables 8.8.2-1 through 8.8.2-4. Upriver summer steelhead, which include UCR steelhead, are categorized as A-run or B-run based on run timing and age and size characteristics. MCR steelhead are all A-run fish.

Limiting Factors & Threats

The key limiting factors and threats for MCR steelhead include hydropower projects, tributary habitat and in-basin hydropower, predation, hatchery effects, harvest and estuary conditions. Ocean conditions generally have been poor over most of the last 20 years, improving only in the last few years. Limiting factors and threats are discussed in detail in the context of critical habitat in Section 8.8.3.3.

Abundance

For three of the 14 populations with estimates of recent abundance, average abundance over the most recent 10-year period is above the average abundance thresholds that the ICTRT identifies as a minimum for low risk (Table 8.8.2-1).[1] The remaining 11 populations have lower average abundance than the ICTRT abundance thresholds. Abundance for most populations was relatively high during the late 1980s, declined to low levels in the mid-1990s, and increased to levels similar to the late 1980s during the early 2000s (Figure 8.8.2-1, showing annual abundance of combined populations).

Figure 8.8.2-1 shows the aggregate abundance of all populations and rolling 5-year geometric mean of abundance for the DPS as a whole. The 1980 to 2002 and the 1990 to 2002 DPS-level trends indicate a declining trend over 1980 to 2002 and an increasing trend for 1990-2002. Geometric mean abundance since 2001 has substantially increased for the DPS as a whole. Geomean abundance of natural-origin fish for the 2001 to the most recent period was 17, 553 compared to 7, 228 for the 1996 to 2000 period, a 143 percent improvement (all aggregate population abundance trend information from Fisher and Hinrichsen 2006). The 5-year geometric mean in 2002 was still less than the 5-year geometric mean in 1988.

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[1] BRT and ICTRT products were developed as primary sources of information for the development of delisting or long-term recovery goals. They were not intended as the basis for setting goals for "no jeopardy" determinations. Although NOAA Fisheries considers the information in the BRT and ICTRT documents in this consultation, its jeopardy determinations are made in a manner consistent with the Lohn memos dated July 12, and September 11, 2006 (NMFS 2006h, i).

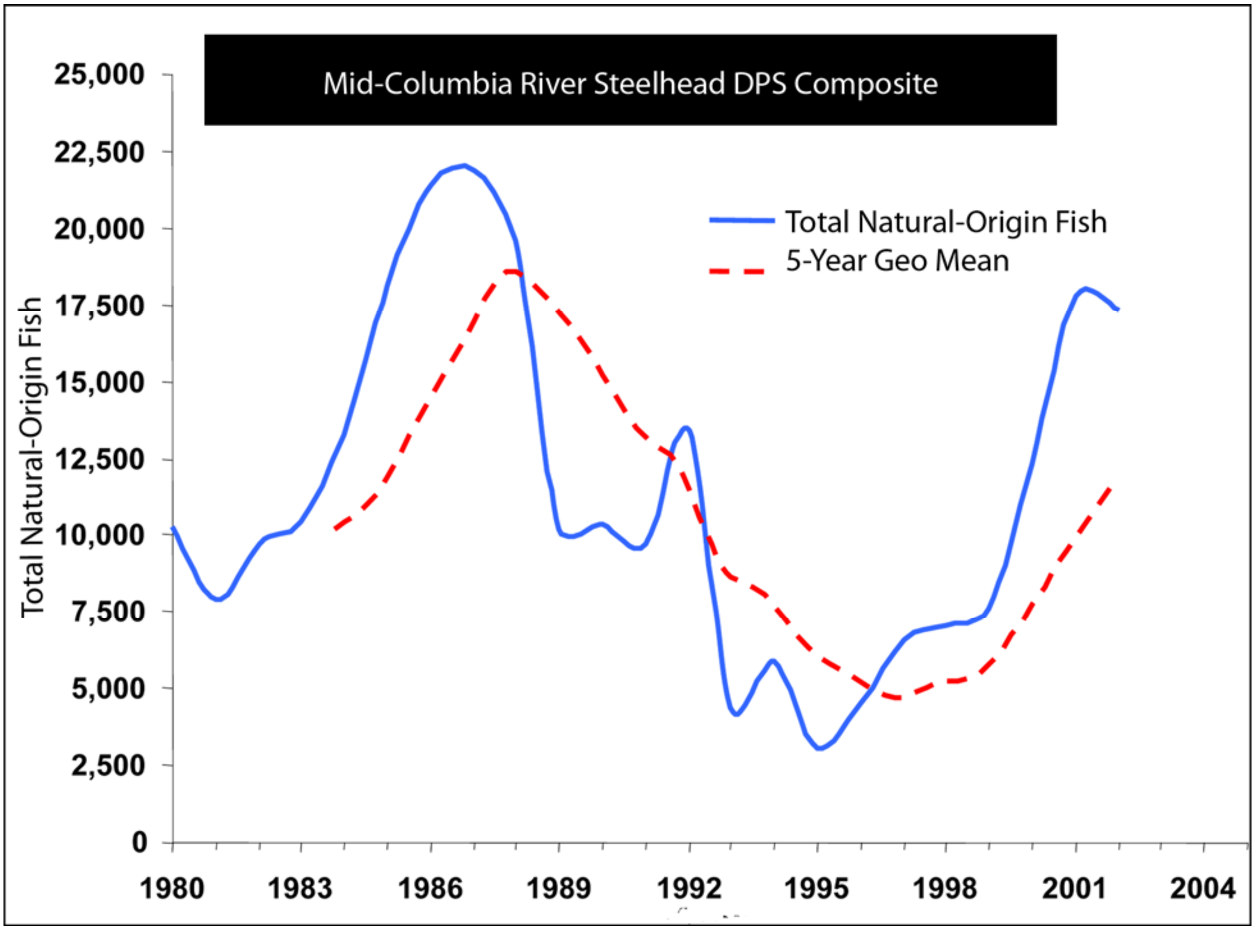

Figure 8.8.2-1. Middle Columbia River Steelhead Abundance Trends (adopted from Fisher and Hinrichsen 2006).

"Base Period" Productivity

Over the last 20 full brood year returns, of the MCR steelhead populations for which estimates are available, most have replaced themselves (R/S>1.0) and a few have not (R/S<1.0; Table 8.8.2-1) when only natural production is considered. These estimates are based on brood years [BY] starting in 1979-1985, depending on population, and ending in 1998 or 1999, including adult returns through 2004 or 2005. In general, R/S productivity was relatively high during the early 1980s, lower during the late 1980s and 1990s, and high again in the most recent brood years (Cooney 2008a)

Intrinsic productivity, which is the average of adjusted R/S estimates for only those brood years with the lowest spawner abundance levels, has been lower than the intrinsic productivity R/S levels identified by the ICTRT as necessary for long-term population viability at ≤5% extinction risk for most of the populations and has been at or above the identified levels for a few (ICTRT 2007c).

The BRT trend in abundance was at or above1.0 during this period for about half of the populations for which this trend could be estimated and less than 1.0 for the remainder (Table 8.8.2-1). Estimates of median population growth rate (lambda) when calculated with the assumption that the effectiveness of hatchery-origin and natural-origin spawners are equal (HF=1; Table 8.8.2-1) were similar to the BRT trend results. Under the HF=0 assumption, most populations have population growth rates greater than 1.0.

Spatial Structure

The ICTRT characterizes the spatial structure risk to MCR steelhead populations as “very low” to “moderate” for all populations except the Upper Yakima (Table 8.8.2-2). This population has “high” diversity risk because 7 of 10 historical major spawning areas are not occupied.

Diversity

The ICTRT characterizes the diversity risk to all but one MCR steelhead population as “low” to “moderate” (Table 8.8.2-2). The Upper Yakima is rated as having “high” diversity risk because of introgression with resident *O. mykiss* and loss of presmolt migration pathways.

“Base Period” Extinction Risk

The draft ICTRT Current Status Summaries (ICTRT 2007d) have characterized the long-term (100 year) extinction risk, calculated from productivity and natural origin abundance estimates of populations during the “base period” described above for R/S productivity estimates, as “Moderate” (6-25% 100-year extinction risk) for most MCR steelhead populations. One population (North Fork John Day) has “very low” (<1%) risk and four populations (Rock Creek, Touchet, Toppenish, and Upper Yakima) have “high” (>25%) risk. The ICTRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50).

The ICTRT assessments are framed in terms of long-term viability and do not directly incorporate short-term (24-year) extinction risk or specify a particular QET for use in analyzing short-term risk. Table 8.8.2-3 displays results of an analysis of short-term extinction risk at four different QET levels (50, 30, 10, and 1 fish) for each population. This short-term extinction risk analysis is also based on the assumption that productivity observed during the “base period” will be unchanged in the future. At QET=50, most of the populations, for which short-term risk could be estimated, had <5% risk of short-term extinction. Confidence limits on these estimates are extremely wide, ranging from 0 to 100% risk of extinction for some populations.

A QET of less than 50 may also be considered a reasonable indicator of short-term risk, as discussed in Section 7.1.1.1. However, for this species, alternative QET estimates had no effect on the number of populations with <5% risk of short-term extinction.

The short-term and ICTRT long-term extinction risk analyses assume that all hatchery supplementation ceases immediately. As described in Section 7.1.1.1, this assumption is not representative of hatchery management under the Prospective Actions. A more realistic assessment of short-term extinction risk will take hatchery programs into consideration, either qualitatively or quantitatively. If hatchery supplementation is assumed to continue at current levels for those populations affected by hatchery programs, short-term extinction risk is likely to be lower, as evidenced by analyses for SR fall Chinook, SR spring/summer Chinook, and UCR steelhead (Hinrichsen 2008, included as Attachment 1 of the Aggregate Analysis Appendix).

Quantitative Survival Gaps

The change in density-independent survival that would be necessary for quantitative indicators of productivity to be greater than 1.0 are displayed in Table 8.8.2-4. Mean base period R/S survival gaps range from no needed change to 16%, no needed change to a 21% improvement for lambda, and BRT trend survival gaps range from no change to 26%. It is not possible to estimate survival changes necessary to reduce short-term extinction risk to ≤5% using the methods employed in this analysis, as described in Chapter 7. However, because base extinction risk is <5% for most populations, there would be no gap except for a few populations.

8.8.2.2 Rangewide Status of Critical Habitat

Designated critical habitat for MCR steelhead includes all Columbia River estuarine areas and river reaches in the following subbasins: Upper Yakima, Naches, Lower Yakima, Middle Columbia/Lake Wallula, Walla Walla, Umatilla, Middle Columbia/Hood, Klickitat, Upper John Day, North Fork John Day, Middle Fork John Day, Lower John Day, Lower Deschutes, Trout, and Upper Columbia/Priest Rapids (NMFS 2005b). There are 114 watersheds within the range of this DPS. Nine watersheds received a low rating, 24 received a medium rating, and 81 received a high rating of conservation value to the DPS (see Chapter 4 for more detail). The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in three of the high value watersheds identified above. This corridor 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. Of the 6,529 miles of habitat areas eligible for designation, 5,815 miles of stream are designated critical habitat. The status of critical habitat is discussed further in Section 8.8.3.3.

8.8.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

8.8.3.1 "Current" Productivity & Extinction Risk

Because the action area encompasses nearly the entire range of the species, the status of the species in the action area is nearly the same as the rangewide status. However, in the Rangewide Status section estimates of productivity and extinction risk were based on performance of populations during a 20-year "base period," ending with the 1998 or 1999 brood year. The environmental baseline, on the other hand, includes current and future effects of Federal actions that have undergone Section 7 consultation and continuing effects of completed actions (e.g., continuing growth of vegetation in fenced riparian areas resulting in improved productivity as the riparian area becomes functional).

Quantitative Estimates

Because a number of ongoing human activities have changed over the last 20 years, the CA includes estimates of a "base-to-current" survival multiplier, which adjusts productivity and extinction risk under the assumption that current human activities will continue into the future and all other factors will remain unchanged. Details of base-to-current adjustments are described in Section Chapter 7.1 of this document. Results are presented in Table 8.8.3-1.

Briefly, reduction in the average base period harvest rate (estimated at approximately a 4% survival change [SCA Harvest Appendix, based on *U.S. v. Oregon* estimates]), improvements in dam configuration and operation (approximately a 0-2% [2] survival change, based on ICTRT base survival and COMPASS analysis of current survival in Corps et al. 2007a Appendix B), and estuary habitat projects (a less than 1% survival change, based on Corps et al. 2007a Appendix D) result in a survival improvement for all MCR steelhead populations. Tributary habitat projects result in approximately 0-4% survival improvements, depending on population (CA Chapter 10, Table 10-8). A conservation hatchery program for the Umatilla population, (see SCA Hatchery Effects Appendix,) and a kelt reconditioning program affecting four Yakima River populations improved survival, but the effects could not be quantified. In contrast, development of tern colonies in the estuary in recent years results in less than a 1% reduction in survival for all populations. Also, marine mammal predation probably reduced survival by 8% for the one winter-run population to which quantitative estimates can be applied (Fifteenmile Creek).

The net result is that, if these human-caused factors continue into the future at their current levels and all other factors remain constant, survival would be expected to decrease 19% for the Fifteenmile Creek population and increase 4-10% for the other populations (Table 8.8.3-1). This also means that the survival "gaps" described in Table 8.8.2-4 would be proportionately reduced by this amount (i.e., ["Gap" ÷ 1.01] to ["Gap" ÷ 1.22], depending on the population).

[2] These numbers probably underestimate the survival improvements made between the base and current periods because they depend upon "average per project survival estimates." This approach may overestimate base period survival at the larger Columbia River projects. Thus these estimates should be viewed as conservative, showing smaller survival improvements than are likely to have actually occurred.

8.8.3.2 Abundance, Spatial Structure & Diversity

The description of these factors under the environmental baseline is identical to the description of these factors in the Rangewide Status section.

8.8.3.3 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. Tributary habitat conditions vary widely among the various drainages occupied by MCR steelhead. Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and forest management continue to threaten the conservation value of critical habitat for this species in some locations in the upper Columbia basin.

Spawning & Rearing Areas

Middle Columbia River steelhead spawn and rear in tributaries to the Columbia River upstream from the Wind River to and including the Yakima (but excluding the Snake) River. Almost all populations are summer-run fish. Juveniles from most of the populations in this DPS rear in the tributaries for 1 to 2 years before outmigrating. The following are the major factors that have limited the functioning and thus the conservation value of habitat used by MCR steelhead for these purposes (i.e., spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that help ensure their survival):

- Tributary barriers *[push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles]*
- Excess sediment in spawning gravels and in substrates that support forage organisms *[land and water management activities]*
- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures *[degraded riparian and channel function]*
- Degraded water quality *[toxics from agricultural runoff; high temperatures due to water withdrawal/return practices]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions to address limiting factors and threats for this DPS in spawning and rearing areas. These include acquiring water to increase streamflow, installing or improving fish screens at irrigation facilities to prevent entrainment, removing passage barriers and improving access, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects provided immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

Juvenile & Adult Migration Corridors

Adults begin to return from the ocean in early spring and enter upper Columbia tributaries during April through July. Juvenile steelhead migrate to salt water in the spring of their second year of life. Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers *[push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles]*

- Juvenile and adult mainstem passage mortality *[hydropower projects in the mainstem Columbia River; northern pikeminnows and other fish predators]*

- Pinniped predation on adults due to habitat changes in the lower river *[existence and operation of Bonneville Dam and an increased sea lion population]*

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators [*Caspian terns and double-crested cormorants*]

In the mainstem FCRPS migration corridor, the FCRPS Action Agencies have improved safe passage through the hydrosystem for juvenile steelhead from the mid-Columbia River with the configuration and operational improvements listed in section 10.3.1.1 in Corps et al. (2007a).

The safe passage of juvenile steelhead through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown since that time. For these salmonids, with a stream-type juvenile life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 10.3.1.3 in Corps et al. 2007a). NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult winter steelhead in the tailrace of Bonneville Dam (NMFS 2008d).[3] This action is expected to increase the survival of winter steelhead by 7.6%.

Areas for Growth & Development to Adulthood

Although MCR steelhead spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the mouth of the Columbia River

[3] Winter-run steelhead return to the Klickitat River and Fifteenmile Creek watersheds.

NMFS (2005b). Therefore, the effects of the Prospective Actions on PCEs in areas for growth and development to adulthood are not considered further in this consultation.

8.8.3.4 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

John Day River MPG

Lower Mainstem John Day

The USFS consulted on three grazing allotment projects and one culvert replacement project in the Lower John Day River—Kahler Creek watershed.

The Corps consulted on the permit for replacing boat docks at Philippi Park at River Mile 3 on the John Day River (Lower John Day River—McDonald Ferry watershed) and a culvert replacement in Wheeler Creek (Lower John Day River—Kahler Creek watershed). The latter project included the construction of step pools and rock weirs to enhance fish passage conditions.

The National Park Service consulted on two pest management projects in the Bridge Creek and Lower John Day River—Clarno Rapids watersheds, respectively. The BLM replaced a push-up dam with a screened water withdrawal facility that allows safe passage and planted cottonwoods along three stream miles to improve shading and provide a future source of LWD in Bridge Creek (Bridge Creek watershed). BLM also consulted on projects to fence off one stream mile in the Lower John Day River – Scott Canyon watershed and to convert an agricultural field to perennial grasses and cottonwood trees in the Lower John Day River – Butte Creek watershed. Both projects were intended to improve riparian conditions including cooler water temperatures. The cottonwoods will provide a future source of LWD.

North Fork John Day

The USFS consulted on eight grazing allotment projects in the North Fork John Day River - Big Creek, Upper Camas Creek, Lower Camas Creek, and North Fork John Day River-Potamus Creek, Wall Creek, and Cottonwood Creek watersheds. The USFS also consulted on a project to reroute the Round Meadows Trail in the Upper Camas Creek and a vegetation management project in the Wall Creek watershed. In Granite Creek, the USFS proposed to move historical mine tailings from Clear Creek (Granite Creek watershed), reconnect the creek with its floodplain, and install large woody debris. The latter project was expected to improve cover, shade, and forage conditions.

The BLM consulted on two bridge repair/replacement projects in the North Fork John Day River - Potamus Creek watershed, one at Skull Canyon and one at Stoney Creek. Both projects included stormwater runoff facilities. The FHWA/ODOT consulted on a culvert retrofit on Beech Creek in the

Cottonwood Creek and projects to replace the Monument and Kimberly bridges in the Lower North Fork John Day River watersheds. The culvert retrofit was expected to enable year-round safe passage and shade (from riparian plantings). The bridge replacements increased the amount of impervious surface at each site but also reduced chronic stormwater inputs and restored shade and cover conditions along the streambank (tree plantings).

Middle Fork John Day

The USFS consulted on three culvert replacement projects on Bridge Creek and Lunch Creek in the Upper Middle Fork John Day River watershed; all were designed to improve fish passage. The USFS also consulted on two riparian planting projects (Flood Meadows and Southeast Galena) in the Camp Creek watershed and two grazing allotment projects in the Big Creek and Long Creek watersheds, respectively.

The FHWA/ODOT consulted on a project to remove four culverts, build four bridges, and improve the stream channel and riparian vegetation on Bridge Creek in the Upper Middle Fork John Day River watershed. The project was expected to restore passage and riparian function and to otherwise improve stream channel function.

South Fork John Day

The USFWS consulted on the effects of water withdrawals and herbicide applications related to managing the Philip W. Schneider Wildlife Area in the Murderers Creek watershed. The project was expected to have small, local negative effects on water quantity, water temperatures, and water quality and sublethal effects on fish condition.

The BLM consulted on a project to develop springs in upland areas of the Middle South Fork John Day watershed, improving streambank and riparian conditions.

Upper Mainstem John Day

The USFS consulted on three grazing allotment projects in the Upper John Day River, Canyon Creek, and Laylock Creek watersheds, respectively. The Corps consulted on a bank stabilization project along 110 feet of the south bank of the John Day River (Laylock Creek watershed) and the installation of stream barbs at River Mile 236 (Upper Middle John Day watershed). The latter project was designed to reduce erosion and support the re-establishment of riparian vegetation by moving flow away from the south bank. The FHWA/ODOT consulted on culvert retrofits at seven locations in Beech Creek (Beech Creek watershed) which were designed to improve fish passage. Riparian plantings were expected to increase shade and thereby to lower instream temperatures. The National Park Service consulted on a vegetation management project in the Rock Creek watershed.

Yakima River Group MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that affect the Toppenish River population.

Yakima River Upper Mainstem

The USFS consulted on a timber sale in the Upper Yakima River watershed and a fuels reduction project and two mining plan projects in the Middle Yakima River watershed. The Corps consulted on permits for a bank stabilization project in the Upper Yakima watershed; maintenance dredging and bank stabilization in the Tenaway River watershed; erosion control and habitat restoration; breakwater, dock, and boat ramp repairs; and installation of a natural gas pipeline in the Middle Yakima River watershed; two fish passage projects in the Yakima River – Umatanum Creek watershed; and dredging at an irrigation withdrawal in the mainstem Columbia River (Upper Lake Wallula). The BLM consulted on campground construction in the Yakima River – Umatanum Creek watershed.

The Department of the Army consulted on several projects at the Yakima Training Center in the Middle Yakima River watershed: a plan for erosion control and resource sustainability, the use of military explosives, facilities repairs, bridge repairs, bank stabilization and riparian improvements, and a plan to modify aerial fire suppression requirements.

The NRCS consulted on habitat restoration in the Yakima River – Umatanum Creek watershed. Reclamation consulted on a fish ladder at a diversion dam, a watercraft barrier at an irrigation wasteway water diversion, a permit for a bank protection structure (Middle Yakima River watershed), and a project to dredge an approach channel and canal to a pumping plant (Upper Lake Wallula).

Naches River

The USFS consulted on a recreation management plan for the Little Naches River watershed and a habitat restoration project in the Naches River – Rattlesnake Creek watershed. USFWS consulted on a wildlife area management plan, the Corps consulted on a bank protection and enhancement project, and Reclamation consulted on bridge repairs and a project to improve fish passage and reduce fallback at a diversion dam in the Naches River – Tieton River watershed. The FHWA/WSDOT consulted on road construction and NOAA Fisheries consulted with itself on funding a barrier removal project in the Ahtanum Creek watershed. The Department of the Army consulted on several projects at the Yakima Training Center in the Upper Lower Yakima River watershed involving the use of military explosives and erosion control. Reclamation consulted on the acquisition of water rights in the Upper Lower Yakima River watershed and a project to dredge an approach channel and canal to a pumping plant (Upper Lake Wallula). The Corps consulted on dredging at an irrigation withdrawal structure in the mainstem Columbia River (Upper Lake Wallula).

Satus Creek

The USFWS consulted on management of a wildlife refuge in the Yakima River – Spring Creek watershed. The Department of the Army consulted on an erosion control project at the Yakima Training Center and the Corps consulted on a permit for a diffuser at a waste disposal site in the Yakima River – Cold Creek watershed. The Corps also consulted on dredging at an irrigation withdrawal structure in the mainstem Columbia River (Upper Lake Wallula). Reclamation consulted on a project to dredge an approach channel and canal to a pumping plant (Upper Lake Wallula).

Walla Walla & Umatilla Rivers MPG

Umatilla River

The USFWS consulted on management of a wildlife refuge (Upper Lake Umatilla) and a wildlife area (Lower Umatilla River watershed). The Corps consulted on construction of a pipeline and a dredging project in the Upper Lake Umatilla watershed; construction of a fuel dock and improvements to fish passage at a water withdrawal location in the Middle Lake Umatilla watershed; fish passage improvements on the West Fork of Birch Creek (Birch Creek watershed); bank stabilization and riparian improvements; repair of a railroad bridge and two road construction/maintenance projects in the Umatilla River – Alkali Canyon watershed; and repair/construction of a boat ramp in the Lower Umatilla River watershed.

The USFS consulted on road construction/maintenance in the Upper Umatilla River watershed, Reclamation consulted on a gravel removal project at a fish weir in the McKay Creek watershed. The FHWA/ODOT consulted on a culvert replacement in the McKay Creek watershed and structural improvements at a highway interchange in the Umatilla River – Alkali watershed.

Willow Creek

The Corps consulted on construction of a commercial dock in the Lower Lake Umatilla watershed.

Walla Walla River

The BLM consulted on a recreation management plan for the Upper Walla Walla River watershed. FHWA/WSDOT consulted on a road construction project in the Mill Creek – Walla Walla River watershed and a bridge replacement project in the Cottonwood Creek watershed. The Corps consulted on several projects in the Cottonwood Creek watershed: several culvert replacements, replacement of a push-up dam at a water diversion, and bridge replacements. All of these projects were expected to improve fish passage. The USFWS consulted on a stream rehabilitation project in Cottonwood Creek.

Touchet River

The Corps consulted on a fish passage project in the Upper Touchet River watershed; a bridge repair project with habitat enhancement elements (LWD, habitat heterogeneity, substrate availability) in the Middle Touchet watershed; and fire suppression in the Upper Touchet watershed.

Cascade Eastern Slope Tributaries MPG

NOAA Fisheries did not complete any Section 7 consultations in the subject timeframe that affect the White Salmon River, Klickitat River, Deschutes West, Deschutes East, Crooked River or Rock Creek populations.

Fifteenmile Creek

The Corps consulted on permits to dredge a culvert outlet and to drill exploratory holes for a bridge repair project in the Fifteenmile Creek watershed, improve railroad facilities in the Fivemile Creek watershed, replace culverts in the Middle Columbia River – Mill Creek watershed, and build a waterfront park and excavate a retention basin in the Mosier Creek watershed. The USFS consulted on a grazing allotment in the Middle Columbia River – Mosier Creek watershed.

Projects Affecting Multiple MPGs/Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.8.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

Federal agencies are implementing numerous projects within the range of MCR steelhead. Some will improve access to blocked habitat, riparian condition, increase channel complexity, and increase instream flows. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Future Federal restoration projects will improve the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PCEs. However, all of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding in any adverse modification of critical habitat.

8.8.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington identified and provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the Interior Columbia Basin. These are detailed in the lists of projects that appear in Chapter 17 of the FCRPS Action Agencies' Comprehensive Analysis which accompanied their Biological Assessment Corps et al. 2007a). They include tributary habitat actions that will benefit the Walla Walla, Deschutes, North Fork John Day, and other populations as well as actions that should be generally beneficial throughout the DPS. Generally, all of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[4] Many address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to significantly improve conditions for Middle Columbia River steelhead. These effects can only be considered qualitatively, however.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for Prospective Actions, non-federal actions with cumulative effects are likely to include water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and

[4] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.8.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in Section 8.8.5.1 and 8.8.5.5. The Prospective Actions will ensure that adverse effects of the FCRPS and Upper Snake projects will be reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions, which are expected to be beneficial. These beneficial effects are described in Sections 8.8.5.2, 8.8.5.3, and 8.8.5.6. Some RM&E actions may have short-term minor adverse effects, but these will be balanced by short- and long-term beneficial effects, as described in Section 8.8.5.7.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix. The Prospective Actions will ensure continuation of the beneficial effects of supplementation hatcheries and will reduce adverse impacts of other hatchery programs.

8.8.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Effects on Species Status

Except as noted below, all hydro effects described in the environmental baseline (Chapter 5) are expected to continue through the duration of the Prospective Actions.

The effects of the Prospective Actions projects also are included in this analysis. These effects on mainstem flows have been included in the HYDSIM modeling used to create the 70-year water record for input into the COMPASS model (Section 8.1.1.3). As such, the effect of diminished spring-time flows on juvenile migrants is aggregated in the COMPASS model results used to estimate the effects of the Prospective Actions in the productivity and extinction risk analysis (see SCA Sections 7.2.1 and 8.1.1.3).

Based on COMPASS modeling of hydro operations for the 70-year water record, full implementation of the Prospective Actions (compared to the Current condition) is expected to increase the in-river survival of MCR steelhead by 0.3%, 5.1%, 8.2% and 10.2% for those populations migrating through the one to four dams in the lower Columbia River.[5] Transportation at McNary Dam is expected to

[5] For MCR steelhead, the in-river survival estimate and total system survival estimate are virtually identical because no fish are likely to be transported in 69 out of 70 years (>98% of the time) in the 70-year water record. This is even truer for MCR steelhead than for UCR steelhead because the great majority of the populations enter the Columbia

occur in only 1 of 70 years, < 2% of the time, when flows at McNary are less than 125 kcfs. In this unlikely circumstance, about 75.7% of the juveniles from the Yakima and Walla Walla River populations arriving at McNary Dam would likely be transported (see Table 11.7 of the FCRPS Biological Opinion [NMFS 2008a]). Based on the very positive benefits observed from transportation study results from the Snake River during the extremely low flow conditions of 2001, NOAA Fisheries anticipates a similar, albeit somewhat smaller, benefit would exist from transportation at McNary Dam.

Because this DPS migrates through only one to four mainstem hydro projects, NOAA Fisheries does not have confidence that the SR steelhead post-Bonneville survival relationships could be used as a surrogate for estimating SARs for MCR steelhead populations. NOAA Fisheries made no attempt to estimate SARS for this DPS with the COMPASS model, thus assuming that no differences in post-Bonneville survival would be observed between the Current and Prospective conditions.

The Prospective Actions addressing hydro operation and the RM&E program should maintain the high levels of survival currently observed for adult MCR steelhead migrating from Bonneville Dam upstream to MCN Dam. The current PIT tag based survival estimate, taking account of harvest and "natural" stray rates within this reach, is approximately 98.5% per project (a total of 95.6 %, 97.0%, and 98.5% for fish passing three, two, and one projects, respectively). Any delayed mortality of adults (mortality that occurs outside of the Bonneville Dam to McNary Dam migration corridor) that currently exists is not expected to be affected by the hydro Prospective Actions.

The Prospective Actions are also likely to positively affect the survival of Mid-Columbia steelhead in ways that are not included in the quantitative analysis. To be clear, NOAA Fisheries considers these expected benefits, but has not been able to quantify these effects.

The Prospective Actions requiring implementation of surface passage routes at McNary and John Day dams, in concert with training spill (amount and pattern) to provide safe egress, should reduce juvenile travel times within the forebays of the individual projects for Yakima and Walla Walla river populations (which migrate through both dams) and for the Umatilla and John Day river populations (which migrate through John Day dam alone). This is likely to result in survival improvements in the forebays of these projects, where predation rates currently are often the highest. Taken together, surface passage routes should increase juvenile migration rates through the migration corridor, and likely improve overall post-Bonneville survival of in-river migrants. Faster migrating juveniles may be less stressed than is currently the case. Finally, improved tailrace egress conditions should increase the survival of migrating fall Chinook smolts in tailraces where juvenile mortality rates are relatively high.

Continuing efforts under the NPMP and continuing and improved avian deterrence at mainstem dams will also address sources of juvenile mortality. In-river survival from McNary Dam to the

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River downstream of McNary Dam and are therefore not subject to transportation under any circumstance (only the Yakima and Walla Walla River populations enter the mainstem Columbia River upstream of McNary Dam).

tailrace of Bonneville Dam, which is an index of the hydrosystem's effects on water quality, water quantity, water velocity, project mortality, and predation, will increase to 52.4% for fish passing four dams and to 90.3% for fish passing one dam. A portion of the 9.7% to 47.6% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that juvenile steelhead would experience in a hypothetical free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of MCR steelhead in a hypothetical unimpounded Columbia River would be 90.6% for fish migrating through four dams. Therefore, approximately 19.7% (9.4%/47.6%) of the expected mortality experienced by in-river juvenile steelhead migrating through four dams is probably due to natural factors.

The direct survival rate of adults through the FCRPS is already quite high. The prospective actions include additional passage improvements (to the ladders at John Day and McNary dams and other improvements in section 10.3.1.1 in Corps et al. 2007a). Adult steelhead survival from Bonneville to above McNary Dam will be approximately 95.6% under the Prospective Actions. With respect to kelts, the Action Agencies will prepare and implement a Kelt management Plan, including measures to increase in-river survival.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit to juvenile migrants in the lower Columbia River by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.8.3.3).

Effects on Critical Habitat

The Prospective Actions described above will improve the function of safe passage in the juvenile and adult migration corridors by addressing water quantity, water velocity, project mortality, and exposure to predators. To the extent that the hydro Prospective Actions result in more adults returning to spawning areas, water quality and forage for juveniles could be affected by the increase in marine-derived nutrients. This was identified as a limiting factor for the Klickitat population by the Remand Collaboration Habitat Technical Subgroup (Habitat Technical Subgroup 2006b).

8.8.5.2 Effects of Tributary Habitat Prospective Actions

Effects on Species Status

The population-specific effects of the tributary habitat Prospective Actions on survival are listed in CA Chapter 10, Table 10-8, p. 10-15 Corps et al. (2007a). For targeted populations in this DPS, the effect is a <1% - 4% expected increase in egg-smolt survival, depending on population, as a result of implementing the tributary habitat Prospective Actions, which improve habitat function by addressing significant limiting factors and threats. For example, as part of the John Day Watershed Restoration project, the Action Agencies will remove passage barriers and improve water quality and riparian habitat. Under the Oregon Fish Screen Project, they will install and replace out-dated fish screens and other passage devices at irrigation diversions in the John Day, Umatilla, and Walla Walla subbasins. In the Yakima, they will screen diversions, install fish passage at migration barriers, and secure riparian easements.

Effects on Critical Habitat

As described above, the tributary habitat Prospective Actions will address factors that have limited the functioning and conservation value of areas that this species uses for spawning and rearing. PCEs expected to be improved are water quality, water quantity, cover/shelter, food, riparian vegetation, space, and safe passage/access. Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long term.

8.8.5.3 Effects of Estuary Prospective Actions

Effects on Species Status

The estimated survival benefit for MCR steelhead (stream-type life history) associated with the specific actions to be implemented from 2007-2010 is 1.4 %. The survival benefit for MCR steelhead (stream-type life history) associated with specific Prospective Actions to be implemented from 2010 through 2018 is 4.3 %. The total survival benefit for MCR steelhead as a result of Prospective Actions implemented to address estuary habitat limiting factors and threats is approximately 5.7% (CA Section 10.3.3.3). These benefits will be derived from estuary habitat restoration projects implemented in the reach between Bonneville Dam and approximately RM 40. The Action Agencies have specified 14 projects to be implemented by 2009 that will improve the value of the estuary as habitat for this species (section 10.3.3.3 in Corps et al. 2007a). These include restoring riparian function and access to tidal floodplains.

Effects on Critical Habitat

The estuary habitat Prospective Actions will address factors that have limited the functioning of PCEs needed by juvenile steelhead from the mid-Columbia River. Restoration actions in the estuary will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (Section 8.8.5.2).

8.8.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Population-specific effects of the hatchery Prospective Actions on survival of MCR steelhead are not quantitatively evaluated by the FCRPS Action Agencies in the Comprehensive Analysis.

Qualitative assessment of the Prospective Actions is provided in Section 10.3.3.5, pages 10-18, of the CA. The hatchery Prospective Actions consist of continued funding of hatcheries as well as reforms to current federally funded programs that will be identified in future ESA consultations (see Tier 2 actions in the BA). Current federally funded programs include one conservation hatchery program, a kelt reconditioning program, and two harvest mitigation programs.

The Prospective Actions require the adoption of programmatic criteria or BMPs for operating salmon and steelhead hatchery programs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated. The FCRPS Action Agencies intend to adopt these programmatic criteria for funding decisions on future mitigation programs for the FCRPS that incorporate BMPs, and site specific application of BMPs will be defined in ESA Section 7, Section 10, and Section 4(d) limits with NOAA Fisheries to be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies (Corps et al. 2007b, page 2-44). ESA consultations for more than one hundred hatchery programs in the Columbia Basin funded by the Action Agencies are to be completed by June 2010. For middle Columbia hatchery programs, consultations are to be initiated in July 2009 and completed by January 2010. Available information and principles and guidance for operating hatchery programs are described in Appendix E of the CA and in SCA Artificial Propagation for Pacific Salmon Appendix. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.8.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

There are three stocks of summer steelhead used for management, including the lower river Skamania stock, upriver A-run stock, and upriver B-run stock. All UCR steelhead populations are designated A-run steelhead. Two populations of the MCR steelhead DPS are winter run populations.

Prospective non-Treaty fisheries, pursuant to the 2008 *U.S. v. Oregon* Agreement, will be managed subject to DPS-specific harvest rate limits. Winter, spring, and summer fisheries are subject to a 2% harvest rate limit on wild steelhead from the Lower Columbia River, Upper Willamette River, and Middle Columbia River steelhead DPS. Non-Treaty fall season fisheries are likewise subject to a 2% harvest rate limit for each steelhead DPS with summer run populations (A-run and B-run). The total annual harvest rate limit for A-run steelhead, for example, is 4%, and 2% for the winter-run population of the MCR steelhead DPS. This is consistent with the ESA-related management. The expected harvest impacts on non-Treaty fisheries are less than those proposed. The incidental catch of winter-run steelhead in non-Treaty winter, spring and summer season fisheries has averaged 1.9% since 1999 (Table 8.8.5.5-1). The yearly incidental catch of A-run steelhead in non-Treaty fisheries has averaged 1.6 since 1999 (Table 8.8.5.5-1). Harvest rates are not expected to change over the course of this Agreement (TAC 2008).

Table 8.8.5.5-1. Harvest rates of A-run steelhead in spring, summer, and fall season fisheries expressed as a proportion of the Skamania and A-run steelhead run size (TAC 2008).

Year	Treaty Indian				Non-Indian			
	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
1985	0.15%	NA	19.40%	19.50%				
1986	0.08%	NA	12.60%	12.70%				
1987	0.05%	NA	14.70%	14.80%				
1988	0.18%	NA	16.10%	16.20%				
1989	0.04%	4.00%	14.90%	18.90%				
1990	0.44%	3.50%	14.10%	18.00%				
1991	0.15%	1.90%	14.40%	16.40%				
1992	0.49%	2.00%	15.20%	17.60%				
1993	0.14%	1.40%	14.60%	16.20%				
1994	0.16%	1.10%	9.70%	10.90%				
1995	0.06%	2.20%	10.00%	12.20%				
1996	0.66%	2.30%	8.40%	11.40%				
1997	0.10%	2.70%	10.10%	12.80%				
1998	0.11%	3.80%	8.40%	12.40%				
1999	0.05%	2.10%	5.20%	7.40%	0.10%	0.30%	0.60%	1.00%
2000	0.11%	1.00%	4.00%	5.10%	0.10%	0.60%	1.00%	1.70%
2001	0.09%	2.10%	3.80%	6.00%	0.10%	0.40%	0.60%	1.10%
2002	0.09%	2.10%	2.40%	4.60%	0.40%	0.40%	0.80%	1.60%
2003	0.12%	2.80%	2.50%	5.40%	0.60%	0.30%	1.00%	1.90%

Year	Treaty Indian				Non-Indian			
	Spring Season	Summer Season	Fall Season	Total	Spring Season	Summer Season	Fall Season	Total
2004	0.13%	3.90%	3.00%	7.00%	0.40%	0.40%	1.00%	1.80%
2005	0.05%	2.30%	3.60%	5.90%	0.40%	0.40%	0.90%	1.70%
2006	0.13%	0.80%	5.00%	6.00%	0.30%	0.40%	1.20%	1.90%
2007					0.30%	0.30%	0.80%	1.40%
1985-06 average	0.16%	2.33%	9.64%	11.70%				
1989-06 average	0.17%	2.33%	8.29%	10.79%				
1998-07 average	0.10%	2.32%	4.21%	6.64%	0.30%	0.40%	0.89%	1.59%

There are no specific harvest rate limits for tribal fisheries on steelhead during the spring or summer seasons which extend through July 31. Some impacts, however, do occur. The harvest rate for tribal winter season fisheries (generally February 1 - March 21) from 2001 to 2007 averaged 2.2% and has ranged from 0.8% to 5.8% (Table 8.8.5.5-2). The spring season extends through June 15. The harvest rate of A-run steelhead for tribal spring season fisheries has been consistent and low, at approximately 0.16% since 1985 (Table 8.8.5.5-1). The harvest rate in summer season fisheries averaged 2.3% since 1985 (Table 8.8.5.5-1). The harvest rate in fall season fisheries averaged 9.64% since 1985 and 4.21% since 1998 (Table 8.8.5.5-1). Impacts resulting from treaty-Indian fall season fisheries during this agreement are similar to the 1998-2006 average of 4.21%. Harvest rates are not expected to change over the course of this Agreement (TAC 2008).

Table 8.8.5.5-2. Treaty Indian harvest rates of winter-run steelhead expressed as a proportion of the unmarked winter-run steelhead counts at Bonneville Dam in the winter season (TAC 2008).

Harvest Year	Rate
2001	3.4%
2002	0.3%
2003	5.8%
2004	0.8%
2005	0.8%
2006	1.8%
2007	2.3%

Average 2001-2007	2.2%

With respect to spring and summer season fisheries, increases in harvest beyond those observed in recent years are unlikely. The spring season extends through June 15. The harvest rate of A-run steelhead has been consistent and low, at approximately 0.2% since 1985 (Table 8.8.5.5-1). No changes in the fishery are proposed or anticipated that would lead to changes in the expected catch of steelhead.

Summer season fisheries extend through July 31. Snake River steelhead are caught regularly in ceremonial and subsistence fisheries (primarily the platform fishery), as well as in commercial fisheries targeting summer Chinook (summer Chinook that are targeted in the fishery are part of the UCR summer/fall ESU and are not listed under the ESA). Summer Chinook were chronically depressed for decades until returns began to increase in 2001. Higher runs provided more fishing opportunity beginning in 2002. However, there is no evidence of an associated increase in the catch of steelhead. The harvest rate of summer Chinook in the tribal fishery averaged 1.5% from 1989 to 2001, and 10.9% from 2002 to 2006 (TAC 2008, Table 6). During those same years, the harvest rate of steelhead averaged 2.3% to 2.4% (Table 8.8.5.5-1). As with the spring fisheries, no further changes in future fisheries are expected as a result of the Prospective Action that would lead to changes in the expected catch of steelhead. However, as a result of analysis from recent PIT-tag data, there is information regarding adult conversion rates that indicates that more UCR steelhead than SR steelhead are lost in upstream passage. It may be that the greater losses are due to differential harvest rates that are not currently detectable. It is also plausible that the losses are due to timing differences, passage conditions, or some combination of factors. If new evidence develops related to the catch of steelhead in the summer season, these conclusions will be reviewed.

Prospective treaty-Indian fall season fisheries will be managed using the abundance-based harvest rate schedule for B-run steelhead contained in the 2008 Agreement (Table 8.8.5.5-3). From 1998 to 2007 treaty-Indian fall season fisheries were managed subject to a 15% harvest rate limit on B-run steelhead. Under the abundance based harvest rate schedule, harvest may vary up or down from the status quo of 15%, depending on the abundance of B-run steelhead. The harvest rate allowed under the prospective schedule is also limited by the abundance of upriver fall Chinook. The purpose of this provision is to recognize that impacts to B-run steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook, is higher and remain consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-run steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right to harvest 50% of the harvestable surplus of fall Chinook in years when conditions are favorable. Even with these provisions, it is unlikely that the treaty right for Chinook or steelhead can be fully satisfied. The harvest rate for B-run steelhead in tribal fall season fisheries may range from 13 to 20%. As indicated above, the non-Treaty fall season fishery harvest rate for B-run steelhead will remain fixed at 2%.

Table 8.8.5.5-3. Abundance Based Harvest Rate Schedule for B-run Steelhead (TAC 2008).

Upriver Summer Steelhead Total B Harvest Rate Schedule				
Forecast Bonneville Total B Steelhead Run Size	**River Mouth URB Run Size**	**Treaty Total B Harvest Rate**	**Non-Treaty Wild B Harvest Rate**	**Total Harvest Rate**
20,000	Any	13%	2.0%	15.0%
20,000	Any	15%	2.0%	17.0%
35,000	>200,000	20%	2.0%	22.0%

As in the past, B-run steelhead will be used as the primary steelhead related harvest constraint for tribal fall season fisheries, and thus are the indicator stock used for management purposes. Generally, the status of B-run steelhead is worse than that of A-run steelhead. B-run steelhead are subject to higher harvest rates because they are larger and thus more susceptible to catch in gillnets. Harvest impacts on B-run steelhead typically are higher because their timing coincides with the return of fall Chinook. A-run steelhead typically return a few weeks earlier, reducing their susceptibility to catch. Consequently, there are no specific management constraints in tribal fisheries for A-run steelhead. Since 1998, when the 15% harvest rate limit was first implemented for B-run steelhead, the harvest rate on A-run steelhead in fall season treaty-Indian fisheries has averaged 4.21% and ranged from 5.4% to 12.4% (Table 8.8.5.5-1).

The abundance based harvest rate schedule allows the tribal harvest rate on B-run steelhead to vary from the fixed rate of 15% that has been in place since 1998, depending on the abundance of B-run steelhead and upriver fall Chinook. By evaluating historical run size data, a determination can be made as to how often fisheries will be subject to the 13%, 15%, or 20% level. This retrospective analysis suggests that the annual harvest rate limit will be 15% or less 12 out of 22 years, and 20% 10 out of 22 years. The primary limiting constraint from this retrospective analysis will be the abundance of upriver fall Chinook. The average allowable harvest rate on B-run steelhead from this retrospective analysis is 17.1% (Table 8.8.5.5-4).

Table 8.8.5.5-4. Retrospective analysis of allowable harvest rates for B-run steelhead in the tribal fall season fisheries (Upriver fall Chinook run size from TAC 2008, Table 7; B-run Steelhead run size from TAC 2008).

Year	Upriver Fall Chinook Run Size	B-run Steelhead Run Size	Allowable Harvest Rate in Tribal Fall Fisheries
1985	196,500	40,870	15%
1986	281,500	64,016	20%
1987	420,600	44,959	20%
1988	340,000	81,643	20%
1989	261,300	77,604	20%
1990	153,600	47,174	15%
1991	103,300	28,265	15%
1992	81,000	57,438	15%
1993	102,900	36,169	15%
1994	132,800	27,463	15%
1995	106,500	13,221	13%
1996	143,200	18,693	13%
1997	161,700	36,663	15%
1998	142,300	40,241	15%
1999	166,100	22,137	15%
2000	155,700	40,909	15%
2001	232,600	86,426	20%
2002	276,900	129,882	20%
2003	373,200	37,229	20%
2004	367,858	37,398	20%
2005	268,744	48,967	20%
2006	230,388	74,127	20%
1985-06 average			17.10%

Although the prospective harvest rate schedule will allow the harvest in tribal fall season fisheries to increase in some years, the observed harvest rates in both the non-Treaty and treaty-Indian fisheries have generally been lower than the allowed rates. Since 1998, fall season fisheries have been subject to a combined 17% harvest rate limit on B-run steelhead. From 1998 to 2006 the observed harvest rate has averaged 12.7% (TAC 2008, Table 39).

For fall season fisheries, it is necessary to consider whether there will be an increase in the harvest of A-run steelhead associated with the Prospective Action. As discussed above, B-run steelhead are used as the indicator stock for steelhead. This is done in order to limit fishery impacts in fall season fisheries. The retrospective analysis suggests that harvest rates on B-run steelhead in the treaty-Indian fall season fisheries may be higher than 15% approximately half of the time. The average of the allowable harvest rate limits from the retrospective analysis is 17.1% (Table 8.8.5.5-4). This represents a 14% increase over the current harvest rate limit of 15% (17.1/15.0 = 1.14). The harvest rates on A-run steelhead will not necessarily increase, but A-run and B-run harvest rates are correlated. It is therefore reasonable to assume that A-run harvest rates will increase in proportion to B-run harvest rates. Table 8.8.5.5-1 shows the tribal fishery harvest rates for A-run steelhead in spring, summer, and fall season fisheries. Since 1998, when the current ESA limits were applied, the yearly fall season treaty-Indian harvest rate averaged 4.2% while the total treaty-Indian harvest rate averaged 6.6%. Under the assumption that fall season harvest rates will increase by 14% in proportion to the expected increase for B-run steelhead, the anticipated future fall season and total harvest rates will be 4.8% (0.042 * 1.140 = 0.48) and 7.2%.

The net result will be a small increase in the current harvest rate (from 6.6% to 7.2%), which will result in approximately a 1% reduction in survival (Harvest Appendix, based on US v Oregon memorandum). Therefore, a 0.99 current-to-future survival adjustment is applied to the prospective harvest action for this species.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor and will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas. This was identified as a limiting factor from the Klickitat population by the Remand Collaboration Habitat Workgroup (Habitat Technical Subgroup 2006b).

8.8.5.6 Effects of Predation Prospective Actions

Effects on Species Status

The estimated relative survival benefit attributed to MCR steelhead from reduction in Caspian tern nesting habitat on East Sand Island and relocation of most of the terns to sites outside the Columbia River Basin (RPA Action 45) is 3.4 % (CA Attachment F-2, Table 4). Compensatory mortality may occur but based on the discussion in 8.3.5.6 is unlikely to significantly affect the results of the action.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery (RPA Action 43) should further reduce consumption rates of juvenile salmon and steelhead by northern pikeminnow. This decrease in consumption is likely to equate to an increase in juvenile migrant survival of about 1% relative to the current condition (CA Appendix F, Attachment F-1: Benefits of Predation Management on Northern Pikeminnow). Continued implementation and improvement of avian deterrence at all lower Columbia River dams will continue to reduce the numbers of smolts taken by birds in project forebays and tailraces (RPA Action 48).

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island, continued implementation of the base Northern Pikeminnow Management Program, continued implementation and improvement of avian deterrence at mainstem dams, and the continuation of the increased reward structure in the sport-reward fishery are expected to improve the long-term conservation value of critical habitat by increasing the survival of juvenile salmonids (safe passage PCE) within the migration corridor.

8.8.5.7 Effects of Kelt Reconditioning Prospective Actions

Effects on Species Status

Effects of the FCRPS outmigrating adult steelhead kelts are not well known but are thought to be significant as both turbine passage survival and passage through juvenile collection and bypass systems are poor. Comparing recent juvenile bypass system kelt counts before and after increases in spring spill and the installation of surface bypass facilities (e.g., RSWs) suggest that steelhead kelts may benefit from spring spill and surface bypass improvements included in the Prospective Actions. However, no definitive information is available to clearly demonstrate such effects. The prospective kelt reconditioning program is likely to increase the number of spawning adult MCR steelhead, but it is not possible to estimate a survival rate change at this time because of uncertainty regarding the percentage of the run that can be collected.

Prospective passage improvements for juvenile salmon and steelhead, including surface passage such as RSWs and sluiceways, are also likely to benefit downstream migrating kelts. This should lead to improved survival through the FCRPS. Reduced forebay residence times which lead to a reduction in total travel time may also contribute to an improvement in kelt return rates. It is not possible to calculate the precise amount of improvement expected, because the interaction between improved surface passage and improved kelt survival and return rates is poorly known. However, some improvement is likely.

The Prospective Actions implementing the reconditioning and transport of steelhead kelts potentially represent a much greater improvement in both outmigration survival and return rates. Reconditioning programs capture kelts and hold them in tanks where they are fed and medicated to enhance survival. Current programs either hold kelts for 3-5 weeks and release them below Bonneville, or hold kelts until they are ready to spawn and release them into their natal streams. Short-term reconditioning efforts have produced average survival rates of 82% and kelt returns of 4% to the Yakima River (Hatch et al. 2006). Long-term reconditioning has produced average survival rates of 35.6%, all of which are returned to their natal stream for spawning (Hach et al. 2006).

There is some concern over the viability of the offspring from long-term reconditioned kelts. Laboratory studies found high rates of post hatching mortality (Branstetter et al. 2006), and studies using DNA analysis to identify the parentage of outmigrating steelhead smolts (Stephenson et al. 2007) have failed to identify any offspring of reconditioned kelts among the juvenile steelhead collected from streams where reconditioned kelts were released. These studies suggest that long-term reconditioning may reduce gamete viability. It is not known if short-term reconditioned kelts may have the same problems with offspring viability; however, because they feed and mature under natural conditions it seems less likely.

Effects on Critical Habitat

NOAA Fisheries will analyze any effects of the kelt reconditioning actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.8.5.8 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of this document.

8.8.5.9 Summary: Quantitative Survival Changes Expected From All Prospective Actions

Expected changes in productivity and quantitative extinction risk are calculated as survival improvements in a manner identical to estimation of the base-to-current survival improvements. The estimates of “prospective” expected survival changes resulting from the Prospective Actions are described in Sections 8.8.5.1 through 8.8.5.7 and are summarized in Table 8.8.5-2. Improvements in hydro operation and configuration, estuary habitat improvement projects, and further reductions in bird and fish predation are expected to increase survival above current levels for all populations in the DPS. Tributary habitat improvement projects are also expected to increase survival for all three populations. The net effect, which varies by population, is 15-37% increased survival, compared to the “current” condition, and 11-39% increased survival, compared to the “base” condition.

8.8.5.10 Aggregate Analysis of Effects of All Actions on Population Status

Quantitative Consideration of All Factors at the Population Level

NOAA Fisheries considered an aggregate analysis of the environmental baseline, cumulative effects, and Prospective Actions. The results of this analysis are displayed in Tables 8.8.6-1 and 8.8.6-2 and in Figures 8.8.6-1 and 8.8.6-2. In addition to these summary tables and figures, the SCA Aggregate Analysis Appendix includes more detailed results, including 95% confidence limits for mean estimates, sensitivity analyses for alternative climate assumptions, metrics relevant to ICTRT long-term viability criteria, and comparisons to other metrics suggested in comments on the October 2007

Draft Biological Opinion. Additional qualitative considerations that generally apply to multiple populations are described in the environmental baseline, cumulative effects, and effects of the Prospective Actions sections and these are reviewed in subsequent discussions at the MPG and DPS level. Additionally, because quantitative short-term extinction risk gaps could not be calculated for this species, future short-term extinction risk is discussed qualitatively in subsequent sections.

8.8.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects, Summarized By Major Population Group

In this section, population-level results are considered along with results for other populations within the same MPG. The multi-population results are compared to the importance of each population to MPG and DPS viability. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

Yakima MPG

This MPG consists of four extant populations, one of which should be highly viable and one of which should be viable to achieve the ICTRT's suggested MPG viability scenario. Either the Naches River or the Upper Yakima should be viable because these are the only two "large" populations. Please see Section 7.3 of this document for a discussion of these MPG viability scenarios.

Productivity based on all three metrics (R/S, lambda, and BRT trend) is expected to be greater than 1.0 for all populations in this MPG under the Prospective Actions, meaning that with implementation of the Prospective Actions the population is expected to replace itself and grow (Table 8.8.6.1-1; Figure 8.8.6-1). There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (e.g., upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1[SCA Aggregate Analysis Appendix; Figure 8.8.6-1]), for some populations. For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival and survival in each tributary as a result of the Prospective Actions, as described in Sections 8.8.5.1 through 8.8.5.7. These actions address limiting factors and threats and more than offset the slight reduction in survival expected from the harvest Prospective Action. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure is "very low" to "moderate," as defined by the ICTRT, for all populations except the Upper Yakima (Table 8.8.2-2). That population has "high" spatial structure risk because 7 of 10 historical major spawning areas are not occupied.

- Current risk associated with diversity is "low" to "moderate," as defined by the ICTRT, for all populations except the Upper Yakima (Table 8.8.2-2). That population has been affected by introgression from planted resident rainbow trout and out-of-basin steelhead. While these practices have stopped, legacy effects continue.

- For these populations, it will take longer than 10 years to resolve the problems that must be addressed in order to have higher productivity. In particular, reduced access to historic spawning areas and reduced genetic diversity will take longer than 10 years to resolve.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under both the ICTRT "historical" and "Warm PDO" (poor) ocean scenarios, all Yakima MPG populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.8.6-2).

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of base period extinction risk indicate 0-1% risk of short-term extinction at QET=50 for the Satus Creek population (Table 8.8.2-3). Quantitative estimates of base period extinction risk indicate 34-79% risk of short-term extinction at QET=50 for the other three populations. The survival gap needed to reduce this risk to <5% is unknown, but may be greater than the 10% base-to-current survival improvement and the proportion of the 26% Prospective Actions survival improvement that will result from immediate actions.

As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Sensitivity analyses indicate the base period extinction risk would be >5% for the upper Yakima, Toppenish, and Naches populations at all QET levels considered in this analysis (Table 8.8.2-3).

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for base period extinction risk at QET=50 range from 0% to near 100% for some populations; Table 8.8.2-3). For this reason, other qualitative information is also considered:

- There are no safety-net hatchery programs for these populations to further reduce extinction risk.
- A kelt reconditioning program affects all four populations in this MPG and is expected to provide an unquantifiable survival improvement.
- The recent 10-year geometric mean abundance has been above the 50 fish QET level (85-472) for all four populations (Table 8.8.2-1). Only the Upper Yakima population has dropped below 50 fish during the available time series (Cooney 2008a).
- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Cascades Eastern Slopes MPG

This MPG consists of five extant populations, one of which should be highly viable and three of which should be viable to achieve the ICTRT's suggested MPG viability scenario. Key populations in this MPG include Fifteenmile Creek because it is the only winter steelhead population and the Deschutes River Westside population because it is the only "large" population. The Klickitat and Deschutes River Eastside populations are the only two "intermediate" sized populations and they are important because two "intermediate" populations should be viable to meet the ICTRT's suggested viability criteria. One historic population (Crooked River) has been extirpated and a second (White River) is functionally extirpated. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Productivity based on all three metrics (R/S, lambda, and BRT trend) is expected to be greater than 1.0 for the three populations with sufficient data to make estimates, under the Prospective Actions (Table 8.8.6.1-1; Figure 8.8.6-1), meaning that with implementation of the Prospective Actions these populations are expected to replace themselves and grow. These three populations (Deschutes West, Deschutes East, and Fifteenmile) are among the critical populations identified by the ICTRT.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (e.g., upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1, SCA Aggregate

Analysis Appendix; Figure 8.8.6-1) for some populations. For this reason, other qualitative information is also considered:

- Life-stage specific survival rates are expected to improve for mainstem hydro survival, estuarine survival and survival in tributaries as a result of the Prospective Actions, as described in Sections 8.8.5.1 through 8.8.5.7. These actions address limiting factors and threats and more than offset the slight reduction in survival expected from the harvest Prospective Actions. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. It also indicates that estimates of productivity >1 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure is "very low" to "moderate," as defined by the ICTRT, for all populations (Table 8.8.2-2). Current risk associated with diversity is "low" to "moderate," as defined by the ICTRT, for all populations. The MPG can achieve the ICTRT suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the ICTRT "historical" ocean scenario, both Eastern Cascades Slopes MPG populations for which estimates are available are expected to have R/S, lambda, and BRT trend greater than 1.0, as under recent climate conditions, but the resulting productivity estimates are higher (SCA Aggregate Analysis Appendix; Figure 8.8.6-2). Under the ICTRT "Warm PDO" (poor) climate scenario, all productivity metrics are also expected to be greater than 1.0, except for lambda, under the assumption that effectiveness of hatchery-origin spawners is equal to that of natural-origin spawners (HF=1), for the Deschutes West population. In this case the estimate was 0.99.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trends for this species, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of base period extinction risk indicate 0-1% risk of short-term extinction at QET=50 for the Deschutes West and Fifteenmile populations (Table 8.8.2-3). However, there is an estimate of 53% risk of short-term extinction at QET=50 for the Deschutes East population. The survival gap needed to reduce this risk to <5% is unknown, but may be greater than the 5% base-to-current survival improvement for this population and the proportion of the 19% Prospective Actions survival improvement that will result from immediate actions. No estimates are available for the Rock Creek and Klickitat populations. However, the ICTRT identified the Rock Creek population as one with a high (>25%) risk of long-term (100-year) extinction.

As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. Sensitivity analyses indicate >5% base short-term extinction risk for the Deschutes East population at all evaluated QET levels (Table 8.8.2-3).

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (95% confidence limits for base period extinction risk at QET=50 range from 0% to 100% for some populations; Table 8.8.2-3). For this reason, other qualitative information is also considered:

- The recent 10-year geometric mean abundance has been well above the 50 fish QET level (456-1599) for the three populations for which 10-year averages are available (Table 8.8.2-1). None of these populations have dropped below 50 fish during the available time series (Cooney 2008b).

- Population abundance is expected to increase in the future for all populations for which trends could be calculated, as a result of actions already completed and additional Prospective Actions (see above).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Walla Walla/Umatilla MPG

This MPG consists of three extant populations, one of which should be highly viable and one of which should be viable to achieve the ICTRT's suggested MPG viability scenario. The Umatilla population is important because it is the only "large" population in the MPG. One historic population (Willow Creek) has been extirpated. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Productivity based on all three metrics (R/S, lambda, and BRT trend) is expected to be greater than 1.0 for the Umatilla population, which is the only population with sufficient data to make estimates, under the Prospective Actions. (Table 8.8.6.1-1; Figure 8.8.6-1). This means that with implementation of the Prospective Actions, these populations are expected to replace themselves and grow.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (e.g., upper 95% confidence limits indicate productivity >1 while lower 95% confidence intervals indicate productivity <1; SCA Aggregate Analysis Appendix) for this population. For this reason, other qualitative information is also considered:

- Life-stage-specific survival rates are expected to improve for mainstem hydro survival, estuarine survival, and survival in each tributary as a result of the Prospective Actions, as described in Sections 8.8.5.1 through 8.8.5.7. These actions address limiting factors and threats and more than offset the slight reduction in survival expected from the harvest Prospective Action. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. They also indicate that estimates of productivity >1 for the Umatilla, and by inference the other populations, are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure is "low" to "moderate," as defined by the ICTRT, for all populations (Table 8.8.2-2). The MPG can achieve the ICTRT suggested viability scenario with moderate risk for this factor, as long as productivity is adequate.

- Current risk associated with diversity is "moderate," as defined by the ICTRT, for all populations (Table 8.8.2-2). The MPG can achieve the ICTRT suggested viability scenario with moderate risk for this factor, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under both the ICTRT "historical" and "Warm PDO" (poor) ocean assumptions, the Umatilla population is expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.8.6-2).

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of base period extinction risk indicate 0% risk of short-term extinction at QET=50 for the Umatilla and Walla Walla populations (Table 8.8.2-3). No estimates are available for the Touchet population. However, the ICTRT identified the Touchet population as one with high (>25%) risk of long-term (100-year) extinction.

As discussed in Section 7.1.1.1, QET levels less than 50 fish may be relevant to short-term extinction risk. It was not possible to estimate extinction risk or generate sensitivity analyses to alternative QET levels for the Touchet population.

There is uncertainty associated with quantitative estimates of extinction risk because of the range of statistical results (95% confidence limits for base period extinction risk at QET=50 range from 0% to 37% for these populations; Table 8.8.2-3). For this reason, other qualitative information is also considered:

- There is a conservation hatchery program for the Umatilla population to further reduce short-term extinction risk.

- The recent 10-year geometric mean abundance has been well above the 50 fish QET level (1003, 1472) for the two populations for which 10-year averages are available (Umatilla and Walla Walla; Table 8.8.2-1). Neither of these populations has dropped below 50 fish during the available time series (Cooney 2007).

- Population abundance is expected to increase in the future for the Umatilla population, which is the only one for which trends could be calculated, as a result of actions already completed and additional Prospective Actions (see above).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

John Day MPG

This MPG consists of five extant populations, one of which should be highly viable and two of which should be viable to achieve the ICTRT's suggested MPG viability scenario. The North Fork John Day and Lower John Day populations are important because they are the only "large" and "very large" populations in the MPG. One historic population (Willow Creek) has been extirpated. The Middle Fork and Upper Mainstem populations are important because they are the only "intermediate" sized populations, one of which must be viable to achieve the ICTRT's viability criteria. Please see Section 7.3 for a discussion of these MPG viability scenarios.

Productivity, based on all three metrics (R/S, lambda, and BRT trend), is estimated to be greater than 1.0 for all five populations (Table 8.8.6.1-1; Figure 8.8.6-1), meaning that with implementation of the Prospective Actions these populations are expected to replace themselves and grow.

There is considerable uncertainty regarding the reliability of quantitative estimates of productivity because of the broad range of statistical results (e.g., upper 95% confidence limits indicates productivity >1 while lower 95% confidence intervals indicates productivity <1 for some populations [SCA Aggregate Analysis Appendix; Figure 8.8.6-1]). For this reason, other qualitative information is also considered:

- Life-stage-specific survival rates are expected to improve for mainstem hydro survival, estuarine survival, and survival in each tributary as a result of the Prospective Actions, as described in Sections 8.8.5.1 through 8.8.5.7. These actions address limiting factors and threats and more than offset the slight reduction in survival expected from the harvest Prospective Action. These survival improvements indicate that, other factors being equal, survival over the life cycle should also increase. They also indicate that estimates of productivity >1 for these populations are not determined solely by favorable environmental conditions.

- Current risk associated with spatial structure and diversity is "very low" to "moderate," as defined by the ICTRT, for all populations (Table 8.8.2-2). The MPG can achieve the ICTRT suggested viability scenario with moderate risk for these factors, as long as abundance and intrinsic productivity increase sufficiently to levels exceeding minimum thresholds

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under both the ICTRT "historical" and "Warm PDO" (poor) ocean scenarios, all John Day MPG populations are expected to have R/S, lambda, and BRT trend greater than 1.0 (SCA Aggregate Analysis Appendix; Figure 8.8.6-2).

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change are considered qualitatively by comparing actions to ISAB climate change recommendations, as described below.

- The Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3, some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects may include restoration and protection of areas that function as thermal refugia and estuary habitat projects may include dike removal and opening off-channel habitat to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

Quantitative estimates of base period extinction risk indicate <5% risk of short-term extinction at QET=50 for all five populations (Table 8.8.2-3).

There is considerable uncertainty associated with quantitative estimates of extinction risk because of the broad range of statistical results (e.g., 95% confidence limits for base period extinction risk at QET=50 range from 0% to 69% for the South Fork John Day population; Table 8.8.2-3). For this reason, other qualitative information is also considered:

- There are no safety-net hatchery programs in this MPG.

- The recent 10-year geometric mean abundance has been above the 50 fish QET level (259-1800) for all populations (Table 8.8.2-1). None of these populations has dropped below 50 fish during the available time series (Cooney 2008b).

- As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

8.8.7 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Middle Columbia River Steelhead DPS

This section summarizes the basis for conclusions at the DPS level.

8.8.7.1 Potential for Recovery

It is likely that the Middle Columbia River steelhead DPS will trend toward recovery.

The future status of all populations and MPGs of MCR steelhead will be improved compared to their current status through the reduction of adverse effects associated with the FCRPS and Reclamation's Upper Snake projects and the implementation of Prospective Actions with beneficial effects, as described in Sections 8.8.5, 8.8.6, and 8.8.7.2. These beneficial actions include reduction of avian and fish predation, estuary habitat improvements, kelt reconditioning, and tributary habitat improvements for most populations. These beneficial actions also completely offset the slightly decreased survival associated with the harvest Prospective Action. Therefore, the status of the DPS as a whole is expected to improve compared to its current condition and to move closer to a recovered condition. This conclusion also takes into account some short-term adverse effects of Prospective Actions related to habitat improvements (Section 8.8.5.3) and RM&E (Section 8.1.4). These adverse effects are expected to be small and localized and are not expected to reduce the long-term recovery potential of this DPS.

The Prospective Actions described above address limiting factors and threats and will reduce their negative effects. As described in Section 8.8.1, key limiting factors and threats affecting the current status of this species (abundance, productivity, spatial structure, and diversity) include: hydropower development, predation, harvest, hatchery programs, and degradation of tributary and estuary habitat. In addition to Prospective Actions, Federal actions in the environmental baseline and non-Federal actions that are appropriately considered cumulative effects also address limiting factors and threats.

The Prospective Actions also include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change. As described in Section 8.1.3 some important improvements include installation of surface spill structures and other passage improvements to reduce delay and exposure to warm temperatures in project forebays in the lower Columbia River. Tributary habitat projects include restoration and protection of areas that function as thermal refugia and estuary habitat projects include dike removal and opening off-channel habitat, which in some cases is likely to encourage increased hyporheic flow. Additionally, Prospective Actions include evaluation of pertinent new information on climate change and effects of that information on limiting factors and project prioritization. Prospective Actions also include investigation of impacts of possible climate change scenarios and inclusion of pertinent information in hydrological forecasting for operation of the FCRPS.

The ICTRT has indicated that the longer hatchery programs are expected to subsidize natural spawners, the more likely their effects will threaten recovery. As described in Section 8.8.5.4, some ongoing hatchery programs that affect this DPS pose risks to diversity and natural productivity. The

Prospective Actions include measures to ensure that hatchery management changes that have been implemented in recent years will continue, that safety-net hatchery programs will continue, and that further hatchery improvements will be implemented to reduce threats to productivity and diversity from continued reliance on hatchery programs to subsidize natural spawning. Some of the problems limiting recovery of MCR steelhead, such as spatial structure and genetic diversity concerns for the Upper Yakima population, will probably take longer than 10 years to correct. However, actions included in the Prospective Actions represent improvements that can be implemented reasonably within the next 10 years.

In addition, the Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In sum, these qualitative considerations suggest that the MCR steelhead DPS will be trending toward recovery when aggregate factors are considered. In addition to these qualitative considerations, quantitative estimates of metrics indicating a trend toward recovery also support this conclusion.

Return-per-spawner (R/S) estimates are indicative of natural survival rates (i.e., the estimates assume no future effects of supplementation). As such, they are somewhat conservative for populations with ongoing supplementation programs, 11 of which are described in Section 8.8.5.4, but R/S may be the best indicator of the ability of populations to be self-sustaining. R/S estimates incorporate many variables, including age structure and fraction of hatchery-origin spawners by year. The availability and quality of this information varies, so in some cases R/S estimates are less certain than lambda and BRT trend metrics.

As described in Section 8.8.6, with implementation of the Prospective Actions, R/S is expected to be greater than 1.0 for all 12 of the populations for which there are quantitative estimates (Table 8.8.6.1-1).

Population growth rate (lambda) and BRT trend estimates, as calculated in this analysis, are indicative of abundance trends of natural-origin and combined-origin spawners, assuming that current supplementation programs continue. These estimates require fewer assumptions and less data than R/S estimates, but may also be limited by data quality. Because of the hatchery assumptions these metrics may be less indicative of a trend toward recovery than R/S for populations significantly influenced by hatchery programs, since recovery requires self-sustaining populations.

As described in Section 8.8.6, all 12 populations in this DPS with population-specific estimates have lambda and BRT trends that are expected to be greater than 1.0 with implementation of the Prospective Actions.

Some important caveats that apply to all three quantitative estimates are as follows:

- Not all beneficial effects of the Prospective Actions could be quantified (e.g., habitat improvements that accrue over a longer than 10-year period), so quantitative estimates of prospective R/S, lambda, and BRT trend may be low.

- This summary of quantitative productivity estimates is based on mean results of analyses that assume that future ocean climate will be identical to that of approximately the last 20 years. As described in Section 7.1.1, these recent ocean conditions have been much worse for salmon and steelhead survival than have historical conditions. Under the ICTRT "historical" ocean scenario, all populations are expected to have R/S, lambda, and BRT trend greater than 1.0, as under recent climate conditions, but the resulting productivity estimates are higher (SCA Aggregate Analysis Appendix; Figure 8.8.6-2). Under the ICTRT "Warm PDO" climate scenario, all populations but one are also expected to have all three metrics greater than 1.0, with only slightly lower productivity estimates than under recent climate conditions. The lambda (HF=1) metric, which assumes that hatchery-origin spawners and natural-origin spawners are equally effective, for the Deschutes West population would be 0.99.

- Changes in climate affecting freshwater life stages could not be captured in the quantitative analysis, which leads to an over-estimate of the likely future trend, as discussed in Section 7.1.1. However, freshwater effects of climate change were considered qualitatively by comparing actions to ISAB climate change recommendations, as described above.

- The mean results represent the most likely future condition but they do not capture the range of uncertainty in the estimates. Under recent climate conditions, R/S estimates for most populations are expected to be greater than 1.0 at the upper 95% confidence limits and less than 1.0 at the lower 95% confidence limits (SCA Aggregate Analysis Appendix). The uncertainty in quantitative estimates indicates that it is important to take qualitative factors into account.

Taken together, the combination of all the qualitative and quantitative factors indicates that the DPS as a whole is likely to trend toward recovery when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. Quantitative estimates of R/S, population growth rate, and BRT trend support this conclusion.

This does not mean that recovery will be achieved without additional improvements in various life stages. As discussed in Chapter 7, increased productivity will result in higher abundance, which in turn will lead to an eventual decrease in productivity due to density effects, until additional improvements resulting from recovery plan implementation are expressed. However, the survival changes in the Prospective Actions and other continuing actions in the environmental baseline and cumulative effects will ensure a level of improvement that results in the DPS being on a trend toward recovery.

8.8.7.2 Short-Term Extinction Risk

It is likely that the species will have a low short-term extinction risk.

Short-term (24 year) extinction risk of the species is expected to be reduced, compared to extinction risk during the recent period, through net survival improvements resulting from the Prospective Actions and a continuation of other current management actions, as described above and in Section 8.8.5.

As described above and in Section 8.8.6, abundance is expected to be increasing for all populations and natural productivity (R/S) is expected to be sufficient for all populations to grow. Recent abundance levels are estimated to be between 92 and 1800 spawners, depending on population, all of which are above the QET levels under consideration (Table 8.8.2-1). These factors also indicate a decreasing risk of extinction.

There is a conservation hatchery program for the Umatilla population, which reduces the likelihood of short-term extinction risk. However, over time this level of supplementation results in a higher level of long-term risk to diversity and natural productivity than would occur in an unsupplemented population.

The Prospective Actions include a strong monitoring program to assess whether implementation is on track and to signal potential problems early. Specific contingent actions are identified within an adaptive management framework for important Prospective Actions, such as lower Columbia River hydro project improvements and tributary habitat actions. Additionally, the Prospective Actions include implementation planning, annual reporting, and comprehensive evaluations to provide any needed adjustments within the ten-year time frame.

In addition to these qualitative considerations, quantitative estimates of short-term (24 year) extinction risk also support this conclusion.

As described in Section 8.2.6, short-term extinction risk derived from performance during the base period is 0-2% at QET=50 for 10 of the 14 populations in this DPS for which estimates are available. The four populations with base period extinction risk greater than 5% are the Upper Yakima, Naches, Toppenish, and Deschutes East populations. Three of these populations are in the Yakima MPG, which suggests that this MPG is at particularly high extinction risk. It was not possible to determine the survival improvements needed to reduce extinction risk to 5% for these populations. However, base-to-current survival improvements range from 5-10% for these populations. Some additional improvements from Prospective Actions that are likely to be implemented immediately will also accrue (an unknown proportion of the 19-26% current-to-prospective survival change). While the effect of these survival changes on reducing short-term extinction risk to <5% cannot be quantified, they should reduce the base period extinction risk significantly.

The mean base period short-term extinction risk estimates represent the most likely future condition but they do not capture the range of uncertainty in the estimates. While we do not have confidence intervals for prospective conditions, the confidence intervals for the base condition range from near 0 to 100% for some populations. This uncertainty indicates that it is important also to consider qualitative factors in reaching conclusions.

As with productivity estimates, quantitative consideration of changes in climate on freshwater life-stage survival were not possible, which likely leads to an under-estimate of risk. However, NOAA Fisheries qualitatively considered whether Prospective Actions would implement proactive measures recommended by the ISAB for reducing risk due to climate change. As described above, the Prospective Actions include measures that correspond to ISAB recommendations to proactively reduce the effects of climate change.

Taken together, the combination of all the factors above indicates that the DPS as a whole is likely to have a low risk of short-term extinction when the environmental baseline and cumulative effects are considered along with implementation of the Prospective Actions. The status of the species has been improving in recent years, compared to the base condition, and abundance is expected to increase in the future as a result of additional improvements. These improvements result in lower short-term extinction risk than in recent years. Quantitative results indicate that most populations and MPGs will have low short-term extinction risk. The most troubling result is that three of the four populations in the Yakima MPG have a high base period extinction risk that may not be reduced sufficiently by current and Prospective Actions. However, all Yakima MPG populations are expected to have productivities greater than 1.0, in fact with R/S ranging from 1.4 to 2.0 (Table 8.8.6.1-1), and these estimates indicate that abundance should increase and risk should decrease as the Prospective Actions are implemented. The combination of recent abundance estimates, expected survival improvements, expected positive trends for all populations, quantitative risk estimates, and a conservation hatchery program for the Umatilla population, indicate that enough populations are likely to have a low enough risk to conclude that the DPS as a whole will have a low risk of short-term extinction.

8.8.7.3 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat

NOAA Fisheries designated critical habitat for MCR steelhead including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Yakima River as well as specific stream reaches in the following subbasins: Upper Yakima, Naches, Lower Yakima, Middle Columbia/Lake Wallula, Walla Walla, Umatilla, Middle Columbia/Hood, Klickitat, Upper John Day, North Fork John Day, Middle Fork John Day, Lower John Day, Lower Deschutes, Trout, and Upper Columbia/Priest Rapids. The environmental baseline within the action area, which encompasses all of these subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for MCR steelhead. The major factors currently limiting the conservation value of critical habitat are juvenile mortality at mainstem hydro projects in the lower Columbia River; avian predation in the estuary; and physical passage barriers, reduced flows, altered channel morphology, excess sediment in gravel, and high summer temperatures in tributary spawning and rearing areas.

Although some current and historical effects of the existence and operation of the hydrosystem, tributary and estuary land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, implementation of surface passage routes at McNary and John Day dams in concert with training spill to provide safe egress (i.e., avoid predators) will improve safe passage in the juvenile migration corridor. Reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles and the removal of sea lions known to eat winter steelhead will do the same for adults from the Fifteenmile and one of the Klickitat populations. Habitat work in tributaries used for spawning and rearing an in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. In addition, a number of actions in the mainstem migration corridor and in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement). There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. The species is expected to survive until these improvements are implemented, as described in "Short-term Extinction Risk," above.

Table 8.8.2-1. Status of MCR steelhead with respect to abundance and productivity VSP factors. Productivity is estimated from performance during the "base period" of the 15-20 most recent brood years (approximately 1980-1985 BY through 1998-1999 BY, depending on population).

			Abundance			R/S Productivity			Lambda			Lambda			BRT Trend		
ESU	**MPG**	**Population**	Most Recent 10-yr Geomean Abundance[1]	Years Included In Geomean	ICTRT Recovery Abundance Threshold[1]	Average R/S: 20-yr non-SAR adj.; non-delimited[2]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=0)[3]	Lower 95% CI	Upper 95% CI	20-yr Median Population Growth Rate (lambda; HF=1)[3]	Lower 95% CI	Upper 95% CI	Ln+1 Regression Slope: 1980 - Current[4]	Lower 95% CI	Upper 95% CI
Mid Columbia Steelhead	Yakima	Upper Yakima	85	1995-2004	1500	1.02	0.69	1.51	1.01	0.74	1.39	1.01	0.74	1.39	1.01	0.95	1.17
		Naches	472	1995-2004	1500	1.02	0.69	1.51	1.02	0.74	1.41	1.00	0.72	1.39	1.02	0.96	1.18
		Toppenish	322	1995-2004	500	1.46	0.89	2.39	1.09	0.76	1.57	1.07	0.74	1.55	1.09	1.02	1.32
		Satus	379	1995-2004	1000	0.86	0.62	1.20	0.98	0.76	1.25	0.96	0.75	1.23	0.98	0.93	1.12
	Eastern Cascades	Deschutes W.	456	1996-2005	1000	0.92	0.67	1.25	1.02	0.81	1.29	0.97	0.78	1.20	0.99	0.96	1.17
		Deschutes E.	1599	1996-2005	1000												
		Klickitat			1000												
		Fifteenmile Cr.	703	1996-2005	500	1.17	0.84	1.63	1.03	0.83	1.28	1.03	0.83	1.28	1.03	0.98	1.15
		Rock Cr.			500												
		White Salmon - Extirpated															
	Umatilla/Walla Walla	Umatilla	1472	1995-2004	1500	0.94	0.73	1.22	1.04	0.86	1.25	0.99	0.83	1.17	1.01	0.98	1.13
		Walla-Walla	650	1996-2005	1000												
		Touchet			1000												
	John Day	Lower Mainstem	1800	1996-2005	2250	1.24	0.76	2.04	1.01	0.71	1.43	1.00	0.71	1.41	0.98	0.94	1.14
		North Fork	1740	1996-2005	1500	1.17	0.79	1.75	1.00	0.80	1.26	1.00	0.79	1.25	0.99	0.95	1.16
		Upper Mainstem	524	1996-2005	1000	1.07	0.71	1.59	0.99	0.77	1.28	0.99	0.77	1.27	0.95	0.92	1.03
		Middle Fork	756	1996-2005	1000	1.17	0.82	1.69	1.01	0.80	1.27	1.00	0.79	1.26	0.97	0.93	1.06
		South Fork	259	1996-2005	500	0.99	0.64	1.54	0.99	0.74	1.33	0.98	0.74	1.32	0.95	0.91	1.09

1 Most recent year for 10-year geometric mean abundance is 2004-2005, depending upon population. ICTRT abundance thresholds are average abundance levels that would be necessary to meet ICTRT viability goals at <5% risk of extinction. Estimates and thresholds are from ICTRT (2007c)
2 Mean returns-per-spawner are estimated from the most recent period of approximately 20 years in Cooney (2008a). Actual years in average vary by population.
3 Median population growth rate (lambda) during the most recent period of approximately 20 years Actual years in estimate vary by population. Lambda estimates are from Cooney (2008b).
4 Biological Review Team (Good et al. 2005) trend estimates and 95% confidence limits updated for recent years in the Aggregate Analysis Appendix, Cooney (2008b).

Table 8.8.2-2. Status of MCR steelhead with respect to spatial structure and diversity VSP factors.

ESU	MPG	Population	ICTRT Current Risk For Spatial Structure[1]	ICTRT Current Risk For Diversity[1]	10-yr Average % Natural-Origin Spawners[2]
Mid Columbia Steelhead	Yakima	Upper Yakima	Currently High Risk (7 of 10 historical MaSAs are not occupied)	Currently High Risk (Introgression with resident O. mykiss and loss of presmolt migration pathways)	0.98
		Naches	Currently Low Risk	Currently Moderate Risk	0.94
		Toppenish	Currently Moderate Risk	Currently Moderate Risk	0.94
		Satus	Currently Low Risk	Currently Moderate Risk	0.94
	Eastern Cascades	Deschutes W.	Currently Very Low Risk	Currently Moderate Risk	0.74
		Deschutes E.	Currently Low Risk	Currently Moderate Risk	0.61
		Klickitat	Currently Low Risk	Currently Moderate Risk	
		Fifteenmile Cr.	Currently Very Low Risk	Currently Low Risk	1.00
		Rock Cr.	Currently Moderate Risk	Currently Moderate Risk	
		White Salmon - Extirpated			
	Umatilla/Walla Walla	Umatilla	Currently Moderate Risk	Currently Moderate Risk	0.64
		Walla-Walla	Currently Low Risk	Currently Moderate Risk	0.98
		Touchet	Currently Low Risk	Currently Moderate Risk	
	John Day	Lower Mainstem	Currently Very Low Risk	Currently Moderate Risk	0.90
		North Fork	Currently Very Low Risk	Currently Low Risk	0.92
		Upper Mainstem	Currently Very Low Risk	Currently Low Risk	0.92
		Middle Fork	Currently Very Low Risk	Currently Low Risk	0.92
		South Fork	Currently Very Low Risk	Currently Low Risk	0.92

1 ICTRT conclusions for MCR steelhead are from draft ICTRT Current Status Summaries (ICTRT 2007d).
2 Average fractions of natural-origin natural spawners are from the ICTRT (2007a).

Table 8.8.2-3. Status of MCR steelhead with respect to extinction risk. Extinction risk is estimated from performance during the "base period" of the 15-20 most recent brood years (approximately 1980-1985 BY through 1998-1999 BY, depending upon population).

			24-Year Extinction Risk											
ESU	**MPG**	**Population**	Risk (QET=1)[1]	Risk (QET=1) Lower 95CI	Risk (QET=1) Upper 95CI	Risk (QET=10)[1]	Risk (QET=10) Lower 95CI	Risk (QET=10) Upper 95CI	Risk (QET=30)[1]	Risk (QET=30) Lower 95CI	Risk (QET=30) Upper 95CI	Risk (QET=50)[1]	Risk (QET=50) Lower 95CI	Risk (QET=50) Upper 95CI
Mid Columbia Steelhead	Yakima	Upper Yakima	0.37	0.00	1.00	0.50	0.00	1.00	0.60	0.00	1.00	0.68	0.08	1.00
		Naches	0.06	0.00	0.58	0.18	0.00	0.77	0.27	0.00	0.83	0.34	0.00	0.87
		Toppenish	0.48	0.00	0.58	0.61	0.00	0.73	0.73	0.00	0.92	0.79	0.00	0.97
		Satus	0.00	0.00	0.04	0.00	0.00	0.13	0.00	0.00	0.22	0.00	0.00	0.30
	Eastern Cascades	Deschutes W.	0.00	0.00	0.48	0.00	0.00	0.75	0.00	0.00	0.84	0.01	0.00	0.90
		Deschutes E.	0.42	0.00	1.00	0.48	0.00	1.00	0.51	0.00	1.00	0.53	0.00	1.00
		Klickitat												
		Fifteenmile Cr.	0.00	0.00	0.22	0.00	0.00	0.32	0.00	0.00	0.40	0.00	0.00	0.44
		Rock Cr.												
		White Salmon - Extirpated												
	Umatilla/Walla Walla	Umatilla	0.00	0.00	0.14	0.00	0.00	0.26	0.00	0.00	0.34	0.00	0.00	0.37
		Walla-Walla	0.00	0.00	0.11	0.00	0.00	0.23	0.00	0.00	0.31	0.00	0.00	0.35
		Touchet												
	John Day	Lower Mainstem	0.00	0.00	0.21	0.00	0.00	0.29	0.00	0.00	0.35	0.00	0.00	0.38
		North Fork	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.00	0.07
		Upper Mainstem	0.00	0.00	0.36	0.00	0.00	0.43	0.00	0.00	0.61	0.00	0.00	0.67
		Middle Fork	0.00	0.00	0.16	0.00	0.00	0.28	0.00	0.00	0.38	0.00	0.00	0.44
		South Fork	0.00	0.00	0.40	0.00	0.00	0.55	0.01	0.00	0.61	0.03	0.00	0.69

1 Short-term (24-year) extinction risk and 95% confidence limits from Hinrichsen (2008), included as Attachment 1in SCA Aggregate Analysis Appendix. If populations fall to or below the quasi-extinction threshold (QET) four years in a row they are considered extinct in this analysis.

Table 8.8.2-4. Changes in density-independent survival of MCR steelhead (“gaps”) necessary for indices of productivity equal to 1.0 and estimates of extinction risk no higher than 5% for MCR steelhead. Survival changes would need to be greater than these estimates for trend or productivity to be greater than 1.0. Estimated “gaps” are based on population performance during the “base period” of approximately the last 20 brood years or spawning years. Factors greater than 1.0 indicate a need for higher survival (e.g., 1.225 indicates that a 22.5% proportional increase in survival is necessary for productivity or trend to equal 1.0); 1.0 indicates no change; and numbers less than 1.0 indicate that additional changes in survival are not necessary for productivity or trend equal to 1.0 and extinction risk to be less than or equal to 5%.

ESU	MPG	Population	Survival Gap For Average R/S=1.0[1]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0 @ HF=0[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 20-yr lambda = 1.0@ HF=1[2]	Upper 95% CI	Lower 95% CI	Survival Gap For 1980-current BRT trend = 1.0[3]	Upper 95% CI	Lower 95% CI	Survival Gap for 24-Yr Ext. Risk <5% (QET=1)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=10)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=30)[4]	Survival Gap for 24-Yr Ext. Risk <5% (QET=50)[4]
Mid Columbia Steelhead	Yakima	Upper Yakima	0.98	1.44	0.66	0.94	3.85	0.23	0.96	4.00	0.23	0.98	1.24	0.49				
		Naches	0.98	1.45	0.66	0.92	3.97	0.21	0.99	4.30	0.23	0.93	1.18	0.48				
		Toppenish	0.69	1.12	0.42	0.68	3.50	0.13	0.73	3.81	0.14	0.69	0.92	0.29				
		Satus	1.16	1.61	0.83	1.11	3.36	0.37	1.21	3.67	0.40	1.12	1.39	0.60				
	Eastern Cascades	Deschutes W.	1.09	1.49	0.80	0.91	2.64	0.32	1.16	3.13	0.43	1.03	1.21	0.50				
		Deschutes E.																
		Klickitat																
		Fifteenmile Cr.	0.85	1.19	0.61	0.88	2.34	0.33	0.88	2.34	0.33	0.88	1.08	0.53				
		Rock Cr.																
		White Salmon - Extirpated																
	Umatilla/Walla Walla	Umatilla	1.06	1.38	0.82	0.86	2.00	0.37	1.07	2.35	0.49	0.98	1.11	0.57				
		Walla-Walla																
		Touchet																
	John Day	Lower Mainstem	0.80	1.32	0.49	0.96	4.61	0.20	1.00	4.67	0.21	1.11	1.35	0.55				
		North Fork	0.85	1.27	0.57	1.00	2.81	0.35	1.02	2.84	0.37	1.05	1.25	0.51				
		Upper Mainstem	0.94	1.40	0.63	1.04	3.24	0.33	1.07	3.30	0.34	1.26	1.49	0.87				
		Middle Fork	0.85	1.23	0.59	0.97	2.79	0.34	1.00	2.84	0.35	1.16	1.37	0.77				
		South Fork	1.01	1.57	0.65	1.05	3.95	0.28	1.08	3.97	0.29	1.26	1.51	0.68				

1 R/S survival gap is calculated as 1.0 ÷ base R/S from Table 8.8.2-1.
2 Lambda survival gap is calculated as (1.0 ÷ base lambda from Table 8.8.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
3 BRT trend survival gap is calculated as (1.0 ÷ base BRT slope from Table 8.8.2-1)^Mean Generation Time. Mean generation time was estimated at 4.5 years for these calculations.
4 Extinction risk survival gap could not be calculated for this species .

Table 8.8.3-1. Proportional changes in average base period survival of MCR steelhead expected from completed actions and current human activities that are likely to continue into the future. Factors greater than one result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to the base period average); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to the base period average).

			Base-to-Current Adjustment (Divisor)							
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2]	Estuary Habitat[3]	Bird Predation[4]	Marine Mammal Predation[5]	Harvest[6]	Hatcheries[7]	Total[8]
Mid Columbia Steelhead	Yakima	Upper Yakima (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
		Naches (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
		Toppenish (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
		Satus (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
	Eastern Cascades	Deschutes W. (above TDA)	0.998	1.002	1.003	0.996	1.00	1.041	1.00	1.04
		Deschutes E. (above TDA)	0.998	1.010	1.003	0.996	1.00	1.041	1.00	1.05
		Klickitat (above BON)	0.999	1.040	1.003	0.996	1.00	1.041	1.00	1.08
		Fifteenmile Cr. (above TDA)	0.998	1.001	1.003	0.996	0.78	1.041	1.00	0.81
		Rock Cr. (above JDA)	1.005	1.000	1.003	0.996	1.00	1.041	1.00	1.05
		White Salmon - Extirpated								
	Umatilla/Walla Walla	Umatilla (above JDA)	1.005	1.040	1.003	0.996	1.00	1.041	1.00	1.09
		Walla-Walla (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
		Touchet (above MCN)	1.018	1.040	1.003	0.996	1.00	1.041	1.00	1.10
	John Day	Lower Mainstem (above JDA)	1.005	1.002	1.003	0.996	1.00	1.041	1.00	1.05
		North Fork (above JDA)	1.005	1.003	1.003	0.996	1.00	1.041	1.00	1.05
		Upper Mainstem (above JDA)	1.005	1.002	1.003	0.996	1.00	1.041	1.00	1.05
		Middle Fork (above JDA)	1.005	1.002	1.003	0.996	1.00	1.041	1.00	1.05
		South Fork (above JDA)	1.005	1.007	1.003	0.996	1.00	1.041	1.00	1.05

1 From SCA Hydro Modeling Appendix, Based on differences in average base and current smolt-to-adult survival estimates.
2 From CA Chapter 10, Table 10-7.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Current 2 S/Baseline 2 S" approach, as described in Attachment F-2.
5 From Supplemental Comprehensive Analysis, SCA Marine Mammal Appendix. Fifteenmile Creek is affected because it is a winter-run steelhead population.
6 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
7 Hatchery improvements considered qualitatively
8 Total survival improvement multiplier is the product of the survival improvement multipliers in each previous column.

Table 8.8.5-1. Estimates of percent juvenile steelhead in-river survival rates through the lower Columbia River under the Prospective Actions and in a hypothetical free-flowing reach of equal length (source: Table 5.1 in NMFS 2004a).

Pool Entered	Prospective Actions Lower Columbia Survival		Hypothetical—Free-flowing Reach
	In-river	Rel. Improvement	
McNary	65	12	89
John Day	70	10	91
The Dalles	83	5	96
Bonneville	93	< 1	99

Table 8.8.5-2. Proportional changes in survival of MCR steelhead expected from the Prospective Actions. Factors greater than one result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change; and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

			Current-to-Future Adjustment (Divisor)									
ESU	MPG	Population	Hydro[1]	Tributary Habitat[2] (2007-2017)	Estuary Habitat[3]	Bird Predation[4]	Pike-minnow Predation[5]	Kelt Reconditioning[6]	Marine Mammal[7]	Allowable Harvest8	Expected Harvest[8]	Hatcheries9
Mid Columbia Steelhead	Yakima	Upper Yakima (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Naches (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Toppenish (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Satus (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
	Eastern Cascades	Deschutes W. (above TDA)	1.05	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Deschutes E. (above TDA)	1.05	1.03	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Klickitat (above BON)	1.00	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Fifteenmile Cr. (above TDA)	1.05	1.00	1.06	1.03	1.01	1.00	1.18	0.99	0.99	1.00
		Rock Cr. (above JDA)	1.08	1.00	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		White Salmon - Extirpated										
	Umatilla/Walla Walla	Umatilla (above JDA)	1.08	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Walla-Walla (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Touchet (above MCN)	1.10	1.04	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
	John Day	Lower Mainstem (above JDA)	1.08	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		North Fork (above JDA)	1.08	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Upper Mainstem (above JDA)	1.08	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		Middle Fork (above JDA)	1.08	1.01	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00
		South Fork (above JDA)	1.08	1.02	1.06	1.03	1.01	1.00	1.00	0.99	0.99	1.00

Table 8.8.5-2. Continued.

			Current-to-Future Adjustment (Divisor)					High	Low
ESU	MPG	Population	Non-Hydro With Allowable Harvest[10]	Non-Hydro With Expected Harvest[10]	Total (Allowable Harvest)[11]	Total (Expected Harvest)[11]		Total Base-Current and Current-Future[12]	Total Base-Current and Current-Future[12]
Mid Columbia Steelhead	Yakima	Upper Yakima (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
		Naches (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
		Toppenish (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
		Satus (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
	Eastern Cascades	Deschutes W. (above TDA)	1.11	1.11	1.16	1.16		1.21	1.21
		Deschutes E. (above TDA)	1.13	1.13	1.19	1.19		1.25	1.25
		Klickitat (above BON)	1.14	1.14	1.15	1.15		1.24	1.24
		Fifteenmile Cr. (above TDA)	1.30	1.30	1.37	1.37		1.11	1.11
		Rock Cr. (above JDA)	1.10	1.10	1.19	1.19		1.24	1.24
		White Salmon - Extirpated							
	Umatilla/Walla Walla	Umatilla (above JDA)	1.14	1.14	1.24	1.24		1.34	1.34
		Walla-Walla (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
		Touchet (above MCN)	1.14	1.14	1.26	1.26		1.39	1.39
	John Day	Lower Mainstem (above JDA)	1.11	1.11	1.20	1.20		1.25	1.25
		North Fork (above JDA)	1.11	1.11	1.20	1.20		1.25	1.25
		Upper Mainstem (above JDA)	1.11	1.11	1.20	1.20		1.26	1.26
		Middle Fork (above JDA)	1.11	1.11	1.20	1.20		1.25	1.25
		South Fork (above JDA)	1.12	1.12	1.21	1.21		1.28	1.28

1 From Supplemental Comprehensive Analysis, SCA Hydro Modeling Appendix. Based on differences in average current and future smolt-to-adult survival estimates.
2 From CA Chapter 10, Table 10-9.
3 From CA Appendix D, Attachment D-1, Table 6.
4 From CA Appendix F, Attachment F-2, Table 4. Estimate is based on the "Prospective 2 S/Current 2 S" approach, as described in Attachment F-2.
5 From CA Appendix F, Attachment F-1.
6 It was not possible to quantify survival changes associated with the kelt reconditioning program.
7 From Supplemental Comprehensive Analysis, SCA Marine Mammal Appendix. Fifteenmile Creek is affected because it is a winter-run steelhead population.
8 From SCA Harvest Appendix. Primary source: memorandum from *US v. Oregon* ad hoc technical workgroup.
9No quantitative survival changes have been estimated to result from hatchery Prospective Actions – future effects are qualitative.
10 This multiplier represents the survival changes resulting from non-hydro Prospective Actions. It is calculated as the product of the survival improvement multipliers in each previous column, except for the hydro multipliers.
11 Same as Footnote 8, except it is calculated from all Prospective Actions, including hydro actions.
12 Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier from Table 8.8.3-1.

Table 8.8.6.1-1. Summary of prospective estimates relevant to the recovery prong of the jeopardy standard for MCR steelhead.

ESU	MPG	Population	20-Yr R/S Recent Climate[1]	20-yr lambda Recent Climate @ HF=0[2]	20-yr lambda Recent Climate @ HF=1[3]	1980-Current BRT Trend Recent Climate[3]	ICTRT MPG Viability Scenario[4]	Recovery Prong Notes for Abundance/Productivity	Recovery Prong Notes for Spatial Structure[5]	Recovery Prong Notes for Diversity[5]
							Need 1 HV and 1 V:			
Mid Columbia Steelhead	Yakima	Upper Yakima (above MCN)	1.42	1.09	1.09	1.39	1 of these 2 populations must be HV or V	All three metrics >1	Currently High Risk (7 of 10 historical MaSAs are not occupied)	Currently High Risk (Introgression with resident *O. mykiss* and loss of presmolt migration pathways)
		Naches (above MCN)	1.42	1.10	1.08	1.41		All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Toppenish (above MCN)	2.02	1.17	1.15	1.51	Can be 1 of the 2 needed HV or V populations	All three metrics >1	Currently Low Risk	Currently Moderate Risk
		Satus (above MCN)	1.20	1.05	1.03	1.35	"Maintained" Population	All three metrics >1	Currently Low Risk	Currently Moderate Risk
							Need 1 HV and 3 V:			
	Eastern Cascades	Deschutes W. (above TDA)	1.11	1.06	1.01	1.20	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
		Deschutes E. (above TDA)					Must be HV or V	No Data	Currently Low Risk	Currently Moderate Risk
		Klickitat (above BON)					Must be HV or V	No Data	Currently Low Risk	Currently Moderate Risk
		Fifteenmile Cr. (above TDA)	1.30	1.05	1.05	1.15	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Low Risk
		Rock Cr. (above JDA)					"Maintained" Population	No Data	Currently Moderate Risk	Currently Moderate Risk
		White Salmon - Extirpated								
							Need 1 HV and 1 V:			
	Umatilla/Walla Walla	Umatilla (above JDA)	1.26	1.11	1.05	1.35	Must be HV or V	All three metrics >1	Currently Moderate Risk	Currently Moderate Risk
		Walla-Walla (above MCN)					1 of these 2 populations must be HV or V	No Data	Currently Low Risk	Currently Moderate Risk
		Touchet (above MCN)						No Data	Currently Low Risk	Currently Moderate Risk
							Need 1 HV and 2 V:			
	John Day	Lower Mainstem (above JDA)	1.56	1.06	1.05	1.22	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Moderate Risk
		North Fork (above JDA)	1.47	1.05	1.05	1.24	Must be HV or V	All three metrics >1	Currently Very Low Risk	Currently Low Risk
		Upper Mainstem (above JDA)	1.34	1.04	1.04	1.20	1 of these 2 populations must be HV or V	All three metrics >1	Currently Low Risk	Currently Low Risk
		Middle Fork (above JDA)	1.47	1.06	1.05	1.21		All three metrics >1	Currently Low Risk	Currently Low Risk
		South Fork (above JDA)	1.26	1.05	1.04	1.21	"Maintained" Population	All three metrics >1	Currently Very Low Risk	Currently Low Risk

1 Calculated as the base period 20-year R/S productivity from Table 8.8.2-1, multiplied by the total base-to-future survival multiplier in Table 8.8.5-2.
2 Calculated as the base period 20-year mean population growth rate (lambda) from Table 8.8.2-1, multiplied by the total base-to-future survival multiplier in Table 8.8.5-2, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
3 Calculated as the base period 20-year mean BRT abundance trend from Table 8.8.2-1, multiplied by the total base-to-future survival multiplier in Table 8.8.5-2, raised to the power of (1/mean generation time). Mean generation time was estimated to be 4.5 years.
4 From ICTRT (2007c), Attachment 2
5 From Table 8.

Figure 8.8.6-1. Summary of prospective mean R/S estimates for MCR steelhead under the “recent” climate assumption, including 95% confidence limits.

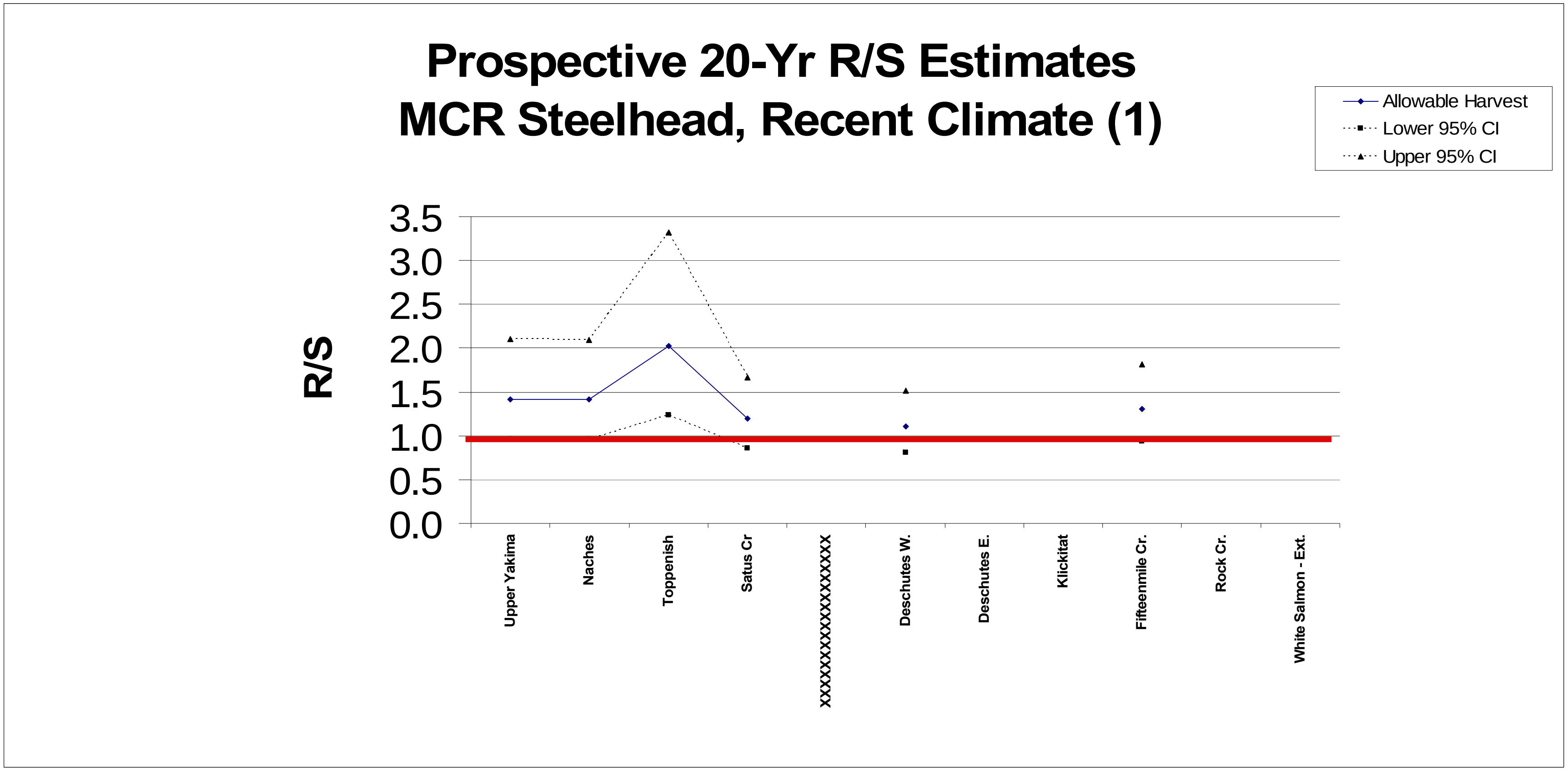


Figure 8.8.6-1. Continued.

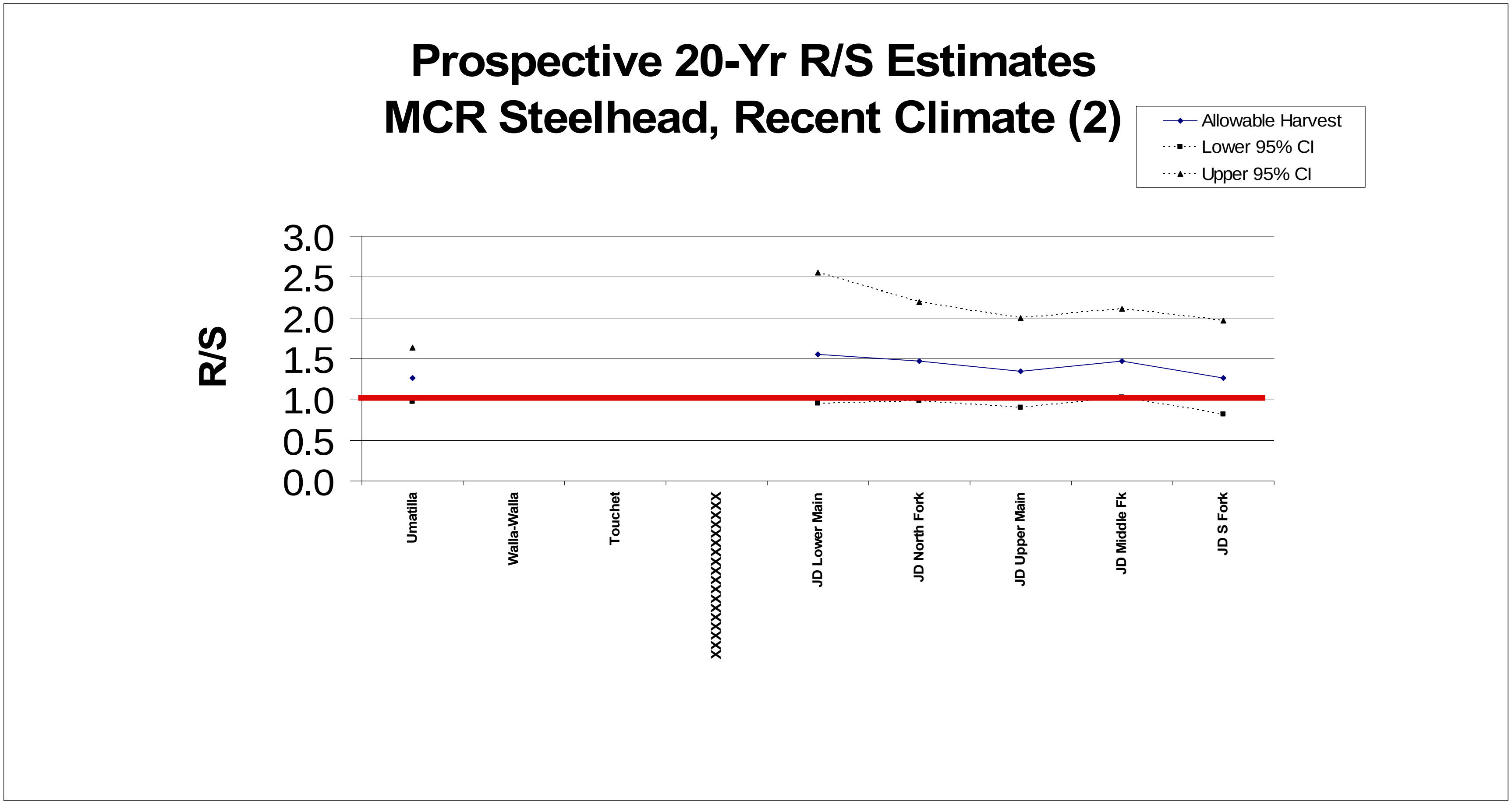


Figure 8.8.6-2. Summary of prospective mean R/S estimates for MCR steelhead under three climate assumptions.

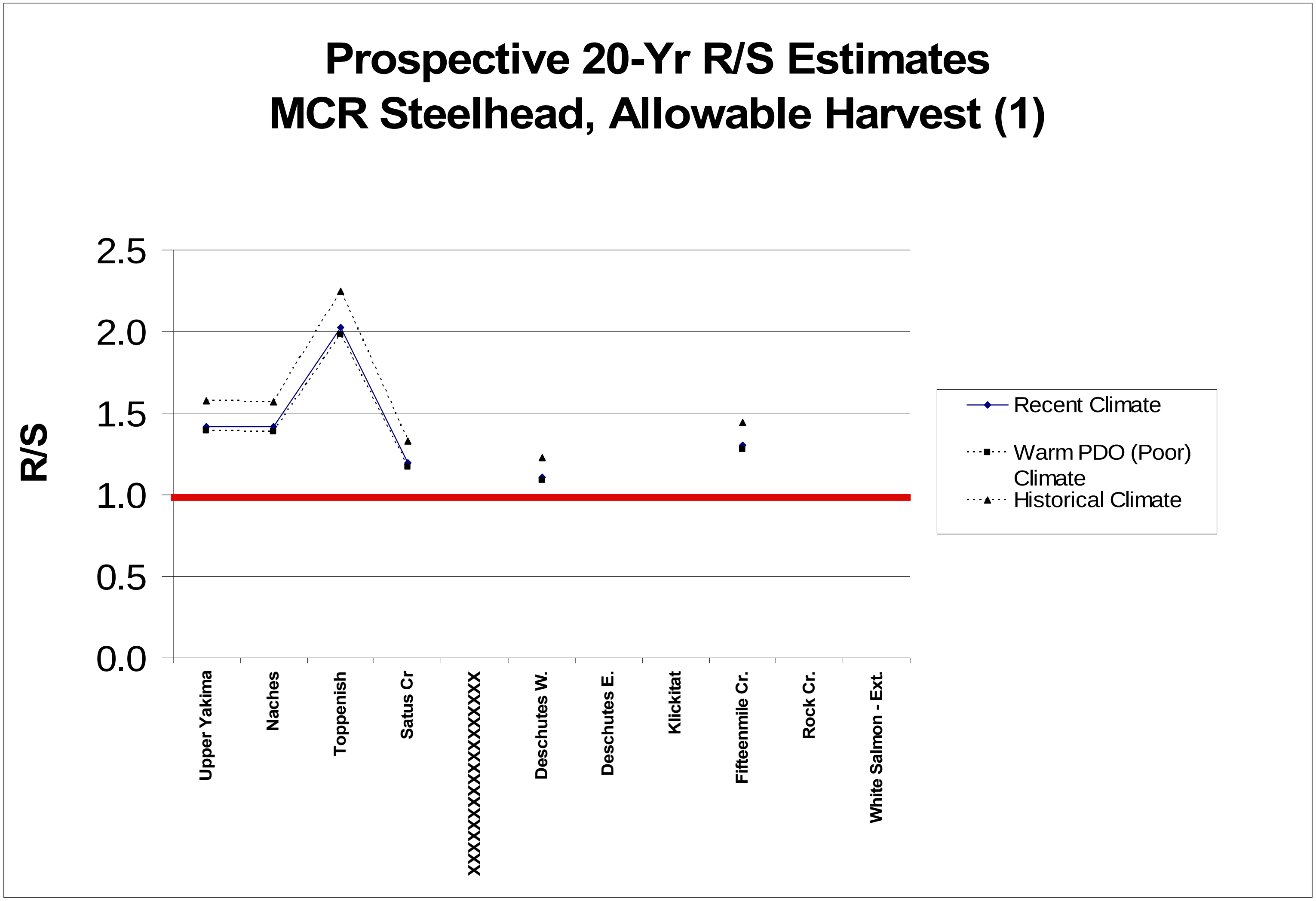
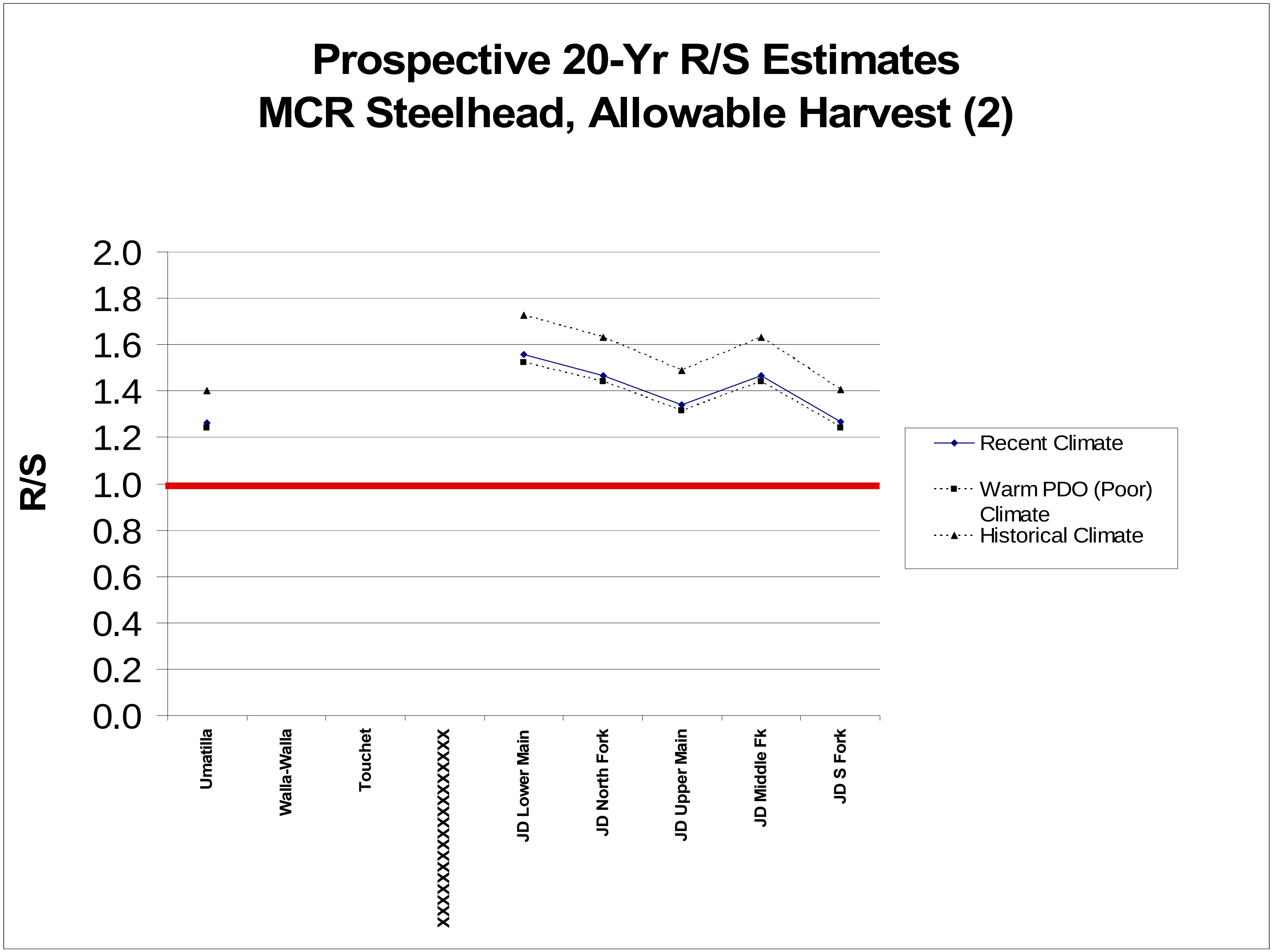


Figure 8.8.6-2. Continued.



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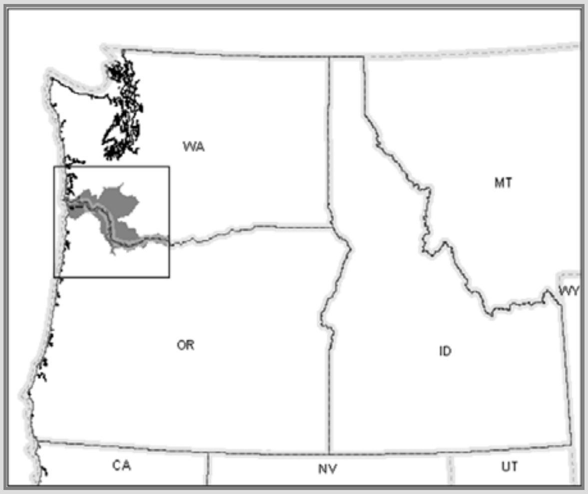
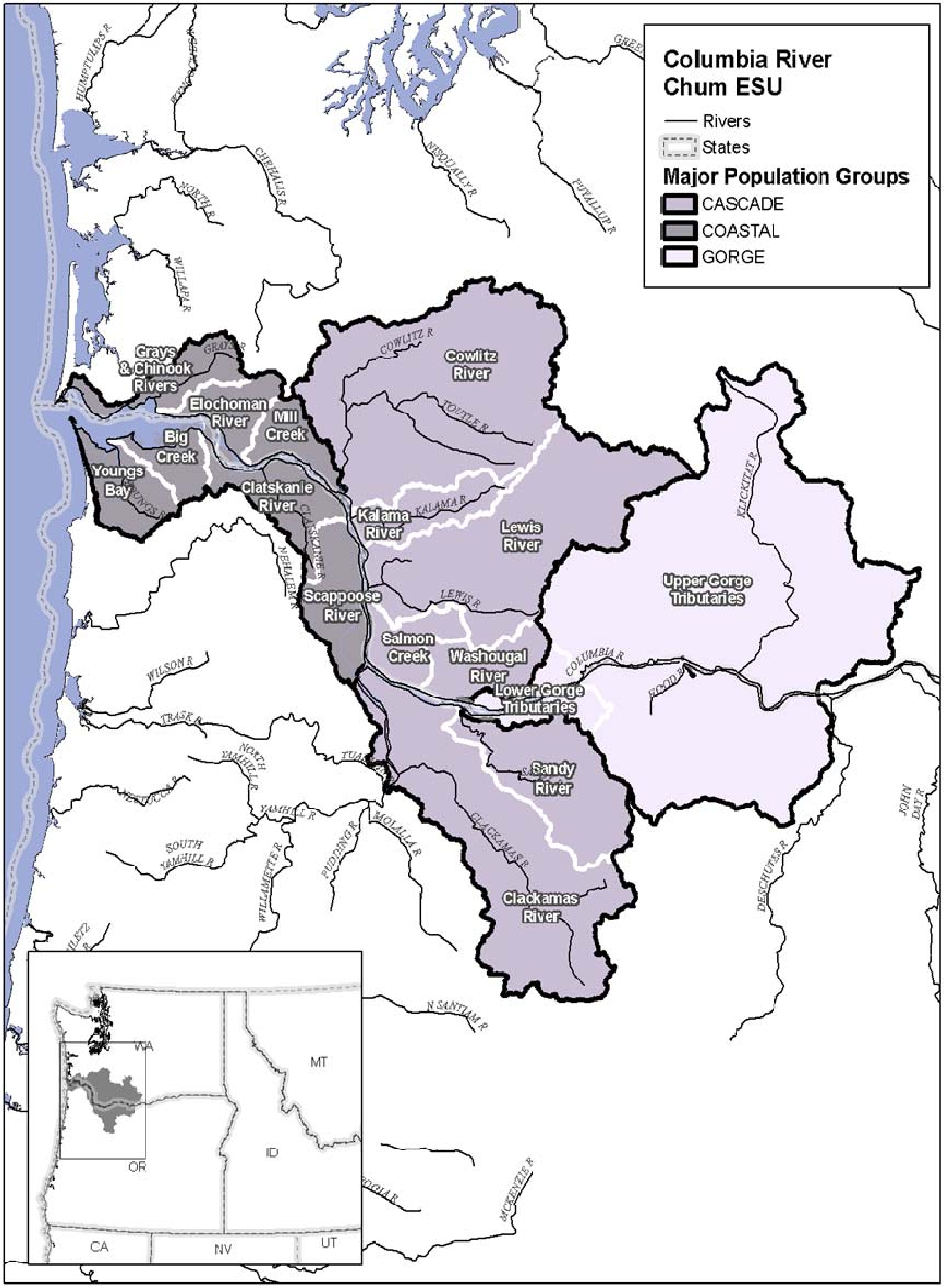
Section 8.9
Columbia River Chum Salmon




Columbia River Chum ESU
Rivers
States
Major Population Groups
CASCADE
COASTAL
GORGE
Grays & Chinook Rivers
Elochoman River
Mill Creek
Big Creek
Youngs Bay
Clatskanie River
Cowlitz River
Kalama River
Lewis River
Scappoose River
Salmon Creek
Washougal River
Lower Gorge Tributaries
Upper Gorge Tributaries
Sandy River
Clackamas River
WA
OR
MT
ID
CA
NV
UT

Section 8.9
Columbia River Chum Salmon

Species Overview

Background

The Columbia River (CR) chum salmon ESU includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries as well as three artificial propagation programs. There were 16 historical populations in three major population groups in Oregon and Washington between the mouth of the Columbia River and the Cascade crest. Significant spawning now occurs for two of the historical populations, meaning that 88% of the historical populations are extirpated or nearly so. Because chum salmon spend only a short time in natal streams before emigration, the loss or impairment of rearing habitat in the Columbia River estuary may have been an important factor in their decline. Another important factor was the inundation of historical spawning areas by Bonneville Reservoir.

Designated critical habitat for this ESU includes all Columbia River estuarine areas and river reaches upstream to the confluence with the White Salmon River and specific stream reaches in a number of subbasins.

Current Status & Recent Trends

Most of the populations in this ESU are extirpated or nearly so. Estimates of abundance and trends are available only for the Grays River and Lower Gorge populations. Abundances for these was low, but trends were relatively stable in the decade beginning 1990. Since then they increased for several years before declining.

Limiting Factors

Human impacts and limiting factors for the Columbia River chum salmon ESU have come from multiple sources, including mainstem and tributary hydropower development and loss or impairment of tributary and estuarine habitat.

Recent Ocean and Mainstem Harvest

Ocean fishing mortality on Columbia River chum salmon is assumed to be zero. Fisheries in the Columbia River are limited to insure that the incidental take of ESA-listed Columbia River chum does not exceed specified rates. Non-Treaty fisheries in the lower Columbia River have been limited to an incidental harvest rate of 5% in recent years. Recent harvest rates have averaged about 1.6%. Columbia River chum are not caught in the treaty Indian fisheries above Bonneville Dam.

8.9.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.9.2.1 Current Rangewide Status of the Species

The Columbia River chum ESU includes 16 historical populations in Oregon and Washington between the mouth of the Columbia River and the Cascade crest. Chum salmon return to the Columbia River in late fall (mid-October to December). They primarily spawn in the lower reaches of rivers, digging their redds along the edges of the mainstem and in tributaries or side channels. Some spawning sites are located in areas where geothermally-warmed groundwater or mainstem flow upwells through the gravel.

Chum fry emigrate from March through May shortly after emergence in contrast to other salmonids (e.g., steelhead, coho salmon, and most Chinook salmon), which usually migrate to sea at a larger size after months or years of freshwater rearing. Juvenile chum salmon feed in estuaries to feed before beginning a long-distance oceanic migration. The period of estuarine residence appears to be a critical life history phase and may play a major role in determining the size of the subsequent adult run back to fresh water. Summary data for the ESU are shown in Table 8.9.2.1-1.

Table 8.9.2.1-1. Columbia River chum ESU description and major population groups (MPGs). (Sources: NMFS 2005a; Myers et al. 2006). The designations "-C" and "-G" identify Core and Genetic legacy populations, respectively.[1]

ESU Description	
Threatened	Listed under ESA in 2005
3 major population groups	16 historical populations
Major Population Group	**Population**
Coastal	Grays (C,G), Elochoman (C), Mill Creek, Youngs Bay (C), Big Creek (C), Clatskanie, Scappoose
Cascade	Cowlitz (C),* Kalama, Lewis (C), Salmon Creek, Washougal, Clackamas (C), Sandy
Gorge	Lower Gorge (C,G), Upper Gorge
Hatchery programs included in ESU (3)	Chinook River (Sea Resources Hatchery), Grays River, and Washougal/Duncan Creek
* Myers et al. 2006 stated that "whether [Cowlitz] summer chum salmon constitute a demographically independent population … needs to be studied further." Subsequent genetic analysis (Small et al. 2006) indicated that Cowlitz summer chum are distinct, but population delineations have not yet been revised.	

[1] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the ESU (WLCTRT 2003).

Human impacts and current limiting factors are primarily related to habitat degradation (Table 8.9.2.1-2). Chum spawning habitat has been substantially limited by the loss of off-channel and side channel habitat and, since 1938, inundation of historically productive areas by Bonneville pool.

Limiting Factors

Summarized below (Table 8.9.2.1-2) are key limiting factors for this ESU and recovery strategies to address those factors as described in the Washington Lower Columbia Recovery and Subbasin Plan [Lower Columbia Fish Recovery Board (LCFRB 2004)]. Oregon is currently engaged in the recovery planning process for Columbia River chum.

Table 8.9.2.1-2. Key limiting factors for Columbia River chum.

Mainstem Hydro	Direct mainstem hydro impacts on the Columbia River chum ESU are most significant for the Upper and Lower Gorge populations. For the Upper Gorge population, some productive historical spawning habitat was inundated by Bonneville pool. FCRPS flow management affects the amount of submerged spawning habitat for the mainstem component of the Lower Gorge population and whether adults can enter (and fry can emerge from) Hardy and Hamilton creeks. Impacts on populations originating in subbasins further downstream (i.e., below the Portland/Vancouver area) are limited to migration and habitat conditions in the lower Columbia River (below Bonneville Dam) including the estuary.
Predation	Avian predators are assumed to have minimal effect on chum salmon. The significance of fish predation on juvenile chum is unknown.
Harvest	Harvest is limited to indirect fishery mortality. In the 1950s, due to severe population declines, commercial chum salmon fisheries were closed or drastically minimized. Now there are neither recreational nor commercial fisheries in the Columbia River. The number of chum landed as take incidental to the lower river commercial gill net fisheries has been less than 50 fish in each of the last five years.
Hatcheries	Historical hatchery practices do not appear to have influenced chum populations. WDFW's conservation hatcheries are currently an element of chum salmon protection and restoration efforts. Along with other state and Federal hatchery programs throughout the lower Columbia River, these are currently the subject of a series of comprehensive reviews for consistency with the protection and recovery of listed salmonids. A variety of beneficial changes to hatchery programs have already been implemented and additional changes are anticipated.
Estuary	The estuary is an important habitat for migrating juveniles from Columbia River chum populations. Alterations in attributes of flow and diking have

	resulted in the loss of emergent marsh, tidal swamp and forested wetlands. These habitats are used extensively by chum juveniles which migrate from their natal areas soon after emergence (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail as part of a comprehensive regional planning process (NMFS 2006b).
Habitat	Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in the low to moderate elevation habitats most often used by chum. The Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004) identifies current habitat values, restoration potential, limiting factors, and habitat protection and restoration priorities for chum by reach in all Washington subbasins. Recovery and subbasin plans also identify a suite of beneficial actions for the protection and restoration of tributary subbasin habitats. Similar information is in development for Oregon subbasins.
Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status the ESU to some extent, future trends, especially during the time period relevant to the Prospective Actions, are unclear. Under the adaptive management implementation approach of the Lower Columbia River Recovery and Subbasin Plan, further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through additional recovery effort (LCFRB 2004).

Abundance, Productivity, & Trends

Base status information through 2000 is shown in Table 8.9.2.1-3. Estimates of abundance and trends are available only for the Grays River and Lower Gorge populations. The 10-year trend was negative for the Grays River population and just over 1.0 for the Lower Gorge. After 2000, populations increased for a few years before declining (Keller 2006).

Table 8.9.2.1-3. Abundance, productivity, and trends of Columbia River chum populations. (Sources: NMFS 2005b; McElhany et al. 2007).

Strata	Population	State	Recent Abundance of Natural Spawners			Long-term trend		Median Growth Rate	
			Years[1]	No.[2]	pHOS[3]	Years	Value[4]	Years	λ[5]
Coastal	Grays	W	96-00	331	na	90-00	0.904[6]	90-00	0.807[6]
	Elochoman	W	na	na	na	na	na	na	na
	Mill Creek	W	na	na	na	na	na	na	na
	Youngs Bay	O	na	na	na	na	na	na	na
	Big Creek	O	na	na	na	na	na	na	na
	Clatskanie	O	na	na	na	na	na	na	na
	Scappoose	O	na	na	na	na	na	na	na
Cascade	Cowlitz	W	na	na	na	na	na	na	na
	Kalama	W	na	na	na	na	na	na	na
	Lewis	W	na	na	na	na	na	na	na
	Salmon	W	na	na	na	na	na	na	na
	Washougal	W	na	na	na	na	na	na	na
	Clackamas	O	na	na	na	na	na	na	na
	Sandy	O	na	na	na	na	na	na	na
Gorge	Lower Gorge	O/W	96-00	425	N/A	90-00	1.003	90-00	1.00
	Upper Gorge	O/W	na	na	na	na	na	na	na

[1] Years of data for recent means
[2] Geometric mean of total spawners
[3] Average recent proportion of hatchery-origin spawners
[4] Long-term trend of total spawners
[5] Long-term median population growth rate (including both natural- and hatchery-origin spawners)
[6] Hymer 2000 as cited in NMFS 2005b

Extinction Probability/Risk

The 100-year risk of extinction (Table 8.9.2.1-4) was derived qualitatively, based on risk categories and criteria identified by the WLC TRT (2004) for use in recovery plan assessments. The rating system categorized extinction risk probabilities as very low (<1%), low (1 to 5%), medium (5 to 25%), high (26 to 60%), and very high (>60%) based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

The risk of extinction is high or very high for all populations except the Washington portion of the Lower Gorge. The Upper Gorge population, and all four of the populations on the Oregon side of the river in the Coastal MPG, are extirpated or nearly so (McElhany et al. 2007).

Table 8.9.2.1-4. Risk of extinction in 100 years; categories for populations of Columbia River chum (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Strata	Population	State	Extinction Risk Category
Coastal	Grays	W	H
	Elochoman	W	H
	Mill Creek	W	VH
	Youngs Bay	O	VH
	Big Creek	O	VH
	Clatskanie	O	VH
	Scappoose	O	VH
Cascade	Cowlitz	W	VH
	Kalama	W	VH
	Lewis	W	VH
	Salmon	W	VH
	Washougal	W	H
	Clackamas	O	VH
	Sandy	O	VH
Gorge	Lower Gorge	O/W	VH/M
	Upper Gorge	O/W	VH/VH

Spatial Structure

The Columbia River chum ESU consists of three MPGs made up of two to seven historical populations each. In the Coastal MPG, spatial structure is limited by tide gates, dikes, culverts, and hatchery weirs. The filling of Bonneville pool eliminated mainstem and lower tributary habitat for the Upper Gorge population (WLCTRT et al. 2004). Over the past several years, few Columbia River chum salmon have been observed in tributaries between The Dalles and Bonneville dams. Surveys of the White Salmon River in 2002 found one male and one female carcass and the latter had not spawned (Ehlke and Keller 2003). Chum salmon were not observed in any of the upper gorge tributaries, including the White Salmon River, during the 2003 and 2004 spawning ground surveys (Keller 2005a, b). Radio-tracking studies show that a few adult chum tagged at Bonneville Dam were near the confluence of the White Salmon, but did not appear to enter the river and did not stay in the area.

In the Cascade MPG, chum salmon habitat was inundated by Mayfield Lake in the Cowlitz River and Merwin Lake in the North Fork Lewis River. The following measures, which could positively affect the spatial structure of chum populations in the Cascade MPG and thus rangewide status, were included in the new FERC licenses for these two projects:

- Lewis River Hydroelectric Project – chum salmon once ascended the mainstem Lewis River above the current location of Merwin Dam. Because this area is now inundated, PacifiCorps may use its In Lieu fund to repair a landslide upstream of the Lewis River Hatchery which buried chum salmon spawning habitat and fund a partnership with a gravel mining company to create spawning habitat on the East Fork Lewis and/or reconnect and enhance side channels and areas with upwelling to restore spawning habitat in the lower mainstem Lewis (NMFS 2007f)

- Cowlitz River Hydroelectric Project – Tacoma Power will provide minimum flows from Mayfield Dam to protect chum habitat during spawning, incubation, and emergence and will implement gravel augmentation projects in the habitat below the dam (NMFS 2004c)

Diversity

Most Columbia River chum populations have been functionally extirpated or are presently at very low abundance levels. However, in the Cascade MPG, chum sampled from each tributary recently were shown to be the remnants of genetically distinct populations (Small et al. 2006).

Historical hatchery introductions were limited to populations in the Coastal MPG and these were both small in scale and intermittent. As a result, they have not had lasting effects on the diversity of the affected populations. Three recently established artificial propagation programs produce chum salmon at this time; these are conservation programs which use naturally-produced adults for broodstock and release juveniles as fry, boosting egg-to-fry productivity. The current Washougal Hatchery program provides chum salmon for re-introduction into recently restored habitat in Duncan Creek (Washington). This program also provides a safety net for the naturally-spawning population in the mainstem Columbia River below Bonneville Dam during low flow years. The other two programs are designed to augment natural production in the Grays River and to reintroduce chum to the Chinook River. Effects on diversity are expected to be neutral.

8.9.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for CR chum salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the White Salmon River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Cowlitz, Lower Columbia, and Grays/ Elochoman (NMFS 2005b). There are 20 watersheds within the range of this ESU. Three watersheds received a medium rating and 17 received a high rating for their conservation value to the ESU (i.e., for recovery). For more information see Chapter 4. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor 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. Of the 725 miles of habitat areas eligible for designation, 708 stream miles are designated critical habitat.

In the lower Columbia River and its tributaries, major factors affecting PCEs are altered channel morphology and stability; lost/degraded floodplain connectivity; loss of habitat diversity; excessive sediment; degraded water quality; increased steam temperatures; reduced stream flow; and reduced access to spawning and rearing areas (LCFRB 2004, ODFW 2006b, PCSRF 2006). The status of critical habitat within the action area is discussed in more detail in Section 8.9.3.8.

8.9.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

Both Federal and non-Federal parties have implemented a variety of actions that have improved the status of CR chum salmon. Actions that have been implemented since the environmental baseline was described in the 2000 FCRPS Biological Opinion (NMFS 2000b) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend developed by the WLC TRT (Table 8.9.2.1-3) will improve.

8.9.3.1 Recent FCRPS Hydro Improvements

Chum salmon have benefited from operations to provide fall and winter tailwater elevations and flows for spawning, incubation, and emergence in habitat just downstream from Bonneville Dam (Lower Gorge population). The flow operation supports spawning, incubation, and emergence and ensures access to Hamilton and Hardy creeks. However, some chum fry have been stranded on shallow water flats on Pierce Island as a result of daily flow fluctuations.

8.9.3.2 Recent Tributary Habitat Improvements

Actions implemented since 2000 range from beneficial changes in land management practices to improving access by replacing culverts and by fish habitat restoration activities at FERC-licensed dams. The latter category includes the removal of Condit Dam in 2009 (NMFS 2006j), a portion of the historical spawning habitat that was inundated by Bonneville pool could be restored over time if sediment released upon the removal of Condit Dam, and natural bedload, deposit in the lower White Salmon River in a way that elevates the stream bottom (NMFS 2006k). However, NOAA Fisheries is uncertain that this action will lead to the restoration of this component of the Upper Gorge population.

As described in Section 8.10.3.2, a comprehensive habitat assessment and restoration plan for the Grays River watershed was conducted by the Pacific Northwest National Laboratory (PNNL) in cooperation with Washington Department of Fish and Wildlife (WDFW) and Pacific States Marine Fisheries Commission (PSMFC) in 2006, focusing on the fall-run Chinook population. Several related projects have been implemented (see attachment to NOAA Fisheries' 2008 Guidance letter to the Pacific Fisheries Management Council PFMC; NMFS 2008i). These include habitat restoration in the upper (reducing excess sediment loads) and lower (reconnecting the river delta-estuarine habitat at Seal Slough, the tidal floodplain at Devils Elbow, estuarine wetlands at Seal Slough, adding large wood to the lower West Fork, reducing temperatures and improving habitat diversity near Grays RM 11.8, and replacing the Nikka tidegate to restore connectivity and increase fish passage) Grays River watersheds. These projects are likely to benefit the Grays River chum salmon population because chum salmon also have a subyearling juvenile life history type and rear in the types of habitats that will be addressed.

8.9.3.3 Recent Estuary Habitat Improvements

The FCRPS Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving wetland and riparian function. These have resulted in an estimated .0.7% survival benefit for Columbia River chum (ocean-type juvenile life history) (Corps et al. 2007a).

8.9.3.4 Recent Predator Management Improvements

Avian Predation
Avian predators are assumed to have little effect on the survival of Columbia River chum salmon.

Piscivorous Fish Predation
The ongoing Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality since it began in 1990. Benefits of recent northern pikeminnow management activities to chum salmon are unknown, but could be comparable to those for other salmon species with a subyearling juvenile life history: 2% (Friesen and Ward 1999).

8.9.3.5 Recent Hatchery Management Issues

Hatchery effects have not been identified as a limiting factor for Columbia River chum salmon (LCFRB 2004; ODFW 2006b). NOAA Fisheries described three programs that release chum salmon below Bonneville Dam (Table 8.9.2.1-1) as improving population viability by increasing abundance and spatial distribution (NMFS 2004b), as well as reducing short-term extinction risk. A summary of progress in hatchery reform for lower Columbia programs that release fish above Bonneville Dam is reported in Table 2 of NMFS (2004b).

8.9.3.6 Recent Harvest Survival Improvements

Columbia River chum salmon are not caught incidentally in tribal fisheries above Bonneville Dam. Colombia River chum are incidentally caught occasionally in non-Indian fall season fisheries below Bonneville. There are no fisheries in the Columbia River that target hatchery or natural-origin chum salmon. The species' later fall return timing is such that they are vulnerable to relatively little potential harvest in fisheries that target Chinook and coho. Colombia River chum rarely take the kinds of sport gear that is used to target other species.

Harvest rates are difficult to estimate since NOAA Fisheries does not have good estimates of total run size. However, the incidental catch of chum amounts to a few tens of fish per year (TAC 2008). The harvest rate in proposed state fisheries in the lower river is estimated to be 1.6% per year and is almost certainly less than 5%.

8.9.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

Gorge MPG

Completed consultations include road maintenance, culvert cleaning, treating invasive plants, a grazing allotment, and vegetation management along a transmission line right-of-way (Upper Gorge); and repairing a creek bank next to a road, parking lot maintenance, and maintenance of a stormwater drainage system along a highway (Lower Gorge).

Projects Affecting Multiple MPGs/Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.9.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration

Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

There projects are likely to affect multiple populations within the ESU. The effects of some on population viability will be positive (treating invasive plants; habitat restoration; tar remediation). Other projects, including road maintenance, dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on water quality (habitat restoration with stormwater facilities; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.9.3.8 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century and have degraded the conservation value of designated critical habitat. Factors affecting the conservation value of critical habitat in areas occupied by chum salmon vary from altered channel morphology and stability, loss of habitat diversity, high sediment loads, and altered/reduced streamflow, and elevated temperatures.

Spawning Areas

Chum salmon spawn in the lower and middle mainstem reaches of large streams and at several sites in the mainstem Columbia River between Bonneville Dam and the confluence of the Willamette River. The following are the major factors that have limited the functioning of PCEs and thus the conservation value of spawning habitat (i.e., substrate, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Tributary barriers *[low flows; culverts; dikes; tidegates]*
- Reduced riparian function *[urban and rural development; forest practices; agricultural practices; channel manipulations]*
- Loss of floodplain and side channel connectivity *[urban and rural development; past forest practices; agricultural practices; channel manipulations]*
- Excessive sediment in spawning gravel *[forest practices; agricultural practices]*
- Elevated water temperatures *[water withdrawals; urban and rural development; forest practices; agricultural practices]*

The functioning of mainstem spawning habitat has improved in recent years with operations to provide fall and winter tailwater elevations and flows for spawning, incubation, and emergence in the mainstem just downstream from Bonneville Dam. The flow operation also supports access (i.e., removes a barrier) to spawning habitat in Hamilton and Hardy creeks.

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions that address some of factors limiting PCEs in tributary habitat. These include removing passage barriers, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. Some projects will provide immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

As described above, future Federal projects with completed consultations will have neutral or short- or even long-term adverse effects on the functioning of the PCEs safe passage, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Some Federal projects, implemented for restoration purposes, will improve these same PCEs.

Juvenile Rearing Areas & Migration Corridors

Factors that have limited PCEs in juvenile rearing areas and migration corridors (i.e., affecting substrate, water quality, water quantity, cover/shelter, food, riparian vegetation, space, and safe passage) are:

- Entrapment and stranding during emergence from mainstem spawning areas *[power operations at Bonneville Dam]*

- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management*].

Short-term (daily) flow fluctuations at Bonneville Dam sometimes create a barrier (i.e., entrapment on shallow sand flats) for fry moving into the mainstem rearing and migration corridor. Flow management and climate changes together have decreased the delivery of suspended particulate matter and fine sediment to the estuary, and flow management and habitat alterations (dikes and revetments) have restricted the processes that create and maintain habitat diversity. The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of PCEs in the estuary, improving the functioning of cover/shelter, food, and riparian vegetation. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Adult Migration Corridors

Factors that have limited PCEs in the adult migration corridor (i.e., affecting safe passage) are:

- Reduced access to mainstem and tributary spawning areas *[construction of Bonneville Dam for habitat further upstream; FCRPS flow management for the mainstem in the Ives Island area; flood control operations at FERC-licensed dams on the Cowlitz, Lewis, and White Salmon rivers]*

Productive historical spawning areas were located in the lower reaches of tributaries in the upper Gorge. These were inundated when Bonneville pool was filled around 1938. Few adults have passed Bonneville Dam in recent years. Some of those that moved further upstream fall back below the dam.

Hydrosystem flow management operations have been altered since the species was first listed in 1998 to support access to mainstem habitat in the Ives Island area. Entry of adult chum into nearby tributary spawning areas (i.e., Hamilton and Hardy creeks and the constructed spawning channel at Hamilton Springs) depends on mainstem flows, but also on local rainfall during November and December.

Areas for Growth & Development to Adulthood

Although CR chum salmon spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 1993). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.9.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin (see lists of projects in Chapter 17 in Corps et al. 2007a). These include tributary habitat actions in the Washougal that will benefit the Lower Gorge population as well as actions that should generally be beneficial throughout the ESU. Generally, all of these actions are either completed, ongoing, or reasonably certain to occur.[2] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve conditions for this ESU.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have

[2] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.9.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in this section. However, the Prospective Actions will ensure that these adverse effects are reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Some habitat restoration and RM&E actions may have short-term, minor, adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Affects Appendix and in the section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

8.9.5.1 Effects of Hydro Operations & Configuration Prospective Actions

The overall mainstem hydro strategy will be to provide adequate surface water elevations for chum salmon in redds downstream from Bonneville Dam; ensure that voluntary spill does not result in unsafe TDG levels for fish in shallow water areas; and provide safe passage for adults that migrate past Bonneville Dam. Specifically, the Prospective Actions require that the Action Agencies:

- Provide a tailwater elevation of approximately 11.5 feet at Bonneville Dam beginning in the first week of November (or when chum arrive) and ending by December 31, if reservoir elevations and climate forecasts indicate this operation can be maintained through incubation and emergence

- Through TMT, if water supply is deemed insufficient to provide mainstem spawning or continuous tributary access, provide as appropriate sufficient mainstem flow intermittently to allow fish access to tributary spawning sites if spawning habitat is available in the tributaries

- Make adjustments to tailwater elevation through the TMT process consistent with the size of the spawning population and water supply forecasts

- After completion of spawning, use the TMT process to establish tailwater elevation needed to provide protection for mainstem chum redds through incubation and the end of emergence

- If the emergence period extends beyond April 10th and the decision is made to maintain the tailwater, TMT will discuss the impacts of TDG associated with spill for fish in the gravel (i.e., the start of spring spill could be delayed)

- Revisit chum protection level decision at least monthly through the TMT process to assure it is consistent with the need to provide spring flows for listed Columbia and Snake River stocks

Based on PIT-tag detections for adult fall Chinook, NOAA Fisheries estimates an upstream passage survival rate of 96.9% for adult chum salmon at Bonneville Dam.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of some flow augmentation water from summer to spring may provide a small benefit to juvenile migrants in the lower Columbia River by slightly reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have shallow water, low velocity habitat, identified as a limiting factor in the estuary (Section 8.9.3.8).

Effects on Species Status

Prospective flow operations will maintain the current abundance, productivity, and spatial structure of the Lower Gorge population. Improvements at Bonneville Dam will increase the passage survival of adult chum salmon that migrate past the project (and of juvenile chum, if any are produced in the upper Gorge).

Effects on Critical Habitat

The flow management operation for mainstem habitat below Bonneville Dam will maintain the current water quantity and quality conditions and substrate supporting spawning, incubation and larval development. Prospective flow operations will also maintain the current access to spawning areas in Hamilton and Hardy creeks.

8.9.5.2 Effects of Tributary Habitat Prospective Actions

Under the Prospective Actions, the FCRPS Action Agencies' will consider funding habitat improvement projects for the historical Columbia River chum salmon population above Bonneville that has been significantly impacted by the FCRPS. Projects will be selected that are consistent with basin-wide criteria for prioritizing projects, including those derived from recovery and subbasin plans. However, the type and distribution of these potential projects is uncertain, in part because the RPA only commits the Action Agencies to achieving specific survival improvements for species in the Interior Columbia Basin.

Effects on Species Status

Tributary habitat projects, if implemented, will be selected such that they also address limiting factors and thus would also be likely to increase the viability of the local population(s).

Effects on Critical Habitat

If implemented, the potential tributary habitat improvements would address limiting factors, improving the functioning of PCEs in tributary habitat used by the Lower or Upper Gorge populations.

8.9.5.3 Effects of Estuary Habitat Prospective Actions

The FCRPS Action Agencies will carry out 44 estuary habitat projects over the first 3-year period of implementing the RPA (Section 12.3.2.3 in Corps et al. 2007b). The expected survival benefit for CR chum salmon associated with these actions will be less than 2.3%. The RPA requires the implementation of additional projects to obtain specified survival benefits for Interior Columbia Basin Chinook populations, but will also provide survival benefits to Columbia River chum salmon (an estimated 6.7%). Prospective Actions will address limiting factors by protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, reducing noxious weeds, and other actions.

Effects on Species Status

Prospective improvements in estuarine habitat will support the increased abundance, productivity, diversity, and spatial structure of CR chum salmon.

Effects on Critical Habitat

Prospective estuarine habitat improvements will improve the functioning of the PCEs of water quality and safe passage in rearing areas for subyearling chum salmon. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.9.5.4 Effects of Hatchery Prospective Actions

Under the Prospective Actions, the Action Agencies will continue to fund a hatchery program to reintroduce chum into Duncan Creek. The Washougal Hatchery program was designed to increase the number of naturally spawning chum salmon in Duncan Creek as part of a habitat improvement project. Adults are collected and transported to WDFW's Washougal Hatchery for broodstock to produce juveniles which are outplanted into Duncan Creek. All fish produced by the program are given an otolith mark so that researchers can determine whether using the hatchery program to boost egg-to-fry survival results in increased adult returns.

The Prospective Actions also require that the Action Agencies fund an assessment of habitat potential, the development of reintroduction strategies, implementation of a pilot supplementation projects in selected tributaries below Bonneville Dam.

Under the RPA (Action 39), the FCRPS Action Agencies will adopt programmatic criteria for funding decisions on hatchery mitigation programs for the FCRPS that incorporate BMPs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated by hatchery operators with the Action Agencies as cooperating agencies. For the lower Columbia, new HGMPs must be submitted to NOAA Fisheries and ESA consultations initiated by July 2009 and consultations must be completed by January 2010. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

Effects on Species Status

The ongoing Washougal Hatchery program and other prospective reintroduction pilot projects are expected to increase the abundance and productivity, as well as the spatial structure, of the Lower Gorge population.

Effects on Critical Habitat

The effects of prospective hatchery actions on PCEs and the conservation value of critical habitat will be evaluated in subsequent consultations on specific projects.

8.9.5.5 Effects of Harvest Prospective Actions

The 1999-2007, annual non-Indian commercial landings averaged 35 fish (TAC 2008, Table 32). Impacts in the recreational fishery (from non-retention mortalities) are expected to be zero fish in 2008-2017 (TAC 2008). The total impact rates on Columbia River chum for 2008-2017 are expected to average 1.6% (TAC 2008), but the incidental harvest rate is limited to no more than 5.0%. There are no records of chum harvest in tribal fisheries and no impacts are expected in treaty Indian fisheries in 2008-2017 (TAC 2008).

Effects on Species Status

The prospective harvest actions are not expected to affect the abundance or productivity of CR chum salmon.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for CR chum salmon.

8.9.5.6 Effects of Predation Prospective Actions

The prospective increase in incentives in the NPMP could result in an additional 1% survival if benefits are similar to those expected for subyearling Chinook salmon (see Section 8.10.5.6).

Effects on Species Status

Prospective actions that reduce predation on juveniles will support the increased abundance and productivity of CR chum salmon populations.

Effects on Critical Habitat

Continued implementation of the base Northern Pikeminnow Management Program and increased sport fishery reward structure could improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.9.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRPS

8.9.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on Columbia River Chum Salmon

This section summarizes the basis for conclusions at the ESU level.

8.9.6.1 Recent Status of the Columbia River Chum Salmon ESU

Columbia River chum salmon is a threatened species. There are only two populations in this ESU with more than a few spawners, the Grays River and Lower Gorge populations in the Coastal and Gorge MPGs, respectively. The construction of Bonneville Dam in the 1930s inundated spawning and early rearing habitat, so that the Upper Gorge population has been extirpated or nearly so. Most historical spawning tributaries below Bonneville are moderately or severely impaired in the lower reaches favored by chum salmon: access is limited by tide gates, dikes, and culverts and floodplains and side channels are no longer connected to the main channel. Flow management and climate changes together have decreased the delivery of suspended particulate matter and fine sediment to the estuary, and flow management and habitat alterations (dikes and revetments) have restricted the processes that create and maintain habitat diversity. Prior to the 1950s, harvest rates were as high as 70%. Large-scale changes in freshwater and marine environments also had substantial effects on salmonid population numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this ESU. The potential for additional risks due to climate change is described in Sections 5.7 and 8.1.3.

In terms of the primary constituent elements of critical habitat, the ability to function in support of the conservation of the species has been limited by the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in tributary spawning and estuary rearing areas. The functioning of mainstem spawning habitat has improved in recent years with operations to provide fall and winter tailwater elevations and flows for spawning, incubation, and emergence in the mainstem just downstream from Bonneville Dam. The flow operation also supports access to spawning habitat in Hamilton and Hardy creeks. However, daily flow fluctuations have sometimes created a barrier (i.e., entrapment on shallow sand flats) for fry moving into the mainstem rearing and migration corridor.

Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement in habitat conditions on state forest lands, which may have downstream effects that improve conditions in the lower gradient reaches needed for the conservation of chum salmon. . Federal agencies are implementing numerous projects within the range of CR chum salmon including road and bridge repairs, dredging and dock maintenance, timber sales, and streambank stabilizations. The effects of these projects on population viability will be neutral or they will have short- or even long-term adverse effects.

8.9.6.2 Effects of the FCRPS, Upper Snake, *U.S. v. Oregon* Prospective Actions on the Columbia River Chum Salmon ESU

NOAA Fisheries has adopted the LCFRB's (2004) recovery plan as its interim recovery plan for the Washington side of the Columbia River, including those populations within the Columbia River chum salmon ESU.[3] In the LCFRB's recovery plan, one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume." The Action Agencies' estuary habitat restoration projects will address this objective. Under the Prospective Actions, the Action Agencies will continue to implement the flow operations begun in recent years that provide spawning habitat in the mainstem and access to habitat in the tributaries just below Bonneville Dam and to fund a hatchery program to reintroduce chum into Duncan Creek. The Prospective Actions also require that the Action Agencies fund an assessment of habitat potential, the development of reintroduction strategies, implementation of a pilot supplementation projects in selected tributaries below Bonneville Dam. If projects are implemented, they could compensate for the loss of historical spawning habitat for the Upper Gorge population (inundated by Bonneville Dam) by improving the overall viability of the ESU.

The principal effects of the Prospective Actions on critical habitat will be an increase in the amount and quality of estuarine habitat (for the transitions between fresh- and saltwater and juvenile growth and development before entering the plume).

8.9.6.3 Cumulative Effects Relevant to the Columbia River Chum Salmon ESU

Habitat-related actions and programs that the states of Oregon and Washington have determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that

[3] The State of Oregon is in the process of developing a plan for this species. Upon its review, NOAA Fisheries will combine the Washington and Oregon plans into a complete recovery plan for the Lower Columbia River Recovery Domain.

affect instream habitat. These actions will primarily affect conditions within the tributary spawning and rearing areas, including the PCEs of critical habitat needed for successful spawning, incubation, and the growth and development of juvenile chum salmon.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for this consultation (the mainstem lower Columbia and tributary areas above Bonneville Dam), these are likely to include urban development and other land use practices.

8.9.6.4 Effects of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Columbia River Chum Salmon ESU

Impacts of the FCRPS and Upper Snake projects on this ESU are most significant for the 2 (out of 16) populations within the ESU that once spawned above or currently spawn just below Bonneville Dam, and are limited relative to impacts from tributary hydropower and tributary habitat. The Upper Gorge population was extirpated the inundation of spawning habitat. The Lower Gorge population will continue to be affected by operations in the Bonneville tailrace, but for populations originating further downstream, only rearing habitat conditions in the mainstem and estuary are affected by the existence and operation of the hydrosystem.

The states of Oregon and Washington have identified tributary habitat actions that are reasonably certain to occur and that will be generally beneficial throughout the ESU. The State of Washington identified actions in the Washougal that will improve habitat conditions for that potion of the Lower Gorge population. Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement in habitat conditions on state forest lands, which may have downstream effects that improve conditions in the lower gradient reaches needed for the conservation of chum salmon.

The Action Agencies' prospective hydrosystem operation and estuary habitat improvements, by addressing the influence of their projects, will contribute to the viability of this ESU and thus to its survival with an adequate potential for recovery. Potential tributary habitat projects could further improve viability by compensation for the loss of populations in the Upper Gorge (above Bonneville Dam). The Prospective Action s will not further deteriorate this pre-action condition.

Long term (100 year) extinction risk is high or very high for almost all populations in the ESU. The only exception is the Lower Gorge population, at least on the Washington side of the river. In the short term, the species extinction risk is expected to be reduced through implementation of the actions described above. In particular, the genetic legacy of the Grays River and mainstem Columbia portion of the Lower Gorge population will continue to be preserved by ongoing hatchery actions as a hedge against the short-term risk of extinction.

8.9.6.5 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat for the Columbia River Chum Salmon ESU

NOAA Fisheries designated critical habitat for CR chum salmon including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the White Salmon River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Cowlitz, Lower Columbia, and Grays/Elochoman. The environmental baseline within the action area, which includes the Middle Columbia/Hood and Lower Columbia/Sandy subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for CR chum salmon. The major factors currently limiting the conservation value of critical habitat are barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, riparian vegetation, and space in some tributary and estuarine areas used for spawning, incubation, and larval growth and development.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions include habitat work in tributaries used for spawning and rearing in the lower Columbia River and estuary, which will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. In addition, a number of actions in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).

The aggregate effect of the environmental baseline, Prospective Actions, and cumulative effects will be an improvement in the functioning of PCEs used for spawning, incubation, juvenile growth and development, migration, and juvenile and adult transitions between fresh and salt water. Considering the ongoing and future effects of the environmental baseline and cumulative effects, the Prospective Actions will be adequate to ensure that they will not reduce the ability of critical habitat to serve its conservation role for this species.

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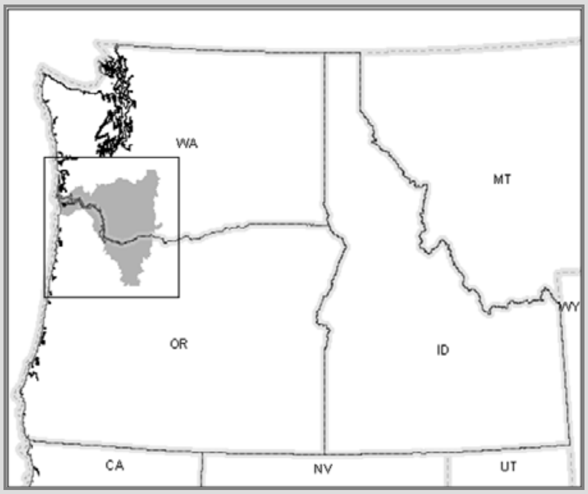
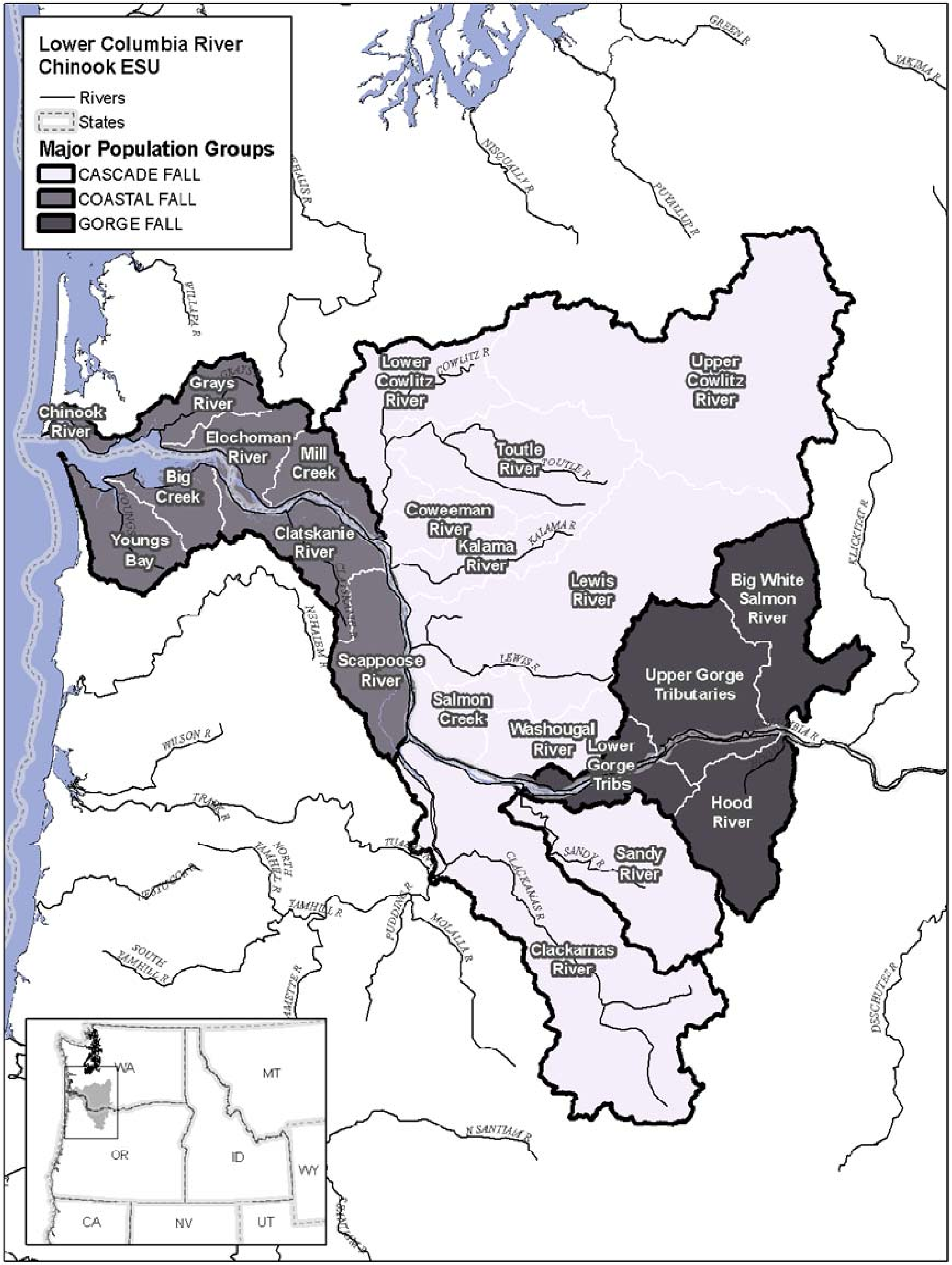
Section 8.10
Lower Columbia River Chinook Salmon




Lower Columbia River
Chinook ESU
Rivers
States
Major Population Groups
CASCADE FALL
COASTAL FALL
GORGE FALL
Chinook River
Grays River
Elochoman River
Mill Creek
Big Creek
Youngs Bay
Clatskanie River
Scappoose River
Lower Cowlitz River
Upper Cowlitz River
Toutle River
Coweeman River
Kalama River
Lewis River
Salmon Creek
Washougal River
Lower Gorge Tribs
Upper Gorge Tributaries
Big White Salmon River
Hood River
Sandy River
Clackamas River
GREEN R
YAKIMA R
NISQUALLY R
PUYALLUP R
WILLAPA R
COWLITZ R
TOUTLE R
KALAMA R
LEWIS R
KLICKITAT R
NEHALEM R
WILSON R
SANDY R
CLACKAMAS R
MOLALLA R
YAMHILL R
SOUTH YAMHILL R
N SANTIAM R
DESCHUTES R
WA
MT
OR
ID
WY
CA
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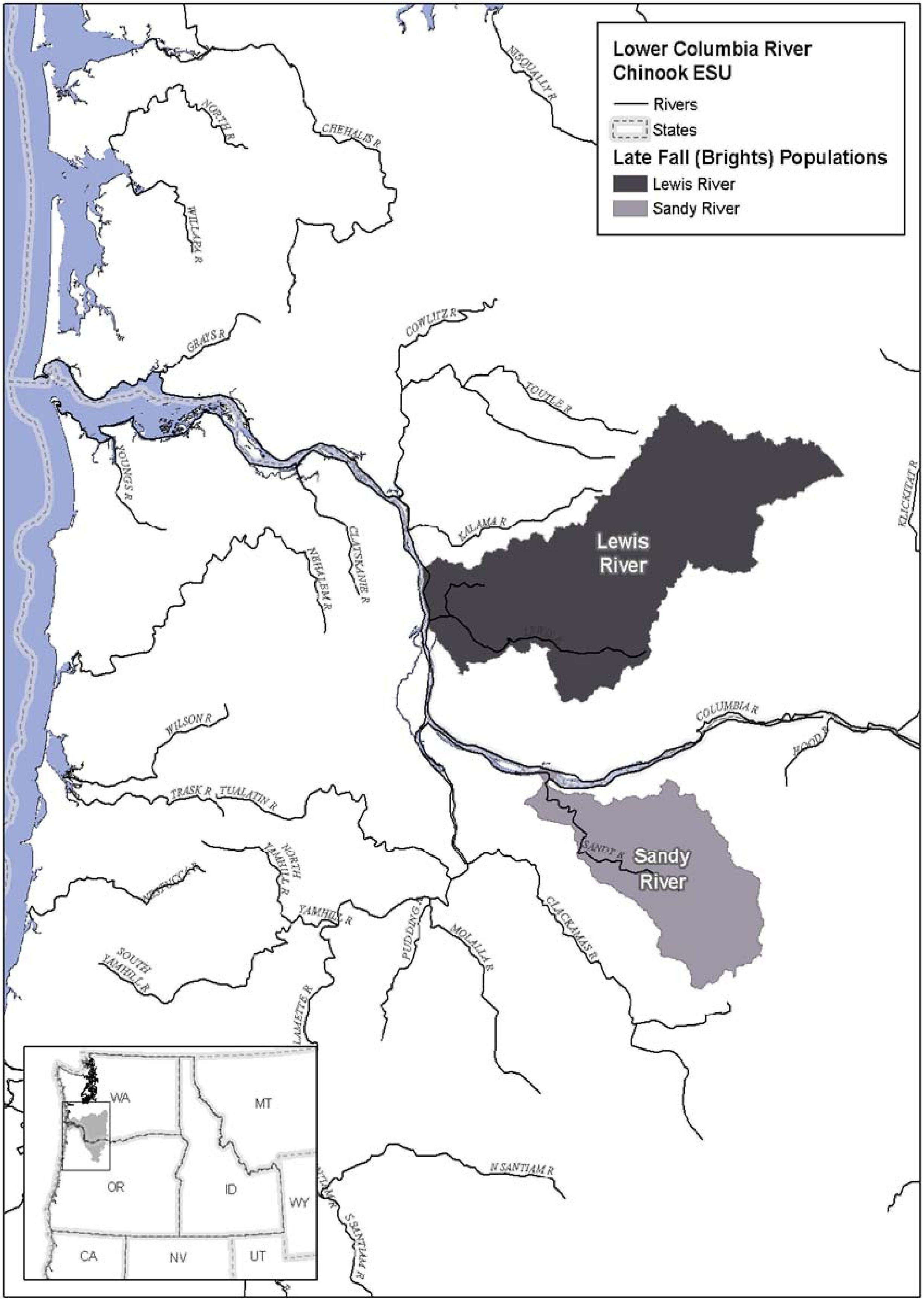
Lower Columbia River
Chinook ESU
Rivers
States
Late Fall (Brights) Populations
Lewis River
Sandy River
Lewis
River
Sandy
River
NISQUALLY R
CHEHALIS R
NORTH R
WILLAPA R
GRAYS R
COWLITZ R
TOUTLE R
YOUNGS R
KALAMA R
CLATSKANIE R
NEHALEM R
KLICKITAT R
COLUMBIA R
HOOD R
WILSON R
TRASK R
TUALATIN R
SANDY R
NORTH YAMHILL R
YAMHILL R
PUDDING R
MOLALLA R
CLACKAMAS R
SOUTH YAMHILL R
N SANTIAM R
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WA
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CA
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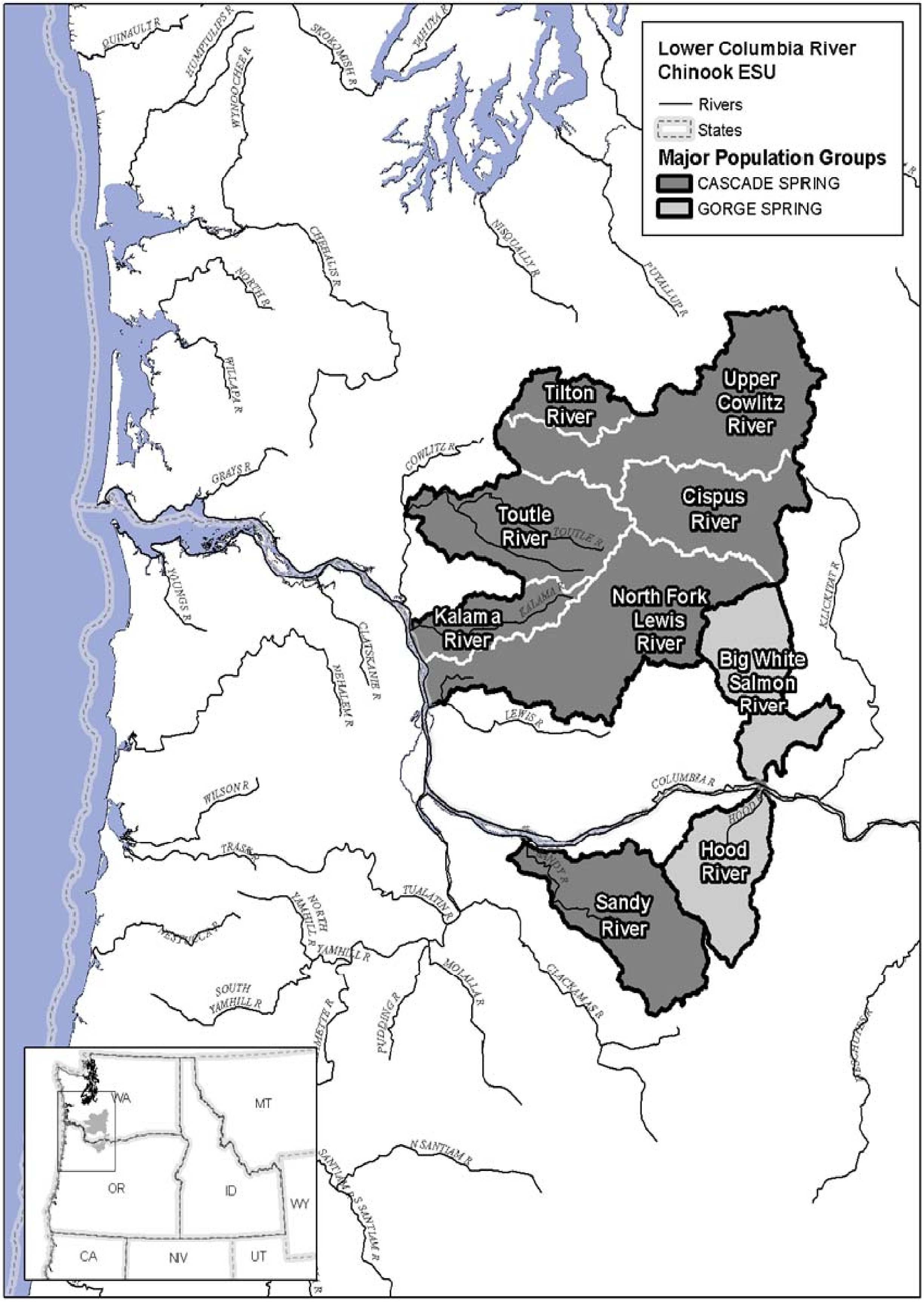
Lower Columbia River Chinook ESU
Rivers
States
Major Population Groups
CASCADE SPRING
GORGE SPRING
Tilton River
Upper Cowlitz River
Cispus River
Toutle River
Kalama River
North Fork Lewis River
Big White Salmon River
Hood River
Sandy River
QUINAULT R
HUMPTULIPS R
WYNOOCHEE R
SKOKOMISH R
CHEHALIS R
NORTH R
WILLAPA R
NISQUALLY R
PUYALLUP R
COWLITZ R
GRAYS R
TOUTLE R
KALAMA R
YOUNGS R
CLATSKANIE R
NEHALEM R
LEWIS R
KLICKITAT R
COLUMBIA R
WILSON R
TRASK R
TUALATIN R
NORTH YAMHILL R
YAMHILL R
SOUTH YAMHILL R
MOLALLA R
CLACKAMAS R
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Section 8.10
Lower Columbia River Chinook Salmon

Species Overview

Background

The Lower Columbia River (LCR) Chinook salmon ESU includes all naturally spawned populations from the mouth of the Columbia River upstream to and including White Salmon River in Washington and the Hood River in Oregon. Additionally, this ESU includes the Willamette River upstream to Willamette Falls (exclusive of the spring-run Chinook salmon in the Clackamas River), as well as 17 artificial propagation programs. There are six major population groups in this ESU, including 32 historical populations, seven of which are extirpated or nearly so. Lower Columbia River Chinook numbers began to decline by the early 1900s because of habitat degradation and harvest rates and were listed under the ESA as threatened in 1999. The listing was reaffirmed in 2005.

Designated critical habitat for this ESU includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in a number of tributary subbasins.

Current Status & Recent Trends

Many of the populations in this ESU currently have for which data are available have low abundances and many of the long- and short-term trends in abundance are negative, some severely so. Some of the natural runs largely have been replaced by hatchery production.

Limiting Factors

Human impacts and limiting factors for the LCR Chinook include habitat degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and predation. Lower Columbia River Chinook populations began declining in the early 1900s because of habitat changes and harvest rates. FCRPS impacts have been limited, but are most significant for the five populations that spawn in tributaries above Bonneville Dam. These populations are affected by upstream and downstream passage and the inundation of spawning habitat for fall-run Chinook in the lower reaches of the tributaries to the reservoir. For populations originating in tributaries below Bonneville, migration and habitat conditions in the mainstem and estuary have been affected by hydrosystem flow operations. Tributary habitat degradation is pervasive due to development and other land uses, and FERC-licensed hydroelectric projects have blocked some spawning areas. Hatchery production for LCR Chinook has reduced the diversity and productivity of natural populations throughout the ESU. Predators take a significant number of juveniles and adults, particularly from spring-run populations.

Recent Ocean and Mainstem Harvest

Lower Columbia River spring Chinook populations are caught incidentally in ocean fisheries, primarily off the Washington coast and as far north as Alaska, and in spring season fisheries in the Columbia River mainstem and tributaries. In recent years, the total exploitation rates for the Cowlitz spring Chinook population (as a surrogate for all spring Chinook populations of the LCR Chinook ESU) were generally higher prior to the mid 1990s, averaging 50% through 1994. Total exploitation rates have averaged approximately 27% since 1995. The average exploitation rates for non-Treaty fisheries in the Columbia River for these same periods were 27% and 12% respectively.

Lower Columbia River fall-run (tule) Chinook populations are caught in ocean fisheries off the coasts of Oregon, Washington, and British Columbia. Total exploitation rates were generally higher through 1993 (averaging 69%), lower from 1994 to 1999 (averaging 34%), then increasing since 2000 (averaging 49%). From 2002 to 2006 fisheries were managed subject to a 49% exploitation rate limit. Total exploitation rates have been higher in some years but have averaged 49% from 2002 to 2006. The average exploitation rates for non-Treaty fisheries in the Columbia River for these same periods were 16%, 8% and 9% respectively.

Total exploitation rates estimates to the North Fork Lewis bright Chinook population (as a surrogate for all “bright” Chinook populations of the LCR Chinook ESU) were generally higher through 1989 (averaging 56%), declining during the decade of the 1990s (averaging 36%), and increased slightly since 2000 (averaging 38%). The average exploitation rates for non-Treaty fisheries in the Columbia River for these same periods were 25%, 14% and 16% respectively.

8.10.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.10.2.1 Current Rangewide Status of the Species

Lower Columbia River Chinook display three life history types including early fall runs ("tules"), late fall run ("brights") and spring-runs (Table 8.10.2.1-1). Both spring and fall runs have been designated as part of a Lower Columbia River Chinook ESU. This ESU includes populations in tributaries from the ocean to the Big White Salmon River in Washington and Hood River in Oregon. Fall Chinook salmon historically were found throughout the entire range, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries). Late fall Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, late fall Chinook salmon also matured at an older average age than either lower Columbia River spring or fall Chinook salmon, and had a more northerly oceanic distribution. Currently, the abundance of fall Chinook greatly exceeds that of the spring component.

Table 8.10.2.1-1. Life history and population characteristics of Chinook salmon originating in Washington portions of the lower Columbia River.

	Racial Features		
Characteristic	**Spring**	**Tule Fall**	**Late Fall Bright**
Number of extant populations	7 (including 4 that are possibly extinct)	13	1
Life history type	Stream	Ocean	Ocean
River entry timing	March-June	August-September	August-October
Spawn timing	August-September	September-November	November-January
Spawning habitat type	Headwater large tributaries	Mainstem large tributaries	Mainstem large tributaries
Emergence timing	December-January	January-April	March-May
Duration in freshwater	Usually 12-14 months	1-4 months, a few up to 12 months	1-4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	Mainstem, tributaries, sloughs, estuary	Mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months

	Racial Features		
Characteristic	**Spring**	**Tule Fall**	**Late Fall Bright**
Ocean migration	As far North as Alaska	As far North as Alaska	As far North as Alaska
Age at return	4-5 Years	3-5 Years	3-5 Years
Estimated historical spawners	125,000	140,000	19,000
Recent natural Spawners	800	6,500	9,000
Recent hatchery adults	12,600 (1990-2000)	37,000 (1991-1995)	NA

The Lower Columbia River Chinook salmon ESU is composed of 32 historical populations. The populations are distributed through three ecological zones. The combination of life history types based on run timing, and ecological zones result in six major population groups (referred to as strata by the Willamette-Lower Columbia Technical Recovery Team (WLC TRT) (Table 8.10.2.1-2 and Lower Columbia River Chinook maps). There are 23 (tule) fall- and (bright) late fall-run populations, and nine spring-run populations, some of which existed historically but are now extirpated or nearly so. Also included in the ESU are 17 hatchery programs. Excluded from the ESU are Carson spring Chinook and introduced bright fall Chinook occurring in the Wind and (Big) White Salmon rivers as well as spring Chinook released at terminal fishery areas in Youngs Bay, Blind Slough, and Deep River and in the mainstem Columbia. Populations of spring Chinook in the Willamette, including the Clackamas, are in a different ESU.

Fall Chinook enter freshwater typically in August through October to spawn in large river mainstems and the juvenile life history stage emigrates from freshwater as subyearlings (ocean type). Spring Chinook enter fresh water in March through June to spawn in upstream tributaries and generally emigrate from freshwater as yearlings (stream type). Listed populations of LCR Chinook salmon are stratified by biological, geographical, and ecological considerations into the six major population groups shown in Table 8.10.2.1-2, below.

Table 8.10.2.1-2 LCR Chinook salmon ESU description and major population groups (MPGs) (Sources: NMFS 2005a; Myers et al. 2006). The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (Appendix B in WLCTRT 2003).[1]

ESU Description	
Threatened	Listed under ESA in 1999; reaffirmed in 2005
6 major population groups	32 historical populations
Major Population Group	**Population**
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, Lewis (C), Sandy (C,G)
Gorge Spring	White Salmon (C), Hood
Coastal Fall	Grays, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose
Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy
Cascade Late Fall	Lewis (C,G), Sandy (C,G)
Gorge Fall	Lower Gorge, Upper Gorge (C,G), White Salmon (C,G), Hood
Hatchery programs included in ESU (17)	Sea Resources Tule Chinook, Big Creek Tule Chinook, Astoria High School (STEP) Tule Chinook, Warrenton High School (STEP) Tule Chinook, Elochoman River Tule Chinook, Cowlitz Tule Chinook Program, North Fork Toutle Tule Chinook, Kalama Tule Chinook, Washougal River Tule Chinook, Spring Creek NFH Tule Chinook, Cowlitz spring Chinook (2 programs), Friends of Cowlitz spring Chinook, Kalama River spring Chinook, Lewis River spring Chinook, Fish First spring Chinook, Sandy River Hatchery (ODFW stock #11)

Limiting Factors

Lower Columbia River Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable given these changing habitat conditions. Human impacts and limiting factors come from multiple sources: habitat degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and ecological factors including predation. Tributary habitat has been degraded by extensive development and other types of land use. Fall Chinook spawning and rearing habitat in tributary mainstems has been adversely affected by sedimentation, increased temperatures, and reduced habitat diversity. Spring Chinook access to subbasin headwaters has been restricted or eliminated by the construction of non-Federal dams without fish passage. Five populations (Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run) are subject to FCRPS impacts involving passage at Bonneville Dam and all populations are affected by habitat alterations in the Columbia River mainstem and estuary. Many naturally-spawning populations have

[1] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the ESU (WLCTRT 2003).

been subject to the effects of a high incidence of naturally-spawning hatchery fish. The species was subject to harvest rates of 50% or more until recent years. Preservation and recovery of this ESU will require significant efforts by many parties.

Summarized below (Table 8.10.2.1-2) are key limiting factors for this ESU and recovery strategies to address those factors as described in the Washington Lower Columbia Recovery and Subbasin Plan [Lower Columbia Fish Recovery Board (LCFRB) 2004]. Oregon is currently engaged in the recovery planning process for LCR Chinook salmon.

Table 8.10.2.1-2. Key limiting factors for LCR Chinook salmon.

Mainstem Hydro	Direct mainstem hydropower system impacts on LCR Chinook salmon are most significant for the five gorge tributary populations upstream from Bonneville Dam (Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run). These populations are affected by upstream and downstream passage at Bonneville Dam and spawning habitat in the lower reaches of the tributaries used by the Upper Gorge fall-run population were inundated by Bonneville pool. Federal hydrosystem impacts on populations originating in downstream subbasins are limited to effects on migration and habitat conditions in the lower Columbia River (below Bonneville Dam) including the estuary.
Predation	Piscivorous birds including Caspian terns and cormorants, fishes including northern pikeminnow, and marine mammals including seals and sea lions take significant numbers of juvenile or adult salmon. Stream-type juveniles, especially yearling smolts from spring-run populations, are vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid water over the channel, which is located near habitat preferred by piscivorous birds (Fresh et al 2005). However, recent research shows that subyearlings from the LCR Chinook ESU are also subject to tern predation, probably because of their long estuarine residence time (Ryan et al. 2006). In addition, spring Chinook are subject to pinniped predation when they return to the estuary as adults (NMFS 2006b). Caspian terns as well as cormorants may be responsible for the mortality of up to 6% of the outmigrating stream-type juveniles in the Columbia River basin [1998 data, from Bonneville Power Administration (BPA 2004) and 2006 data from Roby (2006) as cited in Corps et al. 2007a]. Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999). Ongoing actions to reduce predation effects include redistribution of avian predator nesting areas, a sport reward fishery to harvest pikeminnow, and the exclusion, hazing, and in some cases, lethal take of marine mammals near Bonneville Dam.
Harvest	LCR Chinook salmon are harvested in the Columbia River and its tributaries and in ocean fisheries off Oregon, Washington, and Canada. Historical harvest

	rates on some populations of Chinook salmon reached 80% or more. Permitted incidental harvest rate limits for fall-run Chinook salmon dropped from 65% just after listing to 42% in 2007. Incidental harvest rates on spring-run fish have been reduced from 50 to 25% (LCFRB 2004).
Hatcheries	Hatchery management practices have reduced the diversity and productivity of natural populations throughout the Columbia River Basin. The long-term domestication of hatchery fish has reduced the productivity of some wild stocks where significant numbers of hatchery fish spawn, especially for tule fall Chinook populations. Large numbers of hatchery fish have also contributed to more intensive mixed stock fisheries, which probably overexploited wild populations already weakened by habitat degradation. For spring Chinook, virtually all production in the Washington portion of the lower Columbia River is of hatchery origin, and Oregon populations of spring Chinook are also subject to significant hatchery influence. State and Federal hatchery programs throughout the lower Columbia River are currently the subject of a series of comprehensive reviews for consistency with the recovery needs of listed salmonids. A variety of beneficial changes to hatchery programs have already been implemented and additional changes are anticipated.
Estuary	The estuary is a particularly important habitat for migrating salmonids from LCR Chinook populations. Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats: emergent marshes, tidal swamps, and forested wetlands. These habitats are used extensively by subyearling juveniles. The survival of larger (yearling) juveniles in the ocean can be affected by habitat factors in the estuary such as changes in food availability and the presence of contaminants. Changes in the seasonal hydrograph as a result of water use and reservoir storage throughout the Columbia basin have altered habitat-forming processes including the shape, behavior, size, and composition of the plume compared to historical conditions. Characteristics of the plume are thought to be significant to spring-run yearling migrants during transition to the ocean phase of their lifecycle (Fresh 2004). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2006b).
Habitat	Widespread development and other land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats where fall Chinook salmon spawn and rear. Most of the significant mainstem spawning habitats in large previously-productive systems such as the Cowlitz River have been extensively diked and filled. In addition to cumulative habitat effects, the construction of non-Federal hydropower facilities on Columbia River tributaries has partially or completely

	blocked higher elevation spawning. The Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004) identifies current habitat values, restoration potential, limiting factors, and habitat protection and restoration priorities for Chinook by reach in all Washington subbasins. Similar information is in development for Oregon subbasins.
Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status of this ESU to some extent, future trends, especially during the period relevant to the Proposed Actions, are unclear. Under the adaptive management implementation approach of the Lower Columbia River Recovery and Subbasin Plan, further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through additional recovery effort (LCRFB 2004).

Abundance, Productivity & Trends

The information in Table 8.10.2.1-3 was reported in NOAA Fisheries' most recent status review (Good et al. 2005). Draft status assessments were updated for Oregon populations in a more recent review (McElhany et al. 2007). Some of the natural runs (e.g., the Youngs Bay, Kalama River and Upper and Lower Gorge fall runs, and all of the spring-run populations) have been replaced largely by hatchery production. Quantitative data is only available for about half of the populations

The majority of populations for which data are available have a long-term trend of less than 1.0, indicating the population is in decline. In addition, for most populations there is a high probability that the true trend/growth rate is less than 1.0 (Table 16 in Good et al. 2005). Assuming that the reproductive success of hatchery-origin fish has been equal to that of natural-origin fish, the analysis indicates a negative long-term growth rate for all of the populations except the Coweeman River fall run, which has had very few hatchery-origin spawners. The North Fork Lewis River late fall population is considered the healthiest and is significantly larger than any other population in the ESU. The data used for the analysis shown in Table 8.10.2.1-3 is current only through 2001 for Washington populations and 2004 for Oregon populations. More recent estimates of escapement along with available data for the time series are shown in Tables 8.10.2.1-4 and 8.10.2.1-6 through 8.10.2.1-8.

Table 8.10.2.1-3. Abundance, productivity, and trends of LCR Chinook salmon populations (sources: Good et al. 2005 for Washington and McElhany et al. 2007 for Oregon populations).

Strata	Population	State	Recent Abundance of Natural Spawners			Long-term Trend[b]		Median Growth Rate[c]	
			Years	Geo Mean	pHOS[a]	Years	Value	Years	λ
Cascade Spring	Cowlitz	W	na	na	na	80-01	0.994	na	na
	Cispus	W	2001	1,787	na	na	na	na	na
	Tilton	W	na	na	na	na	na	na	na
	Toutle	W	na	na	na	na	na	na	na
	Kalama	W	97-01	98	na	80-01	0.945	na	na
	NF Lewis	W	97-01	347	na	80-01	0.935	na	na
	Sandy	O	90-04	959	52%	90-04	1.047	90-04	0.834
Gorge Spring	White Salmon	W	na	na	na	na	na	na	na
	Hood	O	94-98	51	na	na	na	na	na
Coastal Fall	Grays	W	97-01	59	38%	64-01	0.965	80-01	0.844
	Elochoman	W	97-01	186	68%	64-01	1.019	80-01	0.800
	Mill	W	97-01	362	47%	80-01	0.965	80-01	0.829
	Youngs Bay	O	na	na	na	na	na	na	na
	Big Creek	O	na	na	na	na	na	na	na
	Clatskanie	O	90-04	41	15%	90-04	1.077	90-04	1.152
	Scappoose	O	na	na	na	na	na	na	na
Cascade Fall	Lower Cowlitz	W	96-01	463	62%	64-00	0.951	80-01	0.682
	Upper Cowlitz	W	na	na	na	na	na	na	na
	Toutle	W	na	na	na	na	na	na	na
	Coweeman	W	97-01	274	0%	64-01	1.046	80-01	1.091
	Kalama	W	97-01	655	67%	64-01	0.994	80-01	0.818
	Lewis	W	97-01	256	0%	80-01	0.981	80-01	0.979
	Salmon	W	na	na	na	na	na	na	na
	Washougal	W	97-01	1,130	58%	64-01	1.088	80-01	0.815
	Clackamas	O	98-01	40	na	67-01	0.937	na	na
	Sandy	O	97-01	183	na	na	na	na	na

Strata	Population	State	Recent Abundance of Natural Spawners			Long-term Trend[b]		Median Growth Rate[c]	
			Years	Geo Mean	pHOS[a]	Years	Value	Years	λ
Gorge Fall	Lower Gorge	W/O	na	na	na	na	na	na	na
	Upper Gorge	W/O	97-01	109	13%	64-01	0.935	80-01	0.955
	White Salmon	W	97-01	218	21%	67-01	0.941	80-01	0.945
	Hood River	O	00-04	36	na	na	na	na	na
Cascade Late Fall	NF Lewis	W	97-01	6,818	13%	64-01	0.992	80-01	0.948
	Sandy	O	90-04	2,771	5%	81-04	0.983	81-04	0.997

The LCFRB Recovery Plan described a recovery scenario for Lower Columbia River Chinook. They identified each population's role in recovery as a primary, contributing, or stabilizing populations which generally refer to a desired viability level. The Recovery Plan also suggested viable abundance goals for each population (Table 8.10.2.1-4).

Table 8.10.2.1-4. The ecological zones and populations for the Lower Columbia River Chinook salmon ESU (LCFRB 2004). Primary populations identified for greater than high viability objectives are denoted with an asterisk.

Population/Strata	Status /Goal[1]	Abundance Range		Recent Average (2002-2006)	
		Viable	Potential	Natural-Origin Spawners	% wild
GORGE SPRING					
White Salmon (WA)	C	1,400	2,800	5,237	19
Hood (OR)	P	1,400	2,800		
CASCADE SPRING					
Upper Cowlitz (WA)	P*	2,800	8,100		
Cispus (WA)	P*	1,400	2,300		
Tilton (WA)	S	1,400	2,800		
Toutle (WA)	C	1,400	3,400		
Kalama (WA)	P	1,400	1,400		
NF Lewis (WA)	P	2,200	3,900		
Sandy (OR)	P	2,600	5,200		

Population/Strata	Status /Goal[1]	Abundance Range		Recent Average (2002-2006)	
		Viable	Potential	Natural-Origin Spawners	% wild
CASCADE LATE FALL					
NF Lewis (WA)	P*	6,500	16,600		
Sandy (OR)	P	5,100	10,200		
COAST FALL (Tule)					
Grays/Chinook (WA)	P	1,400	1,400	336	78
Eloch/Skam (WA)	P	1,400	4,500	4,751	31
Mill/Aber/Germ (WA)	C	2,000	3,200	4,063	23
Youngs Bay (OR)	S	1,400	2,800		
Big Creek (OR)	S	1,400	2,800		
Clatskamie (OR)	P	1,400	2,800	179	43
Scapoose (OR)	S	1,400	2,800		
CASCADE FALL (Tule)					
Lower Cowlitz (WA)	C	3,900	33,200		
Upper Cowlitz (WA)	S	1,400	10,800		
Toutle (WA)	S	1,400	14,100		
Coweeman (WA)	P*	3,000	4,100	1,128	82
Kalama (WA)	P	1,300	3,200	12,680	7
EF Lewis/Salmon (WA)	P*	1,900	3,900	597	75
Washougal (WA)	P	5,800	5,800	5,334	39
Clackamas (OR)	C	1,400	2,800		
Sandy (OR)	S	1,400	2,800		
GORGE FALL (Tule)					
Lower Gorge (WA)	C	1,400	2,800		
Upper Gorge (WA)	S	1,400	2,400		
White Salmon (WA)	C	1,600	3,200		
Hood (OR)	S	1,400	2,800		

[1] *Primary populations* are those that would be restored to high or "high+" viability. At least two populations per strata must be at high or better viability to meet recommended TRT criteria. Primary populations typically, but not always, include those of high significance and medium viability. In several instances, populations with low or very low current viability were designated as primary populations in order to achieve viable strata and ESU conditions. In addition, where factors suggest that a greater than high viability level can be achieved, populations have been designated as High+. High+ indicates that the population is targeted to reach a viability level between High and Very High levels as defined by the TRT. *Contributing populations* are those for which some restoration will be needed to achieve a stratum-wide average of medium viability.

Population/Strata	Status /Goal[1]	Abundance Range		Recent Average (2002-2006)	
		Viable	Potential	Natural-Origin Spawners	% wild
Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery. *Stabilizing populations* are those that would be maintained at current levels (likely to be low viability). Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high.					

WLCTRT (2003) analyzed the number of stream kilometers historically and currently available to salmon populations in the lower Columbia River (Table 8.10.2.1-5). Stream kilometers usable by salmon are determined based on simple gradient cutoffs, as well as on the presence of impassable barriers. This approach overestimates the number of usable stream kilometers, because it does not account for aspects of habitat quality other than gradient. However, the analysis does indicate that the number of kilometers of stream habitat currently accessible is greatly reduced from the historical condition for some populations. Hydroelectric projects in the Cowlitz, Lewis, and White Salmon Rivers have greatly reduced or eliminated access to upstream production areas and therefore extirpated some of the affected populations.

Table 8.10.2.1-5. Current and historically available habitat located below barriers in the Lower Columbia River Chinook salmon ESU (WLCTRT 2003).

Population/Strata	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current/ Historical Habitat Ratio (%)
GORGE SPRING			
White Salmon (WA)	0	232	0
Hood (OR)	150	150	99
CASCADE SPRING			
Upper Cowlitz (WA)	4	276	1
Cispus (WA)	0	76	0
Tilton (WA)	0	93	0
Toutle (WA)	217	313	69
Kalama (WA)	78	83	94
Lewis (WA)	87	365	24
Sandy (OR)	167	218	77
CASCADE LATE FALL			
NF Lewis (WA)	87	166	52
Sandy (OR)	217	225	96
COAST FALL (Tule)			

Population/Strata	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current/ Historical Habitat Ratio (%)
Grays/Chinook (WA)	133	133	100
Eloch/Skam (WA)	85	116	74
Mill/Aber/Germ (WA)	117	123	96
Youngs Bay (OR)	178	195	91
Big Creek (OR)	92	129	71
Clatskamie (OR)	159	159	100
Scapoose (OR)	122	157	78
CASCADE FALL (Tule)			
Lower Cowlitz (WA)	418	919	45
Upper Cowlitz (WA)	-	-	-
Toutle (WA)	217	313	69
Coweeman (WA)	61	71	86
Kalama (WA)	78	83	94
Lewis/Salmon (WA)	438	598	73
Washougal (WA)	84	164	51
Clackamas (OR)	568	613	93
Sandy (OR)	227	286	79
GORGE FALL (Tule)			
Lower Gorge (WA)	34	35	99
Upper Gorge (WA)	23	27	84
White Salmon (WA)	0	71	0
Hood (OR)	35	35	100

As briefly addressed above, the return of spring Chinook to the Cowlitz, Kalama, Lewis, and Sandy river populations have all numbered in the thousands in recent years (Table 8.10.2.1-6). The Cowlitz and Lewis populations on the Washington side are managed for hatchery production since most of the historical spawning habitat is inaccessible due to hydro development in the upper basin. A supplementation program is now operated on the Cowlitz River that involves trap and haul of adults and juveniles. A supplementation program is also being developed on the Kalama with fish being passed above the ladder at Kalama Falls. Historically, the Kalama was a relatively small system compared to the other three (Table 8.10.2.1-5). A supplementation program is also being developed for the Lewis River, but the spring Chinook production is still dependent on hatchery production. These systems have all met their respective hatchery escapement goals in recent years, and are expected to do so again in 2008. The existence of the hatchery programs mitigates the risk to these populations. The Cowlitz and Lewis populations would have been extirpated if not for the hatchery programs.

The Sandy River is managed with an integrated hatchery supplementation program that incorporates natural-origin brood stock. There is some spawning in the lower river, but the area upstream from the old Marmot Dam location is preserved for natural-origin production. The return of natural-origin fish to this area (i.e., upstream from the old Marmot Dam site) has averaged almost 1,800 since 2000. This does not account for the additional spawning of natural-origin fish below the dam (prior to its removal). This tentative viable abundance goal for Sandy River spring Chinook is 2,600, although the goal is subject to reconsideration through Oregon's ongoing recovery planning process. The total return of spring Chinook to the Sandy including hatchery fish has averaged more than 7,000 since 2000 (Table 8.10.2.1-6).

Table 8.10.2.1-6. Total annual escapement of Lower Columbia River spring Chinook populations (TAC 2008).

Year or Average	Cowlitz River [a]	Kalama River	Lewis River [a]	Sandy River (Total)	Sandy River (natural-origin fish at Marmot Dam)[b]
1971-1975	11,900	1,100	200	-	
1976-1980	19,680	2,020	2,980	975	
1981-1985	19,960	3,740	4,220	1,940	
1986-1990	10,691	1,877	11,340	2,425	
1991-1995	6,801	1,976	5,870	5,088	
1996	1,787	627	1,730	3,997	
1997	1,877	505	2,196	4,625	
1998	1,055	407	1,611	3,768	
1999	2,069	977	1,753	3,985	
2000	2,199	1,418	2,515	3,641	1,984
2001	1,649	1,784	3,777	5,329	2,445
2002	5,019	2,883	3,554	5,903	1,275
2003	15,890	4,528	5,104	5,600	1,151
2004	16,712	4,573	11,090	12,675	2,698
2005	9,200	3,100	3,400	7,475	1,808
2006	7,000	5,600	7,500	4,812	1,381

Year or Average	Cowlitz River [a]	Kalama River	Lewis River [a]	Sandy River (Total)	Sandy River (natural-origin fish at Marmot Dam)[b]
2007	3,700	7,300	6,700	3,400	790

[a] Includes hatchery escapements, tributary recreational catch, and natural spawning escapement for 1975 to present. The years 1071-73 are based on using he 1975-76 Cowlitz River recreational fishery adult harvest rate
[b] TAC (2008)

There are two bright Chinook populations in the Lower Columbia River Chinook ESU in the Sandy and North Fork Lewis rivers. The Sandy population is currently the less robust. The escapement of natural-origin fish has been variable, but without apparent trend over the last 14 years and has averaged approximately 750 since 2002 (Table 8.10.1.1-7). The viable abundance goal is 5,100 from the LCFRB Recovery Plan, but this is likely high and is being reviewed as Oregon proceeds with its recovery planning process. The North Fork Lewis population is the principal indicator stock. It is a natural-origin population with little or no hatchery influence. The maximum sustained yield escapement goal is 5,700. The viable abundance goal is 6,500. The population has exceeded its escapement goal, often by a wide margin, in most years over the last twenty years or more, although not in 2007. This is consistent with a pattern of low escapements for other far north migrating bright populations including Oregon coastal stocks and upriver brights that return to the Hanford Reach area. This pattern of low escapements for a diverse range of stocks with similar migration pattern and life history suggests that they were all affected by poor ocean conditions.

Table 8.10.2.1-7. Annual escapement of Lower Columbia River bright fall Chinook populations (TAC 2008).

Year	Sandy River	North Fork Lewis
993	1,314	6,429
1994	941	8,439
1995	1,036	9,718
1996	505	12,700
1997	2,001	8,168
1998	773	5,167
1999	447	2,639
2000	84	8,727
2001	824	11,272
2002	1,275	13,284
2003	619	13,433

2004	601	14,165
2005	770	10,197
2006	1,130	10,522
2007	171	3,170

Table 8.10.2.1-8 shows escapements for several of the tule populations including estimates of the proportion of spawners that are natural-origin. The Coweeman, Grays, and East Fork Lewis populations are subject to less hatchery straying. The Cowlitz, Kalama, Washougal, Elochoman, and Mill/Abernathy/Germany populations are more strongly influenced by hatchery fish because of in-basin hatchery programs, or their close proximity to such programs. The natural-origin populations are generally below their viability abundance goals (Table 8.10.2.1-4). The hatchery origin fish are generally at or above their viability goals, but only because of the contribution of hatchery fish.

Table 8.10.2.1-8. Annual escapement for several Lower Columbia River tule Chinook populations (TAC 2008)

Year	Coweeman		Grays		Lewis		Cowlitz		Kalama		Washougal		Elochoman		Ge/Ab/Mi	
	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild
1977	337	1.00	1,009	0.65	1,086		5,837	0.26	6,549	0.50	1,652	0.46	568			
1978	243	1.00	1,806	0.65	1,448		3,192	0.26	3,711	0.50	593	0.46	1,846			
1979	344	1.00	344	0.65	1,304		8,253	0.26	2,731	0.50	2,388	0.46	1,478			
1980	180	1.00	125	0.65	899	1.00	1,793	0.26	5,850	0.50	3,437	0.46	64	0.42	516	0.49
1981	116	1.00	208	0.65	799	1.00	3,213	0.26	1,917	0.50	1,841	0.46	138	0.42	1,367	0.48
1982	149	1.00	272	0.65	646	1.00	2,100	0.26	4,595	0.50	330	0.46	340	0.42	2,750	0.50
1983	122	1.00	825	0.65	598	1.00	2,463	0.26	2,722	0.50	2,677	0.46	1,016	0.42	3,725	0.51
1984	683	1.00	252	0.65	340	1.00	1,737	0.26	3,043	0.50	1,217	0.46	294	0.42	614	0.52
1985	491	0.95	532	0.65	1,029	1.00	3,200	0.26	1,259	0.50	1,983	0.46	464	0.42	1,815	0.53
1986	396	1.00	370	0.65	696	1.00	2,474	0.26	2,601	0.50	1,589	0.46	918	0.42	980	0.49
1987	386	1.00	555	0.65	256	1.00	4,260	0.26	9,651	0.50	3,625	0.46	2,458	0.42	6,168	0.59
1988	1,890	1.00	680	0.65	744	1.00	5,327	0.26	24,549	0.50	3,328	0.46	1,370	0.42	3,133	0.69
1989	2,549	1.00	516	0.65	972	0.78	4,917	0.26	20,495	0.50	4,578	0.46	122	0.42	2,792	0.69
1990	812	1.00	166	0.65	563	1.00	1,833	0.26	2,157	0.50	2,205	0.46	174	0.42	650	0.63
1991	340	1.00	127	0.94	470	1.00	935	0.26	5,152	0.54	3,673	0.47	196	0.09	2,017	0.85
1992	1,247	1.00	109	1.00	335	1.00	1,022	0.26	3,683	0.48	2,399	0.76	190	1.00	839	0.47
1993	890	1.00	27	1.00	164	1.00	1,330	0.06	1,961	0.89	3,924	0.52	288	0.78	885	0.71
1994	1,695	1.00	30	1.00	610	1.00	1,225	0.19	2,190	0.73	3,888	0.70	706	0.98	3,854	0.40

Year	Coweeman		Grays		Lewis		Cowlitz		Kalama		Washougal		Elochoman		Ge/Ab/Mi	
	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild	#	% wild
1995	1,368	1.00	9	1.00	409	1.00	1,370	0.13	3,094	0.69	3,063	0.39	156	0.50	1,395	0.51
1996	2,305	1.00	280	0.48	403	1.00	1,325	0.58	10,676	0.44	2,921	0.17	533	0.66	593	0.54
1997	689	1.00	15	0.64	305	1.00	2,007	0.72	3,548	0.40	4,669	0.12	1,875	0.11	603	0.23
1998	491	1.00	96	0.41	127	1.00	1,665	0.37	4,355	0.69	2,971	0.24	228	0.25	368	0.60
1999	299	1.00	195	0.51	331	1.00	969	0.16	2,655	0.03	3,129	0.68	718	0.25	575	0.69
2000	290	1.00	169	0.96	515	1.00	2,165	0.10	1,420	0.19	2,155	0.70	196	0.62	416	0.58
2001	802	0.73	261	0.64	750	0.70	3,647	0.44	3,714	0.19	3,901	0.43	2,354	0.82	4,024	0.39
2002	877	0.97	107	1.00	1,032	0.77	9,671	0.76	18,952	0.01	6,050	0.47	7,581	0.00	3,343	0.05
2003	1,106	0.89	398	0.72	738	0.98	7,001	0.88	24,782	0.01	3,444	0.39	6,820	0.65	3,810	0.56
2004	1,503	0.91	766	0.90	1,388	0.29	4,621	0.70	6,680	0.10	10,597	0.25	4,796	0.01	6,804	0.02
2005	853	0.60	147	0.66	607	1.00	2,968	0.17	9,272	0.03	2,678	0.41	2,204	0.05	2,083	0.13
2006	561		383		427		2,944		10,386		2,600		317		322	

Extinction Probability/Risk

The LCFRB Recovery Plan provides an overview of the status of populations in the ESU based on TRT recommendations for assessing viability. The risk of extinction category integrates abundance and other viability criteria (Table 8.10.2.1-9). The Recovery Plan also characterizes population status relative to persistence (which combines the abundance and productivity criteria), spatial structure, and diversity, and also habitat characteristics (Table 8.10.2.1-10). This overview for tule populations suggests that risk related to abundance and productivity are higher than those for spatial structure and diversity. Lower scores indicate higher risk. The scores for persistence for most populations range between 1.5 and 2.0. The scores for spatial structure generally range between 3 and 4, and for diversity between 2 and 3, respectively. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 8.10.2.1-9. Risk of extinction (in 100 years) categories for populations of LCR Chinook salmon (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Strata	Population	State	Extinction Risk Category
Cascade Spring	Cowlitz	W	H
	Cispus	W	H
	Tilton	W	VH
	Toutle	W	VH
	Kalama	W	VH
	NF Lewis	W	VH
	Sandy	O	M
Gorge Spring	White Salmon	W	VH
	Hood	O	VH
Coastal Fall	Grays/Chinook	W	H
	Elochoman/Skamokawa	W	H
	Mill/Abernathy/Germany	W	H
	Youngs Bay	O	VH
	Big Creek	O	VH
	Clatskanie	O	H
	Scappoose	O	VH
Cascade Fall	Lower Cowlitz	W	H
	Upper Cowlitz	W	VH
	Toutle	W	H

Strata	Population	State	Extinction Risk Category
	Coweeman	W	M
	Kalama	W	H
	Lewis	W	M
	Salmon	W	VH
	Washougal	W	H
	Clackamas	O	VH
	Sandy	O	VH
Gorge Fall	Lower Gorge	W/O	H/VH
	Upper Gorge	W/O	H/VH
	White Salmon	W	H
	Hood River	O	VH
Cascade Late Fall	NF Lewis	W	M
	Sandy	O	L

Table 8.10.2.1-10. LCFRB status summaries for Lower Columbia River tule Chinook populations (LCFRB 2004)

Strata	State	Population	Persistence	Spatial Structure	Diversity	Habitat
Coast Fall	WA	Grays	1.5	4	2.5	1.5
	WA	Elochoman	1.5	3	2	2
	WA	Mill/Abern/Ger	1.8	4	2	2
	OR	Youngs Bay				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade Fall	WA	Lower Cowlitz	1.7	4	2.5	1.5
	WA	Coweeman	2.2	4	3	2
	WA	Toutle	1.6	3	2	1.75
	WA	Upper Cowlitz	1.2	2	2	2

Strata	State	Population	Persistence	Spatial Structure	Diversity	Habitat
	WA	Kalama	1.8	4	2.5	2
	WA	Lewis Salmon	2.2	4	3	2
	WA	Washougal	1.7	4	2	2
	OR	Sandy	1.7	4	2	2
	OR	Clackamas				
Gorge Fall	WA	Lower Gorge	1.8	3	2.5	2.5
	WA	Upper Gorge	1.8	2	2.5	2
	OR	Big White Salmon	1.7	2	2.5	1.5
	OR	Hood				

Notes:
Summaries are taken directly from the LCFRB Recovery Plan (Appendix E). All are on a 4 point scale, with 4 being lowest risk and 0 being highest risk.
Persistence: 0 = extinct or very high risk of extinction (0-40% probability of persistence in 100 years); 1 = Relatively high risk of extinction (40-75% probability of persistence in 100 years); 2 = Moderate risk of extinction (75-95% probability of persistence in 100 years); 3 = Low (negligible) risk of extinction (95-99% probability of persistence in 100 years); 4 = Very low risk of extinction (>99% probability of persistence in 100 years)
Spatial Structure: 0 = Inadequate to support a population at all (e.g., completely blocked); 1 = Adequate to support a population far below viable size (only small portion of historic range accessible); 2 = Adequate to support a moderate, but less than viable, population (majority of historical range accessible but fish are not using it); 3 = Adequate to support a viable population but subcriteria for dynamics or catastrophic risk are not met; 4 = Adequate to support a viable population (all historical areas accessible and used; key use areas broadly distributed among multiple reaches or tributaries)
Diversity: 0 = functionally extirpated or consist primarily of stray hatchery fish; 1 = large fractions of non-local hatchery stocks; substantial shifts in life-history; 2 = Significant hatchery influence or periods of critically low escapement; 3 = Limited hatchery influence with stable life history patterns. No extended intervals of critically low escapements; rapid rebounds from periodic declines in numbers; 4 = Stable life history patterns, minimal hatchery influence, no extended intervals of critically low escapements, rapid rebounds from periodic declines in numbers.
Habitat: 0 = Quality not suitable for salmon production; 1 = Highly impaired; significant natural production may occur only in favorable years; 2 = Moderately impaired; significant degradation in habitat quality associated with reduced population productivity; 3 = Intact habitat. Some degradation but habitat is sufficient to produce significant numbers of fish; 4 = Favorable habitat. Quality is near or at optimums for salmon.

The 100-year risk of extinction is high for almost all populations of fall-run Chinook salmon. Exceptions are:[2]

[2] See WLCTRT (2004)

- Coweeman fall run (moderate)—abundance is low, but the trend has been increasing in recent years; population retains its genetic legacy; good habitat in the upper basin; habitat access only slightly impaired

- Lewis fall run (moderate)—abundance is low and trend is slightly negative; population retains its genetic legacy; habitat capacity has been limited by urbanization in the Salmon Creek and lower North and East Forks of the Lewis River and by passage impediments at the FERC-licensed hydroelectric project

- Lewis late-fall run (moderate)—long term high abundance levels (thousands of fish) with little hatchery contribution; long-term trend is slightly negative, although this may be expected for a population that is routinely exceeding its escapement goal; population retains its genetic legacy; habitat capacity has been limited by flow management operations at the FERC-licensed hydroelectric project, but these are addressed in new license (NMFS 2007f).

- Sandy late-fall run (low)—abundance has varied from several hundred to a few thousand in recent years; run has not been supplemented with hatchery fish and there is little chance of introgression from the fall-run programs in neighboring basins due to differences in run and spawn timing; most of the historical production area has remained accessible

Almost all of the spring-run populations of LCR Chinook are at very high risk of extinction. These have been excluded from much of their historical habitat above FERC-licensed dams. The exception is the Sandy River spring-run population, for which the risk of extinction is moderate. Large areas of productive high quality habitat have remained accessible in this watershed, particularly in the forested upper basin where production areas are distributed among several tributaries that drain Mt. Hood (McElhany et al. 2007).

Spatial Structure

The LCR Chinook salmon ESU consists of six MPGs made up of two to nine populations each. Currently, the spatial structures of populations in the Coastal and Cascade Fall Run MPGs are similar to their respective historical conditions. The following FERC-licensed projects soon will either be removed or become passable, allowing the affected populations to re-occupy historical habitat:

- Bull Run Hydroelectric Project, Little Sandy dam (Marmot dam removed in 2007) – removal by 2008 (NMFS 2003d) will improve access to the upper Sandy watershed for spring-run Chinook salmon (designated a Core and Genetic Legacy population by the McElhany et al. (2003))

- Lewis River Hydroelectric Project – upstream and downstream passage facilities will be developed (NMFS 2007f), a first step toward restoring the spring run (Core)

- Cowlitz River Hydroelectric Project - upstream and downstream passage facilities will be developed (NMFS 2004c), allowing restoration in the Cispus Spring Run (Core), Tilton Spring Run, and Upper Cowlitz Spring (Core and Genetic Legacy) and Fall Run population.

In contrast, spatial structure within the Upper Gorge Fall Run population is substantially limited by habitat inundation under Bonneville Pool and spatial structure within the Upper Gorge and Cascade Spring Run MPGs is limited by tributary barriers to migration. Historical tributary barriers include Condit Dam, built on the White Salmon River in the early 20th century, and injury and delay at the inadequate passage facilities, plus adverse effects on downstream habitat, at Powerdale Dam on the Hood River. However, (inefficient) passage was restored at Powerdale some years ago, which along with Condit Dam has been decommissioned and is scheduled for removal (Section 8.10.3.2).

Diversity

The diversity of the Coastal, Cascade and Gorge Fall Run major population groups (i.e., all except the Late Fall Run Chinook MPG) has been eroded by large hatchery influences, and periodically by low effective population sizes. In contrast, hatchery programs for spring Chinook salmon are preserving the genetic legacy of populations that were extirpated from blocked areas.

8.10.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for LCR Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Lower Columbia, Grays/Elochoman, Clackamas, and Lower Willamette (NMFS 2005b). There are 48 watersheds within the range of this ESU. Four watersheds received a low rating, 13 received a medium rating, and 31 received a high rating for their conservation value (i.e., for recovery). For more information, see Chapter 4. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor 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. Of the 1,655 miles of habitat eligible for designation, 1,311 miles of stream are designated critical habitat.

In the lower Columbia River and its tributaries, major factors affecting PCEs are altered channel morphology and stability; lost degraded floodplain connectivity; loss of habitat diversity; excessive sediment; degraded water quality; increased stream temperatures; reduced stream flow; and reduced access to spawning and rearing areas (LCFRB 2004, ODFW 2006b, PCSRF 2006). The status of critical habitat within the action area is discussed in more detail in Section 8.10.3.8.

8.10.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

Both Federal and non-Federal parties have implemented a variety of actions that have improved the status of LCR Chinook salmon. Actions that have been implemented since the environmental baseline was described in the 2000 FCRPS Biological Opinion (NMFS 2000b) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend developed by the WLC TRT (Table 8.10.2.1-3) will improve. The most significant actions involve reduced harvest rates for fall and spring Chinook in fresh water and ocean fisheries, which have significantly increased escapement to the spawning grounds.

8.10.3.1 Recent FCRPS Hydro Improvements

Corps et al. (2007b) estimated that hydropower configuration and operational improvements implemented in 2000 to 2006 have resulted in an 11.3% increase in survival for yearling juvenile LCR Chinook salmon from populations that pass Bonneville Dam. Improvements during this period included the installation of a corner collector at Powerhouse II (PH2) and the partial installation of minimum gap runners at Powerhouse 1 (PH1) and of structures that improve fish guidance efficiency (FGE) at PH2. Spill operations have been improved and Powerhouse 2 is used as the first priority powerhouse for power production because bypass survival is higher than at PH1 and drawing water toward PH2 moves fish toward the corner collector. The bypass system screen was removed from PH1 because tests showed that turbine survival was higher than through the bypass system at that location.

8.10.3.2 Recent Tributary Habitat Improvements

Actions implemented since 2000 range from beneficial changes in land management practices to improving passage by replacing culverts and by reintroducing fish into areas above FERC-licensed dams. The latter category includes two projects in tributaries above Bonneville Dam (i.e., within the action area for this consultation):

- Condit – removal in 2009 (NMFS 2006j) will support the restoration of the spring- and fall-run Chinook populations in the White Salmon River (both were designated Core populations by the WLC TRT (2003))

- Powerdale – removal by 2012 (NMFS 2005o) will support the restoration of the spring- and fall-run populations in the Hood River

Both removals will greatly increase the abundance and productivity of the affected populations by increasing the amount of habitat available for spawning and rearing. Although there is some uncertainty regarding whether the affected populations will become reestablished, NOAA Fisheries has determined that these are the correct next steps toward their restoration.

The Grays River is designated as a priority population for the restoration of the Coastal Fall MPG. It is used as one of the indicator populations for harvest management purposes and was identified by the Lower Columbia Tule Chinook Working Group (2008) as the weakest. A comprehensive habitat assessment and restoration plan was conducted by the Pacific Northwest National Laboratory (PNNL) in cooperation with Washington Department of Fish and Wildlife (WDFW) and Pacific States Marine Fisheries Commission (PSMFC) for the Grays River in 2006. Several related projects have been implemented (see attachment to NOAA Fisheries' 2008 Guidance letter to the Pacific Fisheries Management Council PFMC; NMFS 2008i). These include habitat restoration in the upper (reducing excess sediment loads) and lower (reconnecting the river delta-estuarine habitat at Seal Slough, the tidal floodplain at Devils Elbow, estuarine wetlands at Seal Slough, adding large wood to the lower West Fork, reducing temperatures and improving habitat diversity near Grays RM 11.8, and replacing the Nikka tidegate to restore connectivity and increase fish passage) Grays River watersheds.

8.10.3.3 Recent Estuary Habitat Improvements

The FCRPS Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving riparian and wetland function. These have resulted in an estimated 0.7% survival benefit for fall-run Chinook populations with an ocean-type juvenile life history (Corps et al. 2007b). The estimated survival benefit for spring-run Chinook (stream-type juvenile life history) is 0.3%.

8.10.3.4 Recent Predator Management Improvements

Avian Predation

Caspian tern predation in the Columbia River estuary was reduced from a total of 13,790,000 smolts to 8,210,000 smolts after relocation from Rice to East Sand Island in 1999. Yearling Chinook are generally considered vulnerable to these predators based on PIT-tag data from upriver stocks (Ryan et al. 2006). However, these authors also determined that predation rates for subyearling fall Chinook from populations in the Lower Columbia River ESU were higher than for subyearlings from upriver locations (possibly due to their longer residence time in the estuary), indicating that recent reductions in tern predation have benefited lower Columbia fall Chinook populations as well as those with a yearling life history.

Piscivorous Fish Predation

Since its commencement in 1990, the Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality. The recent improvement in lifecycle survival attributed to the NPMP is estimated to be 2% for both yearling and subyearling juvenile salmonids (Friesen and Ward 1999; Corps et al. 2007b).

Marine Mammal Predation

In recent years, sea lion predation of adult spring-run Chinook in the Bonneville tailrace has increased from 0%, or sufficiently low that it was rarely observed, to about 8.5% (SCA Marine Mammal Appendix). NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the survival of adult spring-run Chinook by 5.5%., so that the continuing negative impact will be approximately 3.0%.

8.10.3.5 Recent Hatchery Management Issues

The presence of naturally spawning hatchery-origin Chinook salmon has been identified as a limiting factor for the viability of this species (LCFRB 2004; ODFW 2006b). Of the 20 programs that release Chinook salmon below Bonneville Dam, NOAA Fisheries has identified only one program (Cowlitz Spring Chinook) as improving population viability by increasing spatial distribution (NMFS 2004b). Fifteen programs were identified as reducing short-term extinction risk, helping to preserve genetic resources important to ESU survival and recovery.[3] A summary of progress in hatchery reform for Lower Columbia programs that release fish above Bonneville Dam is reported in Table 2 of NMFS (2004b).

Most salmonids returning to the region are primarily derived from hatchery fish. In 1987, for example, 70% of the spring Chinook salmon, 80% of the summer Chinook salmon, 50% of the fall Chinook salmon, and 70% of the steelhead returning to the Columbia River Basin originated in hatcheries (CBFWA 1991). Hatcheries have traditionally focused on compensating for impacts to fisheries and it is only recently that risks posed by hatchery programs to natural population viability have been demonstrated.

NOAA Fisheries identified four primary ways hatcheries may harm wild-run salmon and steelhead: (1) ecological effects, (2) genetic effects, (3) overharvest effects, and (4) masking effects (NMFS 2000b). In many areas, hatchery fish provide increased fishing opportunities. However, when natural-origin fish mix with hatchery stocks in these areas, naturally produced fish can be overharvested. Moreover, when migrating adult hatchery and natural-origin fish blend in the spawning grounds, the health of the natural-origin fish and the habitat's ability to support them can be overestimated. This potential overestimate exists because the hatchery fish mask the surveyors' ability to discern actual natural-origin run status, thus resulting in harvest objectives that were too high to sustain the naturally produced populations.

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[3] The buffer against extinction is probably short term because dependence on hatchery intervention can lead to increased risk over time (ICTRT 2007a).

Over the last several years, the role hatcheries play in the Columbia Basin has been expanded from simple production to supporting species recovery. The evaluation of hatchery programs and implementation of hatchery reform in the lower Columbia River is occurring through several processes, including: (1) the Lower Columbia River Recovery and Fish and Wildlife Subbasin Plan; (2) Hatchery Genetic and Management Plan development for ESA compliance; (3) FERC-related plans on the Cowlitz and Lewis Rivers; and, (4) the federally mandated Artificial Production Review and Evaluation. More recently a National Environmental Policy Act (NEPA) review of all Mitchell Act funded hatchery facilities was initiated which will include many of those producing Lower Columbia River Chinook. Washington's Lower Columbia River recovery plan identifies strategies and measures to support recovery of naturally-spawning fish. The plan also includes associated research and monitoring elements designed to clarify interactions between natural and hatchery fish and quantify the effects artificial propagation has on natural fish. The objective is to rehabilitate depleted populations and provide for harvest, while minimizing impacts to wild fish. For more detail on the use of hatcheries in recovery strategies, see the Lower River Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2004).

The states of Oregon and Washington and other fisheries co-managers are currently engaged in a substantial review of hatchery management practices through the Hatchery Scientific Review Group (HSRG). The HSRG was established and funded by Congress to provide an independent review of current hatchery programs in the Columbia River Basin. The HSRG has largely completed their work on LCR tule populations and provided their recommendations. A general conclusion is that the current production programs are not consistent with practices that reduce impacts on naturally-spawning populations, and will have to be modified to reduce adverse effects on key natural populations identified in the Interim Recovery Plan, (i.e., necessary for broad sense recovery). The adverse effects are caused by hatchery-origin adults spawning with natural-origin fish or competing with natural-origin fish for spawning sites.

Early in 2007 NOAA Fisheries expressed the need to change current hatchery programs and anticipated that new direction for those programs would be given soon (NMFS 2007g). NOAA Fisheries followed with a letter to the states of Oregon and Washington in November 2007 that again highlighted the immediate need for decisions about hatchery programs (NMFS 2007h). In response and through their own initiative, the states have embraced the recommendations of the HSRG and have now initiated a comprehensive program of hatchery and associated harvest reforms (WDFW and ODFW 2008). The program is designed specifically to achieve HSRG objectives related to controlling the number of hatchery-origin fish on the spawning grounds and in the hatchery broodstock. The program will require mass marking of released hatchery fish, changing hatchery release strategies, reducing hatchery production at some facilities, and building a system of weirs and improved collection facilities to control the straying of hatchery fish. The program will also require development and implementation of more mark-selective fisheries and increasing the productivity of river basins through habitat management actions (i.e., see Section 8.10.3.2 for habitat projects in the Grays River). Overall, the program represents a comprehensive and integrated approach to recovery that will be advanced by substantive reforms in hatchery practices.

8.10.3.6 Recent Harvest Survival Improvements

Lower Columbia River Chinook are caught in both ocean and in-river fisheries. As discussed in Section 8.10.5.5, LCR tule Chinook in particular are managed subject to a total exploitation rate limit for the combined ocean and in-river fisheries. The necessary sharing between ocean and in-river fisheries is implemented by coordination and the close association between Pacific Fishery Management Council fisheries and the 2008 *U.S. v. Oregon* Agreement and related biological opinions.

Each year, fisheries in the Columbia River will be managed, after accounting for anticipated ocean harvest, so as not to exceed the total exploitation rate limit. In 2008, the total exploitation rate limit is 41%. From 2002 to 2006, the limit was 49%. The exploitation rate limit was reduced to 42% in 2007. NOAA Fisheries' guidance to the Council for 2008 was that Council fisheries should be managed such that the total exploitation rate on Lower Columbia River Chinook tule populations, from all fisheries does not exceed 41%. For 2009 and thereafter, NOAA Fisheries will set a total exploitation rate limit for tule Chinook through their annual guidance letter to the Council. NOAA Fisheries is required to provide such guidance by the Council's Salmon FMP. Fisheries subject to the 2008 *U.S. v. Oregon* Agreement that are part of the set of Prospective Actions must be managed subject to the overall exploitation rate limit as proposed in 2008 and as they have been since 1999.

NOAA Fisheries recently completed a section 7 consultation of the effects of PFMC and Fraser Panel fisheries on Lower Columbia River Chinook. NOAA Fisheries concluded that fisheries managed subject to a total exploitation rate of 41% would not jeopardize the listed species (NMFS 2008e). The PFMC opinion provides the substantive foundation for the review of the management strategy for LCR Chinook.

Tables 8.10.3.6-1, -2, and -3 provide estimates of harvest impacts and their distribution across fisheries for spring, bright, and tule populations in the Lower Columbia River Chinook ESU. Table 8.10.3.6-1 provides estimates of harvest impacts to spring-run populations. Exploitation rates were generally higher prior to the mid 1990s, averaging 50%. Spring-run Chinook stocks in the Columbia River, including Upper Willamette River spring Chinook decreased significantly in the mid 1990s, which led to a significant reduction in harvest, particularly in-river. The abundance of these stocks was gradually restored, reaching another peak by the early part of the 2000s. Fishery impacts increased in response to higher abundance; but by 1999, both Upper Willamette River Chinook and Lower Columbia River Chinook ESUs had been listed under the ESA. As a consequence, fishery managers implemented mass-marking programs for hatchery-origin fish and phased in mark-selective fisheries. Beginning in 1995, total exploitation rates averaged approximately 27%, although actual exploitation rates on unmarked natural-origin fish were lower as a consequence of the implementation of mark-selective fisheries in-river. Those estimates were not immediately available. Fishery impacts reported under the heading of the Columbia River include those that occur in tributary sport fisheries. Tributary sport fisheries are not included in fisheries covered by the 2008 Agreement. Oregon and Washington manage their tributary sport fisheries separately subject to provisions of Fishery

Management and Evaluation Plans (FMEPs). These FMEPs were considered for ESA purposes under limit #4 of the 4(d) Rule (NMFS 2000c).

Table 8.10.3.6-1. Total adult equivalent exploitation rates for the Cowlitz spring Chinook population (as an example of exploitation rates for LCR spring Chinook) (Simmons 2008).

Year	Total Exploitation Rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian	Indian
			WCVI	Other Canada	PFMC	PgtSd	Exp Rate	Exp Rate
1980	52%	2%	5%	4%	17%	0%	24%	0%
1981	48%	3%	5%	4%	17%	0%	20%	0%
1982	55%	2%	5%	3%	15%	0%	30%	0%
1983	57%	2%	9%	5%	9%	0%	32%	0%
1984	54%	2%	11%	5%	4%	0%	31%	0%
1985	43%	1%	5%	3%	8%	0%	25%	0%
1986	52%	1%	5%	3%	12%	0%	31%	0%
1987	45%	1%	5%	3%	11%	0%	25%	0%
1988	49%	1%	5%	2%	16%	0%	26%	0%
1989	50%	1%	3%	3%	19%	0%	25%	0%
1990	57%	1%	5%	2%	23%	0%	26%	0%
1991	54%	1%	4%	3%	14%	0%	32%	0%
1992	46%	1%	5%	3%	19%	0%	19%	0%
1993	48%	1%	5%	3%	15%	0%	25%	0%
1994	45%	1%	4%	3%	3%	0%	35%	0%
1995	10%	1%	2%	1%	4%	0%	1%	0%
1996	11%	1%	0%	0%	7%	0%	2%	0%
1997	16%	1%	1%	2%	5%	0%	7%	0%
1998	12%	1%	0%	2%	9%	0%	0%	0%
1999	38%	1%	1%	1%	15%	0%	20%	0%
2000	38%	1%	3%	1%	9%	0%	25%	0%
2001	21%	1%	2%	1%	7%	0%	10%	0%
2002	43%	1%	2%	2%	13%	0%	24%	0%
2003	34%	1%	3%	2%	13%	0%	16%	0%
2004	31%	1%	3%	2%	13%	0%	11%	0%
2005	36%	1%	4%	2%	17%	0%	11%	0%
2006	34%	1%	4%	3%	16%	0%	11%	0%

Table 8.10.3.6-2 provides estimates of harvest estimates to the North Fork Lewis bright Chinook population. Exploitation rates were generally higher through 1989 (averaging 56%), declining during the decade of the 1990s (averaging 36%), and increased slightly since 2000 (averaging 38%).

Table 8.10.3.6-2. Total adult equivalent exploitation rate for the North Fork Lewis bright Chinook population (Simmons 2008)

Year	Total exploitation rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian Exp Rate	Indian Exp Rate
			WCVI	Other Canada	PFMC	PgtSd		
1979	64%	9%	8%	6%	9%	2%	29%	0%
1980	68%	11%	8%	7%	8%	2%	33%	0%
1981	39%	11%	6%	6%	6%	2%	7%	0%
1982	43%	9%	6%	6%	8%	2%	12%	0%
1983	42%	10%	11%	6%	4%	3%	8%	0%
1984	58%	10%	15%	7%	2%	2%	22%	0%
1985	54%	6%	7%	6%	5%	3%	27%	0%
1986	64%	5%	8%	6%	6%	4%	35%	0%
1987	65%	5%	8%	5%	5%	3%	39%	0%
1988	68%	6%	10%	5%	7%	3%	38%	0%
1989	44%	7%	3%	4%	4%	1%	24%	0%
1990	38%	8%	6%	4%	7%	2%	12%	0%
1991	57%	7%	5%	5%	5%	2%	33%	0%
1992	57%	7%	9%	6%	7%	3%	25%	0%
1993	51%	7%	6%	4%	7%	3%	25%	0%
1994	38%	7%	11%	9%	1%	3%	7%	0%
1995	36%	7%	3%	2%	1%	1%	22%	0%
1996	16%	7%	0%	0%	2%	2%	3%	0%
1997	25%	11%	2%	3%	2%	2%	7%	0%
1998	23%	11%	0%	2%	1%	1%	8%	0%
1999	19%	6%	1%	2%	7%	2%	0%	0%
2000	24%	6%	5%	1%	5%	2%	5%	0%
2001	31%	7%	4%	1%	6%	3%	11%	0%

Year	Total exploitation rate	Ocean					Columbia River	
		Southeast Alaska	Canada		Southern US		Non-Indian Exp Rate	Indian Exp Rate
			WCVI	Other Canada	PFMC	PgtSd		
2002	41%	9%	3%	3%	7%	3%	15%	0%
2003	50%	11%	3%	4%	5%	2%	24%	0%
2004	40%	9%	2%	2%	3%	1%	22%	0%
2005	50%	8%	6%	5%	8%	3%	20%	0%
2006	32%	10%	2%	3%	3%	1%	13%	0%

Table 8.10.3.6-3 provides estimates of harvest impacts for tule Chinook populations based on an aggregate of coded wire tag indicator stocks. Exploitation rates were generally higher through 1993 (averaging 69%), lower through 1999 (averaging 34%), then increasing since 2000 (averaging 49%). From 2002 to 2006 fisheries were managed subject to a 49% exploitation rate limit. Total exploitation rates have been higher in some years but have averaged 49% from 2002 to 2006 (Table 8.10.3.6-3).

Table 8.10.3.6-3. Total adult equivalent exploitation rates for LCR tule populations (Simmons 2008).

Year	Ocean					Columbia River	
	Total Exp. Rate	SEAK Exp. Rate	Canada Exp. Rate	PFMC Exp. Rate	Pgt Snd Exp. Rate	Non-Treaty Exp. Rate	Treaty Exp. Rate
1983	69%	4%	34%	21%	3%	7%	0%
1984	70%	4%	40%	6%	3%	16%	1%
1985	66%	4%	35%	16%	3%	9%	0%
1986	82%	3%	38%	15%	4%	22%	0%
1987	82%	2%	27%	20%	4%	28%	0%
1988	81%	3%	25%	15%	2%	36%	0%
1989	59%	4%	19%	10%	3%	23%	0%
1990	60%	4%	26%	19%	3%	9%	0%
1991	63%	3%	28%	15%	4%	12%	0%
1992	65%	3%	31%	21%	4%	8%	0%
1993	61%	3%	27%	18%	3%	9%	0%
1994	33%	4%	26%	2%	1%	0%	0%
1995	36%	4%	21%	6%	2%	3%	1%
1996	26%	3%	4%	7%	1%	9%	0%

Year	Ocean					Columbia River	
	Total Exp. Rate	SEAK Exp. Rate	Canada Exp. Rate	PFMC Exp. Rate	Pgt Snd Exp. Rate	Non-Treaty Exp. Rate	Treaty Exp. Rate
1997	35%	5%	12%	7%	2%	10%	0%
1998	33%	4%	13%	6%	0%	9%	0%
1999	42%	3%	10%	13%	0%	15%	0%
2000	48%	4%	23%	9%	0%	13%	0%
2001	51%	2%	29%	12%	0%	7%	0%
2002	51%	3%	24%	14%	0%	9%	0%
2003	47%	4%	21%	10%	0%	12%	0%
2004	45%	4%	25%	9%	0%	7%	0%
2005	51%	4%	28%	11%	0%	7%	0%
2006	51%	4%	28%	12%	0%	7%	0%

8.10.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations and their designated critical habitat.

Gorge Fall MPG

Completed consultations include repairing a creek bank next to a road, parking lot maintenance, and maintenance of a stormwater drainage system along a highway (Lower Gorge); road maintenance and culvert cleaning (Upper Gorge); treating invasive plants, a grazing allotment, and vegetation management along a transmission line right-of-way (Hood population). The USFS implemented two habitat restoration projects: improve 5 acres of riparian through thinning and improve 49 acres of riparian and one mile of stream by adding large woody debris (Hood population).

Gorge Spring MPG

Completed consultations include invasive plant treatment, a grazing allotment, and vegetation management in a transmission line right-of-way (Hood). The USFS implemented two habitat restoration projects: improve 5 acres riparian through thinning and improve 49 acres riparian and one mile of stream by adding large woody debris (Hood population).

Projects Affecting Multiple MPGs/Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.10.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-

Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect multiple populations within the ESU. The effects of some on population viability will be positive (treating invasive plants; adding large woody debris; tar remediation). Other projects, including road maintenance, grazing allotments, dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on water quality (adding large woody debris; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.10.3.8 Status of Critical Habitat under the Environmental Baseline

Factors described in Section 8.10.2, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century and have degraded the conservation value of designated critical habitat. These habitat alterations have resulted in the loss of important spawning and rearing habitat and the loss or degradation of migration corridors. Tributary habitat conditions vary widely among the various drainages occupied by LCR Chinook salmon. Factors affecting the conservation value of critical habitat vary from lack of adequate pool/riffle channel structure, high summer water temperatures, low flows, poor overwintering conditions due to loss of connection to the floodplain, and high sediment loads.

Spawning & Rearing Areas

The following are the major factors that have limited the functioning of primary constituent elements and thus the conservation value of tributary habitat used for spawning and both tributary and estuarine habitat used for rearing (i.e., spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Tributary barriers *[culverts; dams; water withdrawals]*
- Reduced riparian function *[urban and rural development; forest practices; agricultural practices; channel manipulations]*
- Loss of wetland and side channel connectivity *[urban and rural development; past forest practices; agricultural practices; channel manipulations]*
- Excessive sediment in spawning gravel *[forest practices; agricultural practices]*
- Elevated water temperatures *[water withdrawals; urban and rural development; forest practices; agricultural practices]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions that address these limiting factors. These include removing passage barriers, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. The dam removal actions at FERC-licensed hydroelectric projects in the White Salmon and Hood rivers (Section 8.10.3.2) are addressing most of the key limiting factors in those watersheds. Some projects will provide immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

As described above, future Federal projects with completed consultations will have neutral or short- or even long-term adverse effects on the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Some Federal projects, implemented for restoration purposes, will improve these same PCEs.

Juvenile & Adult Migration Corridors

Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Juvenile and adult passage mortality *[hydropower projects in the mainstem lower Snake and Columbia rivers]*
- Pinniped predation on spring-run adults (Gorge Spring MPG) due to habitat changes in the lower river *[existence and operation of Bonneville Dam]* and increasing numbers of pinnipeds.
- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*
- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management]*

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these PCEs. For example, the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at Bonneville Dam has improved with the addition of the Bonneville PH2 corner collector. Reductions in piscivorous fish predation have increased the survival of both yearling and subyearling life history types in the estuary.

NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook in the tailrace of Bonneville Dam (NMFS 2008d).This action is expected to increase the survival of spring-run adults by 5.5%; reducing the continuing impact to approximately 3.0%.

The safe passage of both yearling and subyearling LCR Chinook salmon through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown during that same period. For populations with a stream-type juvenile life history, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. For populations with subyearling smolts, restoration projects in the estuary are improving the functioning of cover/shelter, food, and riparian vegetation required by this type of juvenile migrant. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood
Although LCR Chinook spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (NMFS 2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.10.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin (see lists of projects in Chapter 17 in Corps et al. 2007a). These include tributary habitat actions that will benefit the White Salmon and Hood spring-run and the Upper Gorge, White Salmon and Hood fall-run populations as well as actions that should be generally beneficial throughout the ESU. Generally, all of these actions are either completed, ongoing, or reasonably certain to occur.[4] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve conditions for this ESU.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these

[4] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for may of its projects.

factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.10.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in this section. However, the Prospective Actions will ensure that these adverse effects are reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Flow augmentation from the Upper Snake Project (NMFS 2008b) will continue to provide benefits through 2034. Some habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix and in this section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

8.10.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Benefits of Bonneville passage improvements affect only the six populations in the Gorge Fall and Spring Run MPGs. Prospective Actions include completing the installation of minimum gap runners at Bonneville PH1 and the FGE improvements at PH2 and improvements to sluiceway fish guidance system (efficiency and conveyance) at PH1. Collectively these modifications are expected to increase the survival of yearling (spring) and subyearling (fall) Chinook salmon that pass through Bonneville Dam (Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, and Hood River Spring Run populations) by <1%. Spillway survival improvements during this time period are expected to increase the passage survival through Bonneville Dam of yearling (spring) Chinook salmon by an additional 0.5% and of subyearling (fall) Chinook salmon by an additional 3.9%.

As a result of this ten-year program of improvements, an estimated 95.5% of the yearling Chinook that migrate past Bonneville Dam will survive.[5] A portion of the 4.5 % mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that yearling Chinook would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion on Remand, NOAA Fisheries estimated that 98% of the yearling Chinook would survive migration through a free-flowing reach of equal length (see Table 5.1 in NMFS 2004a). Therefore, approximately 35% (1.6%/4.5%) of the expected mortality experienced by in-river migrating yearling Chinook is probably due to natural factors.

[5] NOAA Fisheries has not estimated the in-river survival of subyearling Chinook salmon.

The direct survival rate of adult Chinook at Bonneville Dam is already quite high. Based on PIT-tag detections of SR spring/summer and fall Chinook at Bonneville and later redetected at upstream dams, NOAA Fisheries estimates upstream passage survival rates of 98.6 and 96.9% for adult spring–and fall–run Chinook, respectively (i.e., relevant to the Gorge MPGs).[6]

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit to juvenile migrants in the lower Columbia River by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.10.3.3).

Effects on Species Status

Prospective passage improvements at Bonneville Dam will support increased abundance and productivity of the upper Gorge populations, thereby improving the overall spatial structure of the ESU.

Effects on Critical Habitat

Improvements at Bonneville Dam will increase the functioning of the PCE of safe passage in the juvenile and adult migration corridors.

8.10.5.2 Effects of Tributary Habitat Prospective Actions

The Prospective Actions include funding for habitat improvements in the Hood River that will benefit the spring Chinook population in that watershed (Table 6 of Attachment B.2.2-2 in Corps et al. 2007b). The project, which will complement the effects on habitat of removing Powerdale Dam, includes actions to increase instream habitat complexity, restore and protect riparian vegetation, provide access and safe passage, and to acquire instream flow.

The Prospective Actions also include the Action Agencies' consideration of funding for habitat improvement projects for any of the LCR Chinook populations above Bonneville that have been significantly impacted by the FCRPS. Projects are to be selected that are consistent with basin-wide criteria for prioritizing projects (e.g., address limiting factors), including those derived from recovery and subbasin plans. However, the type and distribution of these potential projects is uncertain, in part because the RPA only commits the Action Agencies to achieving specific survival improvements for species in the Interior Columbia Basin.

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[6] This estimate is adjusted to account for estimated harvest and straying rates of adults within the FCRPS migration corridor, but otherwise captures all other sources of mortality including those resulting from the existence and operation of the FCRPS and other potential sources, including natural mortality (i.e., that would occur without human influence).

Effects on Species Status

Prospective improvements in tributary habitat in the Hood River will support the increased abundance, productivity, and spatial structure of the spring-run population of LCR Chinook. Habitat projects in other tributaries, if implemented, will be selected such that they also address limiting factors and thus would increase the viability of the local population(s).

Effects on Critical Habitat

Prospective habitat improvements in the Hood River will improve the functioning of PCEs for spawning and rearing (spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space). Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale and some, such as the removal of barriers, will improve conditions at the watershed scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more than a few weeks and typically less). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.10.5.3 Effects of Estuary Habitat Prospective Actions

The FCRPS Action Agencies will carry out approximately 44 estuary habitat projects over the first 3-year period of implementing the RPA (Section 12.3.2.3 in Corps et al. 2007b). The estimated survival benefit for fall-run LCR Chinook salmon associated with these specific actions will be less than 2.3%. The estimated benefit for spring-run Chinook is 1.4%.

The RPA requires the implementation of additional projects to obtain specified survival benefits for Interior Columbia Basin Chinook populations, but will also provide benefits to those from the lower Columbia River. The estimated survival benefit for fall-run LCR Chinook salmon is 6.7%. The estimated survival benefit for spring-run Chinook is less than 4.3%. Prospective Actions will address limiting factors by protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reducing of noxious weeds, and other actions.

Effects on Species Status

Prospective improvements in estuarine habitat will support the increased abundance, productivity, diversity, and spatial structure of spring- and fall-run populations of LCR Chinook.

Effects on Critical Habitat

Prospective estuarine habitat improvements will improve the functioning of the PCEs of water quality and safe passage in the migration corridor for yearling Chinook migrants and in rearing areas for subyearling Chinook. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). The positive effects on the functioning of PCEs and the conservation value of critical habitat will be long-term.

8.10.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Under the RPA (Action 39), the FCRPS Action Agencies will continue funding hatcheries as well as adopt programmatic criteria for funding decisions on hatchery mitigation programs for the FCRPS that incorporate BMPs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated by hatchery operators with the Action Agencies as cooperating agencies. For the lower Columbia, new HGMPs must be submitted to NOAA Fisheries and ESA consultations initiated by July 2009 and consultations must be completed by January 2010. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.10.5.5 Effects of Harvest Prospective Actions

Lower Columbia River spring Chinook populations are caught in non-Treaty spring season fisheries in the Columbia River below Bonneville Dam, and in tributary fisheries targeting hatchery-origin fish. The tributary fisheries are not part of the Prospective Action, but have been considered separately for ESA compliance through the 4(d) Rule (NMFS 2000c). There are no specific harvest rate constraints in the 2008 Agreement that apply to LCR spring Chinook. However, management constraints for upriver spring Chinook stocks from the Snake and Upper Columbia ESUs (see Sections 8.3 and 8.6 of this document) that are part of the Agreement substantially limit impacts to natural-origin spring Chinook from the LCR populations. Non-treaty fisheries in the lower Columbia are subject to harvest rate limits under the 2008 Agreement on natural-origin upriver spring Chinook populations that range from 0.5 to 2.7%, depending on run size (see Section 8.3 of this document). Impacts to natural-origin LCR spring Chinook populations, subject to the 2008 Agreement, will be similar to those allowed for upriver spring Chinook. As described above, the spring populations are managed to meet escapement goals for hatchery programs being used for reintroductions and supplementation. Mark selective fisheries are used below Bonneville Dam during the spring season to limit impacts to natural-origin fish. Due to the collective conservation restrictions for several other Chinook populations, hatchery escapement goals have been met exceeded in recent years. NOAA Fisheries expects that escapement goals will be met in 2008 and for the duration of the Agreement.

There are two extant natural-origin bright populations in the LCR Chinook ESU. Bright populations are caught in non-Treaty fall season fisheries in the Columbia River below Bonneville Dam. No specific harvest rate constraints in the 2008 Agreement apply directly to LCR bright Chinook, but fall season fisheries are constrained by limits set on Snake River fall Chinook, Lower Columbia River coho, and summer steelhead. The North Lewis River stock is used as a harvest indicator for ocean and in-river fisheries. The escapement goal used for management purposes for the North Lewis River population is 5,700 based on estimates of maximum sustained yield. The escapement was below goal in 2007 and the forecast for 2008 is for another low return, but escapements have otherwise exceeded the goal by a wide margin in every year but one since 1980. The escapement shortfall in 2007 is consistent with a pattern of low escapements for other far north migrating stocks in the region and can likely be attributed to poor ocean conditions. Given the long history of healthy returns, NOAA Fisheries does not anticipate the need to take specific management actions to protect the bright component of the Lower Columbia River Chinook ESU in 2008 or for the duration of the Agreement. NOAA Fisheries does expect that the states of Washington and Oregon will continue to take appropriate actions through their usual authorities, to ensure that the escapement goal continues to be met. NOAA Fisheries will monitor escapements for the bright populations, and trends for other far north migrating stocks, and take more specific action in the future if necessary.

The majority of harvest impacts to Lower Columbia River tule Chinook populations occur in ocean fisheries (Table 8.10.3.8-3). Since 2002 about 70% of harvest impacts have occurred in the ocean. In the Columbia River, tule populations are caught primarily in non-treaty fall season fisheries below Bonneville Dam. There are no specific harvest constraints in the 2008 U.S. v. Oregon Agreement that apply to Lower Columbia River tule Chinook. Non-treaty fall season fisheries are constrained by limits to Snake River fall Chinook, Lower Columbia River coho, and summer steelhead. NOAA Fisheries has, nonetheless, considered it necessary to define additional constraints for Lower Columbia River tule populations and has done so through its annual guidance letter to the Council (see for example Lohn and McInnis 2008).

For the last several years, NOAA Fisheries has limited Council and in-river fisheries by specifying a total exploitation rate limit. From 2002 to 2006, the limit was 49%. The exploitation rate limit was reduced to 42% in 2007. NOAA Fisheries' guidance to the Council for 2008 was that Council fisheries should be managed such that the total exploitation rate on Lower Columbia River Chinook tule populations, from all fisheries does not exceed 41%. For 2009 and thereafter, NOAA Fisheries will set a total exploitation rate limit for tule Chinook through their annual guidance letter to the Council. NOAA Fisheries is required to provide such guidance by the Council's Salmon FMP. Fisheries subject to the 2008 *U.S. v. Oregon* Agreement that are part of the set of Prospective Actions must be managed subject to the overall exploitation rate limit as proposed in 2008 and have been since 1999.

NOAA Fisheries recently completed a section 7 consultation of the effects of PFMC and Fraser Panel fisheries on Lower Columbia River Chinook. NOAA Fisheries concluded that fisheries managed subject to a total exploitation rate of 41% would not jeopardize the listed species (NMFS 2008e). The

PFMC opinion provides the substantive foundation for the review of the management strategy for LCR Chinook.

The anticipated exploitation rate on Lower Columbia River tule Chinook in Council fisheries is 9.8% (Table 8.10.5.5-1). The exploitation rate in Puget Sound fisheries, which included Fraser Panel fisheries, is 0.2%. Some additional harvest occurs in marine fisheries in the environmental baseline in ocean fisheries outside the Council area. The combined exploitation rate from all marine fisheries is 28.7%. The anticipated exploitation rate from all marine and freshwater fisheries in 2008 is 35.8%, and thus well below the 41% limit.

Table 8.10.5.5-1. Expected exploitation rates on Lower Columbia River tule Chinook in 2008 marine area fisheries (PFMC 2008).

Southeast Alaska	2.1
British Columbia	16.4
Puget Sound	0.3
PFMC	9.8
Total	28.7

Managers responsible for in-river fisheries took NOAA Fisheries' guidance (NMFS 2008i), along with the biological opinion on the Council fisheries (NMFS 2008e), into account when planning the 2008 in-river fishery. The prospective exploitation rate for tule Chinook in the in-river fisheries in 2008 is 7.1%, and thus, when combined with the anticipated exploitation rate from marine area fisheries, complies with the overall limit of 41%. The distribution of fishery impacts between ocean and in-river fisheries, and among in-river fisheries, may be adjusted in-season so long as the total exploitation rate does not exceed 41% in 2008. Managers responsible for in-river fisheries propose to use NOAA Fisheries' guidance, along with the yearly biological opinion on the Council fisheries, into account when planning the 2009-17 in-river fishery seasons.

Effects on Species Status

Prospective improvements in harvest effects support the increased abundance and productivity of spring- and fall-run populations of Lower Columbia River chinook. Harvest levels have been considered in detail in the recent biological opinion for PFMC and Fraser Panel fisheries (NMFS 2008). NOAA Fisheries concluded in that opinion that the proposed total exploitation limit is consistent with the expectation the species' survival and recovery.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR Chinook salmon.

8.10.5.6 Effects of Predation Prospective Actions

Avian predation
The survival of yearling Chinook will increase 2.1% and that of subyearlings will increase at least 0.7% with the reduced Caspian tern nesting habitat in the estuary and the subsequent relocation of most of the terns to sites outside the Columbia River basin (RPA Action 45). Continued implementation and improvement of avian deterrence at Bonneville Dam (RPA Action 48) is also likely to increase juvenile Chinook survival.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous fish predation
The prospective continued increase in incentives in the NPMP (RPA Action 43) will result in an additional 1% survival during the period 2008 to 2018.

Effects on Species Status
Prospective improvements in predation will support the increased abundance and productivity of spring- and fall-run populations of LCR Chinook.

Effects on Critical Habitat
Prospective improvements in predation will improve the functioning of the PCE of safe passage in the migration corridor for yearling Chinook migrants and in rearing areas for subyearling Chinook.

8.10.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRP"S.

8.10.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on Lower Columbia River Chinook Salmon & Critical Habitat

This section summarizes the basis for conclusions at the ESU level and for the rangewide status of critical habitat.

8.10.6.1 Recent Status of the Lower Columbia River Chinook Salmon ESU

Lower Columbia River Chinook salmon is a threatened species. Many of the populations in this ESU currently have low abundance and many of the long-term trends in abundance for individual populations are negative, some severely so. Some of the natural runs (especially the spring Chinook populations in the Cascade and Gorge MPGs) have been replaced largely by hatchery production. The construction of Bonneville Dam in the 1930s inundated spawning and rearing habitat and impeded juvenile and adult migration, significantly limiting the viability of the Gorge Spring and Fall Run MPGs. Flow management and climate changes together have decreased the delivery of suspended particulate matter and fine sediment to the estuary, and flow management and habitat alterations (dikes and revetments) have restricted the processes that create and maintain habitat diversity. These factors have affected populations in the Cascade Fall, Late Fall, and Spring Run and Coastal Fall Run MPGs as well as those above Bonneville Dam. The viability of natural-origin populations has been limited by hatchery practices and by harvest rates that were once as high as 80%. Large-scale changes in freshwater and marine environments have also had substantial effects on salmonid numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this ESU. The potential for additional risks due to climate change is described in Section 5.7 and 8.13.

In terms of the primary constituent elements of critical habitat, the ability to support the conservation of the species has been limited by barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development. In the Lewis, Cowlitz, White Salmon, Sandy, and Hood River watersheds, these problems are being addressed by actions taken at FERC-licensed hydroelectric projects (Section 8.10.3.2). The functioning of mainstem habitat as a juvenile rearing and migration corridor has improved in recent years with habitat restoration projects in the estuary and with the development of the corner collector at Bonneville PH2, respectively. Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement in habitat conditions on state forest lands within the range of LCR Chinook salmon (Section 8.10.3.7). Some future Federal actions with completed section 7 consultations will restore access to blocked habitat, increase channel complexity, and restore riparian condition. Examples are the removal of Condit Dam on the White Salmon and Powerdale on the Hood River. Many actions will have neutral or short- or even long-term negative effects on habitat conditions, but all were found to meet the ESA standards for avoiding jeopardy and for avoiding any adverse modification of critical habitat.

8.10.6.2 Effects of FCRPS, Upper Snake, & *U.S. v. Oregon* Prospective Actions on Lower Columbia River Chinook & Critical Habitat

NOAA Fisheries has adopted the LCFRB's (2004) recovery plan as its interim recovery plan for the Washington side of the lower Columbia River, including those populations within the LCR Chinook salmon ESU.[7] In the LCFRB's recovery plan, one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume." The FCRPS Action Agencies' estuary habitat restoration projects and relocation of most of the Caspian terns to sites outside the Columbia basin will increase the survival of juvenile Chinook. Implementation of habitat improvement projects in the Hood River watershed will address the loss of historical spawning habitat for that fall-run population, which was inundated by Bonneville pool. Actions that will further improve the viability of the Gorge populations include the continued increase in the northern pikeminnow reward fishery, and continued and improved avian

[7] The State of Oregon is in the process of developing a plan for this species. Upon its review, NOAA Fisheries will combine the Washington and Oregon plans into a complete recovery plan for the Lower Columbia River Recovery Domain.

deterrence at Bonneville Dam, and prospective juvenile and adult passage improvements at Bonneville Dam.

The principal effects of the Prospective Actions on critical habitat will be increases in passage survival at Bonneville Dam and in the estuary with the relocation of Caspian terns (juvenile and adult migration corridors free of obstructions); an increase in the amount and quality of estuarine habitat (for the transitions between fresh- and saltwater, juvenile growth and development before entering the plume, and the final development of adults before they migrate to upstream spawning areas); and an improvement in the functioning of PCEs for spawning, incubation, and rearing for the spring-run Chinook population in the Hood River.

8.10.6.3 Cumulative Effects Relevant to Lower Columbia River Chinook & Critical Habitat

Habitat-related actions and programs that the states of Oregon and Washington have determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect instream habitat. These actions will improve the functioning of the PCEs of critical habitat needed for successful spawning, incubation, and the growth and development of juvenile Chinook.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for this consultation (the mainstem lower Columbia and tributary areas above Bonneville Dam), these are likely to include urban development and other land use practices.

8.10.6.4 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Lower Columbia River Chinook ESU

Impacts of the FCRPS and Upper Snake projects are most significant for the 5 (out of 32) populations that spawn above Bonneville Dam and are limited relative to those from tributary hydropower; tributary habitat; harvest; hatcheries; and predation by birds, fish, and marine mammals. These populations are affected by upstream and downstream passage and, for the fall-run populations, by inundation of spawning habitat. For populations originating in tributaries below Bonneville, only migration and habitat conditions in the mainstem and estuary are affected by the existence and operation of the hydro projects.

The states of Oregon and Washington have identified tributary habitat actions that are reasonably certain to occur and that will benefit the White Salmon and Hood spring-run and the Upper Gorge, White Salmon, and Hood fall-run populations, as well as actions that should be generally beneficial throughout the ESU. Habitat blockages in the Lewis, Cowlitz, Sandy, and Hood watersheds are being addressed by actions taken at FERC-licensed hydroelectric projects (Section 8.10.3.2). The functioning of mainstem habitat as a juvenile migration corridor has improved in recent years with the development of the corner collector at Bonneville PH2 and other improvements. Implementation of the State of Washington’s Forest Practices Habitat Conservation Plan will lead to a gradual improvement of habitat conditions on state forest lands within the range of Lower Columbia River Chinook (Section 8.10.3.7).

NOAA Fisheries considered the effects of harvest on the various life-history types and component populations of the LCR Chinook ESU. LCR spring Chinook populations are managed to meet hatchery escapement goals and to maintain the genetic legacy of populations and support supplementation efforts. Fisheries are managed generally to meet the escapement goals of the North Fork Lewis River “bright” population. This population was below goal in 2007, but has otherwise been well above its escapement goal in the past. The LCR tule Chinook populations are affected by ocean and inriver fisheries. Tule Chinook are managed subject to a total exploitation rate limit for all fisheries. In 2008 the total exploitation rate limit was set by NOAA Fisheries at 41% through its yearly guidance to PFMC. A portion of the total exploitation rate is allocated by the States through PFMC-related processes to the inriver fisheries which are managed subject to U.S. v Oregon.

The effect of this management strategy was recently reviewed through a section 7 consultation on PFMC and Fraser Panel fisheries (NNFS 2008e). NOAA Fisheries concluded that the proposed total exploitation rate was not likely to jeopardize the LCR Chinook salmon ESU. The underlying analysis assumed that the total exploitation rate in 2009 and thereafter would be no more than 41%, but NOAA Fisheries indicated that further reductions in harvest may be forth coming as a consequence of ongoing review and subsequent ESA section 7 consultations. Future total exploitation rates will be set through NOAA Fisheries’ yearly guidance to Council and related consultations. Inriver fisheries will necessarily be managed subject to that guidance.

The FCRPS Action Agencies’ prospective passage improvements at Bonneville Dam, estuary habitat improvements, and predator management improvements will contribute to the viability of this ESU by addressing the influence of their projects, contributing to its survival with an adequate potential for recovery. The prospective habitat work in the Hood River and potential funding for tributary projects for the populations above Bonneville is expected to support the restoration of specific populations within the ESU. The Prospective Actions will not further deteriorate the pre-action condition. Long term (100-year) extinction risk is high or very high for almost all populations in this ESU. Exceptions are the Lewis River fall- and late fall- and the Sandy late fall- and spring-run populations. In the short term, the species’ extinction risk is expected to be reduced through implementation of the actions described above. In particular, the genetic legacy of the nearly extirpated spring-run Chinook populations will continue to be preserved by ongoing hatchery actions as a hedge against short-term risk of extinction.

8.10.6.5 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat for Lower Columbia River Chinook

NOAA Fisheries designated critical habitat for LCR Chinook salmon including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Lower Columbia, Grays/Elochoman, Clackamas, and Lower Willamette. The environmental baseline within the action area, which includes the Middle Columbia/Hood and Lower Columbia/Sandy subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for LCR Chinook. The major factors currently limiting the conservation value of critical habitat are barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles and the removal of sea lions known to eat Chinook in the tailrace of Bonneville Dam will do the same for spring-run adults. Habitat work in tributaries used for spawning and rearing in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. In addition, a number of actions in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).

The aggregate effect of the environmental baseline, Prospective Actions, and cumulative effects will be an improvement in the functioning of PCEs used for spawning, incubation, juvenile growth and development, migration, and juvenile and adult transitions between fresh and salt water. Considering the ongoing and future effects of the environmental baseline and cumulative effects, the Prospective Actions will be adequate to ensure that they will not reduce the ability of critical habitat to serve its conservation role for this species.

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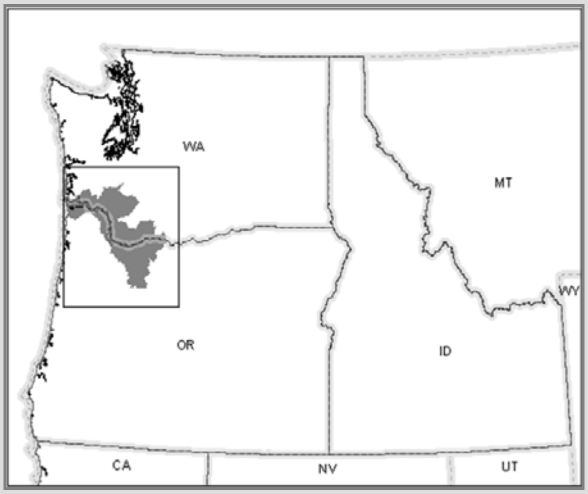
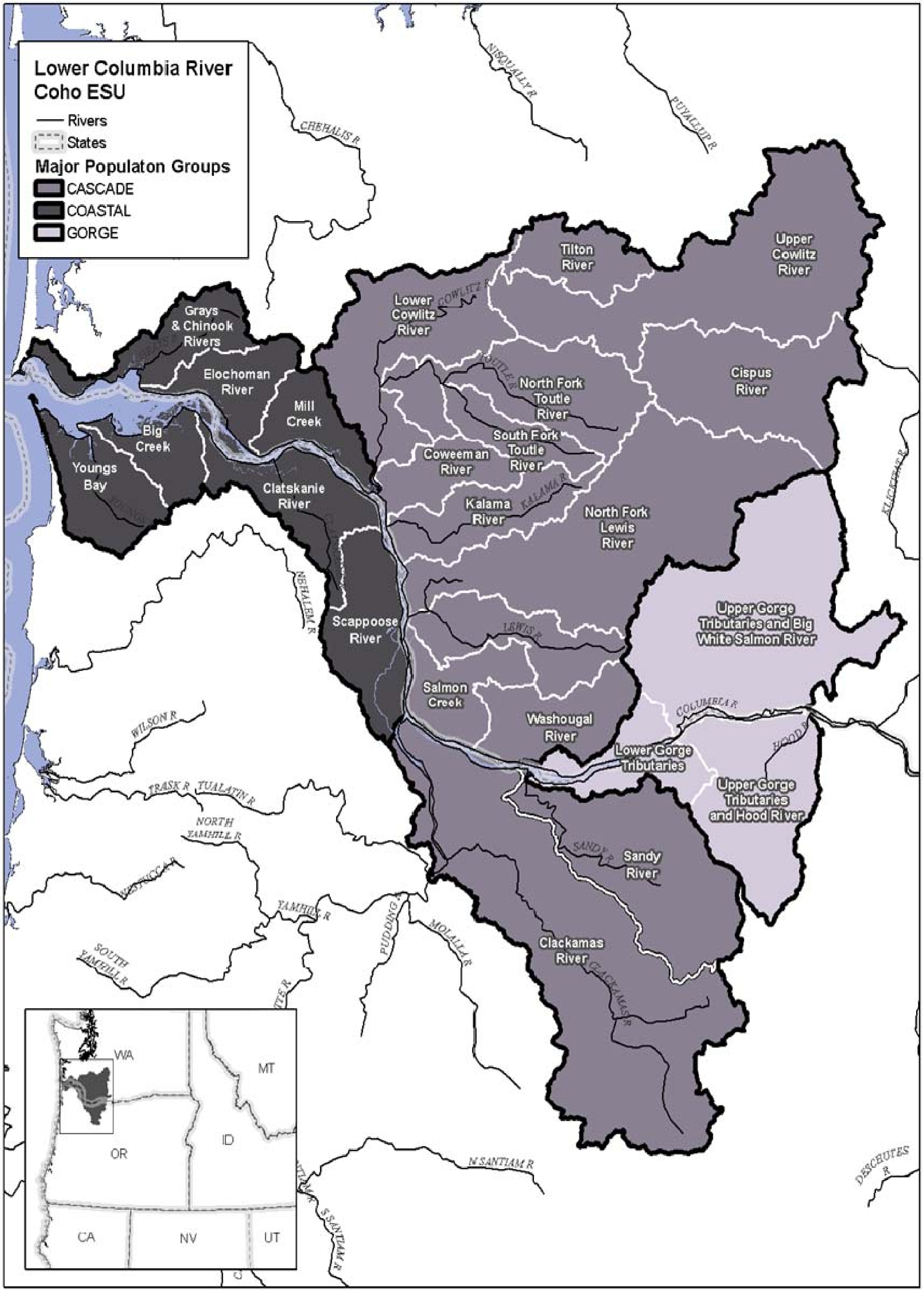
Section 8.11
Lower Columbia River Coho Salmon




Lower Columbia River
Coho ESU
Rivers
States
Major Populaton Groups
CASCADE
COASTAL
GORGE
Tilton River
Upper Cowlitz River
Lower Cowlitz River
Grays & Chinook Rivers
Elochoman River
Mill Creek
Big Creek
Youngs Bay
Clatskanie River
North Fork Toutle River
South Fork Toutle River
Coweeman River
Kalama River
Cispus River
North Fork Lewis River
Upper Gorge Tributaries and Big White Salmon River
Scappoose River
Salmon Creek
Washougal River
Lower Gorge Tributaries
Upper Gorge Tributaries and Hood River
Sandy River
Clackamas River
CHEHALIS R
NISQUALLY R
PUYALLUP R
COWLITZ R
KALAMA R
LEWIS R
COLUMBIA R
HOOD R
KLICKITAT R
NEHALEM R
WILSON R
TRASK R
TUALATIN R
NORTH YAMHILL R
YAMHILL R
SOUTH YAMHILL R
PUDDING R
MOLALLA R
SANDY R
CLACKAMAS R
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DESCHUTES R
WA
MT
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OR
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UT

Section 8.11
Lower Columbia River Coho Salmon

Species Overview

Background

The Lower Columbia River (LCR) coho salmon ESU includes all naturally spawned coho populations in stream and tributaries to the Columbia River in Washington and Oregon, from the mouth of the Columbia up to and including the White Salmon and Hood rivers, and includes the Willamette to Willamette Falls, Oregon, as well as 25 artificial propagation programs. The ESU includes 24 historical populations in three major population groups. The Lower Columbia River coho salmon ESU was listed as threatened under the ESA in 2005.

NOAA Fisheries has not yet designated critical habitat for this ESU.

Current Status & Recent Trends

Data on the status of natural-origin Lower Columbia River coho salmon are very limited. Most populations have low or very low numbers. Most of the natural runs largely have been replaced by hatchery production.

Limiting Factors

Human impacts and limiting factors for the Lower Columbia River coho salmon include habitat degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and predation. Lower Columbia River coho populations have been in decline for the last 70 years. FCRPS impacts have been limited, but most significant for the two populations that spawn in tributaries above Bonneville Dam. These populations are affected by upstream and downstream passage and, for Oregon populations, by inundation of some historical habitat by Bonneville pool. For populations originating in tributaries below Bonneville, migration and habitat conditions in the mainstem and estuary have been affected by hydrosystem flow operations. Tributary habitat degradation is pervasive due to development and other land uses, and FERC-licensed hydroelectric projects have blocked some spawning areas. Coho populations in the lower Columbia River have been heavily influenced by extensive hatchery releases. While those releases represent a threat to the genetic, ecological, and behavioral diversity of the ESU, some of the hatchery stocks at present also protect a significant portion of the ESU's remaining genetic resources.

Recent Ocean and Mainstem Harvest

Lower Columbia River coho are caught in ocean fisheries and non-Treaty fisheries in the mainstem Columbia River below Bonneville Dam. Previously, Oregon Coast Natural coho were used as a surrogate for estimating ocean fisheries impacts to Lower Columbia River coho. In 2006, largely as a consequence of increased attention resulting from its listing, the methods for assessing harvest in ocean fisheries were changed so that these were more specific to natural-origin Lower Columbia River coho.

Until 1993 the exploitation rates in salmon fisheries on Lower Columbia River coho have been very high, contributing to their decline. The combined ocean and in-river exploitation rates for Lower Columbia River coho averaged 91% through 1983, averaged 68% from 1984-1993, and decreased to an average of 17% from 1994-2007. In 2006 and 2007 ocean and inriver fisheries were managed using an abundance-based harvest rate schedule that depends on brood-year escapement and marine survival. Based on the year-specific circumstances, total exploitation rates were limited to 15% and 20%, respectively. NOAA Fisheries will continue to seek to develop harvest schedules that are consistent with information being developed by the Willamette Lower Columbia Technical Recovery Team and through ongoing hatchery reform and recovery planning efforts.

8.11.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.11.2.1 Current Rangewide Status of the Species

The Lower Columbia River coho salmon ESU includes 24 historical populations in Oregon and Washington between the mouth of the Columbia River and the Cascade crest. Although run time variation is inherent to coho life history, the ESU includes two distinct runs: early returning (Type S) and late returning (Type N). Type S coho salmon generally migrate south of the Columbia once they reach the ocean, returning to fresh water in mid-August and to the spawning tributaries in early September. Spawning peaks from mid-October to early November. Type N coho have a northern distribution in the ocean, return to the Columbia River from late September through December and enter the tributaries from October through January. Most Type N spawning occurs from November through January, but some spawning occurs in February and as late as March (LCFRB 2004). Summary data for the ESU are shown in Table 8.11.2.1-1.

Table 8.11.2.1-1. Lower Columbia River coho ESU description and major population groups (MPGs). (Sources: NMFS 2005a; Myers et al. 2006)

ESU Description	
Threatened	Listed under ESA in 2005
3 major population groups	24 historical populations
Major Population Group	**Population**
Coast	Grays, Elochoman, Mill Creek, Youngs Bay, Big Creek, Clatskanie, Scappoose Creek
Cascade	Lower Cowlitz, Coweeman, SF Toutle, NF Toutle, Upper Cowlitz, Cispus, Tilton, Kalama, NF Lewis, EF Lewis, Salmon Creek, Washougal, Clackamas, Sandy
Gorge	Lower Gorge, Washington Upper Gorge and (Big)White Salmon River, Oregon Upper Gorge and Hood River
Hatchery programs included in ESU (25)	Grays River, Sea Resources Hatchery, Peterson Coho Project, Big Creek Hatchery, Astoria High School (STEP) Coho Program, Warrenton High School (STEP) Coho Program, Elochoman Type-S Coho Program, Elochoman Type-N Coho Program, Cathlamet High School FFA Type-N Coho Program, Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers, Cowlitz Game and Anglers Coho Program, Friends of the Cowlitz Coho Program, North Fork Toutle River Hatchery, Kalama River Type-N Coho Program, Kalama River Type-S Coho Program, Lewis River Type-N Coho Program,

ESU Description	
	Lewis River Type-S Coho Program, Fish First Wild Coho Program, Fish First Type-N Coho Program, Syverson Project Type-N Coho Program, Washougal River Type-N Coho Program, Eagle Creek NFH, Sandy Hatchery, and the Bonneville/ Cascade/Oxbow complex coho hatchery programs.

Human impacts and current limiting factors for this ESU come from multiple sources: habitat degradation, habitat blockage by FERC-licensed dams in several subbasins, harvest, hatchery effects, ecological factors including predation, and Bonneville Dam passage for some populations (see Table 8.11.2.1-2).

Limiting Factors

Summarized below (Table 8.11.2.1-2) are key limiting factors for this ESU and recovery strategies to address those factors as described in the Washington Lower Columbia Recovery and Subbasin Plan [Lower Columbia Fish Recovery Board (LCFRB) 2004]. Oregon is currently engaged in the recovery planning process for Lower Columbia River coho.

Table 8.11.2.1-2. Key limiting factors for Lower Columbia River coho.

Mainstem Hydro	Direct mainstem hydro impacts on lower Columbia River ESUs are most significant for the two gorge tributary populations upstream from Bonneville Dam (WA Upper Gorge and [Big] White Salmon River; OR Upper Gorge and Hood River). These populations are affected by upstream and downstream passage at Bonneville Dam and by inundation of historical habitat at the lower ends of the smaller tributaries by the reservoir (WLCTRT 2004, McElhany et al. 2007). On the Oregon side of the gorge, the tributary streams are especially short and end at impassable waterfalls. Federal hydrosystem impacts on populations originating in downstream subbasins are limited to effects on migration and habitat conditions in the lower Columbia River (below Bonneville Dam) including the estuary.
Predation	Piscivorous birds including Caspian terns and cormorants, and fishes including northern pikeminnow, take significant number of juvenile salmon. As stream-type juveniles, coho are probably vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid channel areas located near habitat preferred by piscivorous birds (Fresh et al 2005). PIT-tagged coho smolts (originating above Bonneville Dam) were second only to steelhead in predation rates at the East Sand Island colony in 2007 (Roby et al. 2008). Pikeminnow are significant predators of yearling juvenile migrants (Friesen and Ward 1999). Ongoing actions to reduce predation effects include redistribution of avian predator nesting areas and a sport reward fishery to control numbers of pikeminnow.
Harvest	Lower Columbia River coho are harvested in the ocean and in Columbia

	River and tributary freshwater fisheries of Oregon and Washington. Incidental take of coho salmon prior to the 1990s fluctuated from approximately 60 to 90%, but has been reduced since listing to 15 to 25% (LCFRB 2004). The exploitation of hatchery coho has remained approximately 50% through the use of selective fisheries.
Hatcheries	Coho hatchery programs in the lower Columbia have been tasked to compensate for impacts of fisheries. Important genetic resources can reside in hatcheries and 25 hatchery programs are included in the LCR coho ESU (NMFS 2005a). However, hatchery programs in the LCR have not operated specifically to conserve LCR coho, and these programs threaten the viability of natural populations. The long-term domestication of hatchery fish has eroded the fitness of these fish in the wild and has reduced the productivity of wild stocks where significant numbers of hatchery fish spawn with wild fish. Large numbers of hatchery fish have also contributed to more intensive mixed stock fisheries, which probably overexploited wild populations weakened by habitat degradation. Most LCR coho populations have been heavily influenced by hatchery production over the years. State and Federal hatchery programs throughout the lower Columbia River are currently subject to a series of comprehensive reviews for consistency with the protection and recovery of listed salmonids. A variety of beneficial changes to hatchery programs have already been implemented and additional changes are anticipated.
Estuary	The estuary is an important habitat for migrating juveniles from LCR coho populations. Due to a short residence time in the estuary, stream-type juveniles such as coho have limited mortality associated with a scarcity of habitat, changes in food availability, and the presence of contaminants. However, they are particularly vulnerable to bird predation in the estuary (see above). Coho are likely to be affected by flow and sediment delivery changes in the plume, although mechanisms have not been determined (Casillas 1999). Estuary limiting factors and recovery actions are addressed in detail in a comprehensive regional planning process (NMFS 2006b).
Habitat	Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats. The Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004) identifies current habitat values, restoration potential, limiting factors, and habitat protection and restoration priorities for coho by reach in all Washington subbasins. Similar information is in development for Oregon subbasins.

Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status of this ESU to some extent, future trends, especially during the period relevant to the Proposed Actions, are unclear. Under the adaptive management implementation approach of the Lower Columbia River Recovery and Subbasin Plan, further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through additional recovery effort (LCFRB 2004).

Abundance, Productivity, and Trends

Data on the status of LCR coho salmon are very limited. As indicated in Table 8.11.2.1-3, population-specific abundance estimates are available for only five populations and trend estimates for only two. Base status information was reported in NOAA Fisheries' most recent status review (Good et al. 2005). Draft status assessments were updated for Oregon populations in a more recent review (McElhany et al. 2007). In many cases, populations have low current abundance and natural runs have been extensively replaced by hatchery production. Time series are not available for Washington coho populations.

Table 8.11.2.1-3. Abundance, productivity, and trends of LCR coho populations. (Sources: Good et al. 2005 and Myers et al. 2006)

Strata	Population	St.	Recent Abundance of Natural Spawners			Long-term trend		Median Growth Rate	
			Years[1]	No.[2]	pHOS[3]	Years	Value[4]	Years	λ[5]
Coast	Grays	W	na	na	na	na	na	na	na
	Elochoman	W	na	na	na	na	na	na	na
	Mill Creek	W	na	na	na	na	na	na	na
	Youngs Bay & Big Creek	O	2002	4,473	91%	na	na	na	na
	Clatskanie	O	na	na	na	na	na	na	na
	Scappoose	O	2002	458	0%	na	na	na	na
Cascade	Lower Cowlitz	W	na	na	na	na	na	na	na
	Coweeman	W	na	na	na	na	na	na	na
	SF Toutle	W	na	na	na	na	na	na	na
	NF Toutle	W	na	na	na	na	na	na	na

Strata	Population	St.	Recent Abundance of Natural Spawners			Long-term trend		Median Growth Rate	
			Years[1]	No.[2]	pHOS[3]	Years	Value[4]	Years	λ[5]
	Upper Cowlitz	W	na	na	na	na	na	na	na
	Cispus	W	na	na	na	na	na	na	na
	Tilton	W	na	na	na	na	na	na	na
	Kalama	W	na	na	na	na	na	na	na
	NF Lewis	W	na	na	na	na	na	na	na
	EF Lewis	W	na	na	na	na	na	na	na
	Salmon	W	na	na	na	na	na	na	na
	Washougal	W	na	na	na	na	na	na	na
	Clackamas	O	90-05	482	25%	90-05	1.029	90-05	1.01
	Sandy	O	90-05	482	17%	90-05	1.029	90-05	1.01
Gorge	Lower Gorge Tribs & White Salmon	O/W	na	na	na	na	na	na	na
	Upper Gorge Tribs & Hood River	O/W	2000	1,317[6]	>65[7]	na	na	na	na

Note:
Myers et al. (2006) identified Youngs Bay and Big Creek as demographically independent populations in the Coast MPG and described the following three populations in the Gorge MPG: Lower Gorge, Washington Upper Gorge and White Salmon, Oregon Upper Gorge and Hood River.
[1] Years of data for recent means
[2] Geometric mean of total spawners
[3] Average recent proportion of hatchery-origin spawners
[4] Long-term trend of total spawners
[5] Long-term median population growth rate (including both natural- and hatchery-origin spawners)
[6] Number of natural spawners for Hood River combined with Upper Gorge – Oregon, only
[7] Contains an unknown (i.e., unmarked) additional fraction of hatchery-origin coho from upstream releases

Steel and Sheer (2003) as cited in WLCTRT 2003 analyzed the number of stream kilometers historically and currently available to salmon populations in the lower Columbia River (Table 8.11.2.1-4). Stream kilometers usable by salmon are determined based on simple gradient cutoffs and on the presence of impassable barriers. This approach overestimates the number of usable stream kilometers, because it does not account for aspects of habitat quality other than gradient. However, the analysis does indicate that the number of kilometers of stream habitat currently accessible is greatly reduced from the historical condition for some populations. Hydroelectric projects in the Cowlitz, North Fork Lewis, and White Salmon rivers have greatly reduced or eliminated access to upstream production areas and therefore extirpated some of the affected populations.

Table 8.11.2.1-4. Current and historically available habitat located below barriers in the Lower Columbia River coho salmon ESU.

Population	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current/ Historical Habitat Ratio (%)
Youngs Bay	178	195	91
Grays River	133	133	100
Big Creek	92	129	71
Elochoman River	85	116	74
Clatskanie River	159	159	100
Mill, Germany, Abernathy Creeks	117	123	96
Scappoose Creek	122	157	78
Cispus River	0	76	0
Tilton River	0	93	0
Upper Cowlitz River	4	276	1
Lower Cowlitz River	418	919	45
North Fork Toutle River	209	330	63
South Fork Toutle River	82	92	89
Coweeman River	61	71	86
Kalama River	78	83	94
North Fork Lewis River	115	525	22
East Fork Lewis River	239	315	76
Clackamas River	568	613	93
Salmon Creek	222	252	88
Sandy River	227	286	79
Washougal River	84	164	51
Lower Gorge Tributaries	34	35	99
Upper Gorge Tributaries	23	27	84
White Salmon River	0	71	0

Population	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current/ Historical Habitat Ratio (%)
Hood River	35	35	100
Total	3,286	5,272	62

The abundance of coho returning to the Lower Columbia River from 2001 to 2007 ranged from 318,600 to more than 1,108,300, with most of the abundance comprised of hatchery fish (PFMC 2008). At present, the Lower Columbia River coho hatchery programs reduce risks to ESU abundance and spatial structure, provide uncertain benefits to ESU productivity, and pose risks to ESU diversity. Overall, artificial propagation mitigates the immediacy of ESU extinction risk in the short-term but is of uncertain contribution in the long term (NMFS 2004d).

Natural-origin fish are defined as those whose parents spawned in the wild, while hatchery-origin fish are defined as those whose parents were spawned in a hatchery. There is still significant coho production in the Clackamas and Sandy rivers. Good et al. (2005) reports that there appeared to be little natural production from other populations (References for abundance time series and related data are in Appendix C.5.2 in Good et al. (2005). More recent information indicates that there may have been more spawning and natural-origin production than previously thought.

Recent information from the WLC TRT describing methods used to assess species status and preliminary reports from application of these methods is contained in a review draft report on viability criteria (WLCTRT 2006). An additional review draft report related to the status of the Oregon populations of the Lower Columbia River coho salmon ESU has recently been released (June 2007) for public comment (McElhany et al. 2007).

Oregon Populations

Clackamas

Presently, the Clackamas River population above the North Fork Dam is one of only two populations in the ESU for which natural production trends can be estimated. The portion of the population above the dam has a relatively low fraction of hatchery-origin spawners, while they dominate the area below the dam. A 2002 stratified random survey by ODFW estimated a total of 2,402 coho spawning in the Clackamas River below North Fork Dam (WLCTRT 2003). The survey estimated that 78% of the fish observed were of hatchery origin. Counts at North Fork Dam in 2002 indicate a total of 998 coho went above the dam and 12% of those were of hatchery origin. Also, 100% of coho sampled in Clear Creek (a lower Clackamas River tributary) were of natural origin (Brown et al. 2003, cited Good et al. 2005).

The number of adult coho salmon returns to the North Fork Dam is shown in Figure 8.11.2.1-1 and Table 8.11.2.1-5. Prior to 1973, hatchery-origin adults and juveniles were released above North Fork Dam, and the time series from 1957-1972 contains an unknown fraction of hatchery-origin spawners.

The adult return of coho to the North Fork Dam has been highly variable over the last 50 years, but without an apparent trend.

Figure 8.11.2.1-1. Clackamas North Fork Dam counts of adult (3-year-old) coho salmon, 1957–2007 (TAC 2008).

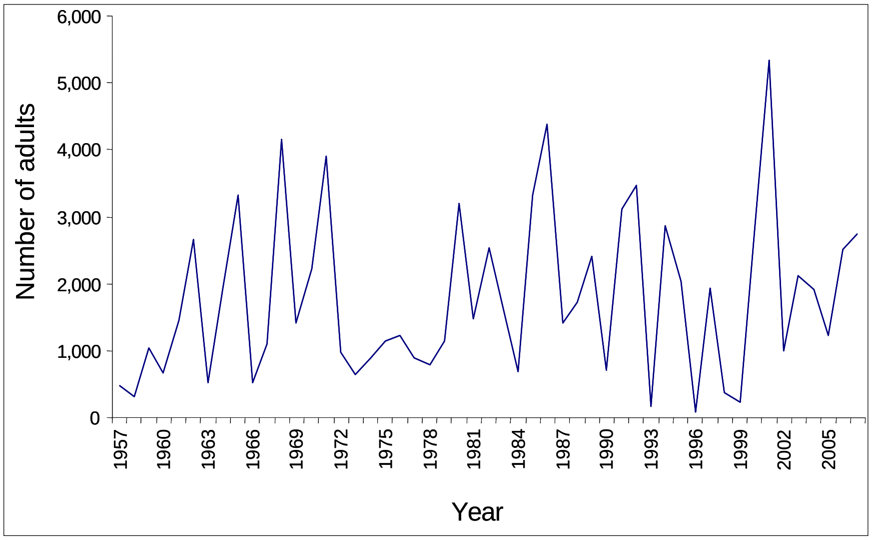


Table 8.11.2.1-5. Abundance of wild Clackamas coho, 1957-2007 (TAC 2008). 2007 data are only through December 31 and are preliminary. The run will not be complete until March 2008 (TAC 2008).

Year	Adult count	Jack count	Total count
1957	484	114	598
1958	309	213	522
1959	1,046	284	1,330
1960	670	1,515	2,185
1961	1,449	740	2,189
1962	2,665	454	3,119
1963	513	1,366	1,879
1964	1,879	597	2,476
1965	3,312	625	3,937
1966	527	250	777
1967	1,096	402	1,498
1968	4,154	542	4,696
1969	1,420	434	1,854
1970	2,220	531	2,751

Year	Adult count	Jack count	Total count
1971	3,912	183	4,095
1972	978	116	1,094
1973	644	96	740
1974	901	36	937
1975	1,133	56	1,189
1976	1,215	19	1,234
1977	893	49	942
1978	790	57	847
1979	1,138	47	1,185
1980	3,192	50	3,242
1981	1,469	112	1,581
1982	2,543	405	2,948
1983	1,599	78	1,677
1984	683	83	766
1985	3,314	592	3,906
1986	4,373	214	4,587
1987	1,402	318	1,720
1988	1,714	210	1,924
1989	2,413	231	2,644
1990	709	162	871
1991	3,123	317	3,440
1992	3,476	210	3,686
1993	168	31	199
1994	2,873	54	2,927
1995	2,036	69	2,105
1996	88	1	89
1997	1,935	37	1,972
1998	367	15	382
1999	238	61	299
2000	2,833	146	2,979
2001	5,344	184	5,528
2002	998	139	1,137

Year	Adult count	Jack count	Total count
2003	2,117	194	2,311
2004	1,915	124	2,039
2005	1,168	152	1,320
2006	2,505	176	2,681
2007	2,739	57	2,796

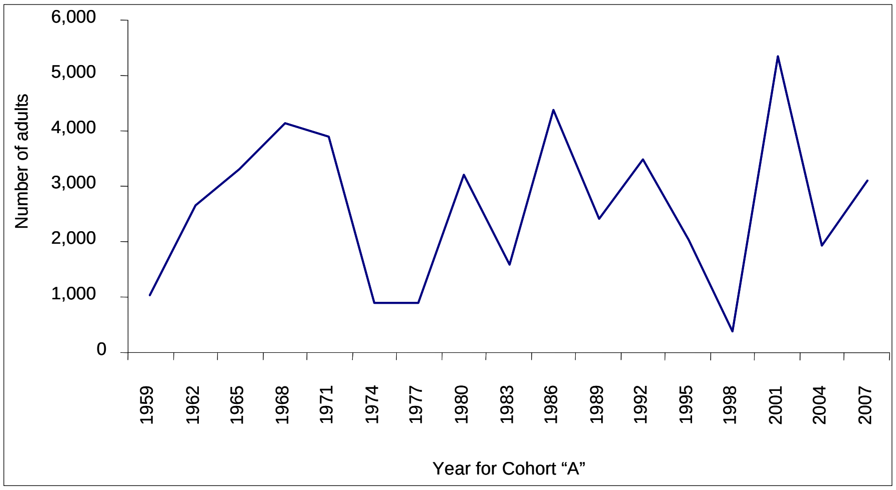
Since almost all Lower Columbia River coho females and most males spawn at 3 years of age, a strong cohort structure is produced. Figure 8.11.2.1-2 shows returns from the three adult cohorts on the Clackamas. Figure 8.11.2.1-2 also shows a pattern that is highly variable, but without an obvious or significant trend for the respective cohorts with the possible exception of cohort "C."

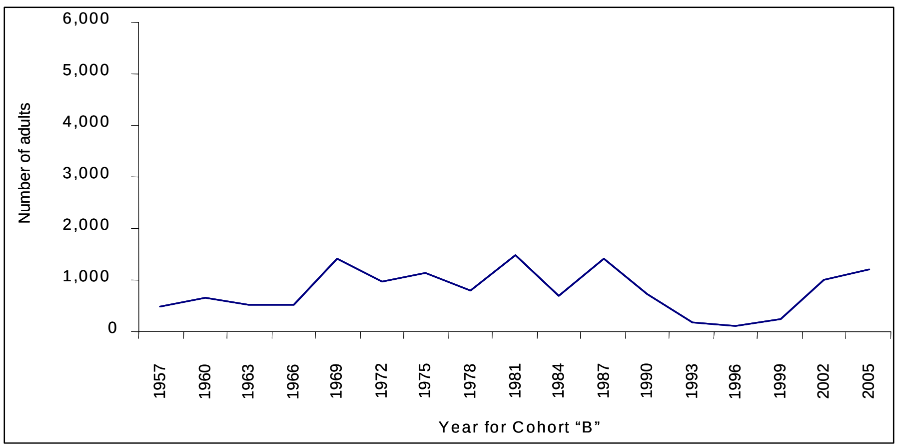
Estimates of smolt out-migration measured at North Fork Dam on the Clackamas also indicate variable, but generally stable production. There was a recent period in the late 1990s where smolt production was reduced followed by higher counts in the first half of this decade (Figure 8.11.2.1-3).

Sandy

The Sandy River population above Marmot Dam is the only other population in the Lower Columbia River coho salmon ESU for which natural production trends can be estimated. The portion of the Sandy River population above Marmot Dam has almost no hatchery-origin spawners, while they dominate the area below the dam (Good et al. 2005). The number of adult coho salmon passing above Marmot Dam is shown in Figure 8.11.2.1-4 and Table 8.11.2.1-6. The abundance of Sandy River coho declined substantially through much of the decade of the 1990s. Returns over the last two brood cycles since 2000 have been substantially higher (Figure 8.11.2.1-4).

Figure 8.11.2.1-2. Clackamas North Fork Dam counts of adult (3-year-old) coho salmon by cohort, 1957-2002. Cohort A, cohort B and cohort C (TAC 2008).





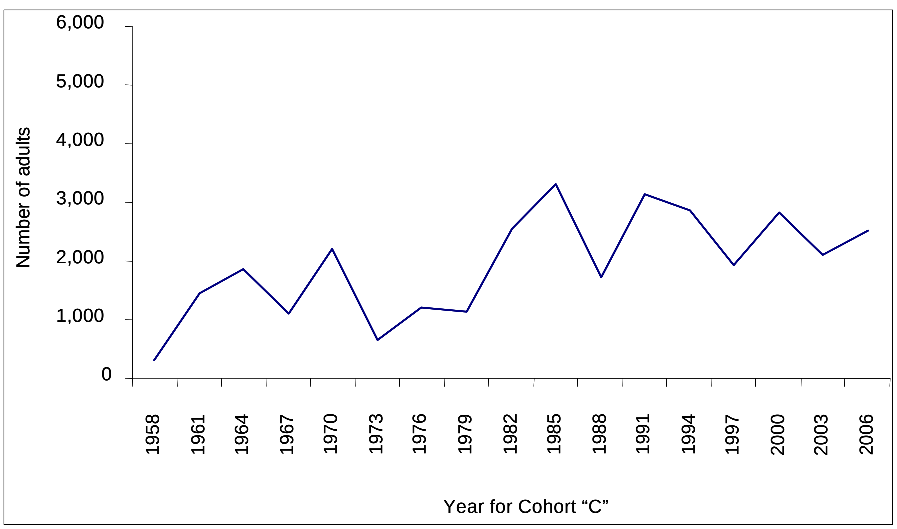


Figure 8.11.2.1-3 Total outmigrating juvenile coho passing Clackamas North Fork Dam (TAC 2008)

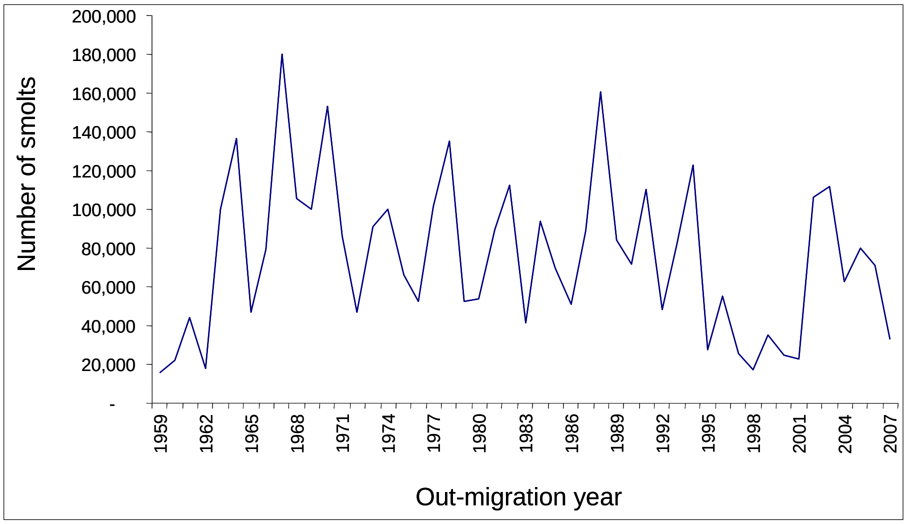


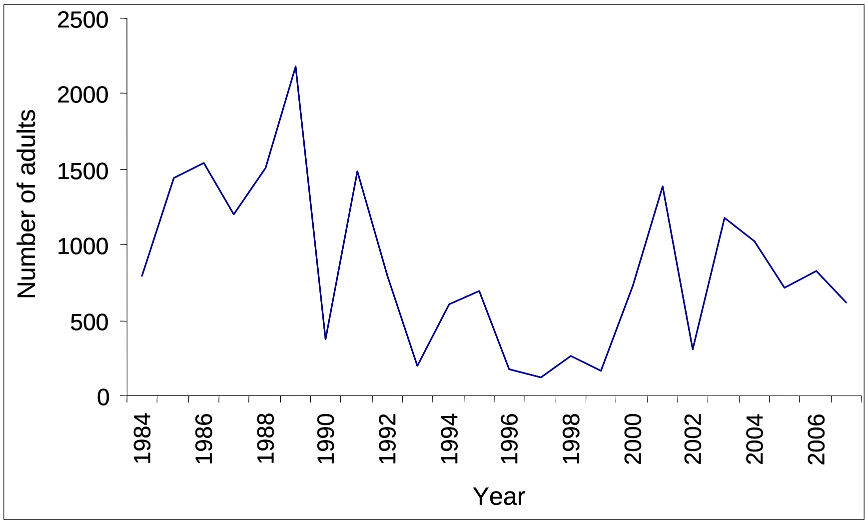
Table 8.11.2.1-6. Abundance of wild Sandy coho, 1957-2006. No data are available for some years. (TAC 2008).

Year	Adult count	Jack count	Total count
1957			264
1958			330
1959			68
1960			1670
1961			1733
1962			1458
1963			2199
1964			1126
1965			1018
1966	162	67	229
1967	386	283	669
1968	841	440	1281
1969	411	305	716
1970			
1971			
1972			
1973			

Year	Adult count	Jack count	Total count
1974			
1975			
1976			
1977			283
1978			426
1979			682
1980			635
1981			620
1982	722	20	742
1983	26	34	60
1984	798	8	806
1985	1445	27	1472
1986	1546	48	1594
1987	1205	198	1403
1988	1506	84	1590
1989	2182	113	2295
1990	376	80	456
1991	1491	1	1492
1992	790	55	845
1993	193	27	220
1994	601	47	648
1995	697	19	716
1996	181	0	181
1997	116	0	116
1998	261	0	261
1999	162	19	181
2000	730	12	742
2001	1388	8	1396
2002	310	1	311
2003	1173	26	1199
2004	1025	7	1032
2005	717	28	745

Year	Adult count	Jack count	Total count
2006	822	13	835
2007	617	0	617

Figure 8.11.2.1-4. Count of adult coho salmon at the Marmot Dam on the Sandy River. Almost all spawners above Marmot Dam are natural origin (TAC 2008).



Other Oregon Populations

ODFW recently initiated an effort to obtain abundance estimates for more Lower Columbia River coho populations using a random stratified sampling protocol (i.e., similar to that used to estimate abundance of Oregon Coastal coho salmon). Results from this survey are presented in Table 8.11.2.1-7. Information related to the proportion of these fish that are of hatchery origin is limited or completely unavailable. Estimates of percent hatchery in 2002 for the Scappoose, Clatskanie, Upper Gorge tributaries, and Youngs Bay and Big Creek are 0%, 60%, 65%, and 91%, respectively. These surveys suggest that hatchery-origin spawners dominate Lower Columbia River ESU coho populations in Oregon, but there are appear to be pockets of natural production.

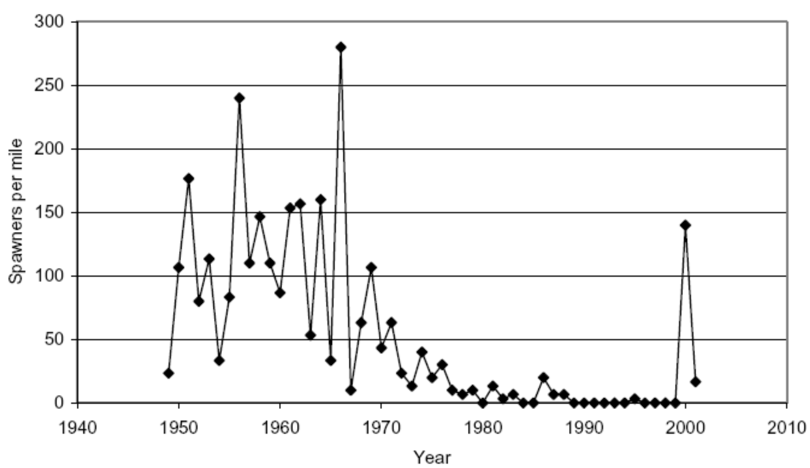
Prior to these recent intensive surveys, ODFW conducted coho salmon spawner surveys in the lower Columbia River. These surveys were combined to obtain spawners-per-mile information at the scale of the population units (Figures 8.11.2.1-4a-d) (Good et al. 2005). In many years over the last two decades, these surveys have reported no natural-origin coho salmon spawners. Based on the spawners-per-mile survey data, previous assessments have concluded that coho salmon in these populations are extinct or nearly so (ODFW 1999, Good et al. 2005). The estimates of a few hundred spawners in each of the Oregon-side populations in the recent years suggests that these areas have been recolonized or that prior spawning surveys missed fish that were nonetheless present.

Table 8.11.2.1-7. Recent abundance of wild coho in other Oregon population areas (TAC 2008).

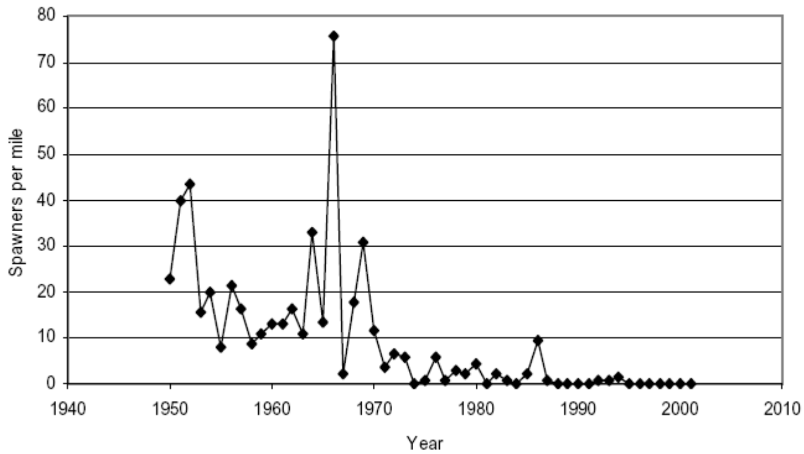
Year	Astoria Area		Clatskanie	Scappoose[1]	Gorge and Hood	
	Youngs Bay	Big Creek[1]			Lower Gorge	Hood[1]
1999	0		0	23	22	
2000	285		66	55	19	
2001	171		131	375	40	
2002	364	125	520	453	338	147
2003	45	190	357	317	NA	41
2004	128	124	758	719	NA	126
2005	77	240	348	336	263	1,262
2006	NA	252	747	689	226	373
2007	NA	216	357	333	NA	352

[1] Counts in Big Creek, Scappoose and Hood are a combination of weir/dam counts and spawning ground counts. Dam counts at the weirs/dams are of unmarked fish; spawning ground counts are wild fish based on mark and scale data.

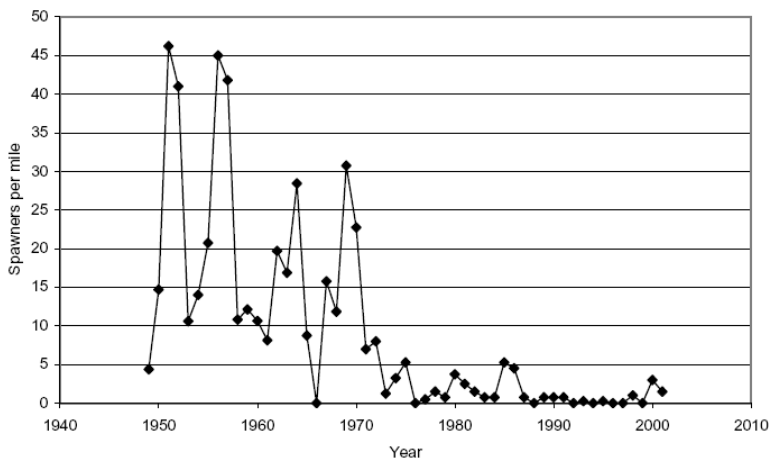
Figures 8.11.2.1-4a. Youngs Bay coho salmon spawners per mile, 1949–2001.



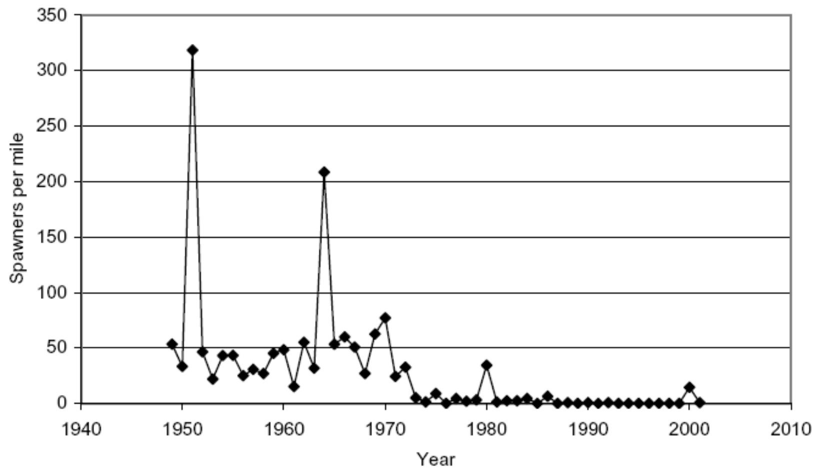
Figures 8.11.2.1-4b. Big Creek coho salmon spawners per mile, 1949–2001.



Figures 8.11.2.1-4c. Clatskanie River coho salmon spawners per mile, 1949–2001.



Figures 8.11.2.1-4d. Scappoose River spawners per mile, 1949–2001.



Abundance estimates for Oregon populations of the Lower Columbia River coho ESU can be compared to available abundance criteria. The WLC TRT defines a reproductive failure threshold (RFT) and quasi-extinction threshold (QET) (WLCTRT 2006). At very low abundance, populations may experience a decrease in reproductive success because of factors such as the inability to find mates, random demographic effects (the variation in individual reproduction become important), changes in predator-prey interactions, and other “Allee” effects. The reproductive failure threshold (RFT) is used to define an abundance below which no recruitment is assumed to occur.

The Interim Regional Lower Columbia Salmon Recovery Plan provides preliminary estimates of minimum abundance levels associated with viable status (LCFRB 2004). Table 8.11.2.1-8 lists the RFT/QET and viability abundance levels for Oregon population of the Lower Columbia River coho salmon ESU.

Table 8.11.2.1-8. RFT/QET and Minimum Viability Abundance Thresholds for Oregon population of the Lower Columbia River coho salmon ESU.

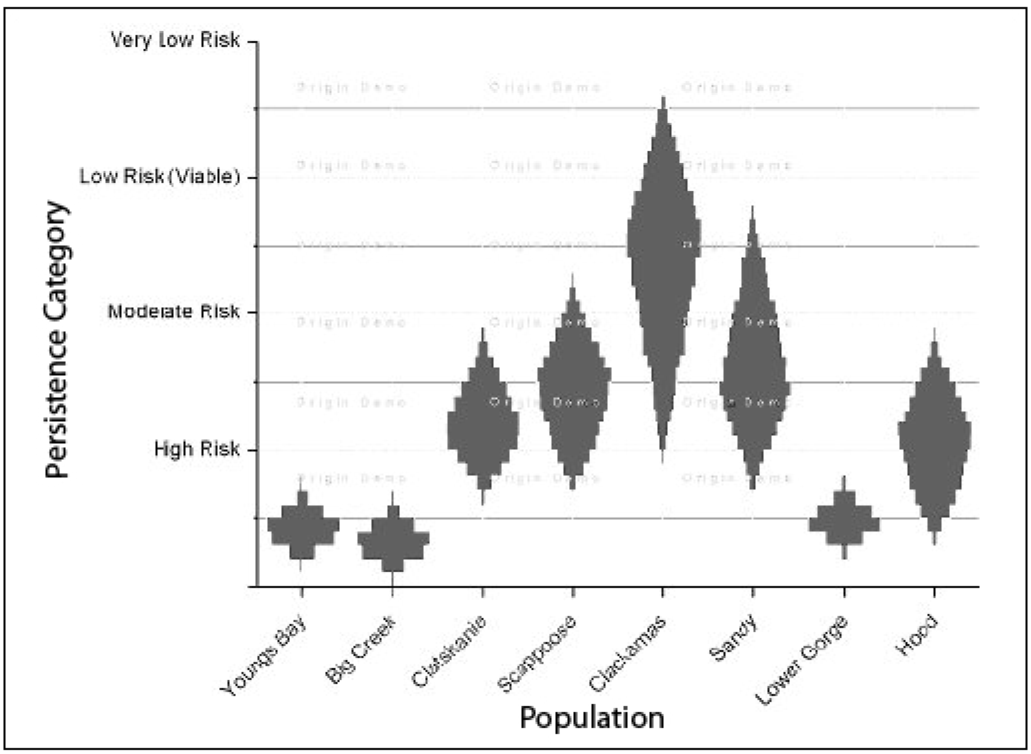
Population	RFT/QET WLCTRT (2006)	Minimum Viability Abundance LCFRB (2004)
Clackamas	200	600
Sandy	300	600
Big Creek	100	600
Youngs Bay	100	600
Clatskanie	200	600
Scappoose	200	600
Lower Gorge Tributaries	100	600

Hood River	200	600

In recent years at least, all the Oregon populations have been above the RFT/QET levels. The Clackamas has been well above the minimum viability abundance level; the Sandy has been above the viability abundance level at least in recent years.

The WLC TRT and ODFW recently reviewed the status of the Oregon population of the Lower Columbia River coho salmon ESU (WLCTRT 2006). They evaluated information related to measures of abundance, productivity, spatial structure and diversity criteria. The methods used are discussed in the draft report in some detail (WLCTRT 2006). The report provides an overall summary of population status for the Oregon population of the Lower Columbia River coho salmon ESU (Figure 8.11.2.1-5). The results generally indicate that many of the populations are currently at high risk with none being in a desirable low risk status.

Figure 8.11.2.1-5. Overall summary of population status for Oregon LCR coho populations.



Washington Populations

Hatchery production also dominates the Washington populations of Lower Columbia River coho; the majority of spawners believed to be hatchery strays. There are no estimates of spawner abundance for these populations, but WDFW began trapping outmigrating juvenile coho several years ago, and these data indicate that natural production (albeit of hatchery-origin fish) is occurring in several areas (Table 8.11.2.1-9).

There is no direct way to determine whether these populations would be naturally self-sustaining in the absence of hatchery-origin spawners. WDFW suggests that juvenile outmigrant production seen in the monitored streams is typical of other Washington Lower Columbia River ESU streams and that a substantial number of natural-origin spawners may return to the lower Columbia River each year, but are not observed because there is no monitoring for coho on the Washington side.

Table 8.11.2.1-9. Estimates of natural coho salmon juvenile outmigrants from Washington Lower Columbia River streams (TAC 2008).

Out-migrant Year	Cedar Creek	Mill Creek	Abernathy Creek	Germany Creek	East Fork Lewis River	Cowlitz Falls Dam	Mayfield Dam
1997						3,700	700
1998	38,400					110,000	16,700
1999	28,000					15,100	9,700
2000	20,300				4,514-9,028	106,900	23,500
2001	24,200	6,300	6,500	8,200		334,700	82,200
2002	35,000	8,200	5,400	4,300		166,800	11,900
2003	36,700	10,500	9,600	6,200		403,600	38,900
2004	37,000	5,700	6,400	5,100		396,200	36,100
2005	58,300	11,400	9,000	4,900		766,100	40,900
2006	46,000	6,700	4,400	2,300		370,000	33,600
2007	29,300	7,000	3,300	2,300		277,400	34,200

Estimates are based on expansions from smolt traps, not total census. Cedar Creek is a tributary of the North Fork Lewis River population. Mill, Germany and Abernathy Creeks are combined into a single population unit for TRT analysis. The Cowlitz River above Cowlitz Falls is partitioned into three independent populations (Upper Cowlitz, Cispus, and Tilton Rivers). The East Fork Lewis River estimate shows a range based on uncertainties about trap efficiency.

The Washington Department of Fish and Wildlife used the estimates of smolt production from monitored streams to estimate the total smolt production from the Washington portion of the Lower Columbia River coho salmon ESU in 2007 (Volkhardt et al. 2008). The estimate of total natural-origin smolt production in 2007 was 476,100 (Table 8.11.2.1-10).

Table 8.11.2.1-10. Estimated smolt production from streams with hatcheries, streams without hatcheries, minimum abundance from monitored streams, and predicted smolt abundance for the Washington-side of the LCR ESU (Volkhardt et al. 2008).

Node	Smolt Abundance			Smolt Density (smolts/sq. mile)		
	5.00%	Median	95.00%	5.00%	Median	95.00%
Unmonitored H_streams	193,700	200,100	206,800	233	241	249
Unmonitored W_streams	79,460	82,520	85,810	128	133	138
Monitored Streams	191,200	193,400	195,800			
Natural-origin Smolt Prediction	467,900	476,100	484,900			

These smolt production estimates, in combination with estimates of marine survival, were used to develop estimates of adult returns of natural-origin Lower Columbia River coho of 9,500 to the Washington side of the ESU (PFMC 2008). This was combined with estimates of 3,900 natural-origin Lower Columbia River coho to the Oregon side of the ESU, for a total of 13,400 natural-origin adults returning in 2008 (PFMC 2008).

This natural-origin production includes a mix of fish from streams that have a substantial amount of hatchery-origin strays and others where hatchery straying is believed to be relatively limited. Information gathered over the last several years suggests there is more coho production on both the Washington and Oregon-side streams than previously believed and that coho production in the ESU is not limited to that which occurs in the Clackamas and Sandy rivers

The populations above Cowlitz Falls on the Cowlitz River (Upper Cowlitz, Cispus, and Tilton Rivers) are also suitable for natural coho production (Table 8.11.2.1-9). However, these populations are not currently considered self-sustaining. Three dams block anadromous passage to the upper Cowlitz River. Currently, adult coho salmon (some of hatchery origin) are collected below the lower dam (Mayfield Dam) and trucked to the area above the upper dam (Cowlitz Falls Dam). There has been no appreciable downstream passage through the dams, so juvenile outmigrants were collected at Cowlitz Falls Dam and trucked below Mayfield Dam. The collection efficiency of outmigrating juveniles was 40–60% and spawners could replace themselves. Thus, hatchery production (in addition to the trap-and-haul operation) has maintained the populations. The new FERC license for the project requires the development of new passage facilities. Hatchery programs will be reformed, but production will continue (see “Spatial Structure,” (below).

Preliminary viability and recovery goals have been established by WLC TRT (2004) and Lower Columbia Fish Recovery Board (LCRFB) and are presented in Table 8.11.2.1-10. The method used to establish recovery goals is described in LCFRB (2004). It should be noted that the viability goal assumes no hatchery fish presence, and average ocean conditions. Due to resource constraints, the recovery goals for coho salmon made assumptions that the spatial distribution of coho was the same as that of steelhead, which probably under-estimates the actual coho salmon distribution. WDFW and LCFRB are currently developing more specific information to be included in the recovery plan for the Lower Columbia River coho. The coho viability goals for abundance therefore should be considered preliminary.

Table 8.11.2.1-11. The ecological zones (strata) and populations for the Lower Columbia River coho salmon ESU(LCFRB 2004). Primary (P), contributing (C), and stabilizing (S) population designations for the recovery scenario. Respective target viabilities are high or better, medium, and no lower than current levels. Primary populations identified for greater than high viability objectives are denoted with an '*'.

Population/Strata	Status/Goal [1]	Abundance Range		Viability	
		Viable	Potential	Current	Goal
COASTAL					
Grays /Chinook (WA)	P	600	4,600	Low	High
Mill, Germany, Abernathy (WA)	C	600	3,700	Low	Med
Elochoman/Skamokawa (WA	P	600	7,000	Low	High
Youngs Bay (OR))	S	600	1,200	na	Low
Big Creek (OR)	P	600	1,200	na	High
Clatskanie (OR)	S	600	1,200	na	Low
Scappoose (OR)	P	600	1,200	na	High
CASCADE					
Upper Cowlitz (WA)	P	600	28,800	V Low	Med
Lower Cowlitz (WA)	C	600	19,100	Low	High
Cispus (WA)	C	600	6,600	V Low	Med
Tilton (WA)	C	600	4,000	V Low	Low
South Fork Toutle (WA)	P	600	32,900	Low	High
North Fork Toutle (WA)	P	600	1,200	Low	High
Coweeman (WA)	P	600	7,600	Low	High
Kalama (WA)	C	600	1,300	Low	Med
North Fork Lewis (WA)	C	600	5,900	Low	High
East Fork Lewis (WA)	P	600	4,100	Low	High
Salmon Creek (WA)	S	600	5,700	V Low	V Low
Washougal (WA)	C	600	4,200	Low	Med

Population/Strata	Status/Goal [1]	Abundance Range		Viability	
		Viable	Potential	Current	Goal
Sandy (OR)	P*	600	1,200	na	High+
Clackamas (OR)	P*	600	1,200	na	High+
GORGE					
Lower Gorge Tributaries (WA)	P	600	1,200	Low	High
Upper Gorge Tributaries (WA)	P	600	1,100	Low	High
White Salmon (WA)	C	600	1,200	V Low	Low
Hood River (OR)	C	600	1,200	na	Med

[1] **Primary populations** are those that would be restored to high or "high+" viability. At least two populations per strata must be at high or better viability to meet recommended TRT criteria. Primary populations typically, but not always, include those of high significance and medium viability. In several instances, populations with low or very low current viability were designated as primary populations in order to achieve viable strata and ESU conditions. In addition, where factors suggest that a greater than high viability level can be achieved, populations have been designated as High+. High+ indicates that the population is targeted to reach a viability level between High and Very High levels as defined by the TRT.
Contributing populations are those for which some restoration will be needed to achieve a stratum-wide average of medium viability. Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery.
Stabilizing populations are those that would be maintained at current levels (likely to be low viability). Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high.

Extinction Probability/Risk

The 100-year risk of extinction (8.11.2.1-4) was derived qualitatively, based on risk categories and criteria identified by the WLC TRT (WLCTRT 2004) for use in recovery plan assessments. The rating system categorized extinction risk probabilities as very low (<1%), low (1 to 5%), medium (5 to 25%), high (26 to 60%), and very high (>60%) based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 8.11.2.1-12. Risk of extinction in 100 years categories for populations of LCR coho (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Strata	Population	State	Extinction Risk Category
Coast	Grays	W	H
	Elochoman	W	H
	Mill Creek	W	H
	Youngs Bay	O	VH

Strata	Population	State	Extinction Risk Category
	Big Creek	O	VH
	Clatskanie	O	H
	Scappoose	O	H
Cascade	Lower Cowlitz	W	H
	Coweeman	W	H
	SF Toutle	W	H
	NF Toutle	W	H
	Upper Cowlitz	W	VH
	Cispus	W	VH
	Tilton	W	VH
	Kalama	W	H
	NF Lewis	W	H
	EF Lewis	W	H
	Salmon	W	VH
	Washougal	W	H
	Clackamas	O	L
	Sandy	O	H
Gorge	Lower Gorge	O/W	VH/H
	WA Upper Gorge and White Salmon River	W	VH
	OR Upper Gorge and Hood River	O	VH

Spatial Structure

The LCR coho ESU consists of three MPGs made up of three to 14 populations each. Spatial structure has been substantially reduced by the loss of access to the upper portions of some basins due to tributary hydro development. Examples are the complete barrier at Condit Dam on the (Big) White Salmon River and delay and injury associated with inadequate passage facilities at Powerdale Dam on the Hood River (FERC-licensed hydropower projects; see Section 8.11.3.2, Environmental Baseline, Tributary Habitat for effects of their scheduled removals). Key coho production areas in the Cowlitz and North Fork Lewis River have been taken out of production due to utility projects. In addition, inundation of historical habitat when Bonneville pool was filled diminished the spatial structure of the Gorge population spawning in the smaller tributary streams above Bonneville Dam.

The following FERC-licensed projects, which although not in the action area do affect rangewide status, will either be removed or become passable, allowing the affected populations to re-occupy historical habitat:

- Bull Run (Little Sandy dam.) – removal by 2008 (NMFS 2003d) will improve passage for the coho population into the upper Sandy watershed (Marmot dam was removed in 2007.)

- Lewis River Hydroelectric Project – upstream and downstream passage facilities will be developed (NMFS 2007f), a first step toward restoring the North Fork Lewis River coho population

- Cowlitz River Hydroelectric Project – upstream and downstream passage facilities will be developed (NMFS 2004c), supporting restoration of the Cowlitz, Cispus, and Tilton coho populations

The Federal Energy Regulatory Commission's (FERC) licenses for the Lewis and Cowlitz river hydroelectric projects require their respective owners/operators to operate hatchery programs. PacifiCorps and Cowlitz PUD operate a hatchery program to support a naturally-spawning, harvestable population of coho salmon throughout its historical range in the North Fork Lewis basin. Tacoma Power operates a conservation hatchery program that is supplementing natural origin and adult coho from naturally spawning hatchery fish now returning to the upper Cowlitz Basin. The North Fork Lewis program is in its very early stages and it is too early to conclude that it will increase overall abundance as well as the spatial structure coho in the Lewis Basin.

Diversity

The diversity of populations in all three MPGs has been eroded by large hatchery influences and periodically, low effective population sizes.

The genetic legacy of the Lewis and Cowlitz River coho populations is preserved in ongoing hatchery programs.

8.11.2.2 Current Rangewide Status of Critical Habitat

NOAA Fisheries has not yet designated critical habitat for this ESU.

8.11.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed *environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.*

Both Federal and non-Federal parties have implemented a variety of actions that have improved the status of LCR coho salmon. Actions that have been implemented since the environmental baseline was described in the 2000 FCRPS Biological Opinion (NMFS 2000) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend in Table 8.11.2.1-3 will improve.

8.11.3.1 Recent FCRPS Hydro Improvements

Corps et al. (2007a) estimated that hydropower configuration and operational improvements implemented in 2000 to 2006 have resulted in an 11.3% increase in survival for yearling Lower Columbia River coho that pass Bonneville Dam. Improvements during this period included the installation of a corner collector at Powerhouse II (PH2) and the partial installation of minimum gap runners at Powerhouse 1 (PH1) and of structures that improve fish guidance efficiency (FGE) at PH2. Spill operations have been improved and Powerhouse 2 is used as the first priority for power production because bypass survival is higher than at PH1 and drawing water toward PH2 moves fish toward the corner collector. The bypass system screen was removed from PH1 because tests showed that turbine survival was higher than through the bypass system at that location.

8.11.3.2 Recent Tributary Habitat Improvements

Actions implemented since 2000 range from beneficial changes in land management practices to improving passage by replacing culverts and by reintroducing fish into areas above FERC-licensed dams. The latter category includes two projects in the tributaries above Bonneville Dam (i.e., within the action area for this consultation):

- Condit – removal in 2009 (NMFS 2006j) will support the restoration of the White Salmon River portion of the WA Upper Gorge coho population

- Powerdale – removal by 2012 (NMFS 2005o) will support the restoration of the Hood River portion of the OR Upper Gorge coho population

Both removals will greatly increase the abundance and productivity of the affected populations by increasing the amount of habitat available for spawning and rearing. Although there is some uncertainty regarding whether the affected populations will become reestablished, NOAA Fisheries has determined that these are the correct next steps toward their restoration.

8.11.3.3 Recent Estuary Habitat Improvements

The FCRPS Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving riparian and wetland function. These have resulted in an estimated 0.3% survival benefit for LCR coho (stream-type juvenile life history).

8.11.3.4 Recent Predator Management Improvements

Avian Predation

Caspian tern predation in the Columbia River estuary was reduced from 13,790,000 smolts to 8,210,000 smolts after relocation from Rice to East Sand Island in 1999. The double-crested cormorant colony has grown during the same period.

Piscivorous Fish Predation

The ongoing Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality since it began in 1990. The recent improvement in lifecycle survival attributed to the NPMP is estimated at 2% for yearling juvenile salmonids (Friesen and Ward 1999).

8.11.3.5 Recent Hatchery Management Issues

The presence of naturally spawning hatchery-origin coho salmon has been identified as a limiting factor for the viability of this species (LCFRB 2004; ODFW 2006b). Of the 29 programs that release coho salmon below Bonneville Dam, NOAA Fisheries identified only four programs as improving population viability by increasing spatial distribution (NMFS 2004b). Twenty-two were identified as reducing short-term extinction risk, helping to preserve genetic resources important to ESU survival and recovery.[1] A summary of progress in hatchery reform for Lower Columbia programs that release fish above Bonneville Dam is reported in Table 2 of NMFS 2004b.

Most salmonids returning to the region are primarily derived from hatchery fish. The production of hatchery fish, among other factors, has contributed to the 90% reduction in natural-origin coho salmon runs in the lower Columbia River over the past 30 years (Flagg et al. 1995).

NOAA Fisheries identified four primary ways hatcheries may harm wild-run salmon and steelhead: (1) ecological effects, (2) genetic effects, (3) overharvest effects, and (4) masking effects (NMFS 2000b). In many areas, hatchery fish provide increased fishing opportunities. However, when natural-origin fish mix with hatchery stocks in these areas, naturally produced fish can be overharvested. Moreover, when migrating adult hatchery and natural-origin fish blend in the spawning grounds, the health of the natural-origin fish and the habitat's ability to support them can be overestimated. This potential overestimate exists because the hatchery fish mask the surveyors' ability to discern actual natural-origin run status, thus resulting in harvest objectives that were too high to sustain the naturally produced populations.

Over the last several years, the role hatcheries play in the Columbia Basin has been expanded from simple production to supporting species recovery. The evaluation of hatchery programs and implementation of hatchery reform in the Lower Columbia River is occurring through several processes, including: (1) the Lower Columbia River Recovery and Fish and Wildlife Subbasin Plan; (2) Hatchery Genetic and Management Plan development for ESA compliance; (3) FERC-related plans on

[1] The buffer against extinction is probably short term because dependence on hatchery intervention can lead to increased risk over time (ICTRT 2007a).

the Cowlitz and Lewis Rivers; and, (4) the federally mandated Artificial Production Review and Evaluation. More recently a National Environmental Policy Act (NEPA) review of all Mitchell Act funded hatchery facilities was initiated which will include many of those producing Lower Columbia River coho. Washington's Lower Columbia River Recovery Plan identifies strategies and measures to support recovery of naturally-spawning fish. The plan also includes associated research and monitoring elements designed to clarify interactions between natural and hatchery fish and quantify the effects artificial propagation has on natural fish. The objective is to rehabilitate depleted populations and provide for harvest, while minimizing impacts to wild fish. For more detail on the use of hatcheries in recovery strategies, see the Lower River Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2004).

The states of Oregon and Washington and other co-managers are currently engaged in a substantial review of hatchery management practices through the Hatchery Scientific Review Group (HSRG). The HSRG was established and funded by Congress to provide an independent review of current hatchery programs in the Columbia River Basin. The HSRG has largely completed their work on Lower Columbia River coho populations and provided their recommendations ([HSRG 2007). A general conclusion from the information generated by the HSRG is that the current production programs are not consistent with practices that reduce impacts on naturally-spawning populations, and will have to be modified to reduce the adverse effects of hatchery fish on key natural populations identified in the Interim Recovery Plan, as necessary for broad sense recovery of the ESU. The adverse effects are caused in part by excess hatchery adults returning to natural spawning grounds.

Early in 2007 NOAA Fisheries expressed the need to change current hatchery programs and anticipated that decisions regarding the direction for those programs would be made soon (NMFS 2007g). NOAA Fisheries followed with a letter to the states of Oregon and Washington in November 2007 that again highlighted the immediate need for decisions about hatchery programs (NMFS 2007h). In response and through their own initiative, the states have embraced the recommendations of the HSRG and have now initiated a comprehensive program of hatchery and associated harvest reform (WDFW and ODFW 2008). The program is designed specifically to achieve HSRG objectives related to controlling the relative abundance of hatchery fish on the spawning grounds and in the hatchery broodstock. The program will require mass marking of released hatchery fish, changing hatchery release strategies, reducing hatchery production at some facilities, and building a system of weirs and improved collection facilities to control the straying of hatchery fish. The program will also require development and implementation of more mark selective fisheries and increasing the productivity of river basins through habitat management actions. Overall, the program represents a comprehensive and integrated approach to recovery that will be advanced by substantive reforms in hatchery practices.

Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

8.11.3.6 Recent Harvest Survival Improvements

Lower Columbia River coho are caught in both ocean and in-river fisheries. As discussed in Section 8.11.5.5, LCR coho are managed subject to a total exploitation rate limit for the combined ocean and in-river fisheries. The necessary sharing between ocean and in-river fisheries is implemented by coordination and the close association between Pacific Fishery Management Council fisheries and the 2008 *U.S. v. Oregon* Agreement and related biological opinions.

Each year, fisheries in the Columbia River will be managed, after accounting for anticipated ocean harvest, so as not to exceed the total exploitation rate limit. In 2008, the total exploitation rate limit is 8% based on the year specific circumstances. For 2009 and thereafter, NOAA Fisheries will set a total exploitation rate limit for LCR coho through their annual guidance letter to the Council. NOAA Fisheries is required to provide such guidance by the Council's Salmon FMP. Fisheries subject to the 2008 *U.S. v. Oregon* Agreement that are part of the set of Prospective Actions must be managed subject to the overall exploitation rate limit as proposed in 2008 and as they have been since 1999.

NOAA Fisheries recently completed a section 7 consultation of the effects of PFMC and Fraser Panel fisheries on Lower Columbia River Chinook. NOAA Fisheries concluded that fisheries managed in 2008 subject to a total exploitation rate of 8% would not jeopardize the listed species (NMFS 2008e). The PFMC opinion provides the substantive foundation for the review of the management strategy for LCR coho.

Table 8.11.3.6-1 includes the available information on exploitation rates of Lower Columbia River coho in ocean and freshwater fisheries. Previously, Oregon Coast Natural coho were used as a surrogate for estimating ocean fisheries impacts to Lower Columbia River coho. In 2006, largely as a consequence of increased attention resulting from its listing, the methods for assessing harvest in ocean fisheries were changed so that these were more specific to Lower Columbia River coho.

Until 1993 the exploitation rates in salmon fisheries on Lower Columbia River coho have been very high, contributing to their decline (Table 8.11.3.6-1). The combined ocean and inriver exploitation rates for Lower Columbia River coho averaged 91% through 1983, averaged 69% from 1984-1993, and decreased to an average of 16.7% from 1994-2007.

Table 8.11.3.6-1. Estimated Ocean (all marine area fisheries) and Inriver Exploitation Rates on Lower Columbia River Natural Coho, 1970-2007 (TAC 2008).

Year	Ocean Exploitation Rate	Inriver Exploitation Rate	Total Exploitation Rate
1970	65.2%	28.4%	93.6%
1971	82.5%	9.9%	92.4%
1972	84.3%	8.6%	92.9%
1973	81.9%	11.2%	93.1%

Year	Ocean Exploitation Rate	Inriver Exploitation Rate	Total Exploitation Rate
1974	83.5%	9.2%	92.7%
1975	81.4%	10.1%	91.5%
1976	89.9%	5.5%	95.4%
1977	88.8%	5.3%	94.1%
1978	82.5%	7.9%	90.4%
1979	79.4%	9.5%	88.9%
1980	73.1%	24.5%	97.6%
1981	81.1%	6.8%	87.9%
1982	61.6%	20.8%	82.4%
1983	78.7%	3.9%	82.6%
1984	31.9%	27.0%	58.9%
1985	43.2%	22.3%	65.5%
1986	33.5%	39.7%	73.2%
1987	59.5%	19.4%	78.9%
1988	56.4%	20.3%	76.7%
1989	55.3%	22.7%	78.0%
1990	68.9%	7.5%	76.4%
1991	45.4%	19.1%	64.5%
1992	50.9%	8.7%	59.6%
1993	42.3%	10.5%	52.8%
1994	7.0%	3.5%	10.5%
1995	12.0%	0.3%	12.3%
1996	8.0%	4.4%	12.4%
1997	12.0%	1.6%	13.6%
1998	8.0%	0.2%	8.2%
1999	9.0%	18.5%	27.5%
2000	7.0%	17.5%	24.5%
2001	7.0%	6.4%	13.4%
2002	12.0%	2.1%	14.1%
2003	14.0%	8.9%	22.9%

Year	Ocean Exploitation Rate	Inriver Exploitation Rate	Total Exploitation Rate
2004	15.0%	9.3%	24.3%
2005	11.0%	6.5%	17.5%
2006	6.8%	6.5%	13.3%
2007	11.9%	6.7%	18.6%

8.10.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations.

Gorge MPG

Completed consultations include road maintenance (Washington Upper Gorge and White Salmon); repairing a creek bank next to a road, parking lot maintenance, and maintenance of a stormwater drainage system along a highway (Lower Gorge), culvert cleaning, treating invasive plants, a grazing allotment, and vegetation management along a transmission line right-of-way (Oregon Upper Gorge and Hood populations). The USFS implemented two habitat restoration projects: improve 5 acres of riparian through thinning and improve 49 acres of riparian and one mile of stream by adding large woody debris (Hood population).

Projects Affecting Multiple MPGs/Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.11.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect multiple populations within the ESU. The effects of some on population viability will be positive (treating invasive plants; adding large woody debris; tar remediation). Other projects, including road maintenance, grazing allotments, dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

8.11.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin (see lists of projects in Chapter 17 in Corps et al. 2007a). These include tributary habitat actions that will benefit the Oregon Upper Gorge and Hood River, Washington Upper Gorge and White Salmon, and Washougal populations, as well as actions that should be generally beneficial throughout the ESU. Generally, all of these actions are either completed, ongoing, or reasonably certain to occur.[2] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve the conditions for this ESU. It is not possible to quantify the extent of these positive effects, however.

[2] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.11.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in this section. However, the Prospective Actions will ensure that these adverse effects are reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Releasing a portion of the flow augmentation water from the Upper Snake Project in May (NMFS 2008b) will provide minor benefits through 2034. Some habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix and in this section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

8.11.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Benefits of Bonneville passage improvements affect only the two populations in the Gorge MPG. Prospective Actions include completing the installation of minimum gap runners at Bonneville PH1 and the FGE improvements at PH2 and improvements to sluiceway fish guidance system (efficiency and conveyance) at PH1. Collectively these modifications are expected to increase the survival of yearling coho that pass through Bonneville Dam (i.e., from the 1) Washington Upper Gorge and White Salmon and 2) Oregon Upper Gorge and Hood River) by 1%. Spillway survival improvements during this time period are expected to increase the passage survival through Bonneville Dam of yearling coho salmon by an additional 0.5%.

As a result of this ten-year program of improvements, an estimated 95.5% of the yearling coho that migrate past Bonneville Dam will survive. A portion of the 4.5% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that yearling coho would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion, NOAA Fisheries estimated that the survival of yearling LCR coho in a hypothetical unimpounded Columbia River would be 95% (Table 5.1 in NMFS 2004a). Therefore, approximately 57.8% (2.6%/4.5%)[3] of the expected mortality experienced by in-river migrating juvenile coho is probably due to natural factors.

Based on PIT-tag detections of SR fall Chinook at Bonneville and redetected at upstream dams, NOAA Fisheries estimates an upstream passage survival rate of 96.9% for adult coho salmon that pass Bonneville Dam (i.e., relevant to the Gorge MPG).

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of some flow augmentation water from summer to spring may provide a small benefit to juvenile migrants in the lower Columbia River by slightly reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat in the lower Columbia River below Bonneville Dam.

8.11.5.2 Effects of Tributary Habitat Prospective Actions

The Prospective Actions include funding for habitat improvements in the Hood River that will benefit the coho population in that watershed (Table 6 in Attachment B.2.2-2; Corps et al. 2007b). The project, which will complement the effects on habitat of removing Powerdale Dam, includes actions to increase instream habitat complexity, restore and protect riparian vegetation, provide access and safe passage, and to acquire instream flow and thus is likely to increase the abundance, productivity, and spatial structure of the Hood River coho salmon population. Adverse effects to habitat during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on habitat (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

The Prospective Actions also include the Action Agencies' consideration of funding for habitat improvement projects for any of the Lower Columbia River coho populations above Bonneville that have been significantly impacted by the FCRPS. Projects are to be selected that are consistent with basin-wide criteria for prioritizing projects (e.g., address limiting factors), including those derived from recovery and subbasin plans. However, the type and distribution of these potential projects is

[3] LCR coho salmon are found in the Klickitat River about 56 km upstream of Bonneville Dam.

uncertain, in part because the RPA only commits the Action Agencies to achieving specific survival improvements for species in the Interior Columbia Basin.

8.11.5.3 Effects of Estuary Prospective Actions

The Action Agencies will carry out approximately 44 estuary habitat projects over the first 3-year period of implementing the RPA. The estimated survival benefit for yearling coho associated with these specific actions will be 1.4%.

The RPA requires Action Agencies will implement projects that achieve an additional survival benefit for LCR coho salmon of 4.3% during the period 2010 to 2018. Prospective Actions will include protection and restoration of riparian areas, the protection of remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reduction of noxious weeds, among others.

8.11.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Under the RPA (Action 39), the FCRPS Action Agencies will continue funding hatcheries as well as adopt programmatic criteria for funding decisions on hatchery mitigation programs for the FCRPS that incorporate BMPs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated by hatchery operators with the Action Agencies as cooperating agencies. For the lower Columbia, new HGMPs must be submitted to NOAA Fisheries and ESA consultations initiated by July 2009 and consultations must be completed by January 2010. Subject to hatchery-specific ESA § 7(a)(2) consultation, implementation of hatchery reform principles will: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are fixed and natural productivity increases. These benefits, however, are not relied upon for this consultation and are pending completion of future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.11.5.5 Effects of Harvest Prospective Actions

Under the Prospective Action the harvest of Lower Columbia River coho will vary from year-to-year using the ocean portion of Oregon's harvest matrix (Table 8.11.5.5-1) (NMFS 2008i). Lower Columbia River coho are caught in non-Treaty fall season fisheries in the Columbia River below Bonneville Dam. The states propose to manage Columbia River salmon fisheries each year during 2008 through 2017 with an associated total exploitation rate (ER) on Lower Columbia River natural-origin coho equivalent to the remainder of the ocean portion of Oregon's harvest matrix after ocean fisheries are accounted for. The total ER for each year will be determined using the ocean portion of Oregon's harvest matrix (Table 8.11.5.5-1), which will be described in NMFS' yearly guidance letter to PFMC. For 2008, NMFS guidance to PFMC is to manage fisheries with a total ER for natural-origin

Lower Columbia River coho of 8% and the expected preseason exploitation rate for inriver fisheries is 2.1% (NMFS 2008e). The ER for natural-origin Lower Columbia River coho ESU in 2008 through 2017 will be estimated as a combined ER for early and late stocks for ocean and inriver fisheries.

Table 8.11.5.5-1. Harvest management matrix for Lower Columbia River coho salmon showing maximum allowable Ocean fishery mortality rate.

Parental Escapement [1]		**Marine Survival Index (based on return of jacks per hatchery smolt)**			
		Critical (<0.0008)	**Low (< 0.0015)**	**Medium (< 0.0040)**	**High (> 0.0040)**
High	> 0.75 full seeding	< 8.0%	< 15.0%	< 30.0%	< 45.0%
Medium	0.75 to 0.50 full seeding	< 8.0%	< 15.0%	< 20.0%	< 38.0%
Low	0.50 to 0.20 full seeding	< 8.0%	< 15.0%	< 15.0%	< 25.0%
Very Low	0.20 to 0.10 of full seeding	< 8.0%	< 11.0%	< 11.0%	< 11.0%
Critical	< 0.10 of full seeding	0 – 8.0%	0 – 8.0%	0 – 8.0%	0 – 8.0%

[1.] Full Seeding: Clackamas River = 3,800, Sandy River = 1,340

The ER is estimated as the sum of total mortalities divided by the total ocean abundance. The ER for natural-origin Lower Columbia River coho is assumed to be equivalent to the ER for unmarked coho. The total ocean abundance of Columbia River unmarked coho is provided by the ocean FRAM model. The FRAM model estimates the exploitation rate for all ocean fisheries and for the Buoy 10 sport fishery. For Columbia River fisheries upstream of Tongue Point, the ER is estimated separately for the mainstem sport fishery, SAFE commercial fisheries and mainstem commercial fisheries.
The states of Oregon and Washington have developed two preseason models: one to allocate in-river impact rates among fisheries and one to monitor harvest to maintain the total ER at or below the allowable combine ER for unmarked coho each year. The preseason model used in fishery planning to estimate catch per statistical week in mainstem and SAFE fisheries uses average harvest rates from historical data. The preseason model will be used to structure coho seasons each year and to allocate coho catch among in-river fisheries while remaining within the prescribed yearly ER limit for unmarked fish.

Effects on Hatchery-Origin coho

Although proposed fisheries are being managed primarily to meet ER limits for natural-origin fish, the status of hatchery-origin fish and associated hatchery programs provide secondary consideration. For the time being, achieving hatchery escapement goals, particularly for programs used for supplementation or conservation purposes is desirable.

Lower Columbia River coho hatchery program management requires that these programs are self-sustaining, restricting the practice of using production from other programs to back-fill shortfalls in production goals (NMFS 2004b). This has not been a concern with the abundant returns in recent years. This is particularly the case for those programs involved in supplementation or re-introduction of natural production. Fishery management plans in 2008 also incorporate conservative expectations of coho abundance in order to maximize the prospect of meeting hatchery escapement goals (Table 8.11.5.5-2).

Table 8.11.5.5-2. Lower Columbia River coho hatchery programs, escapement goals and escapement, by program for the last 10 years. Shaded areas/Italic type highlights programs that are used, at least in part, to support supplementation or reintroduction activities. Numbers in bold indicate years in which the escapement goal was not met for that program.

Facility		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Big Creek	***Goal***	*828*	*828*	*700*	*700*	*700*	*700*	*525*	*700*	*700*	*700*
	Escapement	*1,949*	*1,684*	*4,034*	*10,047*	*8,365*	*7,946*	*3,545*	*6,555*	*6,175*	*3,938*
Bonneville	**Goal**	8,751	8,751	6,000	6,000	5,143	6,074	6,074	6,074	6,000	6,000
	Escapement	6,076	4,512	18,116	45,163	25,888	36,318	24,438	25,609	38,001	33,954
Sandy	***Goal***	*1,382*	*1,382*	*1,300*	*1,300*	*1,207*	*1,000*	*1,000*	*1,200*	*1,300*	*1,300*
	Escapement	*5,476*	***1,013***	*12,506*	*20,454*	*6,979*	*8,921*	*16,126*	*10,015*	*8,507*	*7,555*
Grays R.	**Goal**	861	1,362	1,246	1,341	1,341	1,341	1,341	1,341	600	600
	Escapement	**62**	**710**	12,910	6,483	**600**	**683**	1,676	4,838	835	969
Elochoman early	**Goal**	669	876	510	823	823	823	823	823	420	420
	Escapement	**19**	2,131	6,851	11,729	7,953	7,738	5,124	2,784	2,652	2,113
Elochoman late	**Goal**	496	788	788	997	997	997	776	450	450	450
	Escapement	567	2,693	4,536	7,401	4,161	2,800	1,024	761	**324**	979
Cowlitz	***Goal***	*7,483*	*7,438*	*7,483*	*5,740*	*4,715*	*3,000*	*3,000*	*4,200*	*2,700*	*2,700*
	Escapement	*18,378*	*40,321*	*50,395*	*75,744*	*82,876*	*31,165*	*44,622*	*33,655*	*54,283*	*37,111*
Toutle	***Goal***	*1,250*	*1,250*	*1,480*	*1,168*	*1,168*	*1,168*	*1,168*	*1,168*	*700*	*700*
	Escapement	6,506	12,508	28,774	15,730	18,828	30,207	25,462	8,055	6,523	17,680
Kalama Complex early	**Goal**	477	638	700	460	460	460	460	460	350	350
	Escapement	4,274	6,726	4,289	15,680	4,774	4,697	1,487	1,694	3,354	5,130
Kalama Complex late	**Goal**	1,405	1,310	1,533	671	671	671	671	671	300	300
	Escapement	**282**	1,095	10,110	15,522	4,351	3,198	3,156	1,233	5,344	1,768
Lewis Complex early	**Goal**	2,713	2,937	1,526	1,583	1,583	1,583	1,583	1,583	1,583	900
	Escapement	6,882	17,466	17,037	38,656	17,316	37,904	21,853	19,686	18,451	17,163
Lewis	***Goal***	*2,517*	*2,517*	*4,954*	*5,968*	*4,756*	*5,000*	*5,000*	*3,257*	*2,000*	*2,000*

Facility		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Complex late	*Escapement*	*16,130*	*17,717*	*23,199*	*60,812*	*6,170*	*20,803*	*10,750*	*16,164*	*18,071*	*15,818*
Washougal late	**Goal**	4,565	4,906	742	748	748	748	748	748	2,450	2,450
	Escapement	**1,605**	**2,581**	5,597	18,457	19,282	6,085	4,023	3,277	11,016	5,175
Eagle Creek	**Goal**	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300
	Escapement	12,612	11,779	33,106	30,146	6,285	4,812	7,776	8,921	14,153	11,128

All hatcheries have exceeded their broodstock goals in at least 5 of the most recent 10 years (1998-2007). The five programs marked for supplementation or re-introduction met their goals in all of the last 10 years, except for the Sandy River program, which met the goal in 8 of the last 10 years (Table 8.11.5.5-3). Based on the preseason run size and expected ocean and in-river fisheries, the expected hatchery escapement are: 57,800 early coho to Washington hatcheries compared to the escapement goal of 3,000; 95,500 early coho to Oregon hatcheries compared to the escapement goal of 11,300; and 32,300 late coho to Washington hatcheries compared to the escapement goal of 24,400 (TAC 2008). As a consequence, there is a high likelihood that all hatchery broodstock needs will be met as they have in recent years.

Effects on Species Status

Prospective improvements in harvest effects support the increased abundance, productivity, diversity, and spatial structure of spring- and fall-run populations of LCR coho. Harvest levels have been considered in detail in the recent biological opinion for PFMC and Fraser Panel fisheries (NMFS 2008e). NOAA Fisheries concluded in that opinion that the proposed total exploitation limit is consistent with the expectation the species' survival and recovery.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR coho.

8.11.5.6 Effects of Predation Prospective Actions

Prospective Actions that reduce predation on juvenile coho will support the increased survival and therefore abundance and productivity of LCR coho salmon.

Avian predation

The survival of yearling coho will increase 7.8% with the relocation of most of the Caspian terns to sites outside the Columbia River basin, management of cormorant predation at East Sand Island, and improved avian deterrence at Bonneville Dam.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous fish predation

The Prospective Action to continue the increase in incentives in the NPMP will result in an additional 1% survival.

8.11.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRPS.

8.11.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on Lower Columbia River Coho Salmon

This section summarizes the basis for conclusions at the ESU level.

8.11.6.1 Recent Status of the Lower Columbia River Coho ESU

Lower Columbia River coho salmon is a threatened species. Although there is little quantitative information, it is likely that many of the populations in this ESU have low abundance. Long-term trends and lambda for the Clackamas and Sandy River populations are just over 1.0. The Youngs Bay and Big Creek populations are sustained by hatchery production. The viability of the species has been limited by habitat degradation, habitat blockage by FERC-licensed dams in several subbasins, harvest, hatchery effects, and ecological factors including predation as well as the effects of the existence and operation of the FCRPS and Upper Snake projects. The historical role of the FCRPS and Reclamation projects was the loss of habitat for the Oregon Upper Gorge and Hood River population under Bonneville pool and passage delay and mortality at Bonneville Dam for the two populations in the Gorge MPG. Coho smolts are vulnerable to bird predation in the estuary. Large-scale changes in freshwater and marine environments have also had substantial effects on salmonid numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this ESU. The potential for additional risks due to climate change is described in Section 5.7 and 8.1.3.

8.11.6.2 Effects of the FCRPS, Upper Snake & *U.S. v. Oregon* Prospective Actions on the Lower Columbia River Coho ESU

In the LCFRB's recovery plan,[4] one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume." The Action Agencies' estuary habitat restoration projects and relocation of Caspian terns to reduce predation on juvenile coho will address this objective. Implementation of habitat improvement projects in the Hood watershed will address limiting factors that remain after the FERC-licensed dam is removed. The potential funding for additional habitat projects could address the loss of historical spawning habitat for the Oregon Upper Gorge and Hood River and the Upper Gorge Washington and White Salmon populations, including some habitat that was inundated by Bonneville pool. Actions that will further improve the viability of the Gorge populations include the continued increase in the northern pikeminnow reward fishery, and continued and improved avian deterrence at Bonneville Dam, and prospective juvenile passage improvements at Bonneville Dam.

Some adverse impacts from hatchery practices will continue, and allowable harvest rates will vary according to the year-specific guidance letter from NMFS to Council. In 2009 and thereafter, the Council is required to manage fisheries subject to the ocean portion of the Oregon harvest matrix (Table 8.11.5.1.5-1**)**. Exploitation rates are therefore likely to vary based on year specific circumstances.

The effect of this management strategy was recently reviewed through a section 7 consultation on PFMC and Fraser Panel fisheries (NMFS 2008e). NOAA Fisheries concluded that managing fisheries subject to the ocean portion of the Oregon harvest matrix was not likely to jeopardize the Lower Columbia River coho salmon ESU. The underlying analysis assumed that the total exploitation rate in 2009 and thereafter would be no more than to the ocean portion of the Oregon harvest matrix. Inriver fisheries will necessarily be managed subject to that guidance.

8.11.6.3 Cumulative Effects Relevant to the Lower Columbia River Coho ESU

Habitat-related actions and programs that the states of Oregon and Washington have determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect instream habitat. These actions will improve the functioning of habitat needed for successful spawning, incubation, and the growth and development of juvenile coho.

[4] The LCFRB recovery plan addresses Lower Columbia River coho salmon, but because this species was not listed under the ESA at the time NOAA Fisheries evaluated the plan, the agency did not approve the LCFRB's plan as an interim regional recovery plan for the Washington portion of the Lower Columbia River coho ESU. The LCFRB is updating the coho portion of its plan, and Oregon is developing a recovery plan for the Oregon portion of the ESU. NOAA Fisheries will review and evaluate these plan elements for adequacy as the ESA recovery plan for LCR coho salmon.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for this consultation (the mainstem lower Columbia River and tributary areas above Bonneville Dam), these are likely to include urban development and other land use practices.

8.11.6.4 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Lower Columbia River Coho ESU

Impacts of the FCRPS and Upper Snake projects on this ESU are most significant for the two (out of 24) populations that spawn above Bonneville Dam and are limited relative to those from tributary hydropower, tributary habitat, harvest, hatcheries, and predation by birds and fish. These populations are affected by upstream and downstream passage and, for the Oregon Upper Gorge and Hood River population, by inundation of spawning habitat. For populations originating in tributaries below Bonneville, only migration and habitat conditions in the mainstem and estuary are affected by the existence and operation of the hydrosystem.

The states of Oregon and Washington identified tributary habitat actions that are reasonably certain to occur and that will benefit the Oregon Upper Gorge and Hood River, Washington Upper Gorge and White Salmon, and Washougal populations, as well as actions that should be generally beneficial throughout the ESU. Habitat blockages in the Lewis, Cowlitz, Sandy, and Hood watersheds are being addressed by actions taken at FERC-licensed hydroelectric projects (Section 8.11.3.2). The functioning of mainstem habitat as a juvenile migration corridor has improved in recent years with the development of the corner collector at Bonneville PH2 and other improvements. Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement of habitat conditions on state forest lands within the range of Lower Columbia River coho (Section 8.11.3.7).

The FCRPS Action Agencies' prospective passage improvements at Bonneville Dam, estuary habitat improvements, and predator management improvements will contribute to the viability of this ESU and thus to its survival with an adequate potential for recovery. The Action Agencies' prospective habitat work in the Hood River and additional potential funding for tributary projects for the populations above Bonneville, plus actions at FERC-licensed dams in the Cowlitz, Lewis, White Salmon, Hood, and Sandy subbasins are expected to support the restoration of specific populations within the ESU. The Prospective Actions will not further deteriorate the pre-action condition.

Long term (100 year) extinction risk is high or very high for almost all populations in this ESU. The only exception is the Clackamas population. In the short term, the species' extinction risk is expected to be reduced through implementation of the actions described above. In particular, the genetic legacy of the Lewis and Cowlitz River coho populations will continue to be preserved by ongoing hatchery actions as a hedge against short-term risk of extinction.

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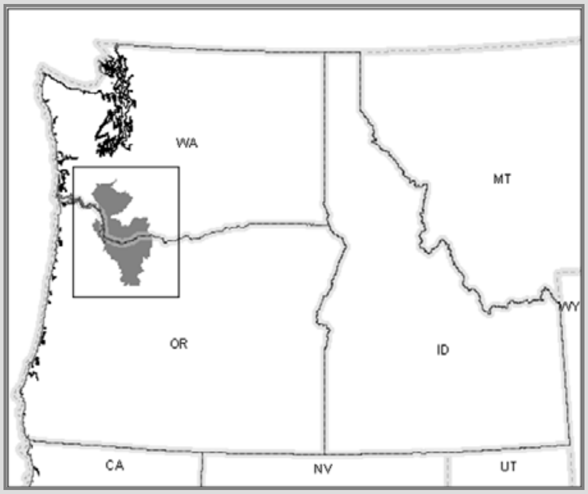
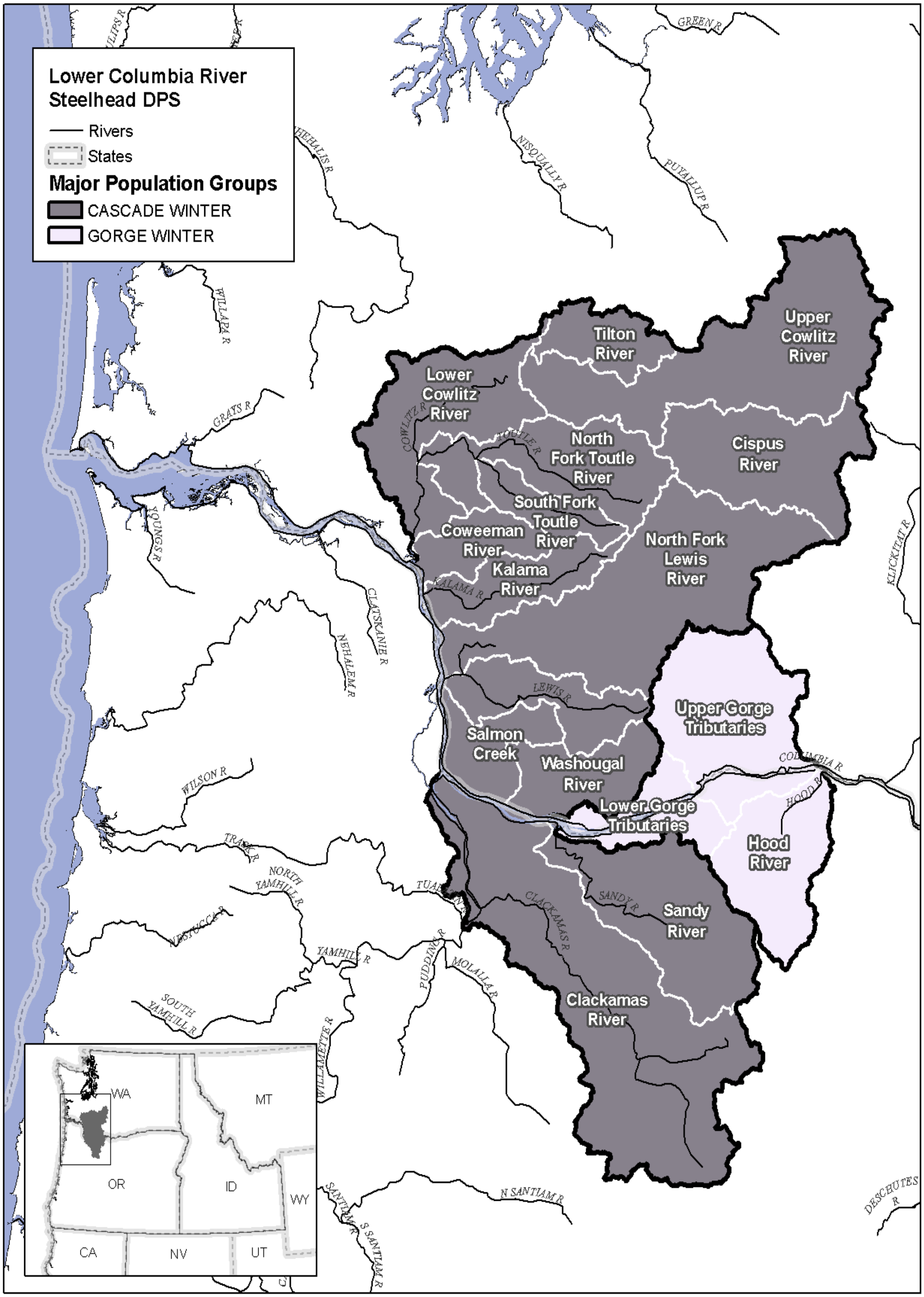
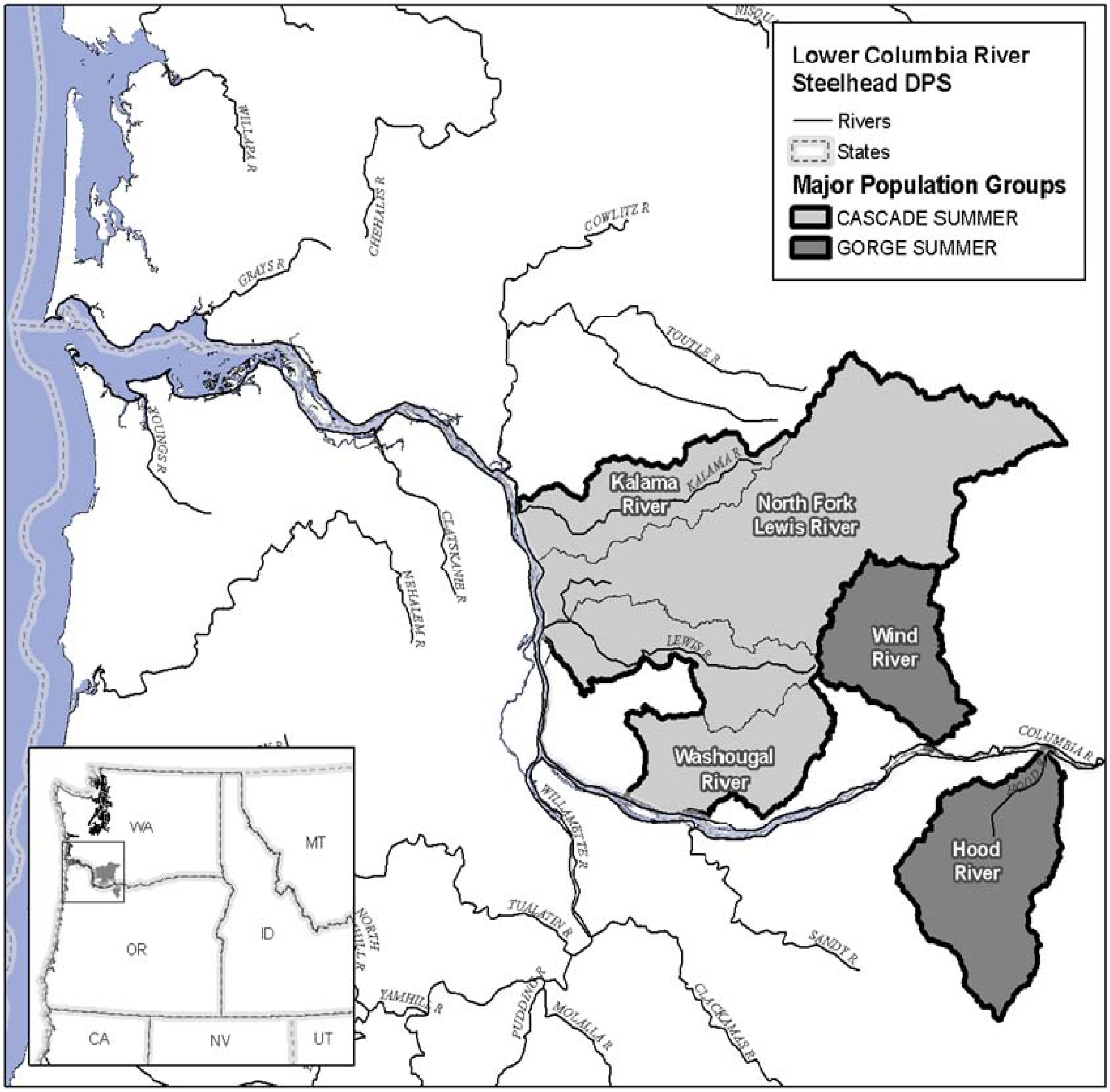
Lower Columbia River Steelhead




Lower Columbia River Steelhead DPS
Rivers
States
Major Population Groups
CASCADE WINTER
GORGE WINTER
Tilton River
Upper Cowlitz River
Lower Cowlitz River
North Fork Toutle River
Cispus River
South Fork Toutle River
Coweeman River
Kalama River
North Fork Lewis River
Upper Gorge Tributaries
Salmon Creek
Washougal River
Lower Gorge Tributaries
Hood River
Sandy River
Clackamas River
WA
MT
OR
ID
WY
CA
NV
UT


Lower Columbia River Steelhead DPS
Rivers
States
Major Population Groups
CASCADE SUMMER
GORGE SUMMER
Kalama River
North Fork Lewis River
Wind River
Washougal River
Hood River
WILLAPA R
CHEHALIS R
COWLITZ R
GRAYS R
TOUTLE R
YOUNGS R
KALAMA R
CLATSKANIE R
NEHALEM R
LEWIS R
COLUMBIA R
WILLAMETTE R
TUALATIN R
SANDY R
YAMHILL R
PUDDING R
MOLALLA R
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Section 8.12
Lower Columbia River Steelhead

Species Overview

Background

The Lower Columbia River steelhead DPS includes 23 historical anadromous populations in four major population groups. This DPS includes both summer- and winter-run types. the Lower Columbia River steelhead DPS was listed as threatened under the ESA in 1998, reaffirmed in 2006.

Designated critical habitat for LCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in a number of tributary subbasins.

Current Status & Recent Trends

Many of the populations comprising this DPS are small and many of the long- and short-term trends in abundance of individual populations are negative, some severely so. In addition, for most populations the probability is high that the trend in natural-origin spawners is less than one. A number of the populations have a substantial fraction of hatchery-origin spawners. Exceptions are the Kalama, North and South Fork Toutle, and East Fork Lewis winter-run populations, which have few hatchery fish spawning in natural spawning areas. These populations have relatively low recent abundance estimates; the largest is the Kalama River with 726 spawners.

Limiting Factors

Human impacts and limiting factors include habitat degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and ecological factors including predation. Tributary habitat has been degraded by extensive development and other effects of changing land use. This has adversely affected stream temperatures and reduced the habitat diversity needed for steelhead spawning, incubation, and rearing. Steelhead access to tributary headwaters has been restricted or blocked by FERC-licensed dams built without passage facilities or facilities that were inadequate and have caused injury and delay. Four populations (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run) are subject to FCRPS impacts involving passage at Bonneville Dam and all populations are affected by habitat alterations in the Columbia River mainstem and estuary. Preservation and recovery of this DPS will require significant efforts by many parties.

Recent Ocean and Mainstem Harvest

The Lower Columbia River steelhead DPS includes both winter and summer-run populations. Ocean fishing mortality on LCR steelhead is assumed to be zero. In recent years, non-Treaty mainstem winter and spring season fisheries have been managed subject to a 2% harvest rate limit on natural-origin winter steelhead. Treaty Indian fisheries only affect those populations above Bonneville Dam. LCR winter steelhead are not caught in non-Treaty summer or fall season fisheries. The harvest rate in non-Treaty fisheries has been limited to a maximum of 2%.

8.12.2 Current Rangewide Status

With this first step of the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.12.2.1 Current Rangewide Status of the Species

Lower Columbia River steelhead is a threatened species composed of 23 historical anadromous populations in four major population groups (called strata by the Willamette-Lower Columbia Technical Recovery Team (WLC TRT) (Table 8.12.2.1-1 and Lower Columbia River Steelhead Map).

Table 8.12.2.1-1. Lower Columbia River steelhead DPS description and major population groups (MPGs) (Sources: NMFS 2006a; Myers et al. 2006). The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (Appendix B in WLCTRT 2003).[1]

DPS Description	
Threatened	Listed under ESA in 1999; reaffirmed in 2006
4 major population groups	23 historical populations
Major Population Group	**Population**
Cascade Summer	Kalama (C), NF Lewis, EF Lewis (G), Washougal (C,G)
Gorge Summer	Wind (C), Hood
Cascade Winter	Lower Cowlitz, Coweeman, NF Toutle (C), SF Toutle, Coweeman, Upper Cowlitz (C,G), Lower Cowlitz, Cispus (C), Tilton, Kalama, NF Lewis (C), EF Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge Winter	Lower Gorge, Upper Gorge, Hood (C,G)
Hatchery programs included in DPS (10)	Cowlitz Trout Hatchery (in the Cispus, Upper Cowlitz, Lower Cowlitz, and Tilton Rivers), Kalama River Wild (winter- and summer-run), Clackamas Hatchery, Sandy Hatchery, and Hood River (winter- and summer-run) steelhead hatchery programs

This DPS includes both summer and winter type steelhead. Summer steelhead return to freshwater from May to November, entering the Columbia River in a sexually immature condition and requiring several months in fresh water before spawning. Winter steelhead enter fresh water from November to April. They are close to sexual maturation and spawn shortly after arrival in their natal streams.

[1] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the DPS (WLCTRT 2003).

Where both races spawn in the same stream, summer steelhead tend to spawn at higher elevations than the winter forms. Juveniles rear in fresh water (stream type life history).

Limiting Factors

Human impacts and limiting factors come from multiple sources: habitat degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and ecological factors including predation. Tributary habitat has been degraded by extensive development and other effects of changing land use. This has adversely affected stream temperatures and reduced the habitat diversity needed for steelhead spawning, incubation, and rearing. Steelhead access to tributary headwaters has been restricted or blocked by FERC-licensed dams built without passage facilities or facilities that were inadequate and have caused injury and delay. Four populations (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run) are subject to FCRPS impacts involving passage at Bonneville Dam and all populations are affected by habitat alterations in the Columbia River mainstem and estuary. Preservation and recovery of this DPS will require significant efforts by many parties.

Summarized below (Table 8.12.2.1-2) are key limiting factors for this DPS and recovery strategies to address those factors as described in the Washington Lower Columbia Recovery and Subbasin Plan [Lower Columbia Fish Recovery Board (LCFRB) 2004]. Oregon is currently engaged in the recovery planning process for LCR steelhead.

Table 8.12.2.1-2. Key limiting factors for LCR steelhead.

Mainstem Hydro	Direct mainstem hydropower system impacts on LCR steelhead are most significant for the four gorge tributary populations upstream from Bonneville Dam (Wind River Summer Run, Hood River Summer Run, Upper Gorge Winter Run, and Hood River Winter Run). These populations are affected by upstream and downstream passage at Bonneville Dam and in the case of the Upper Gorge winter steelhead population, by the inundation of historical habitat under the reservoir (WLCTRT 2004). Impacts on populations originating in subbasins below Bonneville Dam are limited to effects on migration and habitat conditions in the lower Columbia River (below Bonneville Dam) including the estuary.
Predation	Piscivorous birds including Caspian terns and cormorants, fishes including northern pikeminnow, and marine mammals including seals and sea lions take significant numbers of juvenile or adult winter steelhead. Stream-type juveniles, especially steelhead smolts, are vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid water over the channel, which is located near habitat preferred by piscivorous birds (Fresh et al 2005). Steelhead are also subject to pinniped predation when they return to the estuary as adults (NMFS 2006b). Caspian terns as well as cormorants may be responsible for the mortality of up to 6% of the outmigrating stream-

	type juveniles in the Columbia River basin (Corps et al. 2007a). Pikeminnow are significant predators of both juvenile and subjuvenile juvenile migrants (Friesen and Ward 1999). Ongoing actions to reduce predation include redistribution of avian predator nesting areas, a sport reward fishery to harvest pikeminnow, and the exclusion and hazing of marine mammals near Bonneville Dam.
Harvest	Harvest includes direct and indirect fishery mortality. Lower Columbia River steelhead are harvested in Columbia River and tributary freshwater fisheries of Oregon and Washington. Fishery impacts on wild LCR steelhead have been limited to less than 10% since the implementation of mark-selective fisheries during the 1980s.
Hatcheries	The long-term domestication of hatchery fish has eroded the fitness of these fish in the wild and has reduced the productivity of wild stocks where significant numbers of hatchery fish spawn with wild fish. Until selective fisheries were instituted in the early 1990s, large numbers of hatchery fish contributed to intensive mixed stock fisheries, overexploiting wild populations already weakened by habitat degradation. State and Federal hatchery programs throughout the lower Columbia River are currently subject to a series of comprehensive reviews for consistency with the protection and recovery of listed salmonids. A variety of beneficial changes to hatchery programs have already been implemented and additional changes are anticipated.
Estuary	The estuary is an important habitat for migrating juveniles from LCR steelhead populations. Due to a short residence time in the estuary, stream-type juveniles such as steelhead have limited mortality associated with a scarcity of habitat, changes in food availability, and the presence of contaminants. However, they are particularly vulnerable to bird and pinniped predation in the estuary (Fresh et al. 2005). Furthermore, steelhead are believed to be affected by flow and sediment delivery changes in the plume (Casillas 1999). Estuary limiting factors and recovery actions are addressed in detail in a comprehensive regional planning process (NMFS 2006b).
Habitat	Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats. Winter steelhead populations have been blocked from higher elevation spawning habitats by construction of FERC-licensed hydropower facilities. Major hydro projects in the Cowlitz and Lewis basins have blocked access to approximately 80% of the historical steelhead spawning and rearing habitat within both basins (LCFRB 2004). In addition to cumulative habitat effects, the construction of non-Federal hydropower

	facilities on Columbia River tributaries has partially or completely blocked higher elevation spawning. The Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004) identifies current habitat values, restoration potential, limiting factors, and habitat protection and restoration priorities for steelhead by reach in all Washington subbasins. Similar information is in development for Oregon subbasins.
Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status of this DPS to some extent, future trends, especially during the time period relevant to the Prospective Actions, are unclear. Under the adaptive management implementation approach of the Lower Columbia River Recovery and Subbasin Plan, further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through additional recovery effort (LCFRB 2004).

Abundance, Productivity & Trends

The information in Table 8.12.2.1-3 was reported in NOAA Fisheries' most recent status review (Good et al. 2005). Draft status assessments were updated for Oregon populations in a more recent review (McElhany et al. 2007). Long-term averages were used where available, although some of the time series are relatively recent. Many of the populations comprising this DPS are small and many of the long- and short-term trends in abundance of individual populations are negative, some severely so. In addition, for most populations the probability is high that the true trend/growth rate is less than one (Table 43 in Good et al. 2005). A number of the populations have a substantial fraction of hatchery-origin spawners. Exceptions are the Kalama, North and South Fork Toutle, and East Fork Lewis winter-run populations, which have few hatchery fish spawning in natural spawning areas. These populations have relatively low recent mean abundance estimates; the largest is the Kalama River with a geomean of 726 spawners.

Table 8.12.2.1-3. Abundance, productivity, and trends of LCR steelhead populations (Sources: Good et al. 2005 for Washington and McElhany et al. 2007 for Oregon populations).

Strata	Population	State	Recent Abundance of Natural Spawners			Long-term Trend[b]		Median Growth Rate[c]	
			Years	Geo. Mean	pHOS[a]	Years	Value	Years	λ
Cascade Summer	Kalama	W	99-03	474	32%	77-03	0.928	77-03	0.712
	NF Lewis	W	na	na	na	na	na	na	na
	EF Lewis	W	99-03	434	25%	na	na	na	na
	Washougal	W	99-03	264	8%	86-03	0.991	86-03	0.996
Gorge Summer	Wind	W	99-03	472	5%	na	na	na	na
	Hood	O	93-05	195	11.4%	93-05	0.995	93-05	0.811
Cascade Winter	Lower Cowlitz	W	na	na	na	na	na	na	na
	Coweeman	W	98-02	466	50%	87-02	0.916	87-02	0.782
	SF Toutle	W	98-02	504	2%	84-02	0.917	84-02	0.933
	NF Toutle	W	98-02	196	0%	89-02	1.135	89-02	1.062
	Upper Cowlitz	W	na	na	na	na	na	na	na
	Cispus	W	na	na	na	na	na	na	na
	Tilton	W	2002	2,787	73%	na	na	na	na
	Kalama	W	98-02	726	0%	77-02	0.998	77-02	0.916
	NF Lewis	W	na	na	na	na	na	na	na
	EF Lewis	W	na	na	na	na	na	na	na
	Salmon	W	na	na	na	na	na	na	na
	Washougal	W	98-02	323	0%	na	na	na	na
	Clackamas	O	90-05	1168	16.2%	90-05	1.03	90-05	0.976
	Sandy	O	90-05	1040	11%	90-05	0.95	90-05	0.923
Gorge Winter	Lower Gorge	W	na	na	na	na	na	na	na
	Upper Gorge	W	na	na	na	na	na	na	na
	Hood River	O	96-00	756	52%	na	na	na	na

Extinction Probability/Risk

The risk of extinction over 100 years (Table 8.12.2.1-4) was derived qualitatively, based on risk categories and criteria identified by the WLC TRT (2004) for use in recovery plan assessments. The rating system categorized extinction risk probabilities as very low (<1%), low (1 to 5%), medium (5 to 25%), high (26 to 60%), and very high (>60%) based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

The 100-year risk of extinction is high or very high for most populations of LCR steelhead. Exceptions are:

- Wind summer run (moderate)—abundance is low; hatchery fish contribute to a small portion of escapement and genetic analyses indicate that introgression has been limited; habitat access only slightly impaired

- South Fork Toutle winter run (moderate)—abundance is moderate; hatchery fish contribute to a small portion of escapement; much of the upper basin is recovering from the effects of the Mt. St. Helens eruption; much of the historical range is accessible

- Kalama winter run (moderate)—abundance is moderate; hatchery fish contribute to a small portion of escapement; much of the historical range is accessible

- Clackamas winter run (low)—average abundance is near 1,000 fish; hatchery fish contribute to escapement but the broodstock is largely native in origin; upstream and downstream passage through the North Fork Dam may be partially blocked or delayed—lower elevation habitat is degraded, but headwater areas appear to be in good condition

- Hood winter run (moderate)—abundance is moderate; hatchery fish contribute about half of the run; the hatchery stock was reestablished in 1991 using what are presumed to be native fish, although there may have been some introgression, especially from naturally-produced Big Creek fish; blockages are limited to a few headwater reaches that were not significant historical production areas; lower elevation habitat is degraded

Table 8.12.2.1-4. Risk of extinction categories for populations of LCR steelhead (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Strata	Population	State	Extinction Risk Category
Cascade Summer	Kalama	W	H
	NF Lewis	W	VH
	EF Lewis	W	H
	Washougal	W	H
Gorge Summer	Wind	W	M
	Hood	O	VH
Cascade Winter	Lower Cowlitz	W	H

Strata	Population	State	Extinction Risk Category
	Coweeman	W	H
	NF Toutle	W	H
	SF Toutle	W	M
	Upper Cowlitz	W	H
	Cispus	W	H
	Tilton	W	VH
	Kalama	W	M
	NF Lewis	W	H
	EF Lewis	W	H
	Salmon	W	H
	Washougal	W	H
	Clackamas	O	L
	Sandy	O	H
Gorge Winter	Lower Gorge	W/O	H/H
	Upper Gorge	W/O	H/M
	Hood	O	M

Spatial Structure

Spatial structure has been substantially reduced by the loss of access to the upper portions of some basins due to tributary hydro development. For example, since the early 20th century the spatial structure of the summer- and winter-run populations in the Hood River has been limited by delay and injury at the inadequate trap-and-haul facility at Powerdale Dam (see Section 8.12.3, Environmental Baseline, for information about the scheduled removal of this FERC-licensed hydropower project). The following FERC-licensed projects affecting rangewide status soon will either be removed or become passable, allowing the affected populations to re-occupy historical habitat:

- Bull Run (Marmot Dam) – removal by 2008 (NMFS 2003d) will improve passage (i.e., eliminate delay and injury) for the winter-run steelhead population (designated a Core population by the WLC TRT (2003)) into the upper Sandy River watershed

- Lewis River Hydroelectric Project – upstream and downstream passage facilities will be developed (NMFS 2007f), a first step toward restoring the North Fork Lewis winter-run steelhead population

- Cowlitz River Hydroelectric Project – upstream and downstream passage facilities will be developed (NMFS 2004c), supporting the restoration of the Upper Cowlitz, Tilton, and Cispus winter-run steelhead populations

The FERC licenses for the Lewis and Cowlitz River hydroelectric projects require their respective owners/operators to operate hatchery programs. PacifiCorps and Cowlitz PUD operate a hatchery program to support a naturally-spawning, harvestable population of steelhead throughout its historical range in the North Fork Lewis basin. Tacoma Power is planning to operate a conservation hatchery that will produce steelhead for reintroduction into the upper Cowlitz basin. Combined with the new passage facilities at each project, the hatchery programs are expected to increase the number of natural spawners as well as the spatial structure of their respective populations.

Diversity

Before the early 1990s, the diversity of some populations was likely eroded by large hatchery influences. Periodically, many populations have been vulnerable to genetic drift and other effects on diversity associated with low effective population sizes. At present, the role for most steelhead hatchery programs in the lower Columbia River is to compensate for impacts to fisheries. Operations at these hatcheries are designed to minimize competition with and predation upon natural-origin fish by managing the size of juveniles at release and by locating release points below spawning and rearing areas. Adult hatchery fish should not spawn naturally to avoid impacts to population diversity. Some hatchery programs (e.g., the Skamania hatchery program in Washington) outplant non-local steelhead into various areas and attempt to isolate adult returns and prevent them from spawning with natural fish. There is little information available to determine how effective these programs are at avoiding impacts to population diversity.

The genetic legacy of several populations (Hood River summer – and winter – run and the Cowlitz, Sandy, and Clackamas late winter – run populations) is preserved in ongoing hatchery programs.

8.12.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for LCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Clackamas, and Lower Willamette (NMFS 2005b). There are 32 watersheds within the range of this DPS. Two watersheds received a low rating, 11 received a medium rating, and 29 received a high rating of conservation value to the DPS (for more information, see Chapter 4). The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 2,673 miles of habitat eligible for designation, 2,324 miles of stream are designated critical habitat.

In the lower Columbia River and its tributaries, major factors affecting PCEs are altered channel morphology and stability; lost/degraded floodplain connectivity; loss of habitat diversity; excessive sediment; degraded water quality; increased stream temperatures; reduced stream flow; and reduced access to spawning and rearing areas (LCFRB 2004; ODFW 2006; PCSRF 2006). The status of critical habitat within the action area is discussed in more detail in Section 8.12.3.8.

8.12.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

Both Federal and non-Federal parties have implemented a variety of actions that have improved the status of LCR steelhead. Actions that have been implemented since the environmental baseline was described in the 2000 FCRPS Biological Opinion (NMFS 2000b) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend developed by the WLC TRT (Table 8.12.2.1-3) will improve.

8.12.3.1 Recent FCRPS Hydro Improvements

Corps et al. (2007) estimated that hydropower configuration and operational improvements implemented at Bonneville Dam between 2000 and 2006 have resulted in an increase in survival for juvenile LCR steelhead that pass Bonneville Dam, although it was unable to quantify the improvement. Actions during this period included the installation of a corner collector at Powerhouse II (PH2) and the partial installation of minimum gap runners (MGR) at Powerhouse I (PHI) and structures that improved Fish Guidance Efficiency (FGE) at PH2. Spill operations have improved and PH2 is given the first priority for powerhouse operations because bypass survival is higher than at PH1 and drawing water toward PH2 moves fish toward the corner collector. The juvenile bypass system screen was removed from PH1 because testing showed that survival through the turbines was higher than through the bypass system.

8.12.3.2 Recent Tributary Habitat Improvements

Actions since 2000 have ranged from beneficial land management practices through improvement in access due to culvert replacement through improved fish passage into areas above FERC-licensed dams. The latter category refers to the upcoming removal of Powerdale Dam on the Hood River above Bonneville (i.e., within the action area for this consultation) by 2012 (NMFS 2005o). This action is expected to support the restoration of the summer-and winter-run steelhead populations. Hood River winter steelhead were designated a Core and Genetic Legacy (and Hood River summer steelhead a Core) population by the WLCTRT (2003). Although there is some uncertainty that these populations will become reestablished, NOAA Fisheries has determined that this is the correct next step toward their restoration.[2]

8.12.3.3 Recent Estuary Habitat Improvements

The Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving riparian and wetland function. These have resulted in an estimate 0.3% survival benefit for LCR steelhead (stream-type juvenile life history).

8.12.3.4 Recent Predator Management Improvements

Avian Predation

Caspian tern predation in the estuary was reduced from a total of 13,790,000 smolts to 8,201,000 smolts after relocation from Rice to East Sand Island in 1999. The double-crested cormorant colony has grown during the same period. Juvenile steelhead are highly vulnerable to these predators based on PIT-tag data from the upriver stocks (Ryan et al. 2006).

Piscivorous Fish Predation

The ongoing Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality since it began in 1990. The recent improvement in lifecycle survival attributed to the NPMP is estimated at 2% for larger juvenile salmonids (Friesen and Ward 1999).

Marine Mammal Predation

In recent years, sea lion predation of adult winter steelhead (Gorge Winter Run MPG) in the Bonneville tailrace has increase from 0%, or sufficiently low that it was rarely observed, to a mortality rate of about 21.8% (SCA Marine Mammal Appendix). NOAA Fisheries has completed section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on winter-run steelhead in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the relative survival of winter-run steelhead by 18.2%, so that the continuing negative impact will be approximately 7.6%.

8.12.3.5 Recent Hatchery Management Issues

The presence of naturally spawning hatchery-origin steelhead has been identified as a limiting factor for the viability of this species (LCFRB 2004; ODFW 2006b). Of the 25 programs that release steelhead below Bonneville Dam, NOAA Fisheries identified only one program as improving population viability by increasing spatial distribution (NMFS 2004b). Four were identified as reducing short-term extinction risk, helping to preserve genetic resources important to DPS survival

[2] The steelhead population in the (Big) White Salmon River is part of the Mid-Columbia River DPS. Thus, removal of Condit Dam will not affect the status of the Lower Columbia River steelhead DPS.

and recovery.[3] A summary of progress in hatchery reform for Lower Columbia programs that release fish above Bonneville Dam is reported in Table 2 of NMFS 2004 b

8.12.3.6 Recent Harvest Survival Improvements

Fisheries in the mainstem Columbia River are currently managed subject to the terms of the *U.S. v. Oregon* Interim Management Agreement for 2005-2007 in a manner that ensures a limited incidental take of ESA-listed LCR steelhead. In recent years, non-Indian mainstem fisheries have been managed subject to a 2% harvest rate limit on winter steelhead, including the winter populations of the LCR steelhead DPS. The yearly incidental take of winter-run steelhead populations in non-Indian fisheries has averaged 1.9% and has ranged from 0.2-9.3% since 2001 (Table 8.12.3.6-1). The non-Indian harvest rate in 2002 was an anomaly and corrective actions were taken to avoid harvest rates over 2%. The yearly incidental take of winter-run steelhead populations in non-Indian fisheries, excluding 2002, has averaged 0.7% since 2001. The yearly incidental catch of winter-run steelhead populations in tribal fisheries, which is limited to winter populations above Bonneville Dam, has averaged 2.2% and has ranged from 0.8-5.8% since 2001 (Table 8.12.3.6-2).

Table 8.12.3.6-1. Non-Indian harvest rates for winter-run steelhead expressed as a proportion of the total winter-run steelhead run size (TAC 2008, Table 16).

Year	Non-Indian
2001	0.6%
2002	9.3%
2003	1.0%
2004	0.9%
2005	0.6%
2006	0.2%
2007	0.6%
Average 2001-2007	1.91%

Table 8.12.3.6-2. Treaty Indian harvest rates for winter-run steelhead expressed as a proportion of the unmarked winter-run steelhead counts at Bonneville Dam in the winter season (TAC 2008).

Year	Treaty Indian
2001	3.40%

[3] The buffer against extinction is probably short term because dependence on hatchery intervention can lead to increased risk over time (ICTRT 2007a).

Year	Treaty Indian
2002	0.30%
2003	5.80%
2004	0.80%
2005	0.80%
2006	1.80%
2007	2.30%
Average 2001-2007	2.17%

In recent years, non-Indian mainstem winter, spring and summer season fisheries have been managed subject to a 2% harvest rate limit on summer steelhead, including summer steelhead populations of the LCR steelhead DPS. Treaty fisheries are managed for a range of expected impacts on the summer-run component of the LCR steelhead DPS. Actual harvest impacts on summer steelhead populations of the LCR steelhead DPS associated with non-Indian fisheries have generally been lower than the 2% limit; recent actual harvest rates have ranged from 0.2 to 0.5% (Table 8.12.3.6-3). Recent harvest rates on summer steelhead populations of the LCR steelhead DPS associated with Treaty fisheries have ranged from 4.1-12.3% (Table 8.12.3.6-3). The harvest rates in Table 8.12.3.6-3 for Treaty and non-Indian fisheries are not additive. Harvest impacts to the summer-run populations of the LCR steelhead DPS associated with Treaty fisheries in Table 8.12.3.6-3 is the same as for A-run summer steelhead. However, impacts to the summer-run populations of the LCR steelhead DPS would be less than for the other A-run DPS' because its upstream boundary is within the Bonneville Pool and much tribal fishing occurs upstream of this boundary. For the purposes of this analysis however, the harvest impacts on summer steelhead populations of the LCR steelhead DPS associated with Treaty fisheries have ranged from 4.1-12.4% (Table 8.12.3.6-3).

Table 8.12.3.6-3. Treaty Indian and non-Indian harvest rates for summer-run populations of the LCR steelhead DPS (Treaty and non-Indian harvest rates are not additive because these are calculated using a different denominator).

Year	Treaty *	Non-Indian**
1998	12.4%	
1999	7.4%	0.5%
2000	5.1%	0.4%
2001	6.0%	0.3%
2002	4.6%	0.4%

Year	Treaty *	Non-Indian**
2003	5.4%	0.4%
2004	7.0%	0.2%
2005	6.0%	0.3%
2006	6.0%	0.3%
2007	4.1%	0.3%
* TAC 2008 ** TAC 2008		

8.12.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations.

Gorge Summer MPG

Completed consultations include removal of Hemlock Dam, a road maintenance project, and a project to clean culverts and a stream channel (Wind) and treating invasive plants, a grazing allotment, and vegetation management along a transmission line right-of-way (Hood population). The USFS consulted on habitat restoration projects: improve 2 miles of riparian by removing noxious weeds and planting native vegetation (Wind) and improve 5 acres riparian through thinning and 49 acres riparian and 1 mile of stream by adding large wood (Hood population).

Gorge Winter MPG

Completed consultations include repairing a creek bank next to a road, parking lot maintenance at Oneonta Gorge, and stormwater drainage maintenance along the Columbia River Highway (Lower Gorge) and treating invasive plants, a grazing allotment, and vegetation management along a transmission line right-of-way (Hood population). The USFS consulted on habitat restoration projects: improve 2 miles of riparian by removing noxious weeds and planting native vegetation (Upper Gorge) and improve 5 acres riparian through thinning and 49 acres riparian and 1 mile of stream by adding large wood (Hood population).

Projects Affecting Multiple MPGs/Populations

NOAA Fisheries (NMFS 2006k) completed consultation on issuance of a 50-year incidental take permit to the State of Washington for its Washington State Forest Practices Habitat Conservation Plan (HCP). The HCP will lead to a gradual improvement in habitat conditions on state forest lands within the action area, removing barriers to migration, restoring hydrologic processes, increasing the number of large trees in riparian zones (a source of shade and LWD), improving streambank integrity, and reducing fine sediment inputs.

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.12.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect multiple populations within the DPS. The effects of some on population viability will be positive (removal of Hemlock Dam; removing invasive weeds and planting native vegetation; adding large woody debris; tar remediation). Other projects, including road maintenance, grazing allotments, dock and boat launch construction, maintenance dredging, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on safe passage/access (removing Hemlock Dam), water quality (adding large woody debris; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.12.3.8 Status of Critical Habitat under the Environmental Baseline

Factors described in Section 8.12.2, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century and have degraded the conservation value of designated critical habitat. Salmon habitat has been altered through activities such as urban development, logging, grazing, power generation, and agriculture. These habitat alterations have resulted in the loss of important spawning and rearing habitat and the loss or degradation of migration corridors. Tributary habitat conditions vary widely among the various drainages occupied by LCR steelhead. Factors affecting the conservation value of critical habitat vary from lack of adequate pool/riffle channel structure, high summer water temperatures, low flows, poor overwintering conditions due to loss of connection to the floodplain, and high sediment loads.

Spawning & Rearing Areas

The following are the major factors that have limited the functioning of primary constituent elements and thus the conservation value of tributary habitat used for spawning and both tributary and estuarine habitat used for rearing (i.e., spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Tributary barriers *[culverts; dams; water withdrawals]*
- Reduced riparian function *[urban and rural development; forest practices; agricultural practices; channel manipulations]*
- Loss of wetland and side channel connectivity *[urban and rural development; past forest practices; agricultural practices; channel manipulations]*
- Excessive sediment in spawning gravel *[forest practices; agricultural practices]*
- Elevated water temperatures *[water withdrawals; urban and rural development; forest practices; agricultural practices]*

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions that address these limiting factors. These include removing passage barriers, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions. The dam removal action at the FERC-licensed hydroelectric project in the Hood River (Section 8.12.3.2) is addressing most of the key limiting factors in that watershed. Some projects will provide immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

As described above, future Federal projects with completed consultations will have neutral or short- or even long-term adverse effects on the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Some Federal projects, implemented for restoration purposes, will improve these same PCEs.

Juvenile & Adult Migration Corridors

Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Juvenile and adult passage mortality [*hydropower projects in the mainstem lower Snake and Columbia rivers*]

- Pinniped predation on winter-run adults (Gorge Winter MPG) due to habitat changes in the lower river [*existence and operation of Bonneville Dam*] and increasing numbers of pinnipeds.

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*

- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management]*

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these PCEs. For example, the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at Bonneville Dam has improved with the addition of the Bonneville PH2 corner collector. Reductions in piscivorous fish predation have increased the survival of juvenile steelhead in the estuary.

NOAA Fisheries has completed Section 7 consultation on granting permits to the states of Oregon, Washington, and Idaho, under section 120 of the Marine Mammal Protection Act, for the lethal removal of certain individually identified California sea lions that prey on adult winter-run steelhead in the tailrace of Bonneville Dam (NMFS 2008d). This action is expected to increase the survival of winter-run adults so that the continuing impact is reduced to approximately 7.6%.

The safe passage of juvenile LCR steelhead through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. The double-crested cormorant colony has grown during that period. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood

Although LCR steelhead spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.12.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin (see lists of projects in Chapter 17 in Corps et al. 2007a). These include tributary habitat actions that will benefit the Wind and Hood summer-run and the Upper Gorge and Hood winter-run populations, as well as actions that should be generally beneficial throughout the DPS. Generally, all of these actions are either completed, ongoing, or reasonably certain to occur.[4] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve conditions for this DPS.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have

[4] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects.

adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.12.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects, as well as the harvest action, will have continuing adverse effects that are described in this section. However, the Prospective Actions will ensure that these adverse effects are reduced from past levels. The Prospective Actions also include habitat improvement and predator reduction actions that are expected to be beneficial. Releasing a portion of the flow augmentation water from the Upper Snake Project in May (NMFS 2008b) will provide some minor benefits through 2034. Some habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

Continued funding of hatcheries by FCRPS Action Agencies will have both adverse and beneficial effects, as described in the SCA Hatchery Effects Appendix and in this section. The Prospective Actions will ensure continuation of the beneficial effects and will reduce any threats and adverse impacts posed by existing hatchery practices.

8.12.5.1 Effects of Hydro Operations & Configuration Prospective Actions

Benefits of Bonneville passage improvements affect only the five populations in the Gorge Summer and Winter Run MPGs. Prospective Actions include completing the installation of minimum gap runners at Bonneville PH1 and the FGE improvements at PH2 and improvements to sluiceway fish guidance system (efficiency and conveyance) at PH1. Collectively these modifications are expected to increase the survival of juvenile steelhead that pass through Bonneville Dam by 1%. Spillway survival improvements during this time period are expected to increase juvenile passage survival through Bonneville Dam by an additional 2.8%.

As a result of this ten-year program of improvements, an estimated 90.8% of the juvenile steelhead that migrate past Bonneville Dam will survive. A portion of the 9.2% mortality indicated by the juvenile survival metric (i.e., 1 – survival) is due to mortality that juvenile steelhead would experience in a free-flowing reach. In the 2004 FCRPS Biological Opinion on Remand, NOAA Fisheries estimated that 99% of the juvenile steelhead would survive migration through a free-flowing reach of equal length (see Table 5.1 in NMFS 2004a). Therefore, approximately 10% (0.9%/9.2%) of the expected mortality experienced by migrating LCR steelhead from above Bonneville Dam is probably due to natural factors.

The direct survival rate of adult steelhead at Bonneville Dam is already quite high. Based on PIT-tag detections at Bonneville and later at The Dalles Dam, NOAA Fisheries estimates an upstream passage survival rate of 98.5% for adult LCR steelhead (i.e., relevant to the Gorge MPGs).[5] The Action

[5] This estimate is adjusted to account for estimated harvest and straying rates of adults within the FCRPS migration corridor, but otherwise captures all other sources of mortality including those resulting from the existence and

Agencies will evaluate the use of the second powerhouse corner collector as a potential means to provide a safer downstream passage route for kelts from March 1 to April 9 (prior to spill).

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of some of the flow augmentation water from summer to spring may provide a small benefit to juvenile migrants in the lower Columbia River by slightly reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.12.3.3).

Effects on Species Status

Prospective passage improvements at Bonneville Dam will support increased abundance and productivity of the Gorge populations, thereby improving the overall spatial structure of the DPS.

Effects on Critical Habitat

Improvements at Bonneville Dam will increase the functioning of the PCE of safe passage in the juvenile and adult migration corridors.

8.12.5.2 Effects of Tributary Habitat Prospective Actions

The Prospective Actions include funding for habitat improvements in the Hood River that will benefit the summer and winter steelhead populations in that watershed (Table 6 of Attachment B.2.2-2 in Corps et al. 2007b). The project, which will complement the effects on habitat of removing Powerdale Dam, includes actions to increase instream habitat complexity, restore and protect riparian vegetation, provide access and safe passage, and to acquire instream flow. A second project, removal of Hemlock Dam in Trout Creek (a tributary to the Wind River), will provide access to historical habitat for the Wind River summer-run and Upper Gorge winter-run populations in that watershed.

The Prospective Actions also include the Action Agencies' consideration of funding for habitat improvement projects for any of the LCR steelhead populations above Bonneville that have been significantly impacted by the FCRPS. Projects are to be selected that are consistent with basin-wide criteria for prioritizing projects (e.g., address limiting factors), including those derived from recovery and subbasin plans. However, the type and distribution of these potential projects is uncertain, in part because the RPA only commits the Action Agencies to achieving specific survival improvements for species in the Interior Columbia Basin.

Effects on Species Status

Prospective improvements in tributary habitat in the Hood and Wind rivers will support the increased abundance, productivity, and spatial structure of the summer and winter-run populations in those

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operation of the FCRPS and other potential sources, including natural mortality (i.e., that would occur without human influence).

watersheds. Habitat projects in other tributaries, if implemented, will be selected such that they also address limiting factors and thus would also increase the viability of the local population(s).

Effects on Critical Habitat

Prospective habitat improvements in the Hood and Wind rivers will improve the functioning of PCEs for spawning and rearing (spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space). Restoration actions in designated critical habitat will have long-term beneficial effects at the project scale and some, such as the removal of barriers, will improve conditions at the watershed scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more than a few weeks and typically less). Examples include sediment plumes, localized and brief contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008 III). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long term.

8.12.5.3 Effects of Estuary Prospective Actions

The FCRPS Action Agencies will carry out approximately 44 estuary habitat projects over the first 3-year period of implementing the RPA (Section 12.3.2.3 in Corps et al. 2007b). The estimated survival benefit for juvenile steelhead is 1.4%.

The RPA requires the implementation of additional projects to obtain specified survival benefits for Interior Columbia Basin steelhead populations, but will also provide benefits to those from the lower Columbia River. The estimated survival benefit for juvenile steelhead is 4.3%. Prospective Actions will address limiting factors by protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reducing of noxious weeds, and other actions.

Effects on Species Status

Prospective improvements in estuarine habitat will support the increased abundance, productivity, diversity, and spatial structure of summer- and winter-run populations of LCR steelhead.

Effects on Critical Habitat

Prospective estuarine habitat improvements will improve the functioning of the PCEs of water quality and safe passage in the migration corridor for juvenile steelhead migrants. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). The positive effects on the functioning of PCEs and the conservation value of critical habitat will be long-term.

8.12.5.4 Effects of Hatchery Prospective Actions

Effects on Species Status

Under the RPA (Action 39), the FCRPS Action Agencies will continue funding hatcheries as well as adopt programmatic criteria for funding decisions on hatchery mitigation programs for the FCRPS that incorporate BMPs. NOAA Fisheries will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans are updated by hatchery operators with the Action Agencies as cooperating agencies. For the lower Columbia, new HGMPs must be submitted to NOAA Fisheries and ESA consultations initiated by July 2009 and consultations must be completed by January 2010. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NOAA Fisheries approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

Effects on Critical Habitat

NOAA Fisheries will analyze the effects of the hatchery actions on critical habitat designated for this species in subsequent consultations on site-specific actions.

8.12.5.5 Effects of Harvest Prospective Actions

Prospective non-Indian fisheries will be managed subject to 2% harvest rate limits on natural-origin steelhead from the Lower Columbia River. However, the expected incidental harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with proposed non-Indian fisheries (TAC 2008; Table 29a) are expected to be less than ESA-prescribed limits (TAC 2008; Table 29). The incidental catch of winter-run steelhead in non-Indian fisheries has averaged 1.9% since 1999 (Table 8.12.3.6-1). The yearly incidental catch of summer-run steelhead in non-Indian fisheries has averaged 0.3% since 1999 (Table 8.12.3.6-3). Harvest rates associated with non-Indian fisheries are not expected to change over the course of this Agreement (TAC 2008).

There are no specific incidental harvest rate limits for tribal fisheries on the LCR steelhead DPS (TAC 2008; Table 29). The expected incidental harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with prospective tribal fisheries is the same as the range observed in recent years (TAC 2008; Table 29a). The harvest rate for tribal fisheries on the winter-run populations of the LCR steelhead DPS from 2001 to 2007 averaged 2.2% and ranged from 0.8% to 5.8% (Table 8.12.3.6-2). The harvest for tribal fisheries on the summer-run populations of the LCR steelhead DPS are considered the same as for A-run summer steelhead in general. However, harvest impacts to the summer-run populations of the LCR steelhead DPS are in reality less than for A-run as a whole because the upstream boundary of LCR steelhead DPS is within the Bonneville Pool and much tribal fishing impacting A-run fish occurs upstream of this boundary. However, for the purposes of this analysis, the incidental harvest rates on summer steelhead populations of the LCR steelhead DPS associated with Treaty fisheries have ranged from 4.1-12.4% (Table 8.12.3.6-3). Incidental harvest rates for winter-run and summer-run associated with prospective tribal fisheries are not expected to change over the course of this Agreement (TAC 2008).

Effects on Species Status

Prospective harvest effects will be less than or equal to recent harvest effects and thus are expected to support the increased abundance and productivity of winter-run populations of Lower Columbia River steelhead.

Effects on Critical Habitat

The effects of harvest activities in the Prospective Actions on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR steelhead.

8.12.5.6 Effects of Predation Prospective Actions

Avian predation

The survival of juvenile steelhead will increase 3.4% with the reduced Caspian tern nesting habitat in the estuary and the subsequent relocation of most of the terns to sites outside the Columbia River basin (RPA Action 45). Continued implementation and improvement of avian deterrence at Bonneville Dam (RPA Action 48) is also likely to increase juvenile steelhead survival.

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous fish predation

The prospective continued increase in incentives in the NPMP will result in an additional 1% survival during the period 2008 to 2018 (RPA Action 43).

Effects on Species Status

Prospective improvements in predation will support the increased abundance and productivity of summer- and winter-run populations of LCR steelhead.

Effects on Critical Habitat

Prospective improvements in predation will improve the functioning of the PCE of safe passage in the migration corridor for juvenile steelhead migrants.

8.12.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRPS.

8.12.6 Aggregate Effects of the Environmental Baseline, Prospective Actions & Cumulative Effects on Lower Columbia River Steelhead DPS

This section summarizes the basis for conclusions at the DPS level.

8.12.6.1 Recent Status of the Lower Columbia River Steelhead DPS

Lower Columbia steelhead is a threatened species. Many of the populations in this DPS currently have low abundance and many of the long-term trends in abundance for individual populations are negative, some severely so. The historical role of the FCRPS and Upper Snake projects in limiting viability was the loss of historical habitat for the Upper Gorge Winter Run population under Bonneville pool and passage delay and mortality at Bonneville Dam for two populations of summer and two of winter steelhead. Stream-type juveniles, especially steelhead smolts, are vulnerable to bird predation in the estuary and adult winter-run steelhead are subject to pinniped predation at Bonneville Dam. The long-term domestication of hatchery fish eroded the fitness of these populations in the wild. Until selective fisheries were instituted in the early 1990s, intensive mixed-stock fisheries overexploited wild steelhead populations already weakened by habitat degradation. Large-scale changes in freshwater and marine environments have also had substantial effects on salmonid population numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this DPS. The potential for additional risks due to climate change is described in Sections 5.7 and 8.1.3.

In terms of the primary constituent elements of critical habitat, the ability to function in support of the conservation of the species has been limited by barriers to some tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary areas used for spawning, incubation, and larval growth and development. In the Lewis, Cowlitz, Sandy, and Hood River watersheds, these problems will be addressed by actions taken at FERC-licensed hydroelectric projects (Sections 8.12.2.1 and 8.12.3.2). The functioning of mainstem habitat as a juvenile migration corridor has improved in recent years with the development of the corner collector at Bonneville PH2. Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement in habitat conditions on state forest lands within the range of LCR steelhead (Section 8.12.3.2). Some future Federal actions with completed Section 7 consultations will restore access to blocked habitat, increase channel complexity, and restore riparian condition. Examples are the removal of Hemlock Dam in the Wind River subbasin and Powerdale on the Hood River. Many actions will have neutral or short- or even long-term negative effects on habitat conditions, but all were found to meet the ESA standards for avoiding jeopardy and for avoiding any adverse modification of critical habitat.

8.12.6.2 Effects of the FCRPS, Upper Snake & *U.S. v. Oregon* Prospective Actions on the Lower Columbia River Steelhead DPS

NOAA Fisheries has adopted the LCFRB's (2004) recovery plan as its interim recovery plan for the Washington side of the lower Columbia River, including those populations within the LCR steelhead DPS.[6] In the LCFRB's recovery plan, one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume," (2004). The Action Agencies' estuary habitat restoration projects and relocation of most of the Caspian terns to sites outside the Columbia basin will increase the survival of juvenile steelhead. Juvenile steelhead will also experience an estimated 2.8% increase in passage survival at Bonneville Dam. Implementation of habitat improvement projects in the Hood and Wind River watersheds will address the loss of historical spawning habitat for the Upper Gorge Winter Run population that was inundated by Bonneville pool. Actions that will further improve the viability of the Gorge populations include the continued increase in the northern pikeminnow reward fishery, continued and improved avian deterrence at Bonneville Dam, and prospective juvenile and adult passage improvements at Bonneville Dam. Harvest rates will be less than or equal to those in recent years.

The principal effects of the Prospective Actions on critical habitat will be the increase in juvenile passage survival at Bonneville Dam and in the estuary with the relocation of Caspian terns (juvenile and adult migration corridors free of obstructions); an increase in the amount and quality of estuarine habitat for the transitions between fresh- and saltwater, juvenile growth and development before entering the plume, and the final development of adults before they migrate to upstream spawning areas; an improvement in the functioning of PCEs for spawning, incubation, and rearing in the Hood and Sandy rivers; and an increase in the amount of spawning and rearing habitat (space) in the Lewis and Cowlitz watersheds.

8.12.6.3 Cumulative Effects Relevant to the Lower Columbia River Steelhead DPS

Habitat-related actions and programs that the states of Oregon and Washington have determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect instream habitat. These actions will primarily affect conditions within the tributary spawning and rearing areas, including the PCEs of critical habitat needed for successful spawning, incubation, and the growth and development of juvenile steelhead.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for this consultation (the mainstem lower Columbia and tributary areas above Bonneville Dam), these are likely to include urban development and other land use practices.

[6] The State of Oregon is in the process of developing a plan for this species. Upon its review, NOAA Fisheries will combine the Washington and Oregon plans into a complete recovery plan for the Lower Columbia River Recovery Domain.

8.12.6.4 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Lower Columbia River Steelhead DPS

Impacts of the FCRPS and Upper Snake projects are most significant for the 4 (out of 23) populations within the DPS that spawn above Bonneville Dam and are limited relative to impacts from tributary hydropower, tributary habitat, hatcheries, and predation by birds, fish, and marine mammals. These populations are affected by upstream and downstream passage and, for the Upper Gorge winter-run population, by inundation of spawning habitat. For populations originating in tributaries below Bonneville, only migration and habitat conditions in the mainstem and estuary are affected by the existence and operation of the hydrosystem.

The states of Oregon and Washington identified tributary habitat actions that are reasonably certain to occur and that will benefit the Wind and Hood summer-run and the upper Gorge and Hood winter-run populations, as well as actions that should be generally beneficial throughout the DPS. Habitat blockages in the Lewis, Cowlitz, Sandy, and Hood subbasins are being addressed by actions taken at FERC-licensed hydroelectric projects (Section 8.12.2.1). The functioning of mainstem habitat as a juvenile migration corridor has improved in recent years with the development of the corner collector at Bonneville PH2 and other improvements. Implementation of the State of Washington's Forest Practices Habitat Conservation Plan will lead to a gradual improvement of habitat conditions on state forest lands within the range of Lower Columbia River steelhead (Section 8.12.3.7).

NOAA Fisheries considered the effects of harvest on the various life-history types and component populations of the LCR steelhead DPS. Prospective non-Indian fisheries will be managed subject to 2% harvest rate limits on winter and summer natural-origin steelhead populations from the LCR steelhead DPS. There are no specific harvest rate limits for tribal fisheries on LCR steelhead DPS. However, the prospective harvest rates associated with tribal fisheries in the Columbia River over the course of the 2008-2017 *U.S. v. Oregon* Management Agreement are expected to be similar to those observed in recent years. The expected harvest rate for tribal fisheries on winter-run populations of the LCR steelhead DPS is the same as the 2.2% harvest rate average observed from 2001 to 2007 (Table 8.12.3.6-2). The expected harvest rate for tribal fisheries on summer-run populations of the LCR steelhead DPS is the same as the 6.4% harvest rate average observed from 2001 to 2007 (Table 8.12.3.6-3).

The Action Agencies' prospective passage improvements at Bonneville Dam, estuary habitat improvements, and predator management improvements will contribute to the viability of this DPS by addressing the influence of their projects, contributing to its survival with an adequate potential for recovery. The Action Agencies' prospective habitat projects in the Hood and Wind rivers and additional potential funding of tributary projects above Bonneville are expected to support the restoration of specific populations within the DPS. The Prospective Actions will not further deteriorate the pre-action condition.

The full scope of needed improvements in tributary habitat will be outlined in the final recovery plan for the lower Columbia River, but this plan is not complete. Some adverse impacts from hatchery practices will continue, and harvest rates may be as high as 10% unless reduced as a result of ongoing reviews and subsequent section 7 consultations.

Long term (100 year) extinction risk is high or very high for almost all populations in this DPS. Exceptions are the Wind summer- and South Fork Toutle, Kalama, Clackamas, and Hood winter-run populations. In the short term, the species' extinction risk is expected to be reduced through implementation of the actions described above. In particular, the genetic legacy of several populations (Hood River summer- and winter- and the Cowlitz, Sandy, and Clackamas late-winter populations) will continue to be preserved by ongoing hatchery actions as a hedge against the short-term risk of extinction.

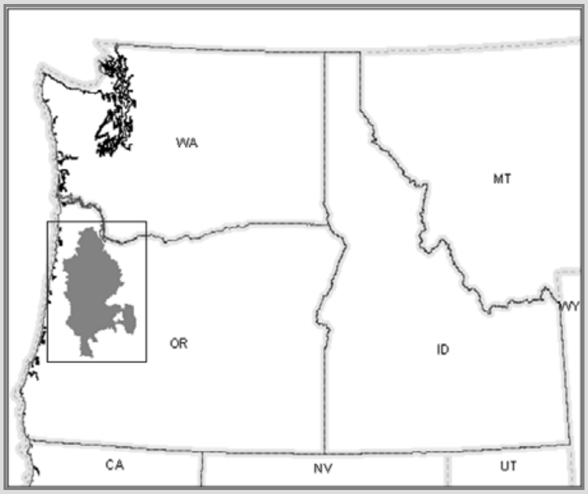
8.12.6.5 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat for the Lower Columbia River Steelhead DPS

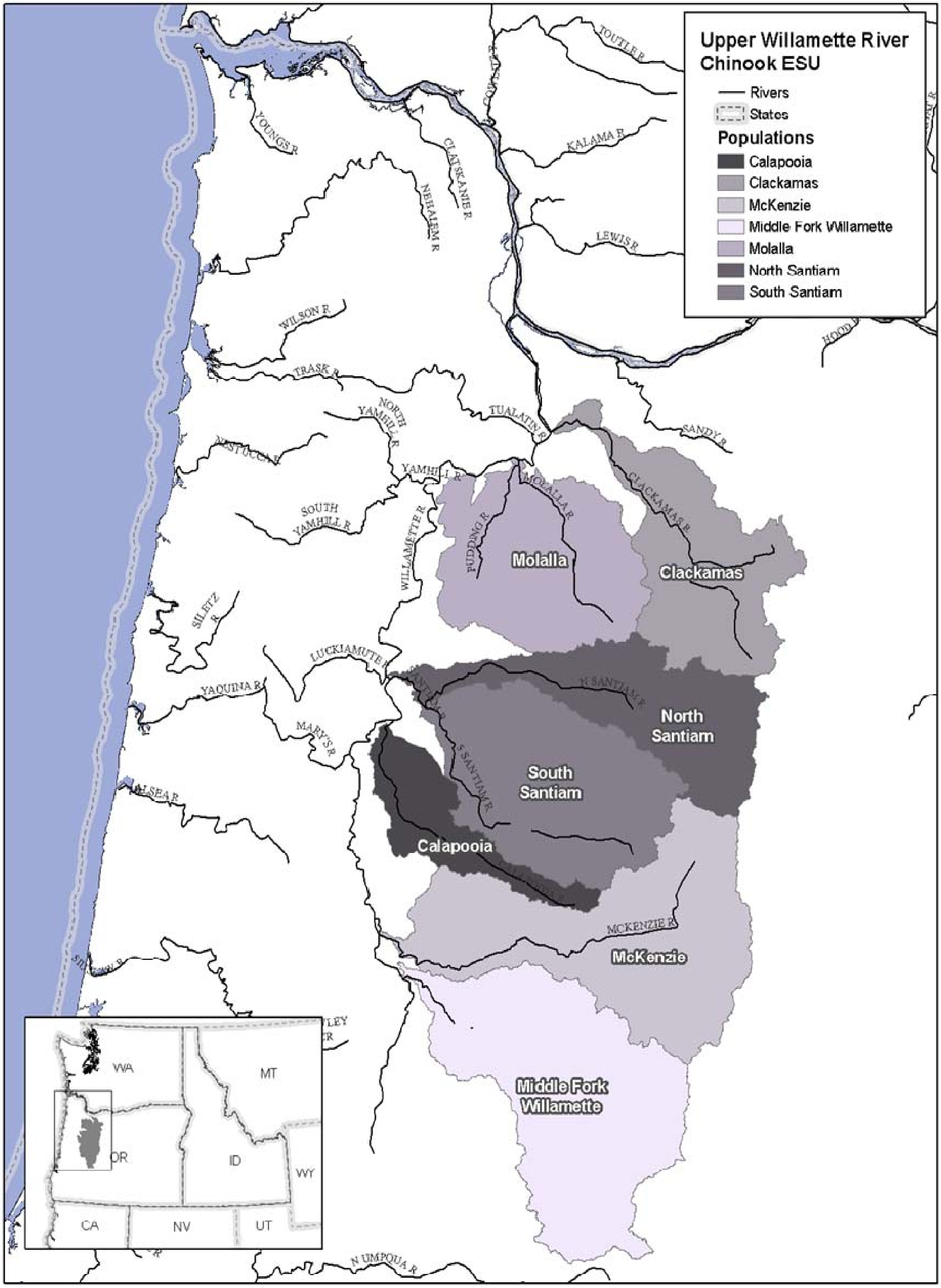
NOAA Fisheries designated critical habitat for LCR steelhead including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Clackamas, and Lower Willamette. The environmental baseline within the action area, which encompasses the Middle Columbia/Hood, Lower Columbia/Sandy, and Lower Columbia/Clatskanie subbasins, has improved over the last decade but does not yet fully support the conservation value of designated critical habitat for LCR steelhead. The major factors currently limiting the conservation value of critical habitat are barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain at least its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will substantially improve the functioning of many of the PCEs; for example, reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles and the removal of sea lions known to eat steelhead in the tailrace of Bonneville Dam will do the same for winter-run adults. Habitat work in tributaries used for spawning and rearing in the lower Columbia River and estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. In addition, a number of actions in tributary and estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).

The aggregate effect of the environmental baseline, Prospective Actions, and cumulative effects will be an improvement in the functioning of PCEs used for spawning, incubation, juvenile growth and development, migration, and juvenile and adult transitions between fresh and salt water. Considering the ongoing and future effects of the environmental baseline and cumulative effects, the Prospective Actions will be adequate to ensure that they will not reduce the ability of critical habitat to serve its conservation role for this species.

Section 8.13
Upper Willamette River Chinook Salmon




Upper Willamette River
Chinook ESU
Rivers
States
Populations
Calapooia
Clackamas
McKenzie
Middle Fork Willamette
Molalla
North Santiam
South Santiam
Molalla
Clackamas
North
Santiam
South
Santiam
Calapooia
McKenzie
Middle Fork
Willamette
TOUTLE R
KALAMA R
LEWIS R
YOUNGS R
CLATSKANIE R
NEHALEM R
WILSON R
TRASK R
TUALATIN R
SANDY R
NORTH YAMHILL R
NESTUCCA R
YAMHILL R
SOUTH YAMHILL R
WILLAMETTE R
PUDDING R
MOLALLA R
CLACKAMAS R
SILETZ R
LUCKIAMUTE R
YAQUINA R
N SANTIAM R
MARY'S R
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ALSEA R
MCKENZIE R
N UMPQUA R
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Section 8.13
Upper Willamette River Chinook Salmon

Species Overview

Background

The Upper Willamette River (UWR) Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon residing in the Clackamas River and in the Upper Willamette River above Willamette Falls, but below impassable natural barriers, as well as seven artificial propagation programs. There is only one major population group in this ESU, comprised of seven historical demographically independent populations. Significant natural production occurs only in the Clackamas and McKenzie rivers. Upper Willamette River Chinook were listed under the ESA as threatened in 1995. This listing was reaffirmed in 2005.

Designated critical habitat for spring-run Upper Willamette River Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in a number of subbasins.

Current Status & Recent Trends

Historically the Upper Willamette supported large numbers (perhaps exceeding 275,000 fish) of spring Chinook. Current abundance of natural-origin fish is estimated to be less than 10,000, with significant natural production occurring only in two populations—the Clackamas and McKenzie. While counts of hatchery- and natural-origin adult spring Chinook salmon over Willamette Falls since 1946 have increased, approximately 90% of the return is now composed of hatchery fish. The majority of the natural-origin populations in this ESU have very low current abundances (less than a few hundred fish). Many of the natural runs largely have been replaced by hatchery production.

Limiting Factors

Human impacts and limiting factors for Upper Willamette River Chinook include habitat loss and degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and predation. FCRPS impacts are limited to habitat conditions in the mainstem below the confluence of the Willamette and in the estuary, which have been affected by hydrosystem flow operations. Habitat degradation has been pervasive in the Willamette mainstem and the lower reaches of its tributaries and both Corps and FERC-licensed hydroelectric projects have blocked some spawning areas. Habitat loss due to blockages has been especially severe in the North Santiam, Calapooia, and Middle Fork Willamette subbasins.

Recent Ocean and Mainstem Harvest

Upper Willamette Chinook migrate far north and are caught incidentally in ocean fisheries, particularly off southeast Alaska and northern Canada, and in spring season fisheries in the mainstem Columbia and Willamette rivers. These fisheries target harvestable hatchery and natural-origin fish. The total adult equivalent exploitation rate on Upper Willamette Chinook in ocean fisheries has averaged 11% in recent years. The harvest rate on natural-origin fish in freshwater fisheries in the lower Columbia and Willamette rivers has ranged from 5.0 to 11.0% in recent years. The total recent exploitation rate for ocean and in-river fisheries combined has averaged approximately 18%.

8.13.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.13.2.1 Current Rangewide Status of the Species

All naturally spawned populations of spring-run Chinook salmon residing in the Clackamas River and in the Willamette River above Willamette Falls, but below impassable natural barriers (e.g., long-standing, natural waterfalls) are considered to be members of the UWR Chinook salmon ESU, as well as seven artificial propagation programs. Seven historical demographically independent populations have been identified (Table 8.13.2.1-1), but significant natural production now occurs only in the Clackamas and McKenzie subbasins. The other naturally spawning populations are small and are mostly composed of hatchery-origin fish.

Upper Willamette River Chinook salmon are different from other Columbia basin Chinook salmon according to both genetic and life history data (Schreck et al. 1986; Utter et al. 1989; Shaklee 1991; Waples et al. 1991; Myers et al. 1998). For example, UWR Chinook salmon exhibit an earlier time of entry into the Columbia River and estuary than other spring Chinook salmon ESUs (Myers et al. 1998). And although juveniles from interior spring Chinook populations reach the mainstem migration corridor as yearlings, some juvenile Chinook salmon in the lower Willamette River are subyearlings (Friesen et al. 2004).

Table 8.13.2.1-1. Upper Willamette River ESU description. (Sources: Myers et al. 2006, NMFS 2005a) The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (Appendix B in WLCTRT 2003).[1]

ESU Description	
Threatened	Listed under ESA in 1995, reaffirmed in 2005
Major Population Group	**Population**
UWR	Clackamas (C), Molalla, North Fork Santiam (C), South Fork Santiam, Calapooia, McKenzie (C, G), and Middle Fork Willamette (C)
Hatchery programs included in ESU	McKenzie River Hatchery (Oregon Department of Fish and Wildlife (ODFW stock #24), Marion Forks/North Fork Santiam River (ODFW stock #21), South Santiam Hatchery (ODFW stock #23) in the South Fork Santiam River, South Santiam Hatchery in the Calapooia River, South Santiam Hatchery in the Molalla River, Willamette Hatchery (ODFW stock #22), and Clackamas

[1] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the ESU (WLCTRT 2003).

	hatchery (ODFW stock #19)

Limiting Factors

Summarized below (Table 8.13.2.1-2) are the key limiting factors for this ESU and recovery strategies to address factors in the mainstem Columbia River (including the estuary) as described in the Washington Lower Columbia River Recovery and Subbasin Plan (LCRFB 2004). Oregon is currently engaged in the recovery planning process for UWR Chinook salmon, which will identify management actions to address factors in the Willamette Basin.

Table 8.13.2.1-2. Key limiting factors for UWR Chinook salmon.

Hydropower	The Corps operates 13 dams in the largest five Willamette tributaries for flood control, irrigation, and hydropower. Major habitat blockages for UWR Chinook salmon resulted circa 1952 from Big Cliff and Detroit dams on the North Fork Santiam River, Cougar Dam on the McKenzie, Hills Creek and Dexter/Lookout Point on the Middle Fork Willamette, and circa 1967 from Green Peter Dam on the South Fork Santiam River (Foster Dam on the South Fork Santiam was built with trap and haul fish passage facilities). Historically, fish spawned in habitat above these dams. In addition to blocking spring Chinook access to historical habitat, these dams affect flows, water quality, sediment transport, and channel structure in the mainstem and in the South and North Santiam, McKenzie, and Middle Fork Willamette rivers where spring Chinook are present. Flow storage and release operations and, to a lesser extent, irrigation withdrawals have also altered temperatures and channel-forming processes. Upper Willamette River Chinook also pass by several smaller hydropower projects: Willamette Falls on the lower mainstem Willamette; City of Albany/Lebanon Dam on the South Santiam; Stayton, Water Street, and Fery projects on the North Santiam; the decommissioned Thompson Mills on the Calapooia; and the Eugene Water and Electric Board's (EWEB) Leaburg-Walterville Project on the McKenzie. Except for the Stayton project, which is currently shutdown, all of these FERC projects have recently or will soon install improved fish screens, ladders, and in some cases, tailrace barriers, thereby reducing adverse effects on UWR Chinook. EWEB is currently engaged with NOAA Fisheries and others in the FERC relicensing process for the Carmen-Smith Hydroelectric Project, which blocks access to historical habitat. It is highly unlikely that fish from this ESU encounter FCRPS mainstem projects. Impacts on Upper Willamette River populations from those projects are limited to effects on migration and habitat conditions in the lower Columbia River (below the confluence of the Willamette) including the estuary.
Hatcheries	Hatcheries have been used as a management tool in the Willamette River basin for over 100 years. For example, hatchery production has been used to mitigate

	lost production due to blocked access to historical spawning habitat. Hatchery-origin fish now outnumber natural-origin spawners in nearly all populations. Even though all of the existing hatchery stocks were derived within the ESU, hatchery management intermixed the various stocks among the populations. All six of the Chinook populations above Willamette Falls and to a lesser degree, the Clackamas population, are potentially at risk for genetic introgression, leading to homogenization and a loss of fitness. The impacts occur at the adult spawner stage—specifically, hatchery fish that interbreed with wild fish create a risk of genetic introgression.
Habitat	Habitat in all tributaries, particularly the lower reaches, and in the mainstem Willamette River is moderately to severely degraded, and some tributaries have numerous small passage barriers. Specific habitat concerns vary by subbasin but include reduced habitat complexity, reduced access to off-channel habitat, reduced floodplain function and connectivity, loss of holding pools, elevated water temperatures, insufficient streamflows, toxic water pollutants, and fine sediments in spawning gravel. Causes of these conditions include the impacts of widespread development, as well as the habitat impacts of large hydropower and flood control dams, smaller passage barriers, and bank hardening. Conditions in most upper tributary subbasins, although not pristine, are relatively good for salmon. Recent improvements include the removal of Brownsville Dam (2007) and the improvements described above (Hydropower) at the FERC-licensed projects.
Harvest	Upper Willamette Chinook are far north migrating and caught incidentally in ocean fisheries, particularly off southeast Alaska and northern Canada, and in spring season fisheries in the mainstem Columbia and Willamette rivers. The total adult equivalent incidental exploitation rate on Upper Willamette Chinook in ocean fisheries has averaged 11% in recent years. All freshwater fisheries are managed subject to the terms of a Fishery Management and Evaluation Plan submitted by the Oregon and approved by NOAA Fisheries under ESA Section 4(d). The total allowable rate of incidental take in all freshwater fisheries is 15%. However, the goal has been to keep impacts to natural-origin fish to substantially less than 15%, a goal that has been achieved primarily through implementation of mass marking and mark selective fisheries. The harvest rate on natural-origin fish in freshwater fisheries in the lower Columbia and Willamette rivers have ranged from 5.0% to 11.0% in recent years.
Predation	Piscivorous birds including Caspian terns and cormorants and fishes including northern pikeminnow take significant numbers of juvenile salmon. Stream-type juveniles, especially yearling smolts from spring-run populations, are vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid water over the channel, which is located near habitat preferred by piscivorous

	birds (Fresh et al. 2005). Caspian terns as well as cormorants may be responsible for the mortality of up to 6% of the outmigrating stream-type juveniles in the Columbia River basin (Corps et al. 2007a). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999). Ongoing actions to reduce predation effects include redistribution of avian predator nesting areas and a sport reward fishery to harvest pikeminnow
Estuary	The estuary is an important habitat for migrating salmonids from the UWR Chinook salmon ESU. Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats: emergent marshes, tidal swamps, and forested wetlands. These habitats are used extensively by subyearling juveniles. The survival of larger (yearling) juveniles in the ocean can be affected by habitat factors in the estuary such as changes in food availability and the presence of contaminants. Changes in the seasonal hydrograph as a result of water use and reservoir storage throughout the Columbia basin have altered habitat-forming processes including the shape, behavior, size, and composition of the plume compared to historical conditions. Characteristics of the plume are thought to be significant to spring-run yearling migrants during transition to the ocean phase of their lifecycle (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2006b).
Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status of this ESU to some extent, future trends, especially during the period relevant to the Prospective Actions, are unclear. Under the adaptive management implementation approach of the Lower Columbia River Recovery and Subbasin Plan, further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through additional recovery effort (LCFRB 2004).

Abundance, Productivity & Trends

Historically the Upper Willamette supported large numbers (perhaps exceeding 275,000 fish) of spring Chinook (Myers et al. 2006) Current abundance of wild fish is estimated to be less than 10,000, with significant natural production occurring only in two populations—the Clackamas and the McKenzie (McElhany et al. 2007). While counts of hatchery- and natural-origin adult spring Chinook salmon over Willamette Falls since 1946 have increased, approximately 90% of the return is now composed of hatchery fish. Most of the natural-origin populations in this ESU have very low current abundances (less than a few hundred fish) and many largely have been replaced by hatchery production. Long- and short-term trends are approximately 1.0 or are negative, depending on the metric examined (i.e., long-term trend [regression of log-transformed spawner abundance] or lambda [median population growth rate]) (Table 8.13.2.1-3).

Table 8.13.2.1-3. Abundance, productivity, and trends of UWR Chinook populations (Source: Good et al. 2005 and McElhany et al. 2007).

Population	Recent Natural Spawners			Long-Term Trend		Median Growth Rate	
	Years[1]	No.[2]	pHOS[3]	Years	Value[4]	Years	λ[5]
Clackamas	90-05	1656	47%	58-05	1.044	58-05	0.967
Molalla	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Calapooia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
McKenzie	90-05	2104	33%	70-05	1.017	70-05	0.927
MF Willamette	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Reported time series correspond to reported values in available information and may not correspond to reference periods identified in analyses of other ESUs of this Biological Opinion.
[1] Years of data for recent means.
[2] Geometric mean of total spawners.
[3] Average recent proportion of hatchery origin spawners
[4] Long-term trend of natural spawners (regression of log-transformed spawner abundances against time).
[5] Long-term median population growth rate after accounting for hatchery spawners (equal spawning success assumption).
N/A = not available

Extinction Probability/Risk

The risk of extinction (Table 8.13.2.1-4) was derived qualitatively, based on risk categories and criteria identified by the WLC TRT (McElhany et al. 2007) for use in recovery plan assessments. The rating system categorized extinction risk probabilities as very low (<1%), low (1 to 5%), medium (5 to 25%), high (26 to 60%), and very high (>60%) based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 8.13.2.1-4. Risk of extinction categories for populations of UWR Chinook (Source: McElhany et al. 2007).

Stratum	Population	Extinction Risk Category
Upper Willamette	Clackamas	L
	Molalla	VH
	NF Santiam	VH
	SF Santiam	VH
	Calapooia	VH
	McKenzie	M
	MF Willamette	VH

Spatial Structure

The UWR spring Chinook salmon ESU consists of seven populations. Spatial structure has been substantially reduced by the loss of access to the upper portions of the North Fork Santiam, South Fork Santiam, McKenzie, and Middle Fork Willamette River basins due to tributary hydropower and flood control development, including dams owned and operated by the Corps. The habitat conditions conducive to salmon survival in the Molalla and Calapooia subbasins have been reduced significantly by land use effects (McElhany et al. 2007).

Diversity

The diversity of some populations has been eroded by hatchery and harvest influences and degraded habitat conditions, which all contributed to low effective population sizes (McElhany et al. 2007).

8.13.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for UWR Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in the following subbasins: Middle Fork Willamette, Coast Fork Willamette, Upper Willamette, McKenzie, North Santiam, South Santiam, Middle Willamette, Molalla/Pudding, Clackamas, and Lower Willamette (NMFS 2005b). There are 60 watersheds within the range of this ESU. Nineteen watersheds received a low rating, 18 received a medium rating, and 23 received a high rating of conservation value to the ESU (for more information, see Chapter 4). The lower Willamette/Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor 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. Of the 1,796 miles of habitat eligible for designation, 1,472 miles of stream are designated critical habitat.

In the lower Columbia and Willamette basins, major factors affecting PCEs are altered channel morphology and stability; lost/degraded floodplain connectivity; loss of habitat diversity; excessive sediment; degraded water quality; increased stream temperatures; reduced stream flow; and reduced access to spawning and rearing areas (LCFRB 2004, ODFW 2006b, PCSRF 2006). A wide variety of actions with the potential to improve PCEs and habitat function have been implemented in the upper Willamette River and its tributaries since 2000, involving non-Federal and Federal parties. Actions have included beneficial land management practices, restoration projects such as culvert replacement to improve access, and improved passage at FERC-licensed and other small dams.[2] The latter include:

- Willamette Falls Hydroproject: FERC completed consultation with NOAA Fisheries (NMFS 2005p) on the relicensing of this project, which is located in the lower mainstem Willamette River. As a result, the project owner has recently completed two large fish passage projects (juvenile fish bypass and controlled flow structure). Six of the seven populations of UWR Chinook will experience a decrease in juvenile fish injury and mortality, in adult upstream passage delay, and in juvenile stranding as a result of these recent improvements (i.e., juvenile and adult migration corridors free of obstructions).

- City of Albany Hydroproject: The Corps completed consultation with NOAA Fisheries (NMFS 2004e) on the construction of a new fish ladder and intake screen and the reconstruction of an existing ladder at Lebanon Dam in the lower South Santiam River. Construction was completed in 2006. This recent action eliminated the only migration barrier and large unscreened intake in the mainstem South Santiam River in the reaches below the Corps' Foster Dam that are currently accessible to UWR Chinook (i.e., juvenile and adult migration corridors free of obstructions).

- Brownsville Dam: Originally built as a timber crib dam in the 1800s to power a mill, Brownsville Dam was rebuilt as a concrete structure with an inadequate fish ladder in the 1960s. The mill is long gone, but the 10-foot high dam continued to impound water for three months of the year, creating an area for swimming and sending water via canal to the City of Brownsville for aesthetic benefits and livestock watering. Brownsville Dam was breached on August 27, 2007 under NOAA's Open Rivers Initiative, allowing spring Chinook safe passage to more than 40 miles of historical spawning and rearing habitat. In 2008, the Brownsville Canal Company will install a small screened pump to facilitate its 2.5 cfs water withdrawal during the dry summer months (i.e., juvenile migration corridors free of obstructions).[3]

- Thompson Mill: This five-story factory, with its water-powered gristmills, was one of the oldest continuously operating businesses in Oregon. With the help of former owner, D. Babbitt, Oregon Parks and Recreation Department purchased the mill several years ago. The Oregon Water Trust paid the owner not to run his electrical generator in the summer months, to leave more water in the river channel. The Trust negotiated a deal with the state to buy 12 of the property's 180-cfs water right to permanently enhance water quantity in spring Chinook rearing areas and migration corridors.

- Cougar Temperature Control: During spring and summer, the sun warms the surface waters of Cougar Reservoir on the South Fork McKenzie River. The reservoir is emptied in the fall in preparation for the flood-control season, in the past this meant discharging warm surface into the

[2] The status of critical habitat within the action area is discussed in more detail in Section 8.13.5.2.
[3] This project was considered implementation of NMFS' programmatic section 7 consultation on NOAA's Restoration Center Programs (NMFS 2004f).

river. The unseasonable warmth hastened the maturation of any salmon eggs buried in the gravel so that the fry emerged in November and December, when there was little insect life on which to feed and survival rates were poor. Also, because the intakes for the powerhouse and regulating outlet were deep, the South Fork below the dam was unnaturally cold during summer, blocking salmon migration and reducing productivity. The Corps modified the intake tower by building a 302-foot tall wet well and a mechanism that allows the selective withdrawal of water from various levels of the reservoir (NMFS and USFWS 2000). The water temperature control tower has been in operation since 2005 and has substantially shifted the thermal conditions back toward the natural temperature regime on the South Fork McKenzie below the dam (i.e., improving water temperature in areas used for spawning, incubation, and rearing).

- Fish Trap at Cougar Dam: The trap-and-haul facility will restore access to over 37 miles of high quality historical spawning and rearing habitat in the South Fork McKenzie River (i.e., juvenile migration corridors free of obstructions) (NMFS 2007i).

- Leaburg-Walterville Hydroelectric Project: Eugene Water and Electric Board has reduced smolt entrainment into the Walterville Canal and Powerhouse, reduced fry mortality on the Leaburg fish screen, reduced the attraction and delay of adults in the tailrace of each project, maintained minimum flows downstream of the Leaburg Dam and the Walterville intake, and met ramping rate criteria to prevent stranding and dessication (i.e., juvenile migration corridors free of obstructions) (NMFS and USFWS 2001).

In addition, the USFS has implemented restoration projects in areas of the North and South Santiam, McKenzie, and Middle Fork Willamette watersheds currently occupied by UWR Chinook. Watershed councils and private landowners also have implemented numerous projects in recent years such as removing fish passage barriers and enhancing stream channel conditions on the local scale.

Summary

Federal and state agencies, watershed councils, and private landowners are implementing numerous projects that are improving the PCEs of critical habitat for UWR Chinook. These include access to previously blocked habitat, increased channel complexity, and the creation of thermal refuges. Some projects, including restoration actions, will have short-term adverse effects and others will have neutral or even adverse long-term effects. Where needed,[4] all of these projects have undergone Section 7 consultation and were found to meet the ESA standards for avoiding jeopardy and any adverse modification of critical habitat.

[4] Projects by watershed councils or private landowners requiring Corps permits under Section 404 of the Clean Water Act were also subject to section 7(a)(2) consultation.

8.13.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

Both Federal and non-Federal parties have implemented a variety of actions in the action area for this consultation that have improved the status of UWR Chinook salmon. Those implemented since the environmental baseline was described in the 2004 FCRPS Biological Opinion (NMFS 2004) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend developed by the WLC TRT (Table 8.13.2.1-3) will improve.

8.13.3.1 Recent FCRPS Hydro Improvements

It is highly unlikely that fish from this ESU encounter the FCRPS projects. Flow management at FCRPS and Upper Snake projects has affected the amount and quality of shallow, low velocity habitat in the lower Columbia River estuary, which is likely to be used by subyearling migrants from this ESU for rearing. Recent estuary habitat improvements to mitigate for this effect are described in Section 8.13.3.3, below.

8.13.3.2 Recent Tributary Habitat Improvements

Tributaries occupied by this species are outside the action area for the Prospective Actions. Information about the species' status in the tributary portion of its life cycle can be found in Section 8.13.2 (Current Rangewide Status).

8.13.3.3 Recent Estuary Habitat Improvements

The FCRPS Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving riparian and wetland function to mitigate for the effects of water management on the seasonal hydrograph and thus the amount of rearing habitat available to subyearling Chinook salmon. These have resulted in an estimated 0.3% survival benefit for yearling Chinook, the predominant juvenile life history type for this species, and 0.7% for subyearling Chinook (Corps et al. 2007a).

8.13.3.4 Recent Predator Management Improvements

Avian Predation

Caspian tern predation in the Columbia River estuary was reduced from a total of 13,790,000 smolts to 8,210,000 smolts after relocation from Rice to East Sand Island in 1999. The double-crested cormorant colony has grown since that time. Yearling Chinook are generally considered vulnerable to these predators based on PIT-tag data from upriver stocks (Ryan et al. 2006).

Piscivorous Fish Predation

The ongoing Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality since it began in 1990. The recent improvement in lifecycle survival attributed to the NPMP is estimated at 2% for both yearling and subyearling salmonids (Friesen and Ward 1999; Corps et al. 2007a).

8.13.3.5 Recent Hatchery Management Issues

Hatcheries for and effects on Upper Willamette River Chinook are located in the upper Willamette Basin and thus are outside the action area for the Prospective Actions. Information about the species status in the upriver portion of its range can be found in Section 8.13.2 (Current Rangewide Status).

8.13.3.6 Recent Harvest Survival Improvements

Fishery impacts for spring Chinook salmon in combined ocean and freshwater fisheries have been reduced from greater than 50% before 2000 to less than 25% currently. Impacts of the freshwater fishery have been reduced more than 75% from previous levels since the regulation changed to allow only marked hatchery fish to be harvested. This reduction protects the weaker listed populations. It was largely achieved by implementing mark-selective sport and commercial fisheries. Harvest reductions immediately increase in-river escapement and reduce extinction risk, particularly during years when the run size is low.

The effects of the ocean fishery were considered in NMFS (2001d), which is still in effect. Effects of the freshwater fishery on this species were considered through an ESA evaluation, pursuant to Section 4(d), of a Fishery Management Evaluation Plan from the State of Oregon (Kruzic 2001a). These fisheries have been managed subject to the terms of the *U.S. v. Oregon* Interim Management Agreement for 2005 to 2007, which ensured that the incidental take of ESA-listed UWR Chinook did not exceed 15% for all Columbia River non-Indian fisheries (actual rates have been approximately 10%). Harvest rates are limited to 10% in freshwater and 11% in ocean fisheries, although the ocean limit may change as a consequence of ongoing negotiations regarding the Pacific Salmon Treaty. Any proposed changes would be subject to Section 7 consultation.

8.13.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between

December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations.

Projects Affecting Multiple Populations

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.13.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect multiple populations within the ESU. The effects of some on population viability will be positive (habitat restoration; tar remediation). Other projects, including dock and boat launch construction, maintenance dredging, road maintenance, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on water quality habitat restoration; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.13.3.8 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. The principal factor affecting the conservation value of critical habitat within the action area is the alteration of seasonal and daily hydrographs.

Spawning & Rearing Areas

Spawning and rearing areas (except the estuary, see Juvenile and Adult Migration Corridors, below) are not within the action area for the Prospective Actions.

Juvenile & Adult Migration Corridors

Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*

- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management*].

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these PCEs. For example, the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at Albany and Willamette Falls dams has improved with the construction of new screens and passage facilities. The safe passage of both yearling and subyearling UWR Chinook salmon through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island, although the cormorant colony grew during that period. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of cover/shelter, food, and riparian vegetation required by this type of juvenile migrant. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Areas for Growth and Development to Adulthood

Although UWR Chinook salmon spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.13.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin (see lists of projects in Chapter 17 in Corps et al. 2007a).[5] Generally, all of these actions are either completed, ongoing, or reasonably certain to occur. They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve the environmental baseline for this ESU.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

8.13.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects will have continuing adverse effects that are described in this section. However, the Prospective Actions also include mainstem lower river habitat improvements and predator reduction actions that are expected to be beneficial. Flow augmentation from the Upper Snake Project (NMFS 2008b) will continue to provide benefits through 2034. Some estuary habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

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[5] The State of Oregon also identified habitat projects that are reasonably certain to occur within the Willamette Basin. Although outside the action area for the Prospective Actions, these will generally be beneficial to the ESU.

8.13.5.1 Effects of the Hydro Operations & Configuration Prospective Actions

Individuals from this ESU are unlikely to pass Bonneville Dam.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit to juvenile migrants in the lower Columbia River by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Table 8.13.1.2-2). The effects of Prospective Actions to mitigate for the remaining effects on estuarine habitat are discussed in Section 8.13.5.3, below.

Effects on Species Status & Critical Habitat

The prospective configuration and operation of the FCRPS and Upper Snake hydro projects will provide a small benefit to the status of the component populations of UWR Chinook salmon and the PCEs of its designated critical habitat.

8.13.5.2 Effects of Tributary Habitat Prospective Actions

The Prospective Actions do not include tributary habitat projects that will affect this ESU or its designated critical habitat.

8.13.5.3 Effects of Estuary Habitat Prospective Actions

The FCRPS Action Agencies will implement approximately 44 estuary habitat projects over the first 3-year period of implementing the RPA (Section 12.3.2.3 in Corps et al. 2007b). The expected survival benefit for yearling Chinook associated with these specific actions will be 1.4%. The estimated benefit for subyearling Chinook will be less than 2.3%.

The RPA requires the implementation of additional estuary habitat projects to obtain specified survival benefits for Interior Columbia Basin Chinook populations, but will also provide benefits to those from the Willamette River. The estimated benefit for yearling Chinook is less than 4.3%; the benefit for subyearling Chinook is 6.7%. Prospective Actions will address limiting factors by protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, reducing noxious weeds, and other actions.

Effects on Species Status

Prospective improvements in estuarine habitat will support the increased abundance, productivity, diversity, and spatial structure of UWR Chinook salmon.

Effects on Critical Habitat

Prospective estuarine habitat improvements will improve the functioning of the PCEs of water quality and safe passage in the migration corridor for yearling Chinook migrants and in rearing areas for subyearling Chinook from the Upper Willamette River ESU. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008h). The positive effects of these projects on the functioning of PCEs (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long-term.

8.13.5.4 Effects of Hatchery Prospective Actions

Hatchery actions in the Willamette are not addressed by the Prospective Actions. They are considered separately in the ongoing consultation on the Willamette Project.

There is considerable interest in the issue of density-dependent effects of releasing large numbers of hatchery-origin fish into areas used by natural-origin juveniles, but the nature and magnitude of these effects is largely unknown (Artificial Propagation for Pacific Salmon Appendix of the SCA).

8.13.5.5 Effects of Harvest Prospective Actions

As described in Section 8.13.3.6, the effects of all freshwater fisheries, including those being considered as part of the Prospective Actions, were reviewed and approved previously through an ESA evaluation pursuant to section 4(d). The 4(d) determination does not expire and so presumably will remain in effect through the duration of the *U.S. v. Oregon* Agreement. Fisheries proposed under the *U.S. v. Oregon* Agreement are entirely consistent with those considered through the 4(d) determination. For a description of the management strategy, see Oregon's Fishery Management and Evaluation Plan (ODFW 2001a).

8.13.5.6 Effects of Predation Prospective Actions

Avian predation
The survival of yearling UWR Chinook salmon will increase 2.1% with the reduced Caspian tern nesting habitat in the estuary and the subsequent relocation of most of the terns to sites outside the Columbia River basin (RPA Action 45)

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous Fish Predation
The prospective continued increase in incentives in the NPMP (RPA Action 43) will result in an additional 1% survival during the period 2008 to 2018.

Effects on Species Status

Prospective Actions that reduce avian and fish predation on juveniles will support the increased abundance and productivity of UWR Chinook populations.

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and management of cormorant predation on East Sand Island will further reduce predation on yearling Chinook, improving the status of safe passage in the juvenile migration corridor. These fish migrate over the deep water channel adjacent to the East Sand Island colony, which has made them especially vulnerable to predation. The benefit of this action will be long term.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery should also improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.13.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1.4 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRPS.

8.13.6 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on Upper Willamette River Chinook Salmon

This section summarizes the basis for conclusions at the ESU level.

8.13.6.1 Recent Status of the Upper Willamette River Chinook Salmon ESU

Upper Willamette River Chinook is a threatened species. Of the seven historical populations in this ESU, two are extirpated or nearly so. The remaining five (Molalla, North Santiam, South Santiam, Calapooia, and Middle Fork Willamette) have very low abundances and most spawners are of hatchery origin. Female prespawning mortality is between 50 and 100%, depending on the population. The construction of the Corps dams on major tributaries in the 1950s through 1970s cut off access to highly productive spawning habitat in the upper North Santiam, Quartzville Creek (South Santiam watershed), South Fork McKenzie, and Middle Fork Willamette subbasins. These dams affect flows, water quality, sediment transport, and other attributes in downstream spawning and rearing habitat. Flood storage and release operations and to a lesser extent, irrigation withdrawals, have also altered temperatures and/or and bank hardening has cut the lower stream reaches off from side channels and the floodplain. Upper Willamette River Chinook also have experienced injury and passage delays at small hydroprojects, but many of these are now shut down or have recently installed improved fish screens, ladders, and in some cases tailrace barriers. It is highly unlikely that any fish from this ESU encounter FCRPS mainstem projects, but water management operations in the upper Columbia basin affect habitat and flow in the lower Columbia River, estuary, and plume. Large-scale changes in freshwater and marine environments have also had substantial effects on salmonid numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this ESU. The potential for additional risks due to climate change is described in Sections 5.7 and 8.1.3.

In terms of the primary constituent elements of critical habitat, the ability to function in support of the conservation of the species has been limited by barriers to many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development. Passage delay and injury at FERC-licensed hydroelectric projects in the lower reaches of the North and South Santiam and the McKenzie River have been addressed in recent years (migration corridors free of obstructions). The functioning of mainstem habitat in the Columbia River as a juvenile migration corridor has also improved in recent years with the reduction in predation by Caspian terns and northern pikeminnows.

8.13.6.2 Effects of the FCRPS, Upper Snake & *U.S. v. Oregon* Prospective Actions on the Upper Willamette River Chinook ESU

NOAA Fisheries has adopted the LCFRB's (2004) recovery plan as its interim recovery plan for the Washington side of the lower Columbia River. In the LCFRB's recovery plan, one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume." The FCRPS Action Agencies' estuary habitat restoration projects are therefore expected to increase the survival of juvenile Upper Willamette River Chinook. Shifting the delivery of some of the flow augmentation water from summer to spring will address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.13.3.8). Relocating most of the Caspian terns to sites outside the Columbia basin, managing cormorant predation, and the continued increase in the northern pikeminnow reward fishery will further improve the viability of the ESU and the conservation value of the lower river as critical habitat.

8.13.6.3 Cumulative Effects Relevant to the Upper Willamette River Chinook Salmon ESU

Habitat-related actions and programs that the states of Oregon and Washington submitted and that NOAA Fisheries determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect instream habitat. The actions will improve the functioning of PCEs of critical habitat needed for the successful growth and development and emigration of juvenile Chinook.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for the Prospective Actions (the mainstem lower Columbia River below the confluence of the Willamette), these are likely to include urban development and other land use practices.

8.13.6.4 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on the Upper Willamette River Chinook Salmon ESU

Impacts of the FCRPS and Upper Snake projects on this ESU are limited relative to those from tributary hydropower, tributary habitat, harvest, hatcheries, and predation by birds and fish. None of the populations in this ESU are affected by upstream or downstream passage at FCRPS projects; only migration and habitat conditions in the mainstem lower Columbia and estuary are affected by the existence and operation of the hydrosystem.

The states of Oregon and Washington have identified habitat actions that will improve conditions along the mainstem lower Columbia River (including the estuary). The State of Oregon also identified tributary habitat actions that are reasonably certain to occur and that generally should be beneficial throughout the ESU. Some future Federal actions with completed Section 7 consultations will restore access to blocked habitat, increase channel complexity, and restore riparian condition. Many actions will have neutral or short- or even long-term negative effects on habitat conditions, but all were found to meet the ESA standards for avoiding jeopardy and for avoiding any adverse modification of critical habitat.

The FCRPS Action Agencies' prospective estuary habitat and predator management improvements will contribute to the viability of this ESU by addressing the influence of their projects, contributing to its survival with an adequate potential for recovery. The Prospective Actions will not further deteriorate the pre-action condition.

The effects of harvest in ocean and inriver fisheries were considered previously for ESA compliance and are thus part of the environmental baseline. Ocean fishery impacts are expected to average approximately 11%, although ocean harvest rates may be reduced in the future as a result of ongoing negotiations regarding the Pacific Salmon Treaty. A new agreement under the Pacific Salmon Treaty would be subject to subsequent section 7 consultation. Under Oregon's Fishery Management and Evaluation Plan all freshwater fisheries in the Columbia and Willamette rivers are subject to a harvest rate limit on natural origin Upper Willamette Chinook of 15%. Since implementing the management plan in 2001 harvest rates in freshwater fisheries have averaged approximately 10% with about half the harvest occurring in Columbia River fisheries that are subject to the *U.S. v. Oregon* Agreement.

Long term (100 year) extinction risk is high or very high for five of the seven populations in this ESU. Exceptions are the Clackamas and McKenzie populations. In the short term, the species' extinction risk is expected to be reduced through implementation of the actions described above.

8.13.6.5 Aggregate Effect of the Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat for the Upper Willamette River Chinook Salmon ESU

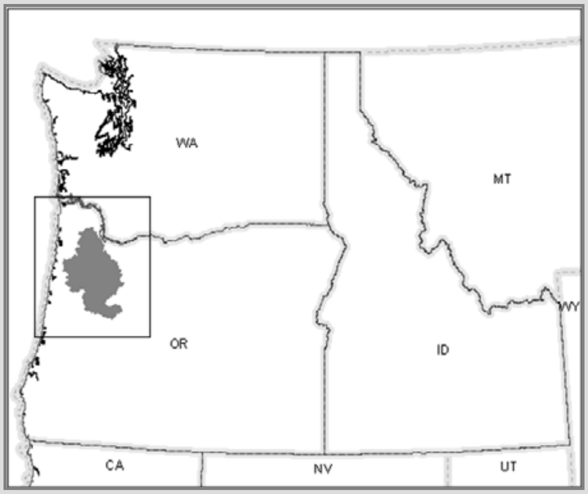
NOAA Fisheries designated critical habitat for UWR Chinook salmon including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in the following subbasins: Middle Fork Willamette, Coast Fork

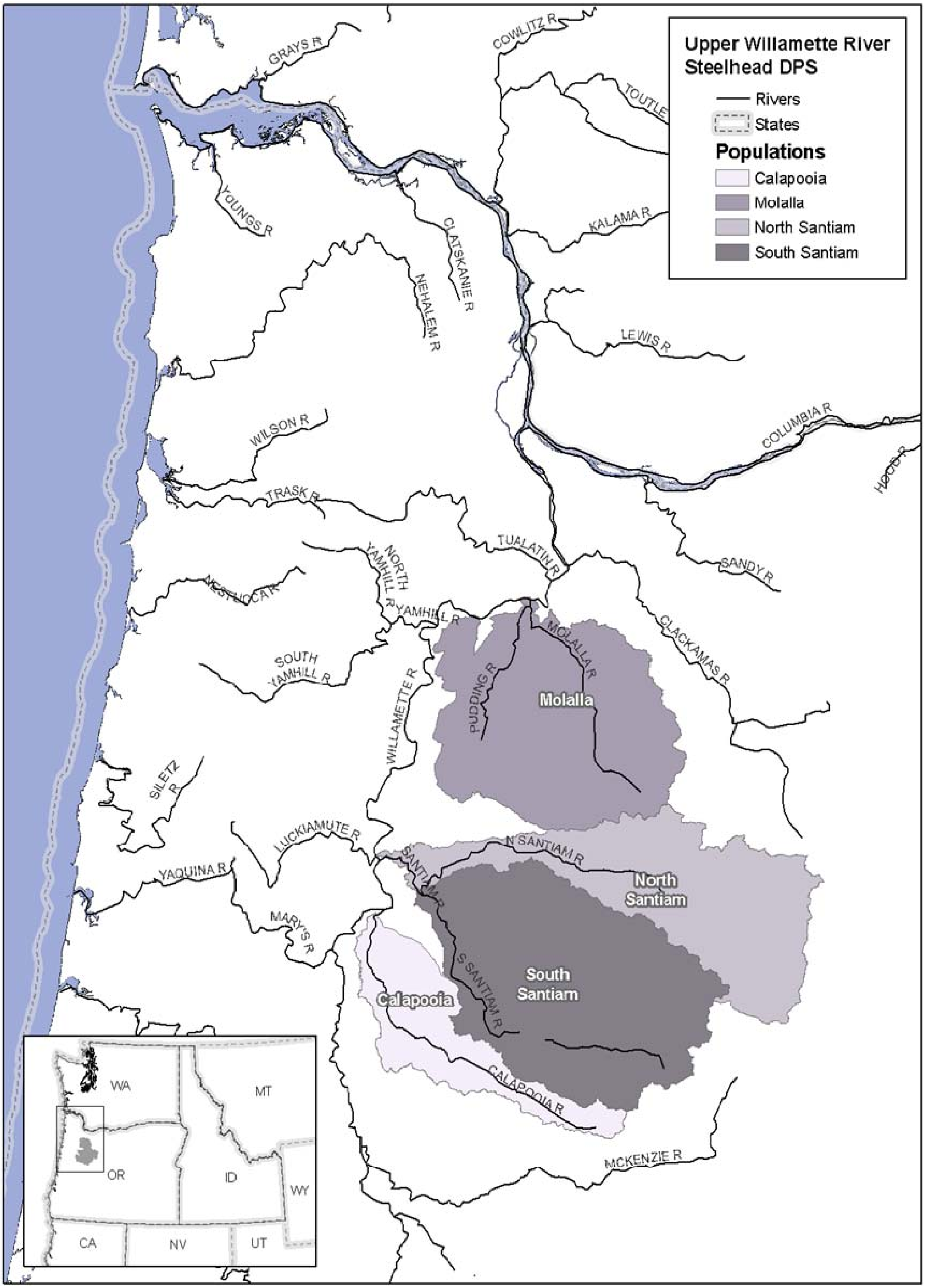
Willamette, Upper Willamette, McKenzie, North Santiam, South Santiam, Middle Willamette, Molalla/Pudding, Clackamas, and Lower Willamette. The environmental baseline within the action area, which includes the lower Columbia River and the estuary, has improved over the last decade but does not yet support the conservation value of designated critical habitat for UWR Chinook. The major factors currently limiting the conservation value of critical habitat are barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will improve the functioning of many of the PCEs in the action area; for example, reducing predation by Caspian terns and cormorants and northern pikeminnows will further improve safe passage for juveniles. Habitat work in the estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. In addition, a number of actions in estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).

The aggregate effect of the environmental baseline, Prospective Actions, and cumulative effects will be an improvement in the functioning of PCEs in the action area used for juvenile growth and development, migration, and juvenile and adult transitions between fresh and salt water. Considering the ongoing and future effects of the environmental baseline and cumulative effects, the Prospective Actions will be adequate to ensure that they will not reduce the ability of critical habitat to serve its conservation role for this species.

Section 8.14
Upper Willamette River Steelhead




Upper Willamette River Steelhead DPS
Rivers
States
Populations
Calapooia
Molalla
North Santiam
South Santiam
GRAYS R
COWLITZ R
TOUTLE
YOUNGS R
CLATSKANIE R
KALAMA R
NEHALEM R
LEWIS R
WILSON R
COLUMBIA R
TRASK R
HOOD R
TUALATIN R
NORTH YAMHILL R
SANDY R
NESTUCCA R
YAMHILL R
MOLALLA R
SOUTH YAMHILL R
CLACKAMAS R
PUDDING R
Molalla
WILLAMETTE R
SILETZ R
LUCKIAMUTE R
N SANTIAM R
SANTIAM R
YAQUINA R
North Santiam
MARY'S R
S SANTIAM R
South Santiam
Calapooia
CALAPOOIA R
MCKENZIE R
WA
MT
OR
ID
WY
CA
NV
UT

Section 8.14
Upper Willamette River Steelhead

Species Overview

Background

The Upper Willamette River (UWR) steelhead DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive). There is only one major population group in this DPS, comprised of four historical populations. All four remain extant and produce moderate numbers of natural-origin steelhead each year. The hatchery summer-run steelhead that occur in the Willamette Basin are an out-of-basin stock that is not part of the DPS. Upper Willamette River steelhead were listed as threatened under the ESA in 1999. This listing was reaffirmed in 2006.

Designated critical habitat for Upper Willamette River steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in a number of subbasins.

Current Status & Recent Trends

The abundance and productivity of Upper Willamette River steelhead populations are depressed from historical levels, but to a much lesser extent than for Upper Willamette River Chinook salmon. All of the historical populations remain extant and moderate numbers of steelhead are produced each year. DPS long-term abundance and productivity trends are stable to slightly decreasing and short-term trends are stable to slightly increasing. The long-term risk of extinction is considered moderate for all four populations.

Limiting Factors

Human impacts and limiting factors for Upper Willamette River steelhead include habitat loss and degradation (including tributary hydropower development), hatchery effects, fishery management and harvest decisions, and predation. FCRPS impacts are limited to habitat conditions in the mainstem below the confluence of the Willamette and in the estuary, which have been affected by hydrosystem flow operations. Mainstem Willamette and tributary habitat degradation have been pervasive, particularly in the lower reaches of tributaries to the Willamette, and both Corps and privately owned dams have blocked some important spawning areas. Habitat loss due to blockages has been especially severe in the North Santiam and Calapooia subbasins.

Recent Ocean and Mainstem Harvest

Ocean fishing mortality on Upper Willamette River steelhead is assumed to be zero. In recent years, non-Treaty mainstem winter and spring season fisheries have been managed subject to a 2% harvest rate limit on winter steelhead. The yearly incidental catch of winter-run steelhead populations in non-Treaty fisheries has averaged 1.9% and has ranged from 0.2 to 9.3% since 2001. The high harvest rate observed in 2002 (i.e. 9.3%) was due to a lack of proper in-season management guidelines. These guidelines were subsequently corrected in 2003 and have been in place since that time. Upper Willamette River steelhead are not caught in non-Treaty summer or fall season fisheries, or in treaty Indian fisheries above Bonneville Dam.

8.14.2 Current Rangewide Status

With this first step in the analysis, NOAA Fisheries accounts for the principal life history characteristics of each affected listed species. The starting point for this step is with the scientific analysis of species' status which forms the basis for the listing of the species as endangered or threatened.

8.14.2.1 Current Rangewide Status of the Species

The Upper Willamette River (UWR) steelhead DPS includes four naturally-spawning anadromous populations in the Willamette River and its tributaries, from Willamette Falls upstream to the Calapooia River (inclusive) (Table 8.14.2.1-1). The West Side Tributaries represent an area of intermittent use, which could be important for the recovery of the species, but is not considered to have been a demographically independent population historically (Myers et al. 2006). This DPS does not include any artificially propagated winter steelhead stocks. The hatchery summer-run steelhead that occur in the Willamette Basin are an out-of-basin stock and are not included in the DPS (NMFS 2006a).

Winter steelhead enter the Willamette River beginning in January and February, but they do not ascend to their spawning areas until late March or April (Dimick and Merryfield 1945). Spawning takes place from April to June 1st and redd counts are conducted in May. The smolt migration past Willamette Falls also begins in early April and extends through early June (Howell et al. 1985), with migration peaking in early- to mid-May. Steelhead smolts generally migrate away from the shoreline and enter the Columbia via Multnomah Channel rather than the mouth of the Willamette. Most spend two years in the ocean before re-entering fresh water to spawn (Busby et al. 1996). Steelhead in the Upper Willamette River DPS generally spawn once or twice; a few fish may spawn three times based on patterns found in the LCR steelhead DPS. Repeat spawners are predominantly female and generally account for less than 10% of the total run size (Busby et al. 1996).

Table 8.14.2.1-1. Upper Willamette River steelhead DPS description. (Sources: Myers et al. 2006, NMFS 2006a) The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (Appendix B in WLCTRT 2003).[1]

DPS Description	
Threatened	Listed under ESA in 1999, reaffirmed in 2006
Major Population Group	**Population**
UWR	Molalla, North Santiam (C,G), South Santiam (C,G) , Calapooia
Hatchery programs included in DPS	None

[1] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the DPS (WLCTRT 2003).

Limiting Factors

Summarized below (Table 8.14.2.1-2 are key limiting factors for this DPS and recovery strategies to address factors in the mainstem Columbia River (including the estuary) as described in the Washington Lower Columbia River Recovery and Subbasin Plan (LCFRB 2004). Oregon is currently engaged in the recovery planning process for UWR steelhead, which will identify management actions to address these factors in the Willamette basin.

Table 8.14.2.1-2 Key limiting factors for Upper Willamette River steelhead.

Hydropower	The Corps operates 13 dams in the largest five Willamette tributaries for flood control, irrigation, and hydropower. Major habitat blockages for UWR steelhead resulted circa 1952 from the construction of Big Cliff and Detroit dams on the North Santiam River, and circa 1967 from Green Peter Dam on the South Santiam River (Foster Dam on the South Santiam was built with trap and haul fish passage facilities). These dams were identified by NOAA Fisheries as the upper limit of winter steelhead distribution in its recent status review, although historically these fish spawned in habitat above the dams (NMFS 2006a). In addition to blocking winter steelhead access to historical upstream habitat in the South and North Santiam rivers these dams also affect flows, water quality, sediment transport, and downstream habitat in the North and South Santiam rivers and in the mainstem Willamette. Flow storage and release operations and, to a lesser extent, irrigation withdrawals have also altered temperatures and channel-forming processes. Adult and juvenile UWR steelhead also pass several smaller, FERC-licensed hydropower projects: Willamette Falls on the lower mainstem Willamette; the City of Albany/Lebanon Dam on the South Santiam; Stayton, Water Street, and Fery projects on the North Santiam; and the decommissioned Thompson Mills on the Calapooia. Except for the Stayton project, which is currently shut down, improved fish screens, ladders, and, in some cases, tailrace barriers have recently been installed at all of these FERC projects, thereby reducing adverse effects on UWR steelhead. It is highly unlikely that fish from this DPS encounter FCRPS projects. Impacts from those projects on Upper Willamette River populations are limited to effects on migration and habitat conditions in the lower Columbia River (below the confluence of the Willamette) including the estuary.
Hatcheries	There are no winter steelhead hatchery programs in the upper Willamette basin. However, the non-native summer steelhead hatchery program is a threat to listed winter steelhead. There is some separation in run and spawn timing between hatchery-origin summer and wild winter steelhead, but the potential exists for genetic introgression. Also, juvenile non-native hatchery-origin summer steelhead may compete with wild winter steelhead for rearing resources (space, food, etc.) and adults may compete for spawning sites.

Habitat	Habitat in all tributaries, particularly the lower reaches, and in the mainstem Willamette River is moderately to severely degraded, and some tributaries have numerous small passage barriers. Specific habitat concerns vary by subbasin but include impaired access on small streams, fine sediments in spawning gravel, reduced habitat complexity, reduced access to off-channel habitat, reduced floodplain function and connectivity, elevated water temperatures, toxic water pollutants, and insufficient stream flows. Causes of these conditions include the impacts of widespread development, as well as the habitat impacts of large hydropower and flood control dams, smaller passage barriers, and bank hardening. Recent improvements include removal of Brownsville Dam (in 2007), decommissioning of Thompson Mills Dam (2005) on the Calapooia River, resulting in increased stream flow and improved upstream and downstream fish passage, and other improvements described above (Hydropower). Conditions in the upper tributary basins, although not pristine, are relatively good. Riparian conditions in the lower portions of small tributaries can be severely degraded and contain numerous passage barriers.
Harvest	Ocean fishing mortality on UWR steelhead is assumed to be zero. Fisheries in the mainstem Columbia River that affect UWR steelhead are currently managed subject to the terms of the *US v. Oregon* Interim Management Agreement for 2005-2007. These fisheries are limited to assure that the incidental take of ESA-listed UWR steelhead does not exceed specified rates. In recent years, non-Indian mainstem winter and spring season fisheries have been managed subject to a 2% incidental harvest rate limit on winter steelhead. Upper Willamette River steelhead are not caught in non-Indian summer or fall season fisheries, or treaty Indian fisheries above Bonneville Dam. The incidental harvest mortality rate expected under current conditions is 2% or less.
Predation	Piscivorous birds including Caspian terns and cormorants and fishes including northern pikeminnow take significant numbers of juvenile or adult steelhead. Stream-type juveniles, especially larger smolts such as steelhead, are vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid water over the channel, which is located near habitat preferred by piscivorous birds (Fresh et al 2005). In addition, steelhead are subject to pinniped predation when they return to the estuary as adults although the magnitude of pinniped predation for Upper Willamette fish is unknown. Caspian terns as well as cormorants may be responsible for the mortality of up to 6% of the outmigrating stream-type juveniles in the Columbia River basin (Corps et al. 2007a). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999). Ongoing actions to reduce predation effects include redistribution of avian predator nesting areas and a sport reward fishery to harvest pikeminnow.

Estuary	The estuary is an important habitat for migrating salmonids from the UWR steelhead DPS. The survival of larger juveniles, such as steelhead, in the ocean can be affected by habitat factors in the estuary such as changes in food availability and the presence of contaminants. Changes in the seasonal hydrograph as a result of water use and reservoir storage throughout the Columbia basin have altered habitat-forming processes including the shape, behavior, size, and composition of the plume compared to historical conditions. Characteristics of the plume are thought to be significant to juvenile migrants during transition to the ocean phase of their lifecycle (Fresh et al 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2006b).
Ocean & Climate	Analyses of lower Columbia River salmon and steelhead status generally assume that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments (e.g., LCFRB 2004). Recent conditions have been less productive for most Columbia River salmonids than the long-term average. Although climate change will affect the future status of this DPS to some extent, future trends, especially during the time period relevant to the Prospective Actions, are unclear.

Abundance, Productivity, & Trends

Steelhead in this DPS are depressed from historical levels, but to a much lesser extent than are spring Chinook in the Willamette basin (McElhany et al. 2007). All of the historical populations remain extant and moderate numbers of wild steelhead are produced each year. Long-term trends are less than one (Table 8.14.2.1-3), but short-term trends are 1.0 or higher (McElhany et al. 2007).

Table 8.14.2.1-3. Abundance, productivity, and trends of UWR Steelhead populations (source: McElhany et al. 2007). The designations "-C" and "-G" identify Core and Genetic legacy populations, respectively (Appendix B in WLCTRT 2003).

Population	Recent Natural Spawners			Long-Term Trend		Median Growth Rate	
	Years[1]	No.[2]	pHOS[3]	Years	Value[4]	Years	λ[5]
Molalla	90-05	914	0%[6]	80-05	0.966	80-05	0.988
North Santiam	90-05	2109	0%[6]	80-05	0.98	80-05	0.983
South Santiam	90-05	2149	0%[6]	68-05	0.981	68-05	0.976
Calapooia	90-05	339	0%[6]	80-05	0.987	80-05	1.023

Note: Reported time series correspond to reported values in available information and may not correspond to reference periods identified in Biological Opinion analyses of other DPSs.
[1] Years of data for recent means.
[2] Geometric mean of total spawners.
[3] Average recent proportion of hatchery origin spawners

[4] Long-term trend of natural spawners (regression of log-transformed spawner abundances against time). [5] Long-term median population growth rate after accounting for hatchery spawners (equal spawning success assumption). [6] Current hatchery fractions reflect termination of hatchery winter steelhead releases into natural production areas in the 1990s. N/A = not available

Extinction Probability/Risk

The risk of extinction (Table 8.14.2.1-4) was derived qualitatively, based on risk categories and criteria identified by the WLC TRT (2004) for use in recovery plan assessments. The rating system categorized extinction risk probabilities as very low (<1%), low (1 to 5%), medium (5 to 25%), high (26 to 60%), and very high (>60%) based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 8.14.2.1-4. Risk of extinction categories for populations of UWR Steelhead (source: McElhany et al. 2007).

Stratum	Population	Extinction Risk Category
	Molalla	M
	North Santiam	M
	South Santiam	M
	Calapooia	M

The risk of extinction is moderate for all four populations.

Spatial Structure

Spatial structure for the North and South Santiam populations has been substantially reduced by the loss of access to the upper North Santiam basin and the Quartzville Creek watershed in the South Santiam subbasin due to construction of the dams owned and operated by the Corps without passage facilities (McElhany et al. 2007). Spatial structure in the Molalla subbasin has been reduced significantly by habitat degradation and in the Calapooia by habitat degradation and passage barriers (WLCTRT 2004).

Diversity

The diversity of some populations has been eroded by small population size, the loss of access to historical habitat, legacy effects of past winter-run hatchery releases, and the ongoing release of summer steelhead (McElhany et al. 2007).

8.14.2.2 Current Rangewide Status of Critical Habitat

Designated critical habitat for UWR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in the following subbasins: Upper Willamette, North Santiam, South Santiam, Middle Willamette, Molalla/Pudding, Yamhill, Tualatin, and Lower Willamette (NMFS 2005b). There are 38 watersheds within the range of this DPS. Seventeen watersheds received a low rating, 6 received a medium rating, and 15 received a high rating of conservation value to the DPS (for more information, see Chapter 4). The lower Willamette/Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor 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. Of the 1,830 miles of habitat eligible for designation, 1,276 miles of stream are designated critical habitat.

In the lower Columbia and Willamette basins, major factors affecting PCEs are altered channel morphology and stability; lost/degraded floodplain connectivity; loss of habitat diversity; excessive sediment; degraded water quality; increased stream temperatures; reduced stream flow; and reduced access to spawning and rearing areas (LCFRB 2004, ODFW 2006b, PCSRF 2006). A wide variety of actions with the potential to improve PCEs and habitat function have been implemented in the upper Willamette River and its tributaries since 2000, involving non-Federal and Federal parties.[2] Actions have included beneficial land management practices, restoration projects such as culvert replacement to improve access, and improved passage at FERC-licensed and other small dams. The latter include:

Although outside the action area for this consultation, a variety of actions with the potential to improve the spatial structure of the DPS have been implemented in the upper Willamette River and its tributaries since 2000, involving non-Federal and Federal parties. Actions have included beneficial land management practices, restoration projects such as culvert replacement to improve access, and improved passage at FERC-licensed and other small dams. The latter include:

- Willamette Falls Hydroproject: FERC completed consultation (NMFS 2005p) on the relicensing of this project, which is located in the lower mainstem Willamette River. As a result, the project owner has recently completed two large fish passage projects (juvenile fish bypass and controlled flow structure). All four populations of UWR steelhead will experience a decrease in juvenile fish injury and mortality, in adult upstream passage delay, and in juvenile stranding as a result of these recent improvements (i.e., improving safe passage in adult and juvenile steelhead migration corridors).

- City of Albany Hydroproject: The Corps completed consultation with NOAA Fisheries (NMFS 2004e) in December, 2004 on the construction of a new fish ladder and intake screen and the

[2] The status of critical habitat within the action area is discussed in more detail in Section 8.14.3.8.

reconstruction of an existing ladder at Lebanon Dam in the lower South Santiam River. Construction was completed in 2006. This recent action eliminated the only migration barrier and large unscreened intake in the mainstem South Santiam below the Corps' Foster Dam (i.e., improving safe passage in adult and juvenile steelhead migration corridors).

- Brownsville Dam: Originally built as a timber crib dam in the 1800s to power a mill, Brownsville Dam was rebuilt as a concrete structure with an inadequate fish ladder in the 1960s. The mill is long gone, but the 10-foot high dam continued to impound water for three months of the year, creating an area for swimming and sending water via canal to the City of Brownsville for aesthetic benefits and livestock watering. Brownsville Dam was breached on August 27, 2007 under NOAA Fisheries' Open Rivers Initiative, allowing winter steelhead safe passage to more than 40 miles of historical spawning and rearing habitat. In 2008, the Brownsville Canal company will install a small screened pump to facilitate its 2.5 cfs water withdrawal during the dry summer months (i.e., juvenile migration corridors free of obstructions).[3]

- Thompson Mill: This five-story factory, with its water-powered gristmills, was one of the oldest continuously operating businesses in Oregon. With the help of former owner, D. Babbitt, Oregon Parks and Recreation Department purchased the mill several years ago. The Oregon Water Trust paid the owner not to run his electrical generator in the summer months, to leave more water in the river channel. The Trust negotiated a deal with the state to buy 12 of the property's 180-cfs water right to permanently enhance water quantity in winter steelhead rearing areas and migration corridors.

In addition, the USFS has implemented restoration projects in areas of the North and South Santiam watersheds currently occupied by UWR steelhead. Watershed councils and private landowners have also implemented numerous projects in recent years that affect UWR steelhead such as removing fish passage barriers and enhancing channel conditions on the local scale.

8.14.3 Environmental Baseline

The following section evaluates the environmental baseline as the effects of past and ongoing human and natural factors within the action area. It includes the past and present impacts of all state, tribal, local, private, and other human activities in the action area, including impacts of these activities that will have occurred contemporaneously with this consultation. The effects of unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the environmental baseline. For a detailed environmental baseline analysis pertinent to all species please see Chapter 5, Environmental Baseline, of the SCA.

Both Federal and non-Federal parties have implemented a variety of actions in the action area for this consultation that have improved the status of UWR steelhead. Those implemented since the

[3] This project was considered implementation of NMFS' programmatic section 7 consultation on NOAA's Restoration Center Programs (NMFS 200f).

environmental baseline was described in the 2004 FCRPS Biological Opinion (NMFS 2004) are discussed in the following sections. To the extent that their benefits continue into the future (and other factors are unchanged), estimates of population growth rate and trend developed by the WLC TRT (Table 8.14.2.1-3) will improve.

8.14.3.1 Recent FCRPS Hydro Improvements

It is highly unlikely that fish from this DPS encounter the FCRPS projects. Flow management at FCRPS and Upper Snake projects has affected the amount and quality of river margin habitat below Bonneville Dam used by juvenile steelhead migrants. Recent habitat improvements to mitigate for this effect are described in Section 8.14.3.3, below.

8.14.3.2 Recent Tributary Habitat Improvements

Tributaries occupied by this species are outside the action area for the Prospective Actions. Information about the species status in the tributary portion of its range can be found in Section 8.14.2 (Current Rangewide Status).

8.14.3.3 Recent Estuary Habitat Improvements

The FCRPS Action Agencies have implemented 21 estuary habitat projects, removing passage barriers and improving riparian and wetland function. These have resulted in an estimated 0.3% survival benefit for juvenile UWR steelhead (Corps et al. 2007a).

8.14.3.4 Recent Predator Management Improvements

Avian Predation

Caspian tern predation in the Columbia River estuary was reduced from a total of 13,790,000 smolts to 8,210,000 smolts after relocation from Rice to East Sand Island in 1999. The double-crested cormorant colony has grown since that time. Juvenile steelhead are considered vulnerable to these predators based on PIT-tag information from upriver stocks (Ryan et al. 2006).

Piscivorous Fish Predation

The ongoing Northern Pikeminnow Management Program (NPMP) has reduced predation-related juvenile salmonid mortality since it began in 1990. The recent improvement in lifecycle survival attributed to the NPMP is estimated at 2% for larger juvenile salmonids (Friesen and Ward 1999; Corps et al. 2007a).

8.14.3.5 Recent Hatchery Management Issues

Effects of hatcheries on Upper Willamette River steelhead take place in the upper Willamette Basin and thus are outside the action area for the Prospective Actions. Information about the species' status in the upriver portion of its range can be found in Section 8.14.2 (Current Rangewide Status).

8.14.3.6 Recent Harvest Survival Improvements

Ocean fishing mortality on UWR steelhead is assumed to be zero. This species is also not caught in non-Indian summer or fall season fisheries or in treaty Indian fisheries above Bonneville Dam. The effects of freshwater fisheries on this species have been considered through an ESA evaluation, pursuant to Section 4(d), of a Fishery Management Evaluation Plan from the State of Oregon (Kruzic 2001b). The non-Indian mainstem winter and spring season fishery was limited in recent years to ensure that the incidental take of ESA-listed UWR steelhead did not exceed 2%. Harvest rates remain approximately 2%. Any proposed changes would be subject to Section 7 consultation.

8.14.3.7 Future Effects of Federal Actions with Completed Consultations

NOAA Fisheries searched its Public Consultation Tracking System Database (PCTS) for Federal actions occurring in the action area that had completed Section 7 consultations between December 1, 2004 and August 31, 2007 (i.e., updating this portion of the environmental baseline description in the 2004 FCRPS Biological Opinion) that have affected the status of the populations.

Projects Affecting Multiple Populations

Federal agencies completed consultation on a large number of projects affecting habitat in the lower Columbia River including maintenance dredging and boat ramp/dock repairs, tar remediation at Tongue Point, bridge and road repairs, an embankment and riprap repair, and several habitat restoration projects that included stormwater facilities and programs. A total of five wave energy projects have been proposed for the Oregon coast and one for the Washington coast. NOAA Fisheries has completed consultation on one project, in Makah Bay on the Olympic Peninsula in Washington (NMFS 2007k).

NOAA Fisheries' Habitat Restoration Programs with Completed Consultations

NOAA Fisheries funds several large-scale habitat improvement programs that will affect the future status of the species considered in this SCA/Opinion and their designated critical habitat. These programs, which have undergone Section 7 consultation provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the States of Washington, Oregon, and Idaho as Cumulative Effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007l), the Restoration Center Programs (NMFS 2004g), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000e). The objectives of these programs are described below, but to avoid "double counting," NOAA Fisheries considered the projects submitted by the states (see Chapter 17 in Corps et al. 2007a) as Cumulative Effects (Section 8.14.4).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Idaho and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NOAA Fisheries Service each year. The fund supplements existing state, tribal and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NOAA Fisheries has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made significant progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

NOAA Restoration Center Programs

NOAA Fisheries has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest. These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NOAA Fisheries funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways. The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

Summary

Effects on Species Status

These projects are likely to affect multiple populations within the DPS. The effects of some on population viability will be positive (habitat restoration; tar remediation). Other projects, including dock and boat launch construction, maintenance dredging, road maintenance, and embankment repair, will have neutral or short- or even long-term adverse effects. All of these projects have undergone section 7 consultation and were found to meet the ESA standards for avoiding jeopardy.

Effects on Critical Habitat

Some of the future federal projects will have positive effects on water quality habitat restoration; tar remediation). The other types of projects will have neutral or short- or even long-term adverse effects on safe passage and water quality. All of these actions have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

8.14.3.8 Status of Critical Habitat under the Environmental Baseline

Many factors, both human-caused and natural, have contributed to the decline of salmon and steelhead over the past century, as well as the conservation value of essential features and PCEs of designated critical habitat. Tributary habitat conditions vary widely among the various drainages occupied by UWR steelhead. Factors affecting the conservation value of critical habitat vary from inadequate access to spawning and rearing areas, altered seasonal and daily hydrographs, high summer water temperatures, lack of adequate pool/riffle channel structure, and poor overwintering conditions due to loss of connection to the floodplain.

Spawning & Rearing Areas

The following are the major factors that have limited the functioning of primary constituent elements and thus the conservation value of tributary habitat used for spawning and both tributary and estuarine habitat used for rearing (i.e., spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space):

- Tributary barriers *[culverts; dams; water withdrawals]*
- Reduced riparian function *[urban and rural development; forest practices; agricultural practices; channel manipulations]*
- Loss of wetland and side channel connectivity *[urban and rural development; past forest practices; agricultural practices; channel manipulations]*
- Elevated water temperatures *[water withdrawals; urban and rural development; forest practices; agricultural practices]*

The Corps operates four dams in two Willamette tributaries within this species' current range (North and South Santiam rivers) for flood control, irrigation, hydropower, and recreation, as well as to benefit fish and wildlife. Impacts of these dams include blocked passage, poor downstream water quality, entrapment and stranding due to flood control and power peaking operations, and degraded functioning of downstream habitat. The Corps, BPA (which markets power produced at these dams), and Reclamation (which markets water storage space in the project reservoirs) are currently consulting with NOAA Fisheries on the effects of these dams on UWR steelhead and its designated critical habitat. In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions that address these limiting factors. These include removing passage barriers, improving channel complexity, and protecting and enhancing riparian areas to improve water quality and other habitat conditions, addressing key limiting factors. Some projects will provide immediate benefits and some will result in long-term benefits with survival improvements accruing into the future.

As described above, future Federal projects with completed consultations will have neutral or short- or even long-term adverse effects on the functioning of the PCEs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Some Federal projects, implemented for restoration purposes, will improve these same PCEs.

Juvenile & Adult Migration Corridors

Factors that have limited the functioning and conservation value of PCEs in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*

- In the lower Columbia River and estuary—diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management*].

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these PCEs. For example, the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at Albany and Willamette Falls dams has improved with the construction of new screens and passage facilities. The safe passage of juvenile UWR steelhead through the Columbia River estuary improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat (see Section 5.3.1.3 in Corps et al. 2007a).

Areas for Growth & Development to Adulthood

Although UWR steelhead spend part of their first year in the ocean in the Columbia River plume, NOAA Fisheries designated critical habitat no farther west than the estuary (i.e., a line connecting the westward ends of the river mouth jetties; NMFS 2005b). Therefore, the effects of the Prospective Actions on PCEs in these areas were not considered further in this consultation.

8.14.4 Cumulative Effects

Cumulative effects includes state, tribal, local, and private activities that are reasonably certain to occur within the action area and likely to affect the species. Their effects are considered qualitatively in this analysis.

As part of the Biological Opinion Collaboration process, the states of Oregon and Washington provided information on various ongoing and future or expected projects that NOAA Fisheries has determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia and Willamette basins (see lists of projects in Chapter 17 in Corps et al. 2007a).[4] Generally, all of these actions are either completed, ongoing, or reasonably certain to occur. They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in designated critical habitat. Therefore these activities are likely to have cumulative effects that will significantly improve the environmental baseline for this DPS.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the Prospective Actions, non-federal actions are likely to include urban development and other land use practices. In coastal waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, and fishing permits. Private activities are likely to be continuing commercial and sport fisheries and resource extraction, all of which can contaminate local or larger areas of the coastal ocean with hydrocarbon-based materials. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NOAA Fisheries finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

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[4] The State of Oregon also identified habitat projects that are reasonably certain to occur within the Willamette Basin. Although outside the action area for the Prospective Actions, these will generally be beneficial to the DPS.

8.14.5 Effects of the Prospective Actions

Continued operation of the FCRPS and Upper Snake projects will have continuing adverse effects that are described in this section. However, the Prospective Actions also include mainstem lower river habitat improvements and predator reduction actions that are expected to be beneficial. Flow augmentation from the Upper Snake Project (NMFS 2008b) will continue to provide benefits through 2034. Some estuary habitat restoration and RM&E actions may have short-term, minor adverse effects, but these will be more than balanced by short- and long-term beneficial effects.

8.14.5.1 Effects of Hydro Operations & Prospective Actions on Species Status

Individuals from this DPS are unlikely to pass Bonneville Dam.

Under the Prospective Actions, flows from the upper Snake basin will continue to be reduced during spring compared to an unregulated system. However, shifting the delivery of much of the flow augmentation water from summer to spring will provide a small benefit to juvenile migrants in the lower Columbia River by reducing travel time, susceptibility to predators, and stress, as described above. Increasing spring flows will also address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.14.2.1-2). The effects of Prospective Actions to mitigate for the remaining effects on estuarine habitat are discussed in Section 8.14.5.3, below.

8.14.5.2 Effects of Tributary Habitat Prospective Actions

The RPA does not include tributary habitat actions that will affect this DPS or its designated critical habitat.

8.14.5.3 Effects of Estuary Habitat Prospective Actions

The FCRPS Action Agencies will implement approximately 44 estuary habitat projects over the first 3-year period of the RPA (2007-2009) (Section 12.3.2.3 in Corps et al. 2007b). The expected survival benefit for juvenile steelhead associated with these actions will be 1.4%.

The Action Agencies will implement projects that achieve an additional survival benefit for juvenile steelhead of less than 4.3% during the period 2010 to 2018. Prospective Actions, including protection and restoration of riparian areas, the protection of remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reduction of noxious weeds will address limiting factors.

Effects on Species Status

Prospective improvements in estuarine habitat will support the increased abundance, productivity, diversity, and spatial structure of UWR steelhead.

Effects on Critical Habitat

Prospective estuarine habitat improvements will improve the functioning of the PCEs of water quality and safe passage in the migration corridor for juvenile steelhead migrants. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist for a short-time (no more than a few weeks and typically less). The positive effects on the functioning of PCEs and the conservation value of critical habitat will be long-term.

8.14.5.4 Effects of Hatchery Prospective Actions

Hatchery programs in the Willamette are not addressed by the hatchery Prospective Actions. They are considered separately in the ongoing consultation on the Willamette Project.

There is considerable interest in the issue of density-dependent effects of releasing large numbers of hatchery-origin fish into areas used by natural-origin juveniles, but the nature and magnitude of these effects is largely unknown (Artificial Propagation for Pacific Salmon Appendix of the SCA).

8.14.5.5 Effects of Harvest Prospective Actions

Effects on Species Status

As described in Section 8.14.3.6, the effects of all freshwater fisheries, including those being considered as part of the Prospective Actions, were reviewed and approved previously through an ESA evaluation pursuant to section 4(d). The 4(d) determination does not expire and so presumably will remain in effect through the duration of the *U.S. v. Oregon* Agreement. Fisheries proposed under the *U.S. v. Oregon* Agreement are entirely consistent with those considered through the 4(d) determination. For a description of the management strategy, see Oregon's Fishery Management and Evaluation Plan (ODFW 2001a).

8.14.5.6 Effects of Predation Prospective Actions

Avian predation

The survival of juvenile UWR steelhead will increase 3.4% with the reduced Caspian tern nesting habitat in the estuary and the subsequent relocation of most of the terns to sites outside the Columbia River basin (RPA Action 45).

The RPA (Action 46) requires that the Action Agencies develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of actions, if warranted, in the estuary.

Piscivorous fish predation

The proposed continued increase in incentives in the NPMP (RPA Action 43) will result in an additional 1% survival during the period 2007 to 2018.

Effects on Species Status

Prospective actions that reduce avian and fish predation on juveniles will support the increased abundance and productivity of UWR steelhead populations.

Effects on Critical Habitat

Reductions in Caspian tern nesting habitat and managing cormorant predation on East Sand Island will further reduce predation on juvenile steelhead, improving the status of safe passage in the juvenile migration corridor. These fish migrate over the deep water channel adjacent to the East Sand Island colony, which has made them especially vulnerable to predation. The benefit of this action will be long term.

Continued implementation of the base Northern Pikeminnow Management Program and continuation of the increased reward structure in the sport-reward fishery will also improve the long-term conservation value of critical habitat by increasing the survival of migrating juvenile salmonids (safe passage PCE) within the migration corridor.

8.14.5.7 Effects of Research & Monitoring Prospective Actions

Please see Section 8.1 of the SCA. Monitoring for this species will be commensurate with the effects of the FCRPS.

8.14.6 Aggregate Effect of the Environmental Baseline, Prospective Actions, and Cumulative Effects on Upper Willamette River Steelhead

This section summarizes the basis for conclusions at the DPS level.

8.14.6.1 Recent Status of the Upper Willamette River Steelhead DPS

Upper Willamette River steelhead is a threatened species. Of the four historical populations in this DPS, three (Molalla, North Santiam, and South Santiam) have relatively high abundances and all spawners are of natural origin. The construction of the Corps dams on major tributaries in the 1950s through 1970s cut off access to highly productive spawning habitat in the upper North Santiam and Quartzville Creek (South Santiam) subbasins. These dams affect flows, water quality, sediment transport, and other attributes in downstream spawning and rearing habitat. Flood storage and release operations and to a lesser extent, irrigation withdrawals, have also altered temperatures and/or and bank hardening has cut the lower stream reaches off from side channels and the floodplain. Upper Willamette River steelhead also have experienced injury and passage delays at small hydroprojects, but many of these are now shut down or have recently installed improved fish screens, ladders, and in some cases tailrace barriers. It is highly unlikely that any fish from this DPS encounter FCRPS mainstem projects, but water management operations in the upper Columbia basin affect habitat and flow in the lower Columbia River, estuary, and plume. Large-scale changes in freshwater and marine environments have also had substantial effects on salmonid numbers. Ocean conditions that affect the productivity of all Pacific Northwest salmonids appear to have contributed to the decline of many of the stocks in this DPS. The potential for additional risks due to climate change is described in Sections 5.7 and 8.1.3.

In terms of the primary constituent elements of critical habitat, the ability to function in support of the conservation of the species has been limited by barriers to many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development. Passage delay and injury at FERC-licensed hydroelectric projects in the lower reaches of the North and South Santiam rivers have been addressed in recent years (migration corridors free of obstructions). The functioning of mainstem habitat in the Columbia River as a juvenile migration corridor has also improved in recent years with the reduction in predation by Caspian terns and northern pikeminnows.

8.14.6.2 Effects of the FCRPS, Upper Snake & *U.S. v. Oregon* Prospective Actions on the Upper Willamette River Steelhead DPS

NOAA Fisheries has adopted the LCFRB's (2004) recovery plan as its interim recovery plan for the Washington side of the lower Columbia River. In the LCFRB's recovery plan, one of the elements considered likely to yield the greatest benefit is to "(p)rotect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume." The FCRPS Action Agencies' estuary habitat restoration projects are therefore expected to increase the survival of juvenile Upper Willamette River steelhead. Shifting the delivery of some of the flow augmentation water from summer to spring will address conditions that have altered channel margin habitat, identified as a limiting factor in the lower Columbia River below Bonneville Dam (Section 8.14.3.8). Relocating most of the Caspian terns to sites outside the Columbia basin, managing cormorant predation, and the continued increase in the northern pikeminnow reward fishery will further improve the viability of the DPS and the conservation value of the lower river as critical habitat.

8.14.6.3 Cumulative Effects Relevant to the Upper Willamette River Steelhead DPS

Habitat-related actions and programs that the states of Oregon and Washington submitted and that NOAA Fisheries has determined are reasonably certain to occur are expected to address the protection and/or restoration of fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect instream habitat. The actions will improve the functioning of PCEs of critical habitat needed for successful emigration of juvenile steelhead.

Other types of non-Federal activities, especially those that have occurred frequently in the past, are likely to have adverse effects on the species and its critical habitat. Within the action area for the Prospective Actions (the mainstem lower Columbia River below the confluence of the Willamette), these are likely to include urban development and other land use practices.

8.14.6.4 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on the Upper Willamette River Steelhead DPS

Impacts of the FCRPS and Reclamation projects on this DPS are limited relative to impacts from tributary hydropower, tributary habitat, harvest, hatcheries, and predation by birds and fish. None of the populations in this DPS are affected by upstream and downstream passage at FCRPS projects; only migration and habitat conditions in the mainstem lower Columbia and estuary have been affected by the existence and operation of the hydrosystem.

The states of Oregon and Washington have identified habitat actions that will improve habitat conditions along the mainstem lower Columbia River (including the estuary). The State of Oregon also identified tributary habitat actions that are reasonably certain to occur and that generally should be beneficial throughout the DPS. Some future Federal actions with completed Section 7 consultations will restore access to blocked habitat, increase channel complexity, and restore riparian condition. Many actions will have neutral or short- or even long-term negative effects on habitat conditions, but all were found to meet the ESA standards for avoiding jeopardy and for avoiding any adverse modification of critical habitat. Harvest rates will remain approximately 2%. Any proposed changes would be subject to Section 7 consultation.

The FCRPS Action Agencies' prospective estuary habitat and predator management improvements will contribute to the viability of this DPS by addressing the influence of their projects, contributing to its survival with an adequate potential for recovery. The Prospective Actions will not further deteriorate the pre-action condition.

Ocean fishing mortality on UWR steelhead is assumed to be zero. This species is also not caught in non-Indian summer or fall season fisheries or in treaty Indian fisheries above Bonneville Dam. Under Oregon's Fishery Management and Evaluation Plan, the non-Indian winter and spring fisheries in the Columbia and Willamette rivers are subject to a harvest rate limit on natural origin Upper Willamette steelhead of 2%. Any proposed changes would be subject to Section 7 consultation.

Long term (100 year) extinction risk is moderate for all four populations in this DPS. In the short term, the species' extinction risk is expected to be reduced through implementation of the actions described above.

8.14.6.5 Effect of the Aggregate Environmental Baseline, Prospective Actions & Cumulative Effects on PCEs of Critical Habitat for the Upper Willamette River Steelhead DPS

NOAA Fisheries designated critical habitat for UWR steelhead including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in the following subbasins: Upper Willamette, North Santiam, South Santiam, Middle Willamette, Molalla/Pudding, Clackamas, and Lower Willamette. The environmental baseline within the action area, which includes the lower Columbia River and the estuary, has improved over the last decade but does not yet support the conservation value of designated critical habitat for UWR steelhead. The major factors currently limiting the conservation value of critical habitat are barriers in many tributary spawning and rearing areas and the impairment of PCEs such as water quality and quantity, substrate, forage, and natural cover in some tributary and estuarine areas used for spawning, incubation, and larval growth and development.

Although some current and historical effects of the existence and operation of the hydrosystem and tributary and estuarine land use will continue into the future, critical habitat will retain its current ability for PCEs to become functionally established and to serve its conservation role for the species in the near- and long-term. Prospective Actions will improve the functioning of many of the PCEs; for example, reducing predation by Caspian terns, cormorants, and northern pikeminnows will further improve safe passage for juveniles. Habitat work in the estuary will improve the functioning of water quality, natural cover/shelter, forage, riparian vegetation, space, and safe passage, restoring the conservation value of critical habitat at the project scale and sometimes in larger areas where benefits proliferate downstream. There are likely to be short-term, negative effects on some PCEs at the project scale during construction, but the positive effects will be long term. In addition, a number of actions in estuarine areas will proactively address the effects of climate change. These various improvements are sufficiently certain to occur and to be relied upon for this determination. They are either required by NOAA Fisheries' RPA for the FCRPS or otherwise the product of regional agreement and Action Agency commitment (Upper Snake actions are supported by the SRBA agreement and harvest by the 2008 *U.S. v. Oregon* Agreement).

The aggregate effect of the environmental baseline, Prospective Actions, and cumulative effects will be an improvement in the functioning of PCEs used for migration and juvenile and adult transitions between fresh and salt water. Considering the ongoing and future effects of the environmental baseline and cumulative effects, the Prospective Actions will be adequate to ensure that they will not reduce the ability of critical habitat to serve its conservation role for this species.

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Chapter 9
Southern Resident Killer Whales

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Chapter 9
Southern Resident Killer Whales

9.1 Current Rangewide Status

The Southern Resident killer whale DPS consists of three pods, identified as J, K, and L pods. In this section, the status of the Southern Resident killer whales throughout their range is summarized. Although the entire Southern Resident DPS has potential to occur in the coastal waters at any time during the year, occurrence is more likely during November to May when Southern Residents are only occasionally found in the inland waters of Washington State. The information on the rangewide status of the species is generally representative of the status of the species in coastal waters. The final recovery plan for Southern Residents was issued in January 2008 (NMFS 2008j). This section summarizes information taken largely from the recovery plan, as well as new data that became available more recently. For more detailed information about this population, please refer to the Final Recovery Plan for Southern Resident Killer Whales, which can be found on the internet at www.nwr.noaa.gov.

9.1.1 Status and Trends

Although there is little information available regarding the historical abundance of Southern Resident killer whales, two methods have been used to estimate a historical population size of 140 to 200. The minimum estimate (~140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time of the captures. The maximum estimate (~200) is based on a recent genetic analysis of microsatellite DNA (NMFS 2003e).

At present, the Southern Resident population has declined to essentially the same size that was estimated during the early 1960s, when it was considered as likely depleted (Olesiuk et al. 1990) (Figure 9.1-1). Since censuses began in 1974, J and K pods have steadily increased their sizes. However, the population suffered approximately a 20% decline from 1996-2001, largely driven by declines in L pod. There have been recent increases in the population from 2002-2006 indicating that L pod's decline may have ended, however such a conclusion is premature. The 2007 census counted 87 Southern Resident killer whales, 25 in J pod, 19 in K pod and 43 in L pod.

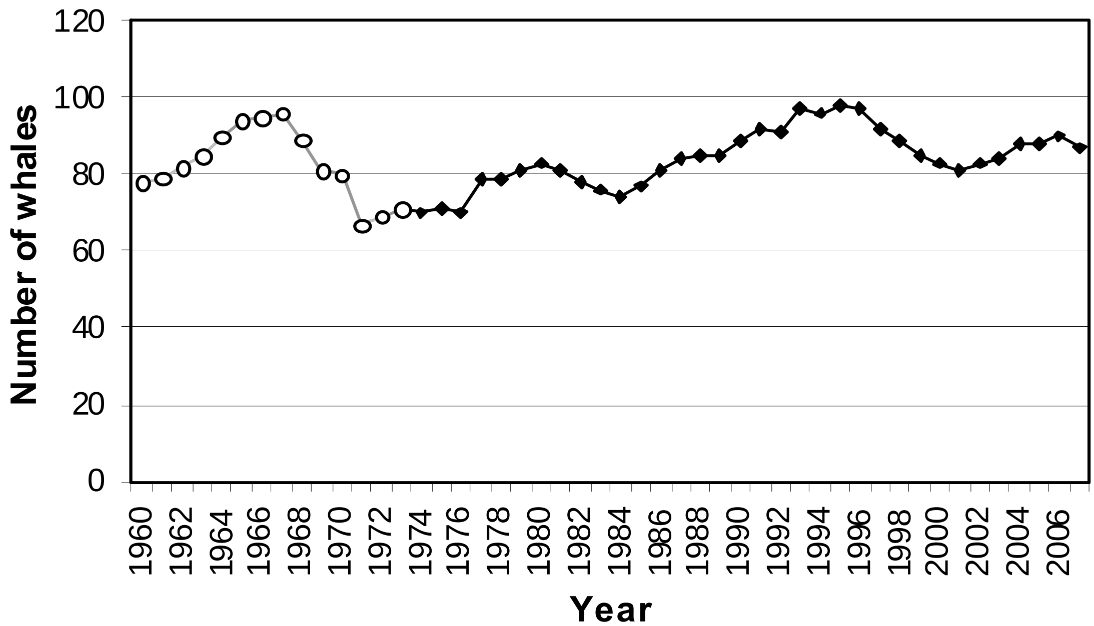

Figure 9.1-1. Population size and trend of Southern Resident killer whales, 1960-2007. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2007 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpubl. data) and NMFS (2008j). Data for these years represent the number of whales present at the end of each calendar year except for 2007, when data extend only through October.

9.1.2 Listing status

The Southern Resident killer whale Distinct Population Segment (DPS) was listed as endangered under the ESA on November 18, 2005 (NMFS 2005d). The final rule included information on the population decline in the 1990s and identified several potential factors that may have caused the decline or may be limiting recovery. These are: quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. Southern Residents are designated as “depleted” and “strategic” under the Marine Mammal Protection Act (MMPA) (NMFS 2003e). Critical habitat for the Southern Resident killer whale DPS was proposed on June 15, 2006 (NMFS 2006l) and the final designation of critical habitat was published November 29, 2006 (NMFS 2006c). Critical habitat includes approximately 2,560 square miles of inland waters in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Southern Resident critical habitat does not occur in the coastal waters, and is therefore not considered further in this consultation.

9.1.3 Range and Distribution

Southern Residents are found throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia (Figure 9.1-2).

Figure 9.1-2. Geographic Range (light shading) of the Southern Resident Killer Whale Population. Reprinted from Wiles (2004).

Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978, Baird 2000). To date, there is no evidence that Southern Residents travel further than 50 km offshore (Ford et al. 2005). Although the entire Southern Resident DPS has potential to occur in coastal waters at any time during the year, occurrence is more likely during November to May.

Southern Residents spend the majority of their time from late spring to early autumn in inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) (Bigg 1982, Ford et al. 2000, Krahn et al. 2002) (Figure 9.1-3). Typically, J, K and L pods arrive in May or June and spend most of their time in the core area of Georgia Basin and Puget Sound until departing in October. K and L pods also make frequent trips to the outer coasts of Washington and southern Vancouver Island during this time, which generally last a few days (Ford et al. 2000).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976				J,K								
1977												
1978			J,K									
1979											J,K	
1980												
1981				J,K								
1982						J,K				J,K		
1983										J,K	J,K	
1984						J,K						
1985						J,K						
1986					J,K							
1987										J,K	J,K	J,K
1988					J,K							
1989			J,K							J,K	J,K	J,K
1990												
1991					J,K					J,K		
1992												
1993					J,K							
1994										J,L		
1995												
1996										J,K	J,K	
1997										J,L	J,L	J,K
1998											J,K	
1999												
2000												
2001												
2002			J,K,L?									
2003												J,K
2004					J,L	J,L						J,K
2005		J?			J,L							
2006	J?											
2007	none					J,L						

Only J Pod present	Two pods present, as indicated	J, K, and L pods present	Data not available

Figure 9.1-3. Monthly occurrence of the three Southern Resident killer whale pods (J, K, and L) in the inland waters of Washington and British Columbia, 1976-2005. This geographic area is defined as the region east of Race Rocks at the southern end of Vancouver Island and Port Angeles on the Olympic Peninsula. Pods were recorded as present during a month if they were sighted on at least one day (Hanson 2008).

Late summer and early fall movements of Southern Residents in the Georgia Basin have remained fairly consistent since the early 1970s, with strong site fidelity shown to the region as a whole. However, presence in inland waters in the fall has increased in recent years (NMFS 2008j). It is uncertain whether potential variability in sighting effort over time has contributed to this trend. During early autumn, Southern Residents, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Osborne 1999). During late fall, winter, and early spring, the ranges and movements of the Southern Residents are less well known.

Sightings through the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts of Vancouver Island and Washington (Krahn et al. 2002).

The Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000). However, recent sightings of members of K and L pods in Oregon (in 1999 and 2000) and California (in 2000, 2003, 2005, 2006 and 2008) have considerably extended the southern limit of their known range (NMFS 2008j). There have been 40 verified sightings or strandings of J, K or L pods along the outer coast from 1975 to present with most made from January to May. These include 16 records off Vancouver Island and the Queen Charlottes, 11 off Washington, four off Oregon, and nine off central California. Most records have occurred since 1996, but this is more likely because of increased viewing effort along the coast for this time of year. Sightings in Monterey Bay, California coincided with large runs of salmon, with feeding witnessed in 2000 (Black et al. 2001). L pod was also seen feeding on unidentified salmon off Westport, Washington, in March 2004 during the spring Chinook run in the Columbia River (M. B. Hanson, personal observation, as cited in Krahn et al. 2004).

9.1.4 Life history

Southern Resident killer whales are a long lived species, with late onset of sexual maturity (review in NMFS 2008j). Females produce a low number of surviving calves over the course of their reproductive life span (5.4 surviving calves over 25 years) (Olesiuk et al. 1990, Bain 1990). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990, Baird 2000, Ford et al. 2000). Groups of related matrilines form pods. Three pods – J, K, and L, make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of J clan.

Southern Resident killer whales are known to consume 22 species of fish and one species of squid (Scheffer and Slipp 1948, Ford et al. 1998, 2000, Ford and Ellis 2006, Saulitis et al. 2000). A long-term study of resident killer whale diet identified salmon as their preferred prey (97 percent of prey consumed during spring, summer and fall) (Ford and Ellis 2006). Feeding records for Southern Residents suggest that diet resembles that of the Northern Residents, with a strong preference for Chinook salmon (78 percent of identified prey) during late spring to fall (Hanson et al. 2005, Ford and Ellis 2006). Chum salmon (11 percent) are also taken in significant amounts, especially in autumn. Other species eaten include coho (5 percent), steelhead (*O. mykiss*, 2 percent), sockeye (*O. nerka*, 1 percent), and non salmonids (e.g., Pacific herring and quillback rockfish [*Sebastes maliger*] 3 percent combined). Chinook were preferred despite the much lower abundance of Chinook in the study area in comparison to other salmonids (such as sockeye), presumably because of the species' large size, high fat and energy content, and year-round occurrence in the area. Killer whales also captured older (i.e., larger) than average Chinook (Ford and Ellis 2006).

Researchers are expanding the sample size for Southern Residents and collecting additional fecal samples for analysis to address the potential biases of scale sampling. In inland waters from May to September, Southern Residents' diet consists of approximately 88% Chinook (Hanson et al. 2007a). These studies also confirmed a shift to chum salmon in fall. Little is known about the winter and early spring diet of Southern Residents. Early results from genetic analysis of fecal and prey samples indicate that Southern Residents consume Fraser River-origin Chinook, as well as salmon from Puget Sound, Washington and Oregon coasts, the Columbia River, and Central Valley California (Hanson et al. 2007b). As further data are analyzed, they will provide information on which specific runs of salmon the whales are consuming in certain locations and seasons.

There are no fecal or prey samples or direct observations of predation events (where the prey was identified to the species) when the whales are in coastal waters. Although less is known about diet preferences of Southern Residents off the Pacific coast, it is likely that salmon are also important during late fall and winter when Southern Residents more predictably occur in coastal waters. Chemical analyses support the importance of salmon in the year round diet of Southern Residents (Krahn et al. 2002, 2007). Krahn et al. (2002), examined the ratios of DDT (and its metabolites) to various PCB compounds in the whales, and concluded that the whales feed primarily on salmon throughout the year rather than other fish species. Krahn et al. (2007) analyzed stable isotopes from tissue samples collected in 1996 and 2004/2006. Carbon and nitrogen stable isotopes indicated that J and L pods consumed prey from similar trophic levels in 2004/2006 and showed no evidence of a large shift in the trophic level of prey consumed by L pod between 1996 and 2004/2006.

Researchers have estimated the energy requirements of killer whales and caloric values for salmon to calculate the number of fish needed per day. Salmon differ significantly in size across species and runs, and prey preference among salmon would affect annual consumption rates. Fewer salmon per day would be required from a larger preferred prey species such as Chinook salmon. NOAA Fisheries provides an estimate of the biological requirements of Southern Residents using the best available information on metabolic needs of the Southern Resident population and the caloric content of salmon (NMFS 2008k).

9.2 Environmental Baseline

Because the entire listed entity is found in the coastal waters during some portion of the year, the status of the species in this area is the same as the range-wide status of the species, described above. The following discussion summarizes the conditions in coastal waters that are known to affect the likelihood that Southern Resident killer whales will survive and recover in the wild. The small size of the population increases the level of concern about any risks to Southern Resident killer whales (NMFS 2008j).

Natural Mortality

Seasonal mortality rates among Southern and Northern Resident whales are believed to be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer field research seasons. At least 12 newborn calves (9 in southern community and 3 in northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale eco-types in Washington and Oregon (Norman et al. 2004). Southern Resident strandings in coastal waters include three separate events (1995 and 1996 off of Northern Vancouver Island and the Queen Charlotte Islands, and 2002 offshore of Long Beach, Washington State), and the causes of death are unknown (NMFS 2008j).

In recent years, sighting reports indicate anecdotal evidence of thin killer whales returning to inland waters in the spring. For example, in March 2006 a thin female from the Southern Resident population (L54) with a nursing calf was sighted off Westport, WA. The sighting report indicated she had lost so much blubber that her ribs were showing under the skin (Cascadia Research 2008).

Prey Availability

Salmon, particularly Chinook salmon, are the preferred prey of Southern Resident killer whales in inland waters of Washington State during spring, summer and early fall. Chemical analyses support the importance of salmon in the year round diet of Southern Residents. Based on the best available information, Southern Residents may equally prefer Chinook salmon in inland and coastal waters. This analysis therefore focuses on effects of the Prospective Actions on Chinook abundance in coastal waters. Focusing on Chinook provides a conservative estimate of potential effects of the Prospective Action on Southern Residents within coastal waters. The total abundance of all salmon and other potential prey species is difficult to quantify, but is orders of magnitude larger than the total abundance of Chinook in coastal waters.

When prey abundance is low, killer whales may spend more time and energy foraging than when prey abundance is high, with the potential for fitness consequences including reduced reproductive rates and higher mortality rates. Ford and Ellis (2006) correlated coastwide reduction in Chinook abundance (Alaska, British Columbia, and Washington) with decreased survival of resident whales (Northern and Southern Residents), but changes in killer whale abundance have not been linked to changes in salmon stock groups.

The availability of prey to Southern Resident killer whales is affected by a number of natural and human actions. Details regarding baseline conditions of those Chinook salmon in the Columbia River basin that are listed under the Endangered Species Act are described in Chapters 8.2 (Snake River fall Chinook), 8.3 (Snake River spring/summer Chinook), 8.6 (Upper Columbia River spring Chinook), 8.10 (Lower Columbia River Chinook), and 8.13 (Upper Willamette River Chinook) sections of the SCA. The baseline also includes Chinook ESUs that are not ESA-listed, notably the typically abundant Hanford Reach fall Chinook ESU and the Mid-Columbia spring Chinook ESU. Adult salmon are also affected by fisheries harvest in fresh and marine waters. In addition, climate effects from Pacific decadal oscillation and El Nino/Southern oscillation conditions and events cause changes in ocean productivity which can affect natural mortality of salmon, as described in more detail in Chapter 5 (5.7 Large-scale Environmental Variation). Predation in the ocean also contributes to natural mortality of salmon. Salmonids are prey for pelagic fishes, birds, and marine mammals.

Based on the best available information regarding diet composition for Southern Residents killer whales (which suggests that Chinook salmon are their preferred prey), their metabolic needs, and the caloric content of salmon, NOAA Fisheries estimates that the Southern Resident population (based on 2007 population size and structure) could need approximately 221,000 Chinook on an annual basis in coastal waters of their range (NMFS 2008k). Based on estimates derived from fisheries catch and escapement data over the past decade, there may be approximately 3.5 million adult Chinook salmon available in the coastal range of Southern Residents (NMFS 2008k). This estimate includes estimated annual reductions in prey availability from fisheries harvest in coastal waters. However, this estimate is likely to vary on an annual basis due to a combination of factors including ocean conditions and harvest management decisions (implementing the regulations for ocean salmon fisheries include ESA section 7 consultation).

Another factor that could affect the number of salmon required is the size of individual Chinook. NOAA Fisheries is not able to assess the potential differences in biomass of individual Chinook available to Southern Residents, and thus relies on abundance estimates as a proxy measure (as in past consultation, i.e., NMFS 2006m). Southern Resident killer whales consume both natural and hatchery salmon (DFO unpubl. data). There is no information available suggesting that Southern Residents would be affected differently by consuming natural or hatchery salmon (i.e., no known differences in size, energy content, contaminant level, or behavior or location in the ocean).

Prey Quality

Contaminants enter fresh and marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. As discussed in the Status of the Species section above, recent studies have documented high concentrations of PCBs, DDTs, and PBDEs in killer whales (Ross et al. 2000, Ylitalo et al. 2001, Reijnders and Aguilar 2002, Krahn et al. 2004). Harmful contaminants are stored in blubber; however, organochlorines can be released from the blubber and become redistributed to other tissues increasing risk of immune or reproductive effects during weight loss from reductions in prey (Krahn et al. 2002).

As top predators, when killer whales consume contaminated prey they accumulate the contaminants in their blubber. When prey is scarce, killer whales metabolize their blubber and the contaminants are mobilized. In addition, nursing females transmit large quantities of contaminants to their offspring. Chinook salmon contain higher levels of some contaminants (i.e., PCBs) than other salmon species (O'Neill et al. 2005). Only limited information is available for contaminant levels of Chinook along the west coast (i.e., higher PCB and PBDE levels may distinguish Puget Sound-origin stocks, whereas higher DDT-signature may distinguish California origin stocks; Krahn et al. 2007). Adult Chinook that originate from the Columbia River may accumulate contaminants through development and growth in the freshwater and marine environment, and become a source of contaminant loading if consumed by Southern Residents.

Vessel Activities and Sound

Commercial shipping, ferry operations, military vessels and recreational vessels occur in the coastal range of Southern Residents; however, the density of traffic is lower in the coastal compared to inland waters of Washington State and British Columbia. Several studies in the inland waters of Washington State and British Columbia have linked interactions of vessels and Northern and Southern Resident killer whales with short-term behavioral changes (Kruse 1991; Williams et al. 2002a, b; Foote et al. 2004, Bain et al. 2006). Although the potential impacts from vessels and the sounds they generate are poorly understood, these activities may affect foraging efficiency, communication, and/or energy expenditure through their physical presence, increased underwater sound level, or both. Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality. There are no known incidents of Southern Resident collisions with vessels in coastal waters, however, very few stranded killer whales are recovered and there are stretches of unpopulated coastline where stranded whales would not be reported.

Vessel sounds in coastal waters are most likely from large ships, tankers and tugs. Most sound generated by large vessels is a source of low frequency (5 to 500 Hz) human-generated sound in the world's oceans (NRC 2003). While ships generate some broadband noise in the hearing range of whales, the majority of energy is below their peak hearing sensitivity. Such vessels do not target whales, move at relatively slow speed and are likely detected and avoided by Southern Residents. It is difficult to precisely quantify or estimate the magnitude of the risks posed by commercial whale watching and recreational vessels in coastal waters; however, weather conditions in the Pacific Ocean in winter limit these activities. The risk to Southern Residents is less in coastal waters than within the inland waters of Washington State and British Columbia, where traffic levels are higher and a greater proportion of traffic may target whales (whale watching and recreational vessels).

Non-Vessel Sound

Anthropogenic (human-generated) sound in coastal waters within the range of Southern Residents is generated by other sources besides vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication).

Sound from in-water construction activities could potentially occur through permits issued by the Army Corps of Engineers under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. Several consultations on federal projects in the coastal range of Southern Residents have been conducted and conservation measures have been included to minimize or eliminate potential effects to marine mammals. Sound, such as sonar generated by military vessels also has the potential to disturb killer whales in coastal waters.

Oil spills

Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by Southern Residents remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters. Numerous oil tankers transit through the coastal range of Southern Residents throughout the year. The magnitude of the risks posed by oil discharges in this area is difficult to precisely quantify or estimate.

The long-term effects of repeated ingestion of sub-lethal quantities of petroleum hydrocarbons on killer whales are not well understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Wursig 1990 and Geraci 1990). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Scientific Research

Most of the scientific research conducted on Southern Resident killer whales occurs in inland waters of Washington State and British Columbia. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. In 2006, NOAA Fisheries issued scientific research permits to seven investigators who intend to study Southern Resident killer whales. Research activities are typically conducted between May and October in inland waters. However, some permits include authorization to conduct research in coastal waters.

In the biological opinion NOAA Fisheries prepared to assess the impact of issuing the permits, we determined that the effects of these disturbances on Southern Residents were likely to adversely affect, but not jeopardize the continued existence of, the Southern Resident killer whales (NMFS 2006n). The annual authorized takes by harassment of Southern Residents under these permits totaled 1,935 non-invasive takes (e.g., surveys and photo-identification); 70 takes from biopsying, tagging, or breath sampling; and 820 takes due to unintentional harassment, although actual anticipated takes are substantially lower. While most of the authorized takes would occur in inland waters, a small portion of this disturbance is part of the baseline in the coastal range of Southern Residents.

Activities Outside U.S. Jurisdiction

The Southern Resident killer whales are highly migratory and may transit in and out of the waters of the United States and the high seas. NOAA Fisheries does not presently have information to assess the impact on Southern Residents of scientific research or boating activities within Canadian jurisdictional waters. NOAA Fisheries included information on Canadian fisheries within the coastal range of Southern Residents using the same methods to quantify U.S. fisheries in this area (NMFS 2008k).

Summary of the Environmental Baseline

Southern Resident killer whales are exposed to a wide variety of past and present state, federal or private actions and other human activities in their coastal range as well as federal projects in this area that have already undergone formal section 7 consultation, and state or private actions that are contemporaneous with this consultation. All of the following activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in coastal waters of their range.

Reductions in food availability, increased exposure to pollutants, and human disturbance have all been identified as potential threats to killer whales in Washington and British Columbia (Ford and Ellis 1999, 2005; Ford et al. 2000; Baird 2001; Krahn et al. 2002, 2004; Taylor 2004, Wiles 2004). Researchers are unsure about which threats are most significant to the Southern Resident population. Although the three primary factors are identified as prey availability, environmental contaminants, and vessel effects and sound, none have been directly linked to or identified as the cause of the recent decline of the Southern Resident killer whales (Krahn et al. 2002). There is limited information on how these factors or additional unknown factors may be affecting Southern Resident killer whales when in coastal waters in winter. For reasons discussed earlier, it is possible that two or more of these factors may act together to harm the whales. The small size of the population increases the level of concern about all of these risks (NMFS 2008j).

9.3 Effects of the Prospective Actions on Southern Resident Killer Whales

The potential effects of the Prospective Actions on Southern Resident killer whales relate to prey availability. Contamination (prey quality) is not an issue because the effects of the Prospective Actions do not include the introduction of contaminants into freshwater. Chapter 2 of the SCA defines the federal actions aggregated in the SCA, or Prospective Actions, which include:

- Operation and configuration of the Federal Columbia River Power System (FCRPS) as described in the 2007 FCRPS Biological Assessment (Corps et al. 2007b) and the mainstem effects of 11 Reclamation irrigation projects (Corps et al. 2007b, Appendix B-1-7), as modified by NOAA Fisheries' RPA for the FCRPS (described in Chapter 4 of the FCRPS Biological Opinion (NMFS 2008a).

- Operation and Maintenance of 12 Irrigation Projects in the Upper Snake (described in Reclamation's 2007 Upper Snake Biological Assessment (USBR 2007).

- NOAA Fisheries' § 10(a)(1)(A) Transportation Permit issued as part of NOAA Fisheries' FCRPS Opinion.

- NOAA Fisheries' participation in the 2008-2017 *U.S. v. Oregon* Management Agreement (hereafter, "2008 *U.S. v. Oregon* Agreement") concerning particular Columbia River fisheries related activities as described in Chapter 2 of NOAA Fisheries' Biological Opinion for that Agreement.

- Federal Action Agencies' funding of all FCRPS mitigation hatchery programs.

Most of the direct effects of the Prospective Actions occur within the freshwater system and plume of the Columbia River; effects experienced by Southern Residents in the coastal area are indirect. The Prospective Actions may affect the abundance of killer whale prey in the ocean. Changes in prey abundance would affect the entire population of Southern Resident killer whales. The best available information indicates that salmon are the preferred prey of killer whales year round, including in coastal waters (Status of the Species), and that Chinook are the preferred salmon species. Prey abundance is a concern for killer whales both in the near and long term. To survive in the near term, killer whales require regular supplies of adult Chinook prey in the ocean, and to recover over the longer term, killer whales require abundant Chinook stocks coast-wide, likely including stocks from the Columbia River (Status of the Species). This analysis considers the short-term (less than ten years) and long-term (ten years and longer) effects of the Prospective Actions described above.

9.3.1 Effects of Hydro and Associated Actions on Southern Resident Killer Whales

Short-Term Effects

The hydro and associated actions combined include operation and configuration of the FCRPS, federal water management in the Upper Snake, and federal actions to improve habitat, reduce predation and fund hatcheries. Included in the hatchery funding is a commitment to review and reform (as needed) future hatchery operations. No details are proposed regarding hatchery reform, and NOAA Fisheries expects that future hatchery production, including reforms, will be subject to additional future consultation when detailed actions are proposed. In the interim, the Prospective Action is to continue funding hatchery operations at current levels.

Effects of Artificial Production

The Prospective Actions include continued funding for artificial propagation of Chinook salmon, which produces killer whale prey. Action agency (BPA, Corps and Reclamation) funding accounts for approximately 50 percent of the Chinook smolts released above Bonneville Dam (Jones 2008). This analysis also assumes that current levels of funding and production will continue over the short term.

For returns prior to 2007, the proportion of hatchery-origin Chinook passing Bonneville Dam ranged between 50 and 80 percent for individual stocks of Chinook from the Columbia River (PCSRF 2007). Since 2000, Chinook hatchery returns to Bonneville Dam represented approximately 70 percent of the total Chinook run, on average (Turner 2008). If the Prospective Actions produce approximately 50% of all returning hatchery Chinook above Bonneville Dam, and all hatchery Chinook combined represent approximately 70% of the Chinook returns at Bonneville, approximately 35% of the total annual return of Chinook above Bonneville Dam can be attributed to the Prospective Actions.

Effects of Hydrosystem Operations

The operation and configuration of the FCRPS causes mortality of migrating juvenile Chinook, which in turn results in fewer adult Chinook in the ocean and reduced prey availability, compared to an absence of dam-related juvenile mortality. For purposes of determining whether the Chinook prey base for killer whales is adversely affected by the proposed action, it is not necessary to precisely quantify the mortality resulting from the hydrosystem operations (as distinguished from other causes), so long as it can be reasonably concluded that the decrease in the prey base for killer whales resulting from hydrosystem operations is less than the increase in the prey base resulting from the hatchery programs funded by the action agencies.

The effect of the hatchery programs is to increase by 35% the number of Columbia and Snake River Chinook originating above Bonneville Dam and available to the killer whales. In order for any decrease caused by the hydrosystem to exceed this increase, the hydrosystem would have to cause a 35% or greater reduction in the total number of Columbia and Snake River Chinook available to killer whales. For the reasons discussed below, it is unlikely that the hydrosystem results in a 35% or greater reduction in the killer whale prey base.

Many factors cause mortality to juvenile salmon as they migrate to the ocean. Natural mortality occurs from predators, competition for food, and disease. Human actions unrelated to the hydrosystem, such as the diking and filling of wetlands, road construction and maintenance, and introduction of pollutants can increase mortality in that part of the migration corridor that is within the hydrosystem. And the “bare existence” of the dams, as well as the operation of the dams, also causes juvenile mortality.

Although we have relatively good estimates of the overall level of mortality experienced by juvenile Chinook as they move through the hydrosystem, available information does not enable us to partition the overall level of mortality among the various potential causes. Attempts to allocate mortality have not been notably successful. Most recently, in *National Wildlife Federation v. NMFS*, CV 01-640-RE (D. OR. May 26, 2005) the Court rejected NOAA Fisheries’ attempt to partition the sources of mortality. The Court directed the federal agencies to focus instead on the actions needed to bring ESA-listed salmon to recovery. Thus, the analysis in other parts of this opinion does not attempt to estimate how many fewer ESA-listed salmon are present as a result of the operating the hydrosystem.

To assure that the effects of the hydro operations in the Prospective Action on the killer whale prey base will not outweigh the benefits to that prey base resulting from the hatchery programs funded as part of that action, NOAA Fisheries compared the percent increase in adult Chinook from the hatchery actions to the total mortality rate for juvenile Chinook passing through the hydrosystem, regardless of cause. This comparison is a very conservative approach since only a portion of these mortalities are, in fact, the result of the hydro operations being consulted upon.

As further described in other portions of this biological opinion dealing with ESA-listed salmon (SCA, Hydro Modeling Appendix), the estimated average survival for spring/summer Chinook passing through the area of the hydrosystem under the proposed action varies from about 67% (for both in-river migrating and transported juveniles from

Lower Granite to Bonneville Dams, assuming a "D" value of 0.709) to more than 95% (passing 1 dam). More than 85% of adult spring/summer Chinook returning to the Columbia and Snake Rivers come from fish that pass 4 dams or fewer dams, which have a survival rate of 73 to over 95%. Thus, for spring/summer Chinook, the total mortality, regardless of cause, is less than 35% (That is, the total survival through the hydrosystem is greater than 65%).

Spring/summer Chinook primarily spawn and rear in tributaries and enter the Snake and Columbia Rivers as yearling smolts that use the area of the hydrosystem primarily as a migratory corridor. Thus, the high level of natural mortality that occurs to all salmon in the egg-to-smolt stage has already taken place before the spring Chinook enter the hydrosystem. For fall Chinook, the reverse is true.

Fall Chinook spawn and rear principally in the mainstem of the Snake and Columbia Rivers. Regardless of whether they originate in the wild or from a hatchery, fall Chinook move through the system primarily as smaller, sub-yearling fish. Due to their size, such fish are more vulnerable to predation and other natural mortalities. This loss is exacerbated by the increased time that sub-yearlings spend rearing in shallow-water habitat as they move through the migratory corridor. Many of these losses would occur regardless of whether the fall Chinook were migrating through a hydrosystem or in a natural river.

Since fall Chinook losses from natural causes are considerably greater than the spring/summer Chinook losses during the downstream migration, it is no surprise that the estimated survival rates for fall Chinook passing through the hydrosystem are considerably lower than those for spring/summer Chinook, but combined these rates exceed 65%. The survival rate[1] for those passing through 8 dams is approximately 33%; for 4 dams survival is about 54%; and for 1 dam survival is approximately 85%.[2] Less than 3% of the fall Chinook adults originate from locations that are above more than 8 dams. About 29% (primarily the Hanford Reach run) pass through 4 dams, and about 68% of the fall Chinook adults (primarily hatchery production) originate above only 1 dam. When the survival rate is weighted based on the percentage of the fall Chinook found in each group, the overall weighted average survival of fall Chinook passing through the hydrosystem is approximately 74% [(3%*33%)+(29%*54%)+(68%*85%)].

[1] The implementation of the Prospective Actions should substantially improve the survival of migrating fall Chinook salmon. However, NOAA Fisheries does not attempt to estimate quantitative improvements for fall Chinook salmon from these actions due to complications arising from the expression of multiple life-history strategies.

[2] Juvenile fall Chinook survival estimates are calculated based on per km survival estimates from McNary tailrace to John Day tailrace (1999 – 2002 migrations, June 19 to July 23 releases) using information presented in Williams et al. 2005 (Table 39). The average of these data is 76.7% over a 123 km reach, or a survival rate of nearly 0.998 / km. The entire FCRPS reach is about 512 km, the Bonneville to McNary reach is about 287 km, and Bonneville dam and reservoir is about 73 km in length.

Because the overall losses occurring within the area of the hydrosystem to both spring/summer and fall Chinook are less than 35%, the hatchery production contained in the Prospective Actions more than mitigates for losses to the killer whale prey base, regardless of the source of loss.

The above assessment does not take into account the increased productivity and survival due to habitat and predator programs, which, if included, would show a further increase in the prey base for killer whales. Additionally, there are more hatchery and natural Chinook salmon available to Southern Resident killer whales from Columbia River stocks than is apparent from returns to Bonneville Dam. Recent estimates of ocean abundance (estimated by extrapolation from fisheries catch data) indicate approximately 1,000,000 adult Chinook originate from Columbia River stocks (NMFS 2008k, CTC 2007, ODFW and WDFW 2007). Although there is large annual variability in adult Chinook returns to the mouth of the Columbia River, returns from 1980 to 2007 indicate a slight positive trend, with average abundance of approximately 800,000 Chinook (Corps et al. 2008a).

Long-Term Effects

Salmon analyses presented in the SCA indicate that Prospective Actions including actions that affect the operation of the hydrosystem, tributary and estuary habitat, harvest, predation (tern, pike minnow and marine mammal), hatcheries, and RM&E overall have positively affected and will continue to positively affect the survival and recovery of the listed entities of salmon and steelhead. These analyses consider whether a sufficient number of populations within specific Major Population Groups (MPGs) will survive (i.e., low 24-year extinction risk) and trend toward recovery (i.e., improved average returns-per-spawner, median population growth rate, and abundance trend) to indicate that a specific MPG trends toward recovery (more details available in SCA, Chapter 7).

As discussed in SCA Section 8.1.5 (Effects of Hatchery Programs), while hatchery Prospective Actions (the Action Agencies' obligation to fund hatcheries) are important steps to reducing risk and assuring the long-term viability of these ESUs, at present the hatchery reform process is underway and it is not possible to quantify results or expect that benefits of these reforms are "reasonably certain to occur," and therefore was not part of the basis for conclusions. The Prospective Actions include implementation of hatchery reform (described in RPA 39) pending completion of separate ESA consultations (target completion dates: November 2009 to June 2010; SCA Section 5.5.1). Thus, hatchery effects from the Prospective Actions were assumed as constant from present until future adoption of hatchery reforms as the result of these separate consultations.

Over the long term, the abundance of Columbia River Chinook, and thus of Southern Resident killer whale prey, may be affected by climate change. The Prospective Actions include monitoring of climate effects on salmonids and mechanisms to synthesize, update, and modify implementation to respond to new information regarding the effects of climate change on listed salmonids (SCA Section 7.1.2.1).

The analysis in the SCA concludes that listed Chinook ESUs, and all other listed salmonid ESUs/DPSs in the Columbia River Basin, are expected to survive with an adequate potential for recovery, and the Prospective Actions are not likely to jeopardize the continued existence of these ESUs. Additionally, the Prospective Actions will not adversely modify the designated critical habitat of these and all other listed ESUs/DPSs addressed, and critical habitat is expected to remain functional (or retain the ability to become functional) to serve the intended conservation role in the near and long term. These conclusions were derived after reviewing the effects of the Prospective Actions, the effects of the environmental baseline, and any cumulative effects presented in the salmon analyses. The long-term recovery of listed Columbia River salmon is a benefit for Southern Resident killer whales in the long term.

The potential harmful effects of artificial production on long-term fitness of salmon populations are discussed in the SCA Appendix, Hatchery Effects Report. Specifically, hatcheries can negatively affect population viability by reducing abundance, productivity, spatial distribution and/or diversity of natural-origin fish (described in McElhany et al. 2000). Table 3 of the SCA Appendix, Hatchery Effects Report, identified risks or threats to population viability for Chinook ESUs, including isolated hatchery practices or non-indigenous hatchery broodstock and/or the influence of strays, in combination with a high proportion of hatchery fish in the population can increase the risks to productivity and diversity. The Prospective Actions contemplate future hatchery reforms intended to address harmful effects of hatchery production on the long-term fitness of the naturally spawning fish. Detailed information is not presently available to evaluate long-term effects of a continuation of current hatchery production on Chinook availability, or of reforms to hatchery operations. Thus, an analysis of long-term effects of the hatchery funding contemplated in the Prospective Actions is not possible at this time and will be considered in separate future consultations when detailed information is available.

9.3.2 Effects of Harvest Actions on Southern Resident Killer Whales

Prospective Actions include the 2008 *U.S. v. Oregon* Agreement, which includes some take of hatchery- and natural-origin Chinook salmon. The terminal fisheries do not directly affect Southern Residents, as the fisheries occur after the fish have returned to the river and are no longer available to the whales in the ocean.

Short-Term Effects

Since the majority of fish available for in-river harvest are hatchery fish, the majority of salmon caught will be hatchery salmon. Although the harvest action is constrained by take limitations on natural-origin salmon, some are incidentally caught. Even with the proposed harvest levels on Chinook, most hatchery programs are expected to meet or exceed escapement goals (SCA Chapter 8), and thus will continue to operate at full production with no effect on the future availability of hatchery Chinook in the ocean. In-river harvest of natural-origin fish reduces the number of adults returning to the spawning grounds, and consequently could reduce the number of offspring in the following generation. Such a reduction could in turn reduce the number of adult Chinook available as prey to killer whales in the ocean.

Spring and fall run Chinook are likely to be affected differently by the prospective harvest actions because of differences in their life histories. Spawning habitat for natural-origin Snake River fall Chinook is fully seeded, and Upper River Brights are above escapement goals. Spawning habitat for fall stocks below Bonneville dam, with few exceptions, is also fully seeded, because of stray hatchery fish. Thus harvest of fall run Chinook is not expected to result in a decrease in the number of offspring in the subsequent generation. In contrast, spring returns of natural-origin Chinook, particularly for upriver stocks, tend to be under-seeded. The prospective harvest action manages take of natural-origin upriver Chinook using a sliding scale, and can result in take levels from 5.5 to 17 percent of natural-origin Chinook. Generally, the level of take can be characterized as 10 percent natural-origin from these ESUs. This analysis makes the conservative assumption that in some cases available spawning habitat will be under-seeded, and that a further reduction may occur as a result of the harvest of natural-origin Chinook. That reduction would be proportional to the allowable harvest rate.

Overall, Chinook returns are approximately 30 percent natural-origin fish (70 percent hatchery), whereas upriver spring Chinook are approximately 12 and 32 percent natural-origin for runs returning to spawn above Priest Rapids Dam on the Columbia River and to the Snake River, respectively (average return, 2003 to 2007). On average, the return of natural-origin Chinook to the mouth of the Columbia River from these stocks combined is approximately 30,000 (average return, 2003 to 2007). The 10 percent take that can be expected from the harvest action is therefore approximately 3,000 natural-origin Chinook.

A conservative assumption is that spawner-to-spawner rates are on the order of one-to-one. Given this assumption, the annual return to the river mouth would be 3,000 additional Chinook had there been no fishing. Approximately 3,000 Chinook represents less than 1 percent of the Chinook stocks available to Southern Residents in the ocean that originate from the Columbia River (~1,000,000 Chinook; NMFS 2008k, CTC 2007, ODFW and WDFW 2007) or that return to the mouth of the Columbia River annually (~800,000 Chinook; Corps et al. 2008a).

Long-Term Effects

Over the long term, reductions in naturally spawning spring Chinook could compound. This could reduce Chinook available for killer whale prey in the year in which the reduction was realized and over the long term if it increased the extinction risk of the listed Chinook stocks. As discussed above, the SCA concludes that the combination of Prospective Actions in all areas is likely to ensure the survival, and maintain the long-term potential for recovery, of the listed Chinook ESUs.

9.4 Cumulative Effects

Cumulative effects are those effects of future tribal, state, local or private activities, not involving Federal activities, reasonably certain to occur within the action area (50 CFR 402.02). For the purpose of the Southern Resident killer whale analysis, this area is the coastal range of the species. Future Federal actions will be reviewed through separate section 7 consultation processes.

Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities are primarily those conducted under state, tribal or federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative. A Final Recovery Plan for Southern Resident Killer Whales was published January 24, 2008 (NMFS 2008l). Although state, tribal and local governments have developed plans and initiatives to benefit marine fish species, ESA listed salmon, and the listed Southern Residents, they must be applied and sustained in a comprehensive way before NOAA Fisheries can consider them "reasonably certain to occur" in its analysis of cumulative effects. Details regarding cumulative effects of Chinook salmon in the Columbia River are described in Chapter 8 sections of the SCA for each ESU affected.

Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in SCA Chapter 8 whether future non-Federal actions will lead to an increase or decrease in prey available to Southern Resident killer whales, or have other effects on their survival and recovery.

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Chapter 10
Green Sturgeon of the Southern DPS

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Chapter 10
Green Sturgeon of the Southern DPS

Purpose

This Chapter provides discusses the status of green sturgeon (*Acipenser medirostris*) and estimates the effects of the proposed action on them. Much of this information was provided by the Action Agencies in the form of a biological assessment on April 18, 2008 (Corps et al. 2008).

10.1 Status of the Species

10.1.1 Listing

Upon completion of a status review, NOAA Fisheries determined that green sturgeon comprise two DPSs that qualify as species under ESA: 1) a northern DPS, consisting of populations in coastal systems from the Eel River, California northward, that was determined to not warrant listing; and 2) a southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River (Adams et al. 2002). The southern distinct population segment (DPS) of green sturgeon was listed as threatened under the ESA by NOAA Fisheries on April 7, 2006 (NMFS 2006d). Take prohibitions via section 4(d) of the ESA have not yet been promulgated, nor has critical habitat yet been designated for the southern DPS, although both actions are expected to occur in 2008.

10.1.2 Life history

Green sturgeon are the most marine-oriented of the North American sturgeon species. Juveniles of this species are able to enter estuarine waters after only one year in freshwater. During this time, they are believed to feed on benthic invertebrates, although little is known about rearing habitats and feeding requirements. Green sturgeon are known to range in nearshore marine waters from Mexico to the Bering Sea, and are commonly observed in bays and estuaries along the west coast of North America, including the Columbia River (NMFS 2008m). McLain (2006) noted that Southern DPS green sturgeon were first determined to occur in Oregon and Washington waters in the late 1950s when tagged San Pablo Bay green sturgeon were recovered in the Columbia River estuary. The proportion of the Southern relative to Northern DPS is high (~ 67-82%, or 121 fish, of 155 fish sampled) (Israel and May 2007). Aggregations of adults occupy the lower Columbia River and estuary, up to the Bonneville Dam, primarily during summer months (WDFW and ODFW 2002, Moser and Lindley 2007). Beamis and Kynard (1997) suggested that green sturgeon move into estuaries of non-natal rivers to feed. Information from fisheries-dependent sampling suggests that green sturgeon only occupy large estuaries during the summer and early fall in the northwestern United States. Green sturgeon are known to enter Washington estuaries during summer (Moser and Lindley 2007). There is no evidence of spawning in the Lower Columbia. Green sturgeon in the Lower Columbia River are most likely feeding, but, to date, all stomachs examined (n>50) have been empty (Rien as cited in Grimaldo and Zeug 2001).

10.1.3 Status/Population Trend

Quality data on current population sizes and trends for green sturgeon is non-existent. Lacking any empirical abundance information, Beamesderfer et al. (2007) recently attempted to characterize the relative size of the Sacramento-San Joaquin green sturgeon population (Southern DPS) by comparison with the Klamath River population (Northern DPS). Using Klamath River tribal fishery harvest rate data and assuming adults represent 10% of the population at equilibrium, they roughly estimate the Klamath population at 19,000 fish with an annual recruitment of 1,800 age-1 fish. Given the relative abundance of the two stocks in the Columbia River estuary based on genetic samples, they speculate abundance of the Sacramento population may equal, or exceed the Klamath population estimate. Collectively, Beamesderfer et al. (2007) estimate abundances of the various green sturgeon populations may be larger than previously thought due to seasonal high abundances in the Columbia River, Willapa Bay, and Grays River estuaries and other coastal tributaries, historical high harvest in different areas at different times, and a significant portion of each population likely remains in the ocean at any given time.

10.1.4 Key Limiting Factors for Green Sturgeon

The principal factor in the decline of the Southern DPS is the reduction of the spawning habitat to a limited section of the Sacramento River (NMFS 2006d). The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon's extirpation. Insufficient freshwater flow rates in spawning areas, contaminants (e.g., pesticides), bycatch of green sturgeon in fisheries, potential poaching (e.g., for caviar), entrainment of juveniles by water projects, influence of exotic species, small population size, impassable migration barriers, and elevated water temperatures in the spawning and rearing habitat likely also pose threats to this species (NMFS 2006d).

10.1.5 Harvest Effects

In the past, take of green sturgeon may have occurred from direct harvest in sport and commercial fisheries and from catch and release mortality in commercial fisheries. In the more recent years, the take of green sturgeon in the Columbia River was incidental to fisheries directed at white sturgeon. The numerous management actions implemented by the states of Oregon and Washington since 1994 to control white sturgeon harvest also reduced harvest of green sturgeon, including a reduction of impacts to the listed Southern DPS. The reduced catch of green sturgeon in recent years is believed to be the result of these collective management actions by the states resulting in lower catch, and is not considered indicative of lower abundance of the stock (TAC 2008).

Incidental take of green sturgeon primarily occurs during the early-fall (August) and late-fall (September-November) seasons, concurrent with peak abundance of green sturgeon in the lower Columbia River. Sturgeon angler effort and catch in the estuary increased steadily during the 1990s and peaked in 1998 when anglers made 86,400 trips and caught 30,300 white sturgeon, or 73% of the total catch below Bonneville Dam (TAC 2008). Since 1989, all fisheries affecting lower Columbia River white sturgeon have been managed for Optimum Sustainable Yield (OSY) to provide sustainable broodstock recruitment and ensure the overall health of the white sturgeon population. Beginning in 1996, the states formally adopted a three-year Joint State management agreement based on OSY to guide Columbia River sturgeon fisheries and management decisions. Although the majority of the tenets within the current Joint State sturgeon management agreement focus on white sturgeon, a few objectives specific to benefit green sturgeon management were also included. Beginning July 7, 2006, and in response to the ESA listing of the Southern DPS, retention of green sturgeon in the commercial fisheries was disallowed (TAC 2008). Beginning in January 2007, the states changed the regulations in the recreational fishery to also disallow retention of green sturgeon (TAC 2008). The delay in the implementation of non-retention requirements in the recreational fishery were related to the prescribed process for changing sport regulations and the need for a concurrent public education process.

Harvest of green sturgeon has declined from an average of 1,388 fish annually during 1991-2000 to 154 fish per year since 2001 due to changes in regulations and season structure (Table 10.1-1). During 1996-2006, an average of 61 green sturgeon were harvested in the recreational fishery (Table 10.1-1). During 1996-2006, anglers released an average of 7 green sturgeon annually (2.7 sub-legal, 3.1 legal, and 1.3 over legal-sized) (TAC 2008). With the listing of the Southern green sturgeon DPS, the states took additional emergency action to disallow retention of green sturgeon during commercial fisheries beginning in July 2006, when the ESA listing became effective. During the remainder of 2006, the states started a public awareness and education process so that the sport fishing community would be better able to recognize the differences between white and green sturgeon. The states also disallowed retention of green sturgeon in the recreational fishery starting in 2007 (TAC 2008).

Table 10.1-1. Lower Columbia River Green Sturgeon Catch, 1991-2007

Green Sturgeon						
Year	Sport	Commercial				
		Winter	Summer	Early Fall	Late Fall	Total
1991	22	4	--	2	3,180	3,208
1992	73	10	--	1,750	400	2,233
1993	15	1	--	--	2,220	2,236
1994	132	1	--	--	240	373
1995	21	--	--	--	390	411
1996	63	1	--	--	610	674
1997	41	2	--	1,474	138	1,655
1998	73	0	--	743	151	967
1999	93	2	--	508	279	882
2000	32	0	--	568	636	1,236
2001	50	4	--	338	--	392
2002	51	7	--	--	156	214
2003	52	1	--	11	27	91
2004	29	1	--	6	51	87
2005	119	0	38	32	21	210
2006	70	16	0	--	--	86
2007						0

10.1.6 Other Effects in the Environmental Baseline

In addition to these harvest effects on green sturgeon, the general discussion of the environmental baseline in Chapter 5 of the SCA, and in the further discussions in Chapters 8.2 through 8.14, also apply and inform these decisions.

10.2 Effects of the Prospective Actions

10.2.1 Effect of Prospective Harvest

Prospective take of green sturgeon would occur from catch and release mortalities in non-Indian recreational and commercial fisheries. Green sturgeon are not known to occur upstream of Bonneville Dam and would not be impacted by treaty Indian fisheries (TAC 2008). Prospective fishing regulations in Washington and Oregon for commercial and recreational fisheries would prohibit retention of green sturgeon. However, there may be a minor level of green sturgeon retained in recreational fisheries due to misidentification by anglers.

The estimated total prospective take of green sturgeon associated with recreational fisheries is expected to be less than those of past years (due to the implementation of non-retention regulations put into effect in January 2007) (TAC 2008). Take would be limited to post-release mortalities and a few fish retained due to misidentification. Post release mortality from hook and line recreational fisheries is unknown, but it is reasonable to expect hook and line mortality to be something less than the post-release mortality assigned to commercial fisheries (i.e. 5.2%). Because the prospective fisheries are similar than for the period of 1996-2006, it is estimated that a total of 67 (1995-2006 average handled + average released) green sturgeon will be handled annually in recreational fisheries conducted in the Columbia River. Of the fish handled, 80% (54) will be from the Southern DPS (TAC 2008). Of those released, some (5.2%) may suffer post- release mortality. Therefore, the total annual take of Southern DPS green sturgeon associated with prospective recreational fisheries in the lower Columbia River is estimated to be 3 fish (TAC 2008, Table 31).

Similarly, it is estimated that a total of 74 green sturgeon will be handled annually in commercial fisheries conducted in the Columbia River (TAC 2008). Of the handled fish, 80% (59) will be from the Southern DPS. Of those released, an estimated 5.2% may suffer post-release mortality. Therefore, the total annual take of Southern DPS green sturgeon associated with future lower Columbia River commercial fisheries is estimated to be 3 fish (59 * 0.52= 3) (TAC 2008). Overall, the estimated total lethal take of green sturgeon of the Southern DPS associated with harvest under the Prospective Action would be approximately 6 fish annually (TAC 2008).

10.2.2 Hydrosystem Effects

- Green sturgeon only encounter the effects of the FCRPS between Bonneville Dam and the Columbia River plume, including the Columbia River estuary.

- Adults are known to be found in this portion of the action area only during late summer and fall. At this time, operation of the FCRPS has a small effect on streamflow (e.g. flows are decreased about 15 kcfs (9%) in August and are increased 5 kcfs or about 5% in September. Such minor flow effects would have unmeasurable effects on benthic fish species such as green sturgeon.

- Larger effects of the FCRPS in the occupied portion of the action area, such as changes in the habitat characteristics of the Columbia River estuary, are unlikely to have substantial effects on green sturgeon because adult green sturgeon tend to use deepwater habitats. No spawning or juvenile rearing is known to occur in the Columbia basin.

- Green sturgeon are bottom (benthic) feeders and are not known to rely on salmonids as a prey base.

Chapter 11
Memoranda of Agreement

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Chapter 11 Memoranda of Agreement

11.1 Effects of the Memoranda of Agreement with Tribes and States

A two-year collaboration between the federal agencies, tribes, and states was an integral part of the remand process. The Action Agencies used the results of this collaboration extensively in the development of their Biological Assessment and Comprehensive Analysis. After those documents were prepared and submitted to NOAA Fisheries on August 21, 2007, discussions between the Action Agencies and individual tribes and states continued. As the result of these continued discussions, Memoranda of Agreement (MOAs) were developed between the three federal action agencies, four tribes, and two states in the time period between the release of the draft Biological Opinion and the completion of this final Biological Opinion.[1]

Since these MOAs were finalized rather late in the process, there has not been sufficient time to fully describe and numerically quantify the effect of the measures proposed in them, nor to insert each of the measures contained within these MOAs into the appropriate specific sections of this opinion so that they could be considered in context. However, there has been adequate opportunity to review the proposed measures to determine the effects, whether they are consistent with the requirements of the Endangered Species Act, and to provide at least a qualitative characterization of the benefit likely to result from their implementation.

The Action Agencies developed an addendum to their FCRPS and Upper Snake BAs and Comprehensive Analysis (Corps et al. 2008b), including updating the description of the proposed action and biological effects analysis, to reflect the actions and commitments made in the MOAs. This assessment is based on that addendum.

The MOAs provide a ten year commitment to specific actions selected because of their targeted fishery benefits. Some actions provide additional survival benefits for listed fish beyond what was considered in the draft Biological Opinion, both to aid in gap filling and

[1] There are separate Agreements between the Action Agencies and:

1. Three Treaty Tribes and the Columbia River Intertribal Fish Commission
   - Confederated Tribes of the Umatilla Indian Reservation
   - Confederated Tribes of the Warm Springs Reservation
   - Confederated Tribes and Bands of the Yakama Nation
   - Columbia River Inter-Tribal Fish Commission
2. Confederated Tribes of the Colville Indian Reservation
3. State of Idaho
4. State of Montana

to provide an additional survival cushion. Some are new actions or clarifications of actions in the draft Biological Opinion that provide additional provisions for implementation of fish and wildlife actions over the ten years of the RPA. All are specific and binding commitments. The MOAs focus especially on ESA-listed salmon and steelhead, but proposed actions for non-listed fish, such as lamprey and non-listed salmon, are also included.

The MOAs also include future actions that will need to undergo additional, site-specific environmental compliance/reviews, prior to their implementation. As those actions are better defined, NOAA Fisheries will provide ESA reviews as appropriate for these future projects.

We note that all of the agreements specifically provide that all activities undertaken pursuant to the MOAs must be in compliance with the Endangered Species Act. Although NOAA Fisheries does not now have sufficient information to quantitatively determine the specific effect of such future actions, by virtue of this express provision, none of these future actions will be implemented unless and until it has been determined, after due consultation, that the particular action will be carried out in such as manner as to not jeopardize ESA-listed species and not adversely modify critical habitat.

Further, the MOAs represent the commitment of the particular tribes, states and CRITFC for their active participation in the work of implementing the FCRPS RPA. This has the potential to contribute to the efficiency, effectiveness and success of the actions called for in the RPA and these MOAs. The non-federal partners each have significant knowledge and experience with the listed salmon and steelhead species that will augment the federal implementation actions.

Overall, we conclude that the actions contained in the proposed MOAs are consistent with the requirements of the Endangered Species Act, that many of them will have a beneficial effect on the ESA-listed species that are the focus of this opinion. In some instances, the benefits are substantial. In some instances the benefits are either difficult to quantify at this point or are likely to be positive but not likely to be substantial, and in some instances the proposed action is not likely to affect the listed species.

NOAA Fisheries' specific findings are as follows:

Hydrosystem Actions

- Measure: Clarification of performance standards and metrics, including the use of the 96%/93% performance standards for spill/bypass operations and the consideration of delay and spill passage efficiency as part of performance.

  Finding
  Beneficial effect. These provisions are consistent with other requirements of this opinion and will further assure compliance with the performance standards.

- Measure: The identification of John Day operation at MOP (minimum operating pool) as a potential contingency action if performance is not on track as part of the 2016 comprehensive review.

  Finding
  No biological effect likely during the term of this opinion.

- Measure: Revised transportation operations to increase survival benefits for Snake River steelhead compared to the BA, as modified by the draft BiOp, subject to continued performance review.

  Finding
  Significant beneficial effect. This provision has been incorporated in the proposed FCRPS operations analyzed in this opinion and its benefits are reflected in the analysis.

- Measure: A more conservative fish trigger for cessation and re-initiation of summer spill during August at Snake River Projects. This includes dropping from 1000 fish collected to 300 fish collected for spill cessation and 1000 fish collected to 500 fish collected for re-initiation of spill.

  Finding
  No adverse effect, potential for beneficial effect. This provision has been incorporated in the proposed FCRPS operations analyzed in this opinion and its benefits are reflected in the analysis.

- Measure: Additional details on the parties' efforts to evaluate and improve dry-year operations.

  Finding
  No adverse effect, potential for beneficial effect. This provision will improve adaptive management under this opinion and may lead to better flow management in dry years.

- Measure: Additional details on the parties' efforts to evaluate summer draft at Lake Roosevelt.

  Finding
  No adverse effect. This measure may lead to better use of available storage to benefit migrating juveniles of all ESUs and to benefit resident fish.

- Measure: Additional details on the parties' efforts to improve water management flexibility through improved forecasting.

  Finding
  No adverse effect, potential for beneficial effect. This measure may lead to additional flow management options to benefit listed ESUs.

- Measure: Additional details regarding coordination on Canadian water negotiations.

  Finding
  No adverse effect.

- Measure: An expanded lamprey program, with dam operations and actions consistent with the needs of listed fish.

  Finding
  No adverse effect. Potentially beneficial to pacific lamprey, a species that is currently in low abundance.

- Measure: Reasonable operations for non-listed fish, with priority for ESA-listed fish in case of conflicts.

  Finding
  No adverse effect. Some potential benefit for listed ESUs by reducing conflict and increasing regional support for hydro operations needed to protect ESA-listed fish.

Habitat Actions

As identified in the Revised Addendum, the MOAs specify 84 individual habitat projects designed to address limiting factors for salmon and steelhead. All of these habitat actions are consistent with RPA 35 of this Opinion. NOAA Fisheries is unable to determine at this time which of these projects are in addition to actions that the Action Agencies might otherwise have taken. At this stage, we also do not have full details regarding the proposed projects. NOAA Fisheries therefore is unable to characterize the incremental benefit of these actions but have determined that they will address factors limiting the survival and recovery of listed ESUs.

All of these actions have beneficial effect. They are relatively widely distributed in the Columbia River Basin, and target some of the most important limiting factors for individual populations. Some of these projects have the potential to have significant beneficial effect for specific populations and would be expected to contribute measurably to the survival and recovery of that population.

Hatchery Actions

Hatchery actions numbered 1-9 in Attachment C will have beneficial effects for specific ESUs. Actions 2, 3, and 7 will have significant beneficial effects. These actions were already identified in the Draft Biological Opinion and those benefits are reflected in the analysis in the opinion. Action 1, reconditioning of Snake River steelhead kelts, was not included in prior analyses and will have a significant beneficial effect on that ESU. The proposed action and analysis in this opinion has been modified to reflect this action, and its benefits are assumed in the analysis.

Hatchery actions 10-17 are not directed toward ESA-listed ESUs. Because of the conditions that the parties have placed on their implementation, they are not expected to have adverse effects on the listed ESUs. They are likely to have a significant beneficial effect on the fulfillment of federal trust and treaty obligations, which is an appropriate and important factor so long as ESA requirements are met.

Tribal Conservation Law Enforcement Actions

While these actions have been characterized in the Revised Addendum as a means of reducing potential illegal take of ESA-listed salmon and steelhead, we believe that the benefits are likely to be more extensive. Based on our experience with the NOAA Fisheries Enforcement officers, we believe that effective conservation law enforcement helps reduce certain types of habitat degradation and increases public awareness and encourages voluntary conservation efforts in addition to deterring harvest violations.

This action will have beneficial effect, and may have substantial beneficial effect, for all upper river and mid-Columbia ESUs: Snake River steelhead; Snake River Spring Chinook; Snake River Fall Chinook; Upper Columbia Spring Chinook; Upper Columbia steelhead; Mid-Columbia River steelhead. A selective fisheries pilot project will also be implemented in the Upper Columbia.

Research, Monitoring and Evaluation

The MOAs include actions to address Biological Opinion priorities and to monitor on-the-ground implementation effectiveness and to address critical uncertainties. Items 1-4 are already included in this opinion. Items 5-12 are in addition to the research, monitoring, and evaluation specifically indentified in this opinion. Those items are expected to have a beneficial effect by furthering understanding and implementation effectiveness. No attempt has been made to quantify the extent of this effect.

Conclusion

The Tribal and State MOAs make commitments of operations and funding that, in general, will have beneficial effects for ESA-listed fish and, in some instances will have significant beneficial effects. They will also provide benefits to non-listed fish.

NOAA Fisheries concurs with the Summary of Effects found in Part IV of the Revised Addendum. NOAA Fisheries agrees that the hydro, habitat, and hatchery actions contained in the MOAs, as described and conditioned, are expected to be positive or neutral to the listed salmon and steelhead that are the subject of this consultation. The MOAs provide a commitment of resources for these future improvements. Collectively, the effect of the MOA actions is to provide additional biological benefits compared to the draft BiOp for the affected ESUs, particularly for Upper Columbia spring Chinook and steelhead; Snake River spring/summer Chinook fall Chinook, and steelhead; and Mid-Columbia steelhead.

Chapter 12
Literature Cited

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Adult Survival Estimates Appendix

May 5, 2008

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

Memorandum - Final F/NWR5

To: Bruce Suzumoto

From: Ritchie Graves

Date: April 21, 2008

RE: Estimates of ESU/DPS-specific adult survival rates within the FCRPS based on PIT tag detections at Bonneville, McNary, and Lower Granite dams.

The purpose of the memorandum is to:
1) document the approach used in the Supplemental Comprehensive Analysis to estimate ESU-specific survival rates of adult salmon and steelhead migrating through the FCRPS,
2) provide the results of this analysis (see attached Excel spreadsheets),
3) discuss issues arising from this analysis,
4) additional exploratory analysis resulting from the identification of these issues, and
5) recommend measures to address them.

Approach

The approach used to estimate ESU/DPS-specific adult survival rates through the FCRPS projects depends upon detections of PIT tagged adults at Bonneville Dam (BON), and the redetection of these same fish at upstream locations (McNary or Lower Granite dams). These raw conversion rates (minimum survival estimates) are then adjusted using best estimates of harvest (from US v Oregon TAC representatives) and straying rates (estimates from adult radio-telemetry studies) to provide a minimum survival estimate for the reach of interest (i.e., BON to MCN or BON to LGR). This method has several advantages over previous methods (i.e., radio-telemetry or dam counts): 1) it relies upon full detection of PIT-tagged adults and so does not require additional handling or surgery which could affect adult migration behavior; 2) it produces survival estimates for individual ESUs / DPSs using known origin fish as surrogates; 3) the calculations are simple and straightforward (only estimates of harvest and straying rates between Bonneville and the upstream detection site are needed); and 4) the PIT-tag database is commonly available – ensuring transparency and reproducible results.

Key Calculations

Specifically, the methodology for estimating adult system survival uses 2002 to 2007[1] adult returns and includes the following steps:

[1] 2002 to 2007 data were used in the calculation of averages unless one of the following conditions warranted that a particular year be excluded: small (n<20) sample sizes, low MCN detection efficiencies, or incomplete adult returns.

1. Determine the number of PIT-tagged adult salmon and steelhead detected at Bonneville Dam that represents the ESU / DPS in question.[2] This is accomplished by selecting adult detections from the PITAGIS database that meet the following requirements: 1) are of known origin, i.e., are from the ESA-listed stock or the best available surrogate stock, and 2) returned as adults (i.e, 1-salt "jack" Chinook salmon are excluded).[3] For example, to represent Upper Columbia River spring Chinook salmon, select all appropriate age 2+ spring Chinook salmon tagged upstream of Rock Island Dam detected at Bonneville Dam to represent Upper Columbia River spring Chinook salmon.

2. Determine the number of PIT-tagged adult salmon and steelhead (of those identified in step 1) that were re-detected at McNary or Lower Granite dam (or at locations upstream of these dams).

3. Calculate an unadjusted survival rate: **S = NU / NB** where S = survival rate, NU = number of fish re-detected at or above the upstream targeted dam (McNary or Lower Granite), and NB = number of fish initially detected at Bonneville Dam.[4]

4a. Calculate an adjusted survival rate for the BON to MCN reach (for all stocks):
$\mathbf{S = (NU / NB) / ((1 - Nharv_{zone\ 6}) \times (1 - Nstray))}$ where Nharv = estimated harvest[5] rates provided by US v Oregon Technical Advisory Committee (TAC) members and Nstray = estimated straying (turning off and remaining in spawning areas before reaching the targeted upstream dam) based primarily on recent radio-telemetry studies.

4b. Calculate an adjusted survival rate for the BON to LGR reach (for Snake River stocks:
$\mathbf{S = (NU / NB) / ((1 - Nharv_{zone\ 6}) \times (1 - Nharv_{upstream\ of\ MCN}) \times (1 - Nstray))}$
where Nharv = estimated harvest[4] rates provided by US v Oregon Technical Advisory Committee (TAC) members and Nstray = estimated straying (turning off and remaining in spawning areas before reaching the targeted upstream dam) based primarily on recent radio-telemetry studies.

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[2] Because increased levels of straying have been associated with transportation as juveniles, this analysis is conducted separately for fish that were transported or migrated inriver as juveniles.

[3] The Action Agencies were advised by NMFS and other PWG parties, most notable Washington to exclude jacks from the adult survival performance metrics because these smaller male fish have little effect on the productivity of populations and harvest and stray rate estimates used to calculate fish losses due to the hydro system are not generally applicable to jacks.

[4] NOTE: An estimated MCN to LGR conversion rate is calculated for SR Chinook and steelhead as ($S_{BON\text{-}LGR}$ / $S_{BON\text{-}MCN}$) where $S_{BON\text{-}LGR}$ is the unadjusted survival estimate from Bonneville to Lower Granite dams and $S_{BON\text{-}MCN}$ is the unadjusted survival estimate from Bonneville to McNary dams.

[5] Harvest estimates in the BON to MCN reach require estimates of zone 6 harvest rates. Harvest Estimates in the BON to LGR reach require estimates of zone 6 harvest and of additional harvest within the McNary pool and lower Snake River.

5. Calculate (for purpose of comparison) the Per Project Adjusted survival rate for the reaches: **PPS = S^(1/n)**, where PPS = Per Project Survival, S = the Reach Survival Estimate, and n = the number of dams within the reach.

Results

The detailed results of this analysis, including estimates of harvest and stray rates, are included in the Excel spreadsheet attached to this memorandum. A summary of the results (reach survival estimates) is provided in Table 1.

Table 1 Summary of Reach Survival Estimates (BON to MCN, MCN to LGR, and BON to LGR) and corresponding Per Project Survival Estimates.

	Adj. Conv. Rate			Per Project Adj. Conv. Rate		
Species	**BON to MCN**	**MCN to LGR**	**BON to LGR**	**BON to MCN**	**MCN to LGR**	**BON to LGR**
SR Fall Chinook (inriver)	88.0	92.0	**81.0**	95.6	97.9	**96.9**
SR Fall Chinook (transported)	84.8	88.3	**74.9**	94.5	96.9	**95.8**
SR spr/sum Chinook (inriver)	94.9	95.9	**91.0**	98.3	99.0	**98.6**
SR spr/sum Chinook (transported)	89.2	94.3	**84.1**	96.2	98.6	**97.5**
SR sockeye (inriver)*	91.4	Assumes = per project survival	**81.1**	97.1	Assumes = per project survival	**97.1**
SR steelhead (inriver)	95.3	94.6	**90.1**	98.4	98.6	**98.8**
SR steelhead (transported)	89.6	92.9	**83.3**	96.4	98.2	**97.4**
UCR spring Chinook (inriver)	**90.1**			**96.6**		
UCR steelhead (inriver)	**84.5**			**94.5**		

NOTE: Bold text

* These results are based on surrogates (Lake Wenatchee and Okanogan River sockeye salmon) tagged as adults and released at Bonneville Dam in 2006 and 2007). The BON to MCN reach survivals were expanded to the BON to LGR reach by assuming that the average per project survival (BON to MCN) would apply equally to the four dams in the MCN to LGR reach. None of these fish were transported.

Data Provided by:

PIT Tag detections at BON and redetections at MCN and LGR were provided by Charlie Paulsen (BPA Contractor) in January 2008.

PIT Tag detections of sockeye salmon at BON and redetections at MCN were provided by Paul Ocher (Corps of Engineers) in Oct. 2008.

Harvest rate estimates were provided by Stuart Ellis (CRITFC) - member of the U.S. v Oregon Technical Advisory Committee in Jan 2008.

Stray rate estimates were summarized by David Klugston (COE) in October 2007 from:

M.L. Keefer, C.A. Peery, J. Firehammer, and M.L. Moser. 2005 Straying Rates of known-origin adult Chinook salmon and steelhead within the Columbia River basin, 2000-2003. Technical Report 2005-5.

Note regarding McNary Detection Efficiencies:

McNary adult PIT tag detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

Summary of Expected Adult Survival based on PIT Tag Conversion Rate Analysis of Snake River and Upper Columbia River ESUs

Adults - That Migrated Inriver As Juveniles	Adjusted Conversion Rates			Adjusted Conversion Rates	
	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Minimum	Maximum
SR Fall Chinook	88.0%	92.0%	81.0%	58.8%	98.6%
SR Spr-Sum Chinook	94.9%	95.9%	91.0%	81.6%	97.9%
SR Sockeye Salmon	91.4%		81.1%	79.1%	83.2%
SR Steelhead	95.3%	94.6%	90.1%	85.6%	93.8%
UCR Spr Chinook	90.1%			86.1%	96.1%
UCR Steelhead	84.5%			77.6%	90.7%

Surrogate Estimates for Lower River ESUs / Populations

MCR Steelhead - 1 dam	98.5%	97.8%	99.1%
MCR Steelhead - 2 dam	97.0%	95.6%	98.2%
MCR Steelhead - 3 dam	95.6%	93.5%	97.3%
CR Chum - 1 dam	96.9%	92.7%	99.8%
LCR Chinook - 1 dam (spring run)	98.6%	97.1%	99.7%
LCR Chinook - 1 dam (fall run)	96.9%	92.7%	99.8%
LCR Coho - 1 dam	96.9%	92.7%	99.8%
LCR Steelhead - 1 dam	98.5%	97.8%	99.1%

SR Fall Chinook - Conversion Rate Estimates from Bonneville to McNary and Lower Granite Dams

4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles.
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

Adults (wild and hatchery) that migrated inriver as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*	52	32	31	61.5%	96.9%	59.6%	22.4%	0.2%	3.3%	82.0%	97.1%	79.6%	93.6%	99.3%	96.8%
2003	146	126	119	86.3%	94.4%	81.5%	14.4%	0.1%	3.3%	104.3%	94.6%	98.6%	101.4%	98.6%	99.8%
2004	308	254	239	82.5%	94.1%	77.6%	14.3%	0.1%	3.3%	99.5%	94.2%	93.7%	99.8%	98.5%	99.1%
2005	251	173	142	68.9%	82.1%	56.6%	17.8%	0.0%	3.3%	86.7%	82.1%	71.2%	95.3%	95.2%	95.3%
2006	193	98	87	50.8%	88.8%	45.1%	20.7%	0.0%	3.3%	66.2%	88.8%	58.8%	87.2%	97.1%	92.7%
2007	247	176	165	71.3%	93.8%	66.8%	17.6%	0.0%	3.3%	89.4%	93.8%	83.9%	96.3%	98.4%	97.5%
Mean				**70.2%**	**91.9%**	**64.5%**	**17.9%**	**0.1%**	**3.3%**	**88.0%**	**92.0%**	**81.0%**	**95.6%**	**97.9%**	**96.9%**
												86.4%			

Adults (wild and hatchery) that were transported as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*								0.2%							
2003	17	16	14	94.1%	87.5%	82.4%	14.4%	0.1%	3.3%	113.7%	87.6%	99.6%	104.4%	96.8%	99.9%
2004	65	55	51	84.6%	92.7%	78.5%	14.3%	0.1%	3.3%	102.1%	92.8%	94.7%	100.7%	98.2%	99.2%
2005	67	44	40	65.7%	90.9%	59.7%	17.8%	0.0%	3.3%	82.6%	90.9%	75.1%	93.8%	97.6%	96.0%
2006	23	13	11	56.5%	84.6%	47.8%	20.7%	0.0%	3.3%	73.7%	84.6%	62.4%	90.3%	95.9%	93.5%
2007	28	18	15	64.3%	83.3%	53.6%	17.6%	0.0%	3.3%	80.7%	83.4%	67.2%	93.1%	95.6%	94.5%
Mean				**67.8%**	**88.4%**	**59.9%**	**17.6%**	**0.0%**	**3.3%**	**84.8%**	**88.3%**	**74.9%**	**94.5%**	**96.9%**	**95.8%**
												80.5%			

Notes:

1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.
4. MCN to LGR conversion estimates are calculated indirectly as (BON to LGR # / BON to MCN #)

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur.

SR Fall Chinook Mortality Estimates 4/24/2008

Mortality Estimates = (1-Survival)

Adults (w+h) that migrated inriver as juveniles

	Mortality Estimates			**Avg per Project Mortality Est.**		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*	18.0%	2.9%	20.4%	6.4%	0.7%	3.2%
2003	-4.3%	5.4%	1.4%	-1.4%	1.4%	0.2%
2004	0.5%	5.8%	6.3%	0.2%	1.5%	0.9%
2005	13.3%	17.9%	28.8%	4.7%	4.8%	4.7%
2006	33.8%	11.2%	41.2%	12.8%	2.9%	7.3%
2007	10.6%	6.2%	16.1%	3.7%	1.6%	2.5%
Mean	**10.8%**	**8.0%**	**18.8%**	**4.0%**	**2.1%**	**3.1%**

Adults (w+h) that were transported as juveniles

	Mortality Estimates			**Avg per Project Mortality Est.**		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*						
2003	-13.7%	12.4%	0.4%	-4.4%	3.2%	0.1%
2004	-2.1%	7.2%	5.3%	-0.7%	1.8%	0.8%
2005	17.4%	9.1%	24.9%	6.2%	2.4%	4.0%
2006	26.3%	15.4%	37.6%	9.7%	4.1%	6.5%
2007	19.3%	16.6%	32.8%	6.9%	4.4%	5.5%
Mean	**15.2%**	**11.7%**	**25.1%**	**5.5%**	**3.1%**	**4.2%**

SR Spring/Summer Chinook - Conversion Rate Estimates from Bonneville to McNary and Lower Granite Dams

4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles.
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

Adults (wild and hatchery) that migrated inriver as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*	1136	989	963	87.1%	97.4%	84.8%	11.4%	0.3%	2.0%	100.2%	97.7%	97.9%	100.1%	99.4%	99.7%
2003	913	774	749	84.8%	96.8%	82.0%	8.5%	0.2%	2.0%	94.6%	97.0%	91.7%	98.2%	99.2%	98.8%
2004	1774	1527	1481	86.1%	97.0%	83.5%	9.5%	0.6%	2.0%	97.1%	97.6%	94.8%	99.0%	99.4%	99.2%
2005	608	533	509	87.7%	95.5%	83.7%	6.8%	0.1%	2.0%	96.0%	95.6%	91.7%	98.6%	98.9%	98.8%
2006	267	213	198	79.8%	93.0%	74.2%	7.2%	0.2%	2.0%	87.7%	93.1%	81.6%	95.7%	98.2%	97.1%
2007	168	142	133	84.5%	93.7%	79.2%	8.4%	0.4%	2.0%	94.1%	94.0%	88.5%	98.0%	98.5%	98.3%
Mean				**85.0%**	**95.6%**	**81.2%**	**8.6%**	**0.3%**	**2.0%**	**94.9%**	**95.9%**	**91.0%**	**98.3%**	**99.0%**	**98.6%**
												92.9%			

Adults (wild and hatchery) that were transported as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*	1142	901	863	78.9%	95.8%	75.6%	11.4%	0.3%	2.0%	90.8%	96.1%	87.3%	96.9%	99.0%	98.1%
2003	1196	952	903	79.6%	94.9%	75.5%	8.5%	0.2%	2.0%	88.8%	95.1%	84.4%	96.1%	98.7%	97.6%
2004	525	424	403	80.8%	95.0%	76.8%	9.5%	0.6%	2.0%	91.1%	95.7%	87.1%	96.9%	98.9%	98.1%
2005	502	416	403	82.9%	96.9%	80.3%	6.8%	0.1%	2.0%	90.7%	97.0%	88.0%	96.8%	99.2%	98.2%
2006	396	297	265	75.0%	89.2%	66.9%	7.2%	0.2%	2.0%	82.4%	89.4%	73.7%	93.8%	97.2%	95.7%
2007	416	341	314	82.0%	92.1%	75.5%	8.4%	0.4%	2.0%	91.3%	92.4%	84.4%	97.0%	98.0%	97.6%
Mean				**79.8%**	**94.0%**	**75.1%**	**8.6%**	**0.3%**	**2.0%**	**89.2%**	**94.3%**	**84.1%**	**96.2%**	**98.6%**	**97.5%**
												90.3%			

Notes:
1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.
4. MCN to LGR conversion estimates are calculated indirectly as (BON to LGR # / BON to MCN #)

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur.

SR Spring-Summer Chinook Mortality Estimates

4/24/2008

Mortality Estimates = (1-Survival)

Adults (w+h) that migrated inriver as juveniles

	Mortality Estimates			Avg per Project Mortality Est.		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*	-0.2%	2.3%	2.1%	-0.1%	0.6%	0.3%
2003	5.4%	3.0%	8.3%	1.8%	0.8%	1.2%
2004	2.9%	2.4%	5.2%	1.0%	0.6%	0.8%
2005	4.0%	4.4%	8.3%	1.4%	1.1%	1.2%
2006	12.3%	6.9%	18.4%	4.3%	1.8%	2.9%
2007	5.9%	6.0%	11.5%	2.0%	1.5%	1.7%
Mean	**5.1%**	**4.1%**	**9.0%**	**1.7%**	**1.0%**	**1.4%**

Adults (w+h) that were transported as juveniles

	Mortality Estimates			Avg per Project Mortality Est.		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*	9.2%	3.9%	12.7%	3.1%	1.0%	1.9%
2003	11.2%	4.9%	15.6%	3.9%	1.3%	2.4%
2004	8.9%	4.3%	12.9%	3.1%	1.1%	1.9%
2005	9.3%	3.0%	12.0%	3.2%	0.8%	1.8%
2006	17.6%	10.6%	26.3%	6.2%	2.8%	4.3%
2007	8.7%	7.6%	15.6%	3.0%	2.0%	2.4%
Mean	**10.8%**	**5.7%**	**15.9%**	**3.8%**	**1.4%**	**2.5%**

SR Sockeye - Conversion Rate Estimates from Bonneville to McNary and Lower Granite Dams 4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

	Adults (wild and hatchery) that migrated inriver as juveniles										
	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate	Adjustment Estimates			Adjusted Conversion Rates		Adj. Conversion Rates	
Year	**Number at BON**	**Redet. @ MCN***	**Redet. @ LGR**	**BON to MCN (%)**	**Zone 6 Harvest Rate****	**Above MCN Harvest Rate****	**Stray Rate**	**BON to MCN (%)**	**Est. of BON to LGR %**	**BON to MCN (3rd root)**	**BON to LGR (7th root)**
2002*											
2003											
2004											
2005											
2006	493	436		88.4%	4.3%	0.0%	0.0%	92.4%	83.2%	97.4%	97.4%
2007	456	390		85.5%	5.4%	0.0%	0.0%	90.4%	79.1%	96.7%	96.7%
Mean				**87.0%**	**4.9%**	**0.0%**	**0.0%**	**91.4%**	**81.1%**	**97.1%**	**97.1%**

Important - This analysis uses Sockeye Salmon PIT-tagged at BON (likely of Lake Wenatchee and Okanogan River origin) as surrogates for SR sockeye survival.
- Because no sockeye habitat or populations exist downstream of MCN, no stray rate is assumed in this analysis.

Notes:
1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.
4. Est. of BON to LGR % adjusted conversion rate is estimated as the BON to MCN (3rd root) estimate per project conversion rate to the 7th power.

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur.

SR Sockeye Mortality Estimates 4/24/2008

Mortality Estimates = (1-Survival)

Adults (w+h) that migrated inriver as juveniles

	Mortality Estimates		Avg per Project Mortality Est.	
Year	**BON to MCN (%)**	**Est. of BON to LGR %**	**BON to MCN per Project**	**BON to LGR (7th root)**
2002*				
2003				
2004				
2005				
2006	7.6%	16.8%	2.6%	2.6%
2007	9.6%	20.9%	3.3%	3.3%
Mean	**8.6%**	**18.9%**	**2.9%**	**2.9%**

SR Steelhead - Conversion Rate Estimates from Bonneville to McNary and Lower Granite Dams 4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles.
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

Adults (wild and hatchery) that migrated inriver as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*	766	611	580	79.8%	94.9%	75.7%	8.1%	1.2%	3.8%	90.2%	96.0%	86.7%	96.6%	99.0%	98.0%
2003	99	82	78	82.8%	95.1%	78.8%	10.8%	0.6%	5.3%	98.0%	95.7%	93.8%	99.3%	98.9%	99.1%
2004	307	250	246	81.4%	98.4%	80.1%	9.4%	0.4%	4.7%	94.3%	98.8%	93.1%	98.1%	99.7%	99.0%
2005	214	172	158	80.4%	91.9%	73.8%	8.6%	0.9%	4.7%	92.3%	92.7%	85.6%	97.4%	98.1%	97.8%
2006	94	81	72	86.2%	88.9%	76.6%	11.1%	1.1%	4.7%	101.7%	89.9%	91.4%	100.6%	97.4%	98.7%
2007	98	81	70	82.7%	86.4%	71.4%	10.5%	1.1%	4.7%	96.9%	87.3%	84.6%	98.9%	96.7%	97.6%
Mean				**82.1%**	**93.8%**	**77.0%**	**9.6%**	**0.8%**	**4.6%**	**95.3%**	**94.6%**	**90.1%**	**98.4%**	**98.6%**	**98.5%**
												90.7%			

Adults (wild and hatchery) that were transported as juveniles

	PIT Tag Detections at BON and upstream redetections			Unadjusted Conversion Rate			Adjustment Estimates			Adjusted Conversion Rates			Adj. Conversion Rates		
Year	Number at BON	Redet. @ MCN*	Redet. @ LGR	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	Zone 6 Harvest Rate**	Above MCN Harvest Rate**	Stray Rate	BON to MCN (%)	MCN to LGR (%)	BON to LGR (%)	BON to MCN (3rd root)	MCN to LGR (4th root)	BON to LGR (7th root)
2002*	606	448	414	73.9%	92.4%	68.3%	8.1%	1.2%	3.8%	83.6%	93.5%	78.2%	94.2%	98.3%	96.5%
2003	297	248	224	83.5%	90.3%	75.4%	10.8%	0.6%	5.3%	98.8%	90.9%	89.8%	99.6%	97.6%	98.5%
2004	357	270	252	75.6%	93.3%	70.6%	9.4%	0.4%	4.7%	87.6%	93.7%	82.0%	95.7%	98.4%	97.2%
2005	291	232	217	79.7%	93.5%	74.6%	8.6%	0.9%	4.7%	91.6%	94.4%	86.4%	97.1%	98.6%	97.9%
2006	128	94	86	73.4%	91.5%	67.2%	11.1%	1.1%	4.7%	86.6%	92.5%	80.2%	95.3%	98.1%	96.9%
2007	141	111	87	78.7%	78.4%	61.7%	10.5%	1.1%	4.7%	92.2%	79.2%	73.1%	97.3%	94.3%	95.6%
Mean				**77.2%**	**92.2%**	**71.2%**	**9.6%**	**0.8%**	**4.6%**	**89.6%**	**92.9%**	**83.3%**	**96.4%**	**98.2%**	**97.4%**
												88.0%			

Notes:
1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.
4. MCN to LGR conversion estimates are calculated indirectly as (BON to LGR # / BON to MCN #)

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur. Additional, unreported but significant harvest, is known to occur between MCN and LGR in some years.

SR Steelhead Mortality Estimates 4/24/2008

Mortality Estimates = (1-Survival)

Adults (w+h) that migrated inriver as juveniles

	Mortality Estimates			Avg per Project Mortality Est.		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*	9.8%	4.0%	13.3%	3.4%	1.0%	2.0%
2003	2.0%	4.3%	6.2%	0.7%	1.1%	0.9%
2004	5.7%	1.2%	6.9%	1.9%	0.3%	1.0%
2005	7.7%	7.3%	14.4%	2.6%	1.9%	2.2%
2006	-1.7%	10.1%	8.6%	-0.6%	2.6%	1.3%
2007	3.1%	12.7%	15.4%	1.1%	3.3%	2.4%
Mean	**4.7%**	**5.4%**	**9.9%**	**1.6%**	**1.4%**	**1.5%**

Adults (w+h) that were transported as juveniles

	Mortality Estimates			Avg per Project Mortality Est.		
Year	**BON to MCN (%)**	**MCN to LGR (%)**	**BON to LGR (%)**	**BON to MCN per Project**	**MCN to LGR Per Project**	**BON to LGR Per Project**
2002*	16.4%	6.5%	21.8%	5.8%	1.7%	3.5%
2003	1.2%	9.1%	10.2%	0.4%	2.4%	1.5%
2004	12.4%	6.3%	18.0%	4.3%	1.6%	2.8%
2005	8.4%	5.6%	13.6%	2.9%	1.4%	2.1%
2006	13.4%	7.5%	19.8%	4.7%	1.9%	3.1%
2007	7.8%	20.8%	26.9%	2.7%	5.7%	4.4%
Mean	**10.4%**	**7.1%**	**16.7%**	**3.6%**	**1.8%**	**2.6%**

UCR Spring Chinook - Conversion Rate Estimates from Bonneville to McNary Dams

4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles.
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

	Adults (hatchery) that migrated inriver as juveniles						
	PIT Tag Detections at BON and upstream redetections		Unadjusted Conversion Rate	Adjustment Estimates		Adjusted Conversion Rates	Adj. Conversion Rates
Year	Number at BON	Redet. @ MCN*	BON to MCN (%)	Zone 6 Harvest Rate**	Stray Rate	BON to MCN (%)	BON to MCN (3rd root)
2002*	83	65	78.3%	11.7%	2.0%	90.5%	96.7%
2003	63	51	81.0%	9.1%	2.0%	90.9%	96.9%
2004	813	690	84.9%	9.9%	2.0%	96.1%	98.7%
2005	806	656	81.4%	7.1%	2.0%	89.4%	96.3%
2006	647	505	78.1%	7.5%	2.0%	86.1%	95.1%
2007	154	121	78.6%	8.7%	2.0%	87.8%	95.7%
Mean			**80.4%**			**90.1%**	**96.6%**

The vast majority of tagged fish in this analysis are of hatchery origin.

Notes:
1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur.

UCR Spring Chinook Mortality Estimates 4/24/2008

Mortality Estimates = (1-Survival)

Adults (h) that migrated inriver as juveniles		
	Mortality Estimates	**Avg per Project Mortality Est.**
Year	**BON to MCN (%)**	**BON to MCN per Project**
2002*	9.5%	3.3%
2003	9.1%	3.1%
2004	3.9%	1.3%
2005	10.6%	3.7%
2006	13.9%	4.9%
2007	12.2%	4.3%
Mean	**9.9%**	**3.4%**

UCR Steelhead - Conversion Rate Estimates from Bonneville to McNary Dams

4/24/2008

Based on PIT tag detections of known origin adults (excluding one-ocean jacks) that migrated inriver or were transported as juveniles.
Adjusted conversion rates are calculated as (# at MCN or LGR / # at BON) / ([1-Harvest Rate]*[1-Stray Rate])

	Adults (hatchery) that migrated inriver as juveniles						
	PIT Tag Detections at BON and upstream redetections		Unadjusted Conversion Rate	Adjustment Estimates		Adjusted Conversion Rates	Adj. Conversion Rates
Year	**Number at BON**	**Redet. @ MCN***	**BON to MCN (%)**	**Zone 6 Harvest Rate****	**Stray Rate**	**BON to MCN (%)**	**BON to MCN (3rd root)**
2002*	294	232	78.9%	7.3%	3.8%	88.5%	96.0%
2003	44	34	77.3%	10.1%	5.3%	90.7%	96.8%
2004	3448	2468	71.6%	8.0%	4.7%	81.6%	93.4%
2005	6123	4200	68.6%	7.3%	4.7%	77.6%	91.9%
2006	6790	4944	72.8%	9.2%	4.7%	84.1%	94.4%
2007	1167	856	73.4%	8.8%	4.7%	84.4%	94.5%
Mean			**73.8%**	**8.4%**	**4.6%**	**84.5%** **95.9% equals .986^3**	**94.5%**

The vast majority of tagged fish in this analysis are of hatchery origin.

The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.

NOTE: Harvest estimate was assumed to be equal to that of A&B-run hatchery SR steelhead.

Notes:
1. Shaded data were not used in the calculation of averages due to small (n<20) sample sizes, low MCN detection efficiencies, or incomplete returns.
2. Stray rates for "inriver" migrants were also used for "transported" migrants as a base condition for assessing the effect of transportation on adult conversion.
3. The Zone 6 harvest estimate for 2007 was estimated as the average of the 2004-2006 estimates.

* McNary detectors became operational in 2002. However, near 100% detection rates were not achieved until 2003.

** Assumes that harvest rates are the same for spring and summer Chinook salmon; radio-telemetry studies indicate that reported harvest rate estimates may be lower than actually occur. Also, there are also some unaccounted losses upstream of McNary Dam - possibly due to harvest of an unknown magnitude.

UCR Steelhead Mortality Estimates 4/24/2008

Mortality Estimates = (1-Survival)

Adults (hatchery) that migrated inriver as juveniles		
	Mortality Estimates	**Avg per Project Mortality Est.**
Year	**BON to MCN (%)**	**BON to MCN per Project**
2002*	11.5%	4.0%
2003	9.3%	3.2%
2004	18.4%	6.6%
2005	22.4%	8.1%
2006	15.9%	5.6%
2007	15.6%	5.5%
Mean	**15.5%**	**5.5%**

Source: query of PITagis database provided by C. Paulsen
Adult Fish only (jacks are excluded)

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	Trans. Conv.	BON to LGR Inriver Conv.	Trans. Conv.
SR fall Chinook (wild & hatchery)	2002	52	32	31	1	0	0	61.5%	0.0%	59.6%	0.0%
	2003	146	126	119	17	16	14	86.3%	94.1%	81.5%	82.4%
	2004	308	254	239	65	55	51	82.5%	84.6%	77.6%	78.5%
	2005	251	173	142	67	44	40	68.9%	65.7%	56.6%	59.7%
	2006	193	98	87	23	13	11	50.8%	56.5%	45.1%	47.8%
	2007	247	176	165	28	18	15	71.3%	64.3%	66.8%	53.6%

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	Trans. Conv.	BON to LGR Inriver Conv.	Trans. Conv.
SR spring/summer Chinook (wild & hatchery)	2002	1136	989	963	1142	901	863	87.1%	78.9%	84.8%	75.6%
	2003	913	774	749	1196	952	903	84.8%	79.6%	82.0%	75.5%
	2004	1774	1527	1481	525	424	403	86.1%	80.8%	83.5%	76.8%
	2005	608	533	509	502	416	403	87.7%	82.9%	83.7%	80.3%
	2006	267	213	198	396	297	265	79.8%	75.0%	74.2%	66.9%
	2007	168	142	133	416	341	314	84.5%	82.0%	79.2%	75.5%

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	Trans. Conv.	BON to LGR Inriver Conv.	Trans. Conv.
UCR spring Chinook (wild & hatchery)	2002	83	65	N/A	NOT APPLICABLE			78.3%			
	2003	63	51	N/A	NOT APPLICABLE			81.0%			
	2004	813	690	N/A	NOT APPLICABLE			84.9%			
	2005	806	656	N/A	NOT APPLICABLE			81.4%			
	2006	647	505	N/A	NOT APPLICABLE			78.1%			
	2007	154	121	N/A	NOT APPLICABLE			78.6%			

Source: query of PITagis database provided by C. Paulsen

Includes 1-salt and 2-salt adults

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	BON to MCN Trans. Conv.	BON to LGR Inriver Conv.	BON to LGR Trans. Conv.
SR summer Steelhead (wild & hatchery)	2002	766	611	580	606	448	414	79.8%	73.9%	75.7%	68.3%
	2003	99	82	78	297	248	224	82.8%	83.5%	78.8%	75.4%
	2004	307	250	246	357	270	252	81.4%	75.6%	80.1%	70.6%
	2005	214	172	158	291	232	217	80.4%	79.7%	73.8%	74.6%
	2006	94	81	72	128	94	86	86.2%	73.4%	76.6%	67.2%
	2007	98	81	70	141	111	87	82.7%	78.7%	71.4%	61.7%

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	BON to MCN Trans. Conv.	BON to LGR Inriver Conv.	BON to LGR Trans. Conv.
UCR steelhead (hatchery)	2002	294	232	N/A	NOT APPLICABLE			78.9%			
	2003	44	34	N/A	NOT APPLICABLE			77.3%			
	2004	3448	2468	N/A	NOT APPLICABLE			71.6%			
	2005	6123	4200	N/A	NOT APPLICABLE			68.6%			
	2006	6790	4944	N/A	NOT APPLICABLE			72.8%			
	2007	1167	856	N/A	NOT APPLICABLE			73.4%			

Species and Run	Year	Fish migrated as juveniles: Inriver No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	Fish migrated as juveniles: Transport No. Detected at BON	No. Redetected at MCN	No. Redetected at LGR	BON to MCN Inriver Conv.	BON to MCN Trans. Conv.	BON to LGR Inriver Conv.	BON to LGR Trans. Conv.
SR Sockeye	2002			N/A	NOT APPLICABLE			#DIV/0!			
	2003			N/A	NOT APPLICABLE			#DIV/0!			
	2004			N/A	NOT APPLICABLE			#DIV/0!			
	2005			N/A	NOT APPLICABLE			#DIV/0!			
	2006			N/A	NOT APPLICABLE			#DIV/0!			
	2007			N/A	NOT APPLICABLE			#DIV/0!			

Harvest Estimates - provided by S. Ellis (CRITFC) - January 2008.

ZONE 6 HARVEST ESTIMATES

Year	SR Fall Chinook [1]	SR spr/sum Chinook [2]	UCR spr Chinook [3]	SR steelhead [4]	UCR steelhead [5]	SR Sockeye [6]
2002	22.4%	11.4%	11.7%	8.1%	7.3%	5.2%
2003	14.4%	8.5%	9.1%	10.8%	10.1%	2.8%
2004	14.3%	9.5%	9.9%	9.4%	8.0%	3.5%
2005	17.8%	6.8%	7.1%	8.6%	7.3%	3.8%
2006	20.7%	7.2%	7.5%	11.1%	9.2%	4.3%
2007	17.6%	8.4%	8.7%	10.5%	8.8%	5.4%

1. Uses Est. total harvest rate for Fall Chinook.
   2007 harvest estimated as average of 2004-2007 harvest rates.
2. Uses average total harvest rate estimates for spring Chinook.
3. Uses average total harvest rate estimates for UCR spring Chinook.
   2007 harvest estimated as SR spr/sum Chinook total harvest rate + 0.3% (avg diff. of previous 3 years).
4. Uses Snake River steelhead A&B run total harvest rate estimates
5. Uses UCR steelhead A-run total harvest rate estimates.
6. Uses total harvest estimate for sockeye.

HARVEST ESTIMATES UPSTREAM OF MCNARY DAM

Year	SR Fall Chinook [1]	SR spr/sum Chinook [2]	UCR spr Chinook [3]	SR steelhead [4]	UCR steelhead [5]	SR Sockeye [6]
2002	0.2%	0.3%	N/A	1.2%	N/A	0.0%
2003	0.1%	0.2%	N/A	0.6%	N/A	0.0%
2004	0.1%	0.6%	N/A	0.4%	N/A	0.0%
2005	0.0%	0.1%	N/A	0.9%	N/A	0.0%
2006	0.0%	0.2%	N/A	1.1%	N/A	0.0%
2007	0.0%	0.4%	N/A	1.1%	N/A	0.0%

Aggregate Analysis Appendix

May 5, 2008

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ATTACHMENTS

Overview of Information in the Aggregate Analysis Appendix

This appendix includes detailed quantitative results of prospective aggregate analyses for six interior Columbia River species: SR fall Chinook, SR spring/summer Chinook, SR steelhead, UCR spring Chinook, UCR steelhead, and MCR steelhead. The aggregate analyses represent the combination of the effects of the environmental baseline, Proposed Actions, and cumulative effects. As described for each species in the SCA, not all effects could be evaluated quantitatively, so a description of the combination of quantitative and qualitative effects is included in each species chapter (Sections 8.2-8.3 and 8.5-8.8).

In addition to the summary results presented in Sections 8.2-8.3 and 8.5-8.8 of the SCA, the tables in this appendix present the following additional prospective aggregate analysis results:

- *Survival gaps remaining after implementation of the prospective action.* Only the remaining survival gaps associated with 24-year extinction risk are displayed in Chapter 8 of the SCA.
- *Sensitivity analysis to three different future ocean climate scenarios, as described in SCA Section 7.1.1.* Multipliers used to adjust “recent” ocean climate scenario estimates to “warm PDO” and “historical” ocean climate scenario estimates are from Table 1 of ICTRT (2007c).
- *95% confidence limits for estimates (where possible), derived from the variance of the base period estimates.* Methods for R/S, lambda, and BRT trend confidence limit estimates are described in (McElhany and Payne 2006). Hinrichsen (2008), which is included as Attachment 1 of this Appendix, describes methods for confidence limits on extinction risk. ICTRT (2007c) describes methods for estimating the confidence limits on “intrinsic productivity.”
- Probability that median population growth rate (lambda) will be greater than 1.0, derived from the variance of the base period lambda estimate. The method for this calculation is described in (McElhany and Payne 2006).
- *Productivity estimates derived from an alternative base period of approximately 1990 to the present.* This alternative time period is described in the Metrics memo [NMFS 2006h]). Methods are identical to those used to calculate the same metrics derived from a longer (approximately 20 years) base period (Chapter 7.1).
- *ICTRT long-term viability survival gaps (5% risk) and the ICTRT’s “intrinsic productivity” metric, as described in SCA Section 7.1.1 and ICTRT (2007c),*
- *Remaining survival gaps apportioned to the FCRPS through the NWF v NMFS Remand Collaboration’s “Conceptual Framework” process.* Methods are

described in Framework Work Group (2006) and the FCRPS Action Agencies' August 2007 Comprehensive Analysis (CA), Section 3.1.3.2. Estimates of needed survival improvements allocated to the FCRPS are from Tables 4-9, 5-11, 7-10, 8-9, 9-11 and 10-10 of the CA. Those estimates rely on a range of FCRPS relative impacts from Framework Work Group (2006), applied to ICTRT long-term viability survival gaps (5% risk).

- *Alternative projection period of 100 years for extinction risk estimates (where possible), in response to comments.* Methods and results are from Hinrichsen (2008), which is included as Attachment 1 of this Appendix.
- *Figures comparing expected survival improvements with the survival gaps associated with alternative goals recommended in comments on the October 2007 Draft Biological Opinion.* These alternative metrics are: the ICTRT 5% risk criteria; NWF v NMFS Collaboration's "Conceptual Framework" allocation of the ICTRT's 5% risk gap; 5% extinction risk based on 100-year projections; R/S = 1.42; and Lambda = 1.08. These metrics are discussed above and in SCA Section 7.1.

Detailed methods and results of the extinction risk analysis conducted by Hinrichsen (2008) are included as Attachment 1 of this Appendix. Hinrichsen (2008) also contains alternative estimates of the variance associated with BRT trend and R/S, as described in Chapter 7.1.

Table 1. Detailed prospective survival gap estimates for Chinook salmon ESUs under recent ocean climate assumptions Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

PROSPECTIVE		Recent Climate															
			Survival Gap For Productivity ≥ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.82	1.24	0.54	0.94	2.07	0.43	0.70	3.51	0.14	1.10	4.79	0.53	0.76	>10	0.01
		Asotin - Functionally Extirpated															
	Grande Ronde / Imnaha	Catherine Creek	1.08	2.08	0.56	0.49	0.80	0.30	0.66	3.00	0.14	1.20	8.52	0.26	0.44	1.48	0.13
		Lostine/Wallowa Rivers	0.94	1.66	0.54	0.57	1.00	0.33	0.60	2.10	0.17	0.88	3.95	0.52	0.85	1.46	0.50
		Minam River	0.74	1.26	0.43	0.68	1.12	0.41	0.47	1.47	0.15	0.64	2.76	0.51	0.60	1.35	0.27
		Imnaha River	1.20	1.76	0.82	1.13	2.20	0.58	0.71	2.80	0.18	1.45	4.34	0.66	0.43	0.51	0.37
		Wenaha River	0.78	1.27	0.48	0.68	1.04	0.44	0.43	1.45	0.13	0.72	3.62	0.38	0.49	1.98	0.12
		Upper Grande Ronde	1.44	2.54	0.81	1.17	1.96	0.70	0.59	1.49	0.23	1.16	5.03	0.42	0.49	1.10	0.22
		Big Sheep Creek - Functionally Extirpated															
		Lookingglass- Functionally Extirpated															
	South Fork Salmon	South Fork Salmon Mainstem	0.82	1.22	0.56	1.38	2.65	0.72	0.49	1.66	0.14	0.74	2.73	0.65	0.65	>10	0.00
		Secesh River	0.60	0.88	0.41	0.55	1.15	0.26	0.54	1.43	0.20	0.56	1.47	0.60	0.56	6.69	0.05
		East Fork S. Fork Salmon (including Johnson)	0.74	1.08	0.51	1.22	2.37	0.62	0.56	1.29	0.24	0.58	1.34	0.59	0.76	>10	0.00
		Little Salmon River (including Rapid R.)															
	Middle Fork Salmon	Big Creek	0.59	1.08	0.33	0.73	1.99	0.26	0.48	2.21	0.10	0.48	2.21	0.50	0.52	>10	0.00
		Bear Valley/Elk Creek	0.53	0.87	0.32	0.67	1.60	0.28	0.45	2.04	0.10	0.45	2.04	0.58	0.55	>10	0.00
		Marsh Creek	0.76	1.39	0.41	1.29	3.89	0.43	0.50	2.24	0.11	0.50	2.24	0.33	0.56	>10	0.00
		Sulphur Creek	0.74	1.60	0.34	1.79	6.51	0.49	0.53	4.00	0.07	0.53	4.00	0.55	1.04	>10	0.00
		Camas Creek	0.91	1.86	0.45	0.90	4.71	0.17	0.60	3.87	0.09	0.60	3.87	0.72	0.41	>10	0.00
		Loon Creek	0.65	1.34	0.31	0.70	1.60	0.31									
		Chamberlain Creek															
		Lower Middle Fork Salmon (below Ind. Cr.)															
		Upper Middle Fork Salmon (above Ind. Cr.)															
	Upper Salmon	Lemhi River	0.62	1.06	0.36	0.51	1.25	0.21	0.60	4.23	0.08	0.60	4.23	0.67	0.47	>10	0.00
		Valley Creek	0.66	1.16	0.38	0.61	1.47	0.25	0.52	3.07	0.09	0.52	3.07	0.55	0.38	>10	0.00
		Yankee Fork	0.91	1.95	0.43	1.33	6.19	0.29	0.42	3.31	0.05	0.42	3.31	0.55	0.40	>10	0.00
		Upper Salmon River (above Redfish L.)	0.42	0.75	0.23	0.39	0.91	0.17	0.53	2.50	0.11	0.69	3.25	0.61	0.56	>10	0.01
		North Fork Salmon River															
		Lower Salmon River (below Redfish L.)	0.59	0.94	0.37	0.39	0.75	0.20	0.62	2.41	0.16	0.62	2.41	0.64	0.59	6.42	0.05
		East Fork Salmon River	0.67	1.31	0.34	0.38	1.01	0.14	0.58	3.60	0.09	0.66	4.54	0.71	0.52	>10	0.01
		Pahsimeroi River	1.00	2.33	0.43	0.39	0.62	0.25									
		Panther - Extirpated															
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.86	1.39	0.53	1.14	2.94	0.44	0.79	6.14	0.10	0.99	6.09	0.56	0.85	>10	0.00
		Methow R.	0.74	1.29	0.42	2.07	6.86	0.62	0.48	5.85	0.04	0.70	6.08	0.54	0.95	>10	0.00
		Entiat R.	0.70	1.03	0.48	0.84	1.80	0.39	0.57	2.18	0.15	0.72	2.38	0.45	0.68	>10	0.00
		Okanogan R. (extirpated)															
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	1.08	1.74	0.66				0.55	1.22	0.25	1.02	2.20	0.48			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	1.01	1.64	0.62				0.52	1.15	0.23	0.96	2.06	0.45			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest				0.73	0.97	0.54							0.43	1.50	0.12
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest				0.68	0.91	0.51							0.40	1.41	0.12

Table 1. Continued.

PROSPECTIVE		Recent Climate														
			Productivity ≥ 1.0			TRT Gap			Framework Gap		Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Adjusted 25% Gap	Adjusted 5% Gap	Adjusted 1% Gap	High	Low	1980-current trend	1980-current trend Upper95	1980-current trend Lower95	1990-current trend (not b-t-c adjusted)	1990-current trend Upper95	1990-current trend Lower95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.57	>10	0.02	0.89	1.33	2.07	0.87	0.75	0.88	1.25	0.62	0.74	1.57	0.31
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	0.74	5.65	0.10	0.62	0.93	1.45	0.91	0.67	0.67	0.87	0.51	0.39	0.63	0.24
		Lostine/Wallowa Rivers	1.51	7.60	0.30	0.71	1.08	1.34	1.12	0.91	0.65	0.82	0.51	0.42	0.58	0.30
		Minam River	0.80	3.96	0.16	0.88	1.20	1.74	0.83	0.72	0.54	0.66	0.44	0.51	0.76	0.34
		Imnaha River	0.68	1.28	0.36	0.82	1.22	1.90	1.16	0.95	0.78	0.95	0.63	0.56	0.83	0.38
		Wenaha River	0.75	5.38	0.11	0.75	1.15	1.80	1.00	0.78	0.43	0.54	0.34	0.39	0.56	0.27
		Upper Grande Ronde				0.72	1.11	1.73	1.03	0.71	0.68	0.86	0.54	0.72	1.25	0.42
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	1.17	>10	0.00	0.73	0.94	1.37	1.06	0.92	0.56	0.67	0.47	0.60	0.94	0.37
		Secesh River	0.59	6.94	0.05	0.75	1.03	1.62	1.02	0.89	0.58	0.69	0.49	0.51	0.77	0.34
		East Fork S. Fork Salmon (including Johnson)	0.81	>10	0.00	0.93	1.68	1.94	0.99	0.87	0.65	0.81	0.52	0.70	1.33	0.37
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	0.52	>10	0.00	0.78	1.67	1.88	1.10	0.93	0.66	0.92	0.47	0.47	1.03	0.21
		Bear Valley/Elk Creek	0.55	>10	0.00	0.73	1.19	1.43	0.88	0.82	0.57	0.78	0.42	0.45	0.98	0.21
		Marsh Creek	0.56	>10	0.00	0.90	1.58	3.42	1.42	1.10	0.70	1.04	0.47	0.61	1.97	0.19
		Sulphur Creek	1.04	>10	0.00	0.87	1.73	3.29	1.33	1.06	0.65	0.96	0.44	0.85	2.22	0.33
		Camas Creek	0.41	>10	0.00	1.02	1.91	4.16	1.32	1.05	0.73	1.01	0.53	0.41	0.87	0.20
		Loon Creek				0.86	1.50	3.26	1.39	1.09	0.54	0.78	0.37	0.33	0.98	0.11
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	0.47	>10	0.00	0.80	1.36	1.49	0.88	0.77	0.72	0.96	0.55	0.48	0.91	0.25
		Valley Creek	0.38	>10	0.00	0.84	1.47	3.18	1.21	0.97	0.62	0.86	0.45	0.41	0.79	0.21
		Yankee Fork	0.40	>10	0.00	0.96	1.80	3.91	1.15	0.88	0.45	0.68	0.30	0.39	1.06	0.15
		Upper Salmon River (above Redfish L.)	0.77	>10	0.02	0.63	0.90	1.06	0.86	0.71	0.61	0.78	0.48	0.48	0.79	0.28
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	0.59	6.42	0.05	0.77	1.67	1.79	1.53	1.07	0.70	0.88	0.56	0.54	0.86	0.35
		East Fork Salmon River	0.61	>10	0.01	0.84	1.29	1.52	0.82	0.78	0.68	0.96	0.49	0.41	0.79	0.22
		Pahsimeroi River				1.04	1.49	2.16	1.36	0.75						
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.30	>10	0.00	0.89	1.11	1.31	0.87	0.78	1.08	1.46	0.80	0.88	2.00	0.38
		Methow R.	1.63	>10	0.00	0.85	1.09	1.48	0.66	0.60	0.87	1.48	0.51	1.31	6.64	0.26
		Entiat R.	0.91	>10	0.00	0.89	1.23	1.54	0.67	0.60	0.69	0.86	0.55	0.67	1.28	0.35
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				0.90	1.02	1.11	1.00	0.92	0.54	0.63	0.46			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				0.85	0.96	1.04	0.94	0.87	0.51	0.59	0.44			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	0.88	2.58	0.30	0.90	0.92	1.07	1.08	1.01				0.35	0.46	0.27
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	0.83	2.42	0.29	0.85	0.86	1.01	1.02	0.95				0.33	0.43	0.25

Table 1. Continued.

PROSPECTIVE		Recent Climate																
			Gap For 24- Year Extinction ≤ 5%								Gap For 100- Year Extinction ≤ 5%							
			Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions				Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions			
ESU	**MPG**	**Population**	**Gap (QET=1)**	**Gap (QET=10)**	**Gap (QET=30)**	**Gap (QET=50)**	**Gap (QET=1)**	**Gap (QET=10)**	**Gap (QET=30)**	**Gap (QET=50)**	**Gap (QET=1)**	**Gap (QET=10)**	**Gap (QET=30)**	**Gap (QET=50)**	**Gap (QET=1)**	**Gap (QET=10)**	**Gap (QET=30)**	**Gap (QET=50)**
Snake River Spring/ Summer Chinook Salmon	**Lower Snake**	Tucannon	0.26	0.46	0.69	0.90	0.20	0.34	0.51	0.67	0.46	0.69	0.98	1.27	0.34	0.51	0.73	0.95
		Asotin - Functionally Extirpated																
	Grande Ronde / Imnaha	Catherine Creek	0.85	1.45	2.04	2.57	0.60	1.02	1.44	1.82	1.76	2.61	3.69	4.62	1.24	1.85	2.61	3.27
		Lostine/Wallowa Rivers	0.39	0.69	1.01	1.27	0.33	0.59	0.86	1.09	0.79	1.17	1.65	2.10	0.67	1.00	1.41	1.79
		Minam River	0.18	0.34	0.54	0.72	0.16	0.29	0.47	0.63	0.34	0.52	0.77	1.02	0.29	0.45	0.67	0.89
		Imnaha River	0.34	0.57	0.79	0.97	0.29	0.49	0.68	0.83	0.70	0.94	1.23	1.48	0.60	0.81	1.06	1.28
		Wenaha River	0.33	0.57	0.82	1.02	0.28	0.49	0.71	0.89	0.65	0.91	1.26	1.56	0.56	0.79	1.10	1.36
		Upper Grande Ronde	0.36	0.73	1.23	1.74	0.26	0.52	0.87	1.23	0.60	1.08	1.71	2.42	0.42	0.76	1.21	1.71
		Big Sheep Creek - Functionally Extirpated																
		Lookingglass- Functionally Extirpated																
	South Fork Salmon	South Fork Salmon Mainstem	0.13	0.22	0.31	0.37	0.11	0.19	0.26	0.32	0.27	0.35	0.41	0.49	0.24	0.30	0.36	0.42
		Secesh River	0.26	0.43	0.57	0.70	0.23	0.37	0.49	0.60	0.54	0.69	0.84	0.97	0.46	0.59	0.72	0.83
		East Fork S. Fork Salmon (including Johnson)	0.32	0.52	0.67	0.78	0.28	0.45	0.58	0.68	0.70	0.83	0.94	1.04	0.60	0.72	0.82	0.91
		Little Salmon River (including Rapid R.)																
	Middle Fork Salmon	Big Creek	0.35	0.79	1.52	2.23	0.30	0.68	1.31	1.92	0.67	1.37	2.63	3.87	0.58	1.18	2.27	3.33
		Bear Valley/Elk Creek	0.22	0.44	0.74	1.04	0.19	0.38	0.65	0.91	0.42	0.71	1.17	1.65	0.37	0.62	1.01	1.43
		Marsh Creek	0.74	1.51	2.57	3.54	0.64	1.31	2.24	3.08	1.54	2.75	4.59	6.32	1.34	2.39	3.99	5.50
		Sulphur Creek	0.24	0.88	2.20	3.52	0.21	0.76	1.91	3.06	0.43	1.52	3.87	6.31	0.37	1.32	3.37	5.49
		Camas Creek																
		Loon Creek																
		Chamberlain Creek																
		Lower Middle Fork Salmon (below Ind. Cr.)																
		Upper Middle Fork Salmon (above Ind. Cr.)																
	Upper Salmon	Lemhi River																
		Valley Creek	0.26	1.05	2.70	4.42	0.23	0.91	2.33	3.81	0.47	1.80	4.53	7.49	0.40	1.55	3.90	6.45
		Yankee Fork																
		Upper Salmon River (above Redfish L.)	0.06	0.17	0.39	0.61	0.04	0.13	0.30	0.46	0.09	0.25	0.56	0.89	0.07	0.19	0.43	0.68
		North Fork Salmon River																
		Lower Salmon River (below Redfish L.)	0.16	0.47	1.13	1.80	0.13	0.40	0.97	1.55	0.26	0.73	1.78	2.82	0.23	0.63	1.53	2.43
		East Fork Salmon River																
		Pahsimeroi River																
		Panther - Extirpated																
Upper Columbia Spring Chinook	**Eastern Cascades**	Wenatchee R.	0.10	0.23	0.38	0.51	0.08	0.19	0.31	0.42	0.36	0.65	1.08	1.45	0.29	0.53	0.88	1.19
		Methow R.																
		Entiat R.	0.24	0.46	0.76	1.08	0.16	0.32	0.52	0.74	0.41	0.68	1.13	1.57	0.28	0.46	0.77	1.07
		Okanogan R. (extirpated)																
Snake River Fall Chinook Salmon	**Main Stem and Lower Tributaries**	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest																
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest																

Table 2. Detailed prospective productivity estimates for Chinook salmon ESUs under recent ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

PROSPECTIVE		Recent Climate																		
			Productivity																	
ESU	MPG	Population	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Upper 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.33	0.99	1.77	1.22	0.81	1.84	1.06	0.48	2.34	1.08	0.76	1.55	0.71	0.98	0.71	1.36	0.43
		Asotin - Functionally Extirpated																	
	Grande Ronde / Imnaha	Catherine Creek	1.90	1.30	2.77	0.93	0.48	1.79	2.04	1.25	3.33	1.10	0.78	1.54	0.76	0.96	0.62	1.49	0.41
		Lostine/Wallowa Rivers	1.15	0.79	1.69	1.06	0.60	1.86	1.74	1.00	3.03	1.12	0.85	1.48	0.84	1.03	0.74	1.44	0.59
		Minam River	1.73	1.21	2.46	1.36	0.79	2.32	1.48	0.89	2.45	1.18	0.92	1.52	0.93	1.10	0.80	1.53	0.78
		Imnaha River	1.12	0.91	1.38	0.83	0.57	1.23	0.88	0.46	1.71	1.08	0.80	1.47	0.74	0.92	0.72	1.17	0.20
		Wenaha River	1.42	1.02	1.99	1.28	0.79	2.08	1.48	0.96	2.27	1.21	0.92	1.58	0.94	1.08	0.75	1.54	0.70
		Upper Grande Ronde	0.90	0.57	1.42	0.70	0.39	1.23	0.85	0.51	1.43	1.13	0.92	1.39	0.91	0.97	0.70	1.34	0.40
		Big Sheep Creek - Functionally Extirpated																	
		Lookingglass- Functionally Extirpated																	
	South Fork Salmon	South Fork Salmon Mainstem	1.68	1.18	2.39	1.21	0.82	1.79	0.72	0.38	1.38	1.17	0.89	1.54	0.92	1.07	0.80	1.43	0.74
		Secesh River	1.69	1.34	2.13	1.68	1.14	2.47	1.83	0.87	3.85	1.15	0.92	1.43	0.92	1.14	0.92	1.41	0.92
		East Fork S. Fork Salmon (including Johns	1.43	0.88	2.33	1.35	0.93	1.96	0.82	0.42	1.60	1.14	0.94	1.37	0.94	1.13	0.94	1.36	0.93
		Little Salmon River (including Rapid R.)																	
	Middle Fork Salmon	Big Creek	1.71	1.19	2.46	1.69	0.93	3.07	1.38	0.50	3.78	1.18	0.84	1.65	0.87	1.18	0.84	1.65	0.87
		Bear Valley/Elk Creek	2.02	1.48	2.77	1.88	1.14	3.08	1.49	0.62	3.54	1.19	0.85	1.66	0.90	1.19	0.85	1.66	0.90
		Marsh Creek	1.41	0.94	2.11	1.32	0.72	2.43	0.77	0.26	2.34	1.17	0.84	1.63	0.88	1.17	0.84	1.63	0.88
		Sulphur Creek	3.29	1.86	5.80	1.35	0.62	2.90	0.56	0.15	2.03	1.15	0.73	1.80	0.81	1.15	0.73	1.80	0.81
		Camas Creek	1.15	0.66	1.99	1.10	0.54	2.25	1.11	0.21	5.84	1.12	0.74	1.69	0.75	1.12	0.74	1.69	0.75
		Loon Creek	1.47	0.85	2.54	1.55	0.75	3.21	1.42	0.63	3.24	1.20	0.85	1.70	0.89	1.20	0.85	1.70	0.89
		Chamberlain Creek																	
		Lower Middle Fork Salmon (below Ind. Cr.)																	
		Upper Middle Fork Salmon (above Ind. Cr.)																	
	Upper Salmon	Lemhi River	1.60	1.03	2.50	1.61	0.94	2.75	1.96	0.80	4.76	1.12	0.73	1.73	0.77	1.12	0.73	1.73	0.77
		Valley Creek	1.51	0.99	2.29	1.51	0.86	2.64	1.64	0.68	3.95	1.15	0.78	1.71	0.84	1.15	0.78	1.71	0.84
		Yankee Fork	1.24	0.71	2.14	1.09	0.51	2.33	0.75	0.16	3.49	1.21	0.77	1.91	0.86	1.21	0.77	1.91	0.86
		Upper Salmon River (above Redfish L.)	2.40	1.64	3.51	2.40	1.34	4.33	2.57	1.10	6.00	1.15	0.82	1.62	0.84	1.08	0.77	1.53	0.73
		North Fork Salmon River																	
		Lower Salmon River (below Redfish L.)	1.71	1.26	2.33	1.70	1.06	2.71	2.56	1.33	4.94	1.11	0.82	1.51	0.81	1.11	0.82	1.51	0.81
		East Fork Salmon River	1.51	0.95	2.41	1.50	0.77	2.93	2.63	0.99	6.98	1.13	0.75	1.69	0.77	1.10	0.71	1.69	0.71
		Pahsimeroi River	1.06	0.56	2.02	1.00	0.43	2.33	2.56	1.62	4.05								
		Panther - Extirpated																	
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.45	0.88	2.41	1.17	0.72	1.90	0.87	0.34	2.25	1.05	0.67	1.67	0.63	1.00	0.67	1.50	0.51
		Methow R.	1.49	0.96	2.32	1.36	0.78	2.37	0.48	0.15	1.60	1.17	0.68	2.04	0.79	1.08	0.67	1.75	0.68
		Entiat R.	2.06	1.46	2.92	1.42	0.97	2.09	1.19	0.56	2.56	1.13	0.84	1.53	0.86	1.08	0.82	1.40	0.78
		Okanogan R. (extirpated)																	
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				1.01	0.57	1.51				1.14	0.96	1.37	0.95	0.99	0.84	1.18	0.47
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				1.07	0.61	1.60				1.16	0.97	1.38	0.96	1.01	0.85	1.20	0.55
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest							1.38	1.03	1.84								
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest							1.47	1.10	1.95								

Table 2. Continued.

PROSPECTIVE		Recent Climate														
			Productivity								BRT Trend					
ESU	MPG	Population	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	1980-current trend	1980-current trend Lower95	1980-current trend Upper95	1990-current trend	1990-current trend Lower95	1990-current trend Upper95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.06	0.37	3.04	0.59	0.90	0.34	2.41	0.35	1.03	0.95	1.11	1.08	0.90	1.30
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	1.20	0.92	1.57	0.95	1.07	0.68	1.68	0.71	1.09	1.03	1.16	1.23	1.11	1.38
		Lostine/Wallowa Rivers	1.17	0.86	1.60	0.92	1.07	0.69	1.65	0.71	1.10	1.05	1.16	1.21	1.13	1.31
		Minam River	1.12	0.94	1.34	0.94	1.05	0.74	1.50	0.69	1.15	1.10	1.20	1.16	1.06	1.27
		Imnaha River	1.13	0.60	2.12	0.76	0.88	0.48	1.59	0.22	1.06	1.01	1.11	1.14	1.04	1.24
		Wenaha River	1.20	1.16	1.25	1.00	1.09	0.94	1.25	0.94	1.21	1.15	1.27	1.23	1.14	1.34
		Upper Grande Ronde	1.08	0.96	1.22	0.95	0.95	0.66	1.36	0.31	1.09	1.03	1.15	1.07	0.95	1.22
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	1.10	0.15	7.88	0.68	0.97	0.13	6.97	0.43	1.14	1.09	1.18	1.12	1.01	1.24
		Secesh River	1.14	0.66	1.97	0.79	1.13	0.65	1.95	0.77	1.13	1.09	1.17	1.16	1.06	1.27
		East Fork S. Fork Salmon (including Johns	1.06	0.23	4.97	0.65	1.05	0.23	4.71	0.62	1.10	1.05	1.16	1.08	0.94	1.25
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	1.16	0.10	>10	0.70	1.16	0.10	>10	0.70	1.10	1.02	1.18	1.18	0.99	1.41
		Bear Valley/Elk Creek	1.14	0.11	>10	0.70	1.14	0.11	>10	0.70	1.13	1.06	1.21	1.19	1.00	1.42
		Marsh Creek	1.14	0.12	>10	0.70	1.14	0.12	>10	0.70	1.08	0.99	1.19	1.11	0.86	1.44
		Sulphur Creek	0.99	0.11	9.35	0.49	0.99	0.11	9.35	0.49	1.10	1.01	1.20	1.04	0.84	1.28
		Camas Creek	1.22	0.05	>10	0.71	1.22	0.05	>10	0.71	1.07	1.00	1.15	1.22	1.03	1.44
		Loon Creek									1.15	1.06	1.24	1.28	1.01	1.64
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	1.18	0.24	5.76	0.80	1.18	0.24	5.76	0.80	1.07	1.01	1.14	1.18	1.02	1.36
		Valley Creek	1.24	0.22	6.83	0.82	1.24	0.22	6.83	0.82	1.11	1.04	1.19	1.22	1.05	1.41
		Yankee Fork	1.23	0.03	>10	0.70	1.23	0.03	>10	0.70	1.19	1.09	1.31	1.23	0.99	1.53
		Upper Salmon River (above Redfish L.)	1.14	0.50	2.59	0.71	1.06	0.46	2.42	0.61	1.11	1.06	1.18	1.18	1.05	1.32
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	1.12	0.66	1.91	0.78	1.12	0.66	1.91	0.78	1.08	1.03	1.14	1.14	1.03	1.27
		East Fork Salmon River	1.16	0.47	2.86	0.72	1.11	0.42	2.95	0.66	1.09	1.01	1.17	1.22	1.05	1.41
		Pahsimeroi River														
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.04	0.02	>10	0.54	0.94	0.03	>10	0.43	0.98	0.92	1.05	1.03	0.86	1.24
		Methow R.	1.01	0.01	>10	0.51	0.90	0.01	>10	0.40	1.03	0.92	1.16	0.94	0.66	1.35
		Entiat R.	1.09	0.07	>10	0.62	1.02	0.09	>10	0.53	1.09	1.03	1.14	1.09	0.95	1.26
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest									1.15	1.11	1.19			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest									1.16	1.13	1.20			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	1.21	0.91	1.59	0.95	1.03	0.81	1.30	0.67				1.26	1.19	1.34
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	1.22	0.93	1.62	0.96	1.04	0.82	1.32	0.74				1.28	1.20	1.35

Table 3. Detailed prospective survival gap estimates for Chinook salmon ESUs under warm PDO (poor) ocean climate assumptions. Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

PROSPECTIVE		Warm PDO (Poor) Climate															
			Survival Gap For Productivity ≥ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.93	1.41	0.62	1.07	2.36	0.48	0.80	3.99	0.16	1.25	5.44	0.60	0.86	>10	0.01
		Asotin - Functionally Extirpated															
	Grande Ronde / Imnaha	Catherine Creek	1.22	2.37	0.63	0.56	0.91	0.34	0.75	3.41	0.16	1.36	9.68	0.29	0.50	1.69	0.15
		Lostine/Wallowa Rivers	1.07	1.88	0.61	0.65	1.14	0.38	0.68	2.39	0.19	1.00	4.49	0.59	0.97	1.65	0.57
		Minam River	0.84	1.43	0.49	0.77	1.28	0.46	0.54	1.67	0.17	0.73	3.13	0.57	0.68	1.53	0.30
		Imnaha River	1.36	2.00	0.93	1.29	2.50	0.66	0.80	3.18	0.20	1.65	4.93	0.75	0.49	0.59	0.42
		Wenaha River	0.89	1.44	0.55	0.77	1.18	0.50	0.49	1.64	0.14	0.82	4.12	0.43	0.56	2.25	0.14
		Upper Grande Ronde	1.63	2.89	0.92	1.33	2.23	0.79	0.67	1.69	0.26	1.32	5.72	0.47	0.55	1.25	0.25
		Big Sheep Creek - Functionally Extirpated															
		Lookingglass- Functionally Extirpated															
	South Fork Salmon	South Fork Salmon Mainstem	0.94	1.38	0.63	1.57	3.01	0.82	0.56	1.88	0.16	0.84	3.10	0.74	0.73	>10	0.00
		Secesh River	0.68	1.00	0.46	0.62	1.30	0.29	0.61	1.63	0.23	0.63	1.66	0.68	0.64	7.61	0.05
		East Fork S. Fork Salmon (including Johnson)	0.84	1.22	0.58	1.38	2.70	0.71	0.63	1.47	0.27	0.66	1.52	0.67	0.87	>10	0.00
		Little Salmon River (including Rapid R.)															
	Middle Fork Salmon	Big Creek	0.67	1.22	0.37	0.82	2.26	0.30	0.54	2.51	0.12	0.54	2.51	0.57	0.59	>10	0.00
		Bear Valley/Elk Creek	0.60	0.99	0.37	0.76	1.82	0.32	0.52	2.32	0.11	0.52	2.32	0.65	0.63	>10	0.00
		Marsh Creek	0.86	1.58	0.47	1.47	4.42	0.49	0.56	2.55	0.13	0.56	2.55	0.38	0.64	>10	0.00
		Sulphur Creek	0.84	1.82	0.39	2.04	7.39	0.56	0.60	4.55	0.08	0.60	4.55	0.63	1.18	>10	0.00
		Camas Creek	1.03	2.11	0.51	1.02	5.35	0.19	0.69	4.40	0.11	0.69	4.40	0.82	0.47	>10	0.00
		Loon Creek	0.73	1.52	0.35	0.80	1.82	0.35									
		Chamberlain Creek															
		Lower Middle Fork Salmon (below Ind. Cr.)															
		Upper Middle Fork Salmon (above Ind. Cr.)															
	Upper Salmon	Lemhi River	0.71	1.21	0.41	0.58	1.42	0.24	0.68	4.80	0.10	0.68	4.80	0.76	0.54	>10	0.00
		Valley Creek	0.75	1.32	0.43	0.69	1.67	0.29	0.59	3.49	0.10	0.59	3.49	0.62	0.44	>10	0.00
		Yankee Fork	1.04	2.22	0.49	1.51	7.03	0.33	0.48	3.76	0.06	0.48	3.76	0.63	0.45	>10	0.00
		Upper Salmon River (above Redfish L.)	0.47	0.85	0.26	0.44	1.03	0.19	0.60	2.84	0.13	0.79	3.69	0.69	0.64	>10	0.02
		North Fork Salmon River															
		Lower Salmon River (below Redfish L.)	0.67	1.07	0.42	0.44	0.85	0.23	0.70	2.74	0.18	0.70	2.74	0.72	0.67	7.29	0.06
		East Fork Salmon River	0.76	1.48	0.39	0.43	1.15	0.16	0.66	4.09	0.11	0.75	5.16	0.81	0.59	>10	0.01
		Pahsimeroi River	1.14	2.65	0.49	0.44	0.70	0.28									
		Panther - Extirpated															
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.88	1.43	0.54	1.18	3.04	0.46	0.81	6.33	0.10	1.02	6.28	0.57	0.87	>10	0.00
		Methow R.	0.76	1.33	0.44	2.13	7.07	0.64	0.50	6.03	0.04	0.72	6.27	0.55	0.97	>10	0.00
		Entiat R.	0.72	1.06	0.49	0.87	1.86	0.40	0.59	2.25	0.15	0.74	2.45	0.47	0.70	>10	0.00
		Okanogan R. (extirpated)															
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	1.08	1.74	0.66				0.55	1.22	0.25	1.02	2.20	0.48			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	1.01	1.64	0.62				0.52	1.15	0.23	0.96	2.06	0.45			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest				0.73	0.97	0.54							0.43	1.50	0.12
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest				0.68	0.91	0.51							0.40	1.41	0.12

Table 3. Continued.

PROSPECTIVE		Warm PDO (Poor) Climate	Productivity ≥ 1.0			TRT Gap			Framework Gap		Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Adjusted 25% Gap	Adjusted 5% Gap	Adjusted 1% Gap	High	Low	1980-current trend	1980-current trend Upper95	1980-current trend Lower95	1990-current trend (not b-t-c adjusted)	1990-current trend Upper95	1990-current trend Lower95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.78	>10	0.02	1.01	1.51	2.35	0.98	0.86	1.00	1.42	0.70	0.84	1.78	0.35
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	0.84	6.43	0.11	0.71	1.05	1.65	1.04	0.76	0.76	0.99	0.58	0.44	0.71	0.27
		Lostine/Wallowa Rivers	1.71	8.64	0.34	0.81	1.23	1.52	1.27	1.04	0.74	0.93	0.58	0.48	0.66	0.34
		Minam River	0.91	4.50	0.18	1.01	1.36	1.98	0.95	0.82	0.62	0.75	0.50	0.58	0.86	0.39
		Imnaha River	0.77	1.45	0.41	0.93	1.39	2.16	1.32	1.08	0.88	1.07	0.72	0.64	0.95	0.43
		Wenaha River	0.86	6.11	0.12	0.85	1.31	2.05	1.13	0.89	0.49	0.61	0.39	0.44	0.64	0.30
		Upper Grande Ronde				0.81	1.26	1.97	1.18	0.81	0.77	0.97	0.61	0.82	1.42	0.47
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	1.33	>10	0.00	0.83	1.07	1.55	1.21	1.04	0.64	0.76	0.54	0.68	1.07	0.43
		Secesh River	0.67	7.88	0.06	0.85	1.17	1.84	1.16	1.02	0.66	0.78	0.55	0.58	0.87	0.39
		East Fork S. Fork Salmon (including Johnson)	0.92	>10	0.00	1.06	1.91	2.21	1.13	0.99	0.73	0.92	0.59	0.80	1.51	0.42
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	0.59	>10	0.00	0.88	1.89	2.14	1.25	1.06	0.75	1.05	0.54	0.54	1.17	0.24
		Bear Valley/Elk Creek	0.63	>10	0.00	0.83	1.35	1.63	1.00	0.93	0.65	0.89	0.48	0.51	1.12	0.23
		Marsh Creek	0.64	>10	0.00	1.02	1.79	3.88	1.61	1.26	0.79	1.18	0.53	0.70	2.24	0.22
		Sulphur Creek	1.18	>10	0.00	0.99	1.96	3.74	1.51	1.21	0.74	1.09	0.50	0.97	2.52	0.37
		Camas Creek	0.47	>10	0.00	1.16	2.18	4.73	1.50	1.20	0.83	1.15	0.60	0.47	0.98	0.22
		Loon Creek				0.98	1.70	3.70	1.58	1.24	0.62	0.89	0.43	0.37	1.11	0.12
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	0.54	>10	0.00	0.91	1.54	1.69	1.00	0.88	0.82	1.09	0.62	0.54	1.04	0.28
		Valley Creek	0.44	>10	0.00	0.96	1.67	3.62	1.37	1.11	0.71	0.97	0.51	0.47	0.90	0.24
		Yankee Fork	0.45	>10	0.00	1.09	2.04	4.44	1.31	1.00	0.51	0.77	0.34	0.45	1.21	0.17
		Upper Salmon River (above Redfish L.)	0.87	>10	0.02	0.72	1.03	1.20	0.98	0.81	0.70	0.88	0.55	0.54	0.90	0.32
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	0.67	7.29	0.06	0.87	1.90	2.03	1.74	1.22	0.79	1.00	0.63	0.62	0.98	0.39
		East Fork Salmon River	0.70	>10	0.01	0.95	1.47	1.73	0.94	0.88	0.78	1.09	0.55	0.47	0.90	0.24
		Pahsimeroi River				1.18	1.69	2.46	1.55	0.85						
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.34	>10	0.00	0.92	1.14	1.35	0.90	0.80	1.12	1.50	0.83	0.90	2.07	0.39
		Methow R.	1.68	>10	0.00	0.88	1.12	1.52	0.68	0.62	0.90	1.52	0.53	1.35	6.85	0.27
		Entiat R.	0.94	>10	0.00	0.91	1.27	1.59	0.69	0.62	0.71	0.89	0.57	0.69	1.32	0.36
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				0.90	1.02	1.11	1.00	0.92	0.54	0.63	0.46			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				0.85	0.96	1.04	0.94	0.87	0.51	0.59	0.44			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	0.88	2.58	0.30	0.90	0.92	1.07	1.08	1.01				0.35	0.46	0.27
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	0.83	2.42	0.29	0.85	0.86	1.01	1.02	0.95				0.33	0.43	0.25

Table 3. Continued.

PROSPECTIVE		Warm PDO (Poor) Climate																
			Gap For 24- Year Extinction ≤ 5%								Gap For 100- Year Extinction ≤ 5%							
			Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions				Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions			
ESU	MPG	Population	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.30	0.52	0.78	1.03	0.22	0.38	0.58	0.76	0.53	0.78	1.12	1.44	0.39	0.58	0.83	1.07
		Asotin - Functionally Extirpated																
	Grande Ronde / Imnaha	Catherine Creek	0.96	1.64	2.31	2.92	0.68	1.16	1.64	2.07	2.00	2.97	4.20	5.25	1.41	2.10	2.97	3.71
		Lostine/Wallowa Rivers	0.44	0.79	1.15	1.45	0.38	0.67	0.98	1.23	0.90	1.33	1.88	2.39	0.76	1.13	1.60	2.03
		Minam River	0.21	0.39	0.61	0.82	0.18	0.34	0.53	0.71	0.39	0.59	0.88	1.16	0.34	0.51	0.76	1.01
		Imnaha River	0.38	0.64	0.90	1.10	0.33	0.55	0.78	0.95	0.79	1.07	1.40	1.69	0.68	0.92	1.20	1.45
		Wenaha River	0.37	0.64	0.93	1.16	0.32	0.56	0.81	1.01	0.74	1.04	1.43	1.77	0.64	0.90	1.25	1.54
		Upper Grande Ronde	0.41	0.83	1.40	1.98	0.29	0.59	0.99	1.40	0.68	1.23	1.94	2.75	0.48	0.87	1.37	1.94
		Big Sheep Creek - Functionally Extirpated																
		Lookingglass- Functionally Extirpated																
	South Fork Salmon	South Fork Salmon Mainstem	0.15	0.25	0.35	0.42	0.13	0.22	0.30	0.36	0.31	0.40	0.47	0.55	0.27	0.34	0.40	0.48
		Secesh River	0.30	0.49	0.65	0.79	0.26	0.42	0.56	0.68	0.61	0.78	0.95	1.10	0.53	0.67	0.82	0.95
		East Fork S. Fork Salmon (including Johnson)	0.37	0.59	0.76	0.88	0.32	0.52	0.66	0.77	0.79	0.94	1.07	1.19	0.69	0.82	0.93	1.03
		Little Salmon River (including Rapid R.)																
	Middle Fork Salmon	Big Creek	0.40	0.90	1.73	2.54	0.34	0.78	1.49	2.19	0.76	1.55	2.99	4.40	0.66	1.34	2.58	3.79
		Bear Valley/Elk Creek	0.25	0.50	0.85	1.19	0.22	0.43	0.74	1.03	0.48	0.81	1.33	1.87	0.42	0.70	1.15	1.63
		Marsh Creek	0.84	1.71	2.92	4.03	0.73	1.49	2.54	3.50	1.75	3.12	5.22	7.19	1.52	2.72	4.54	6.25
		Sulphur Creek	0.27	1.00	2.50	4.00	0.24	0.87	2.18	3.48	0.49	1.73	4.40	7.18	0.43	1.50	3.83	6.24
		Camas Creek																
		Loon Creek																
		Chamberlain Creek																
		Lower Middle Fork Salmon (below Ind. Cr.)																
		Upper Middle Fork Salmon (above Ind. Cr.)																
	Upper Salmon	Lemhi River																
		Valley Creek	0.30	1.20	3.07	5.03	0.26	1.03	2.64	4.33	0.53	2.04	5.15	8.51	0.46	1.76	4.43	7.32
		Yankee Fork																
		Upper Salmon River (above Redfish L.)	0.07	0.20	0.44	0.69	0.05	0.15	0.34	0.53	0.10	0.28	0.64	1.01	0.08	0.21	0.49	0.77
		North Fork Salmon River																
		Lower Salmon River (below Redfish L.)	0.18	0.53	1.28	2.04	0.15	0.46	1.10	1.76	0.30	0.83	2.02	3.21	0.26	0.72	1.74	2.76
		East Fork Salmon River																
		Pahsimeroi River																
		Panther - Extirpated																
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.10	0.23	0.39	0.52	0.09	0.19	0.32	0.43	0.37	0.67	1.11	1.50	0.30	0.55	0.91	1.23
		Methow R.																
		Entiat R.	0.24	0.48	0.79	1.11	0.17	0.33	0.54	0.76	0.42	0.70	1.16	1.61	0.29	0.48	0.79	1.10
		Okanogan R. (extirpated)																
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest																
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest																

Table 4. Detailed prospective productivity estimates for Chinook salmon ESUs under warm PDO (poor) ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

PROSPECTIVE		Warm PDO (Poor) Climate																		
			Productivity																	
ESU	MPG	Population	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Upper 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.17	0.87	1.56	1.07	0.71	1.62	0.94	0.42	2.06	0.95	0.67	1.36	0.36	0.86	0.62	1.20	0.14	
		Asotin - Functionally Extirpated																		
	Grande Ronde / Imnaha	Catherine Creek	1.67	1.14	2.44	0.82	0.42	1.58	1.80	1.10	2.93	0.97	0.69	1.35	0.40	0.85	0.55	1.31	0.17	
		Lostine/Wallowa Rivers	1.01	0.69	1.49	0.93	0.53	1.64	1.53	0.88	2.67	0.99	0.75	1.30	0.45	0.91	0.65	1.26	0.23	
		Minam River	1.52	1.07	2.16	1.19	0.70	2.04	1.30	0.78	2.16	1.04	0.81	1.34	0.65	0.97	0.70	1.35	0.41	
		Imnaha River	0.99	0.80	1.21	0.73	0.50	1.08	0.78	0.40	1.51	0.95	0.70	1.29	0.34	0.81	0.64	1.03	0.04	
		Wenaha River	1.25	0.90	1.75	1.13	0.69	1.83	1.30	0.85	2.00	1.06	0.81	1.39	0.72	0.95	0.66	1.35	0.35	
		Upper Grande Ronde	0.79	0.50	1.25	0.61	0.35	1.08	0.75	0.45	1.26	0.99	0.81	1.22	0.46	0.85	0.61	1.18	0.12	
		Big Sheep Creek - Functionally Extirpated																		
		Lookingglass- Functionally Extirpated																		
	South Fork Salmon	South Fork Salmon Mainstem	1.48	1.04	2.11	1.07	0.72	1.58	0.64	0.33	1.22	1.03	0.79	1.35	0.63	0.94	0.70	1.26	0.28	
		Secesh River	1.49	1.18	1.87	1.47	1.00	2.17	1.61	0.77	3.39	1.01	0.81	1.25	0.55	1.00	0.81	1.24	0.51	
		East Fork S. Fork Salmon (including Johns	1.26	0.77	2.05	1.19	0.82	1.72	0.72	0.37	1.41	1.00	0.83	1.21	0.51	0.99	0.82	1.19	0.45	
		Little Salmon River (including Rapid R.)																		
	Middle Fork Salmon	Big Creek	1.51	1.05	2.17	1.49	0.82	2.70	1.21	0.44	3.32	1.04	0.74	1.45	0.61	1.04	0.74	1.45	0.61	
		Bear Valley/Elk Creek	1.78	1.30	2.44	1.65	1.01	2.71	1.31	0.55	3.11	1.05	0.75	1.46	0.66	1.05	0.75	1.46	0.66	
		Marsh Creek	1.24	0.83	1.86	1.16	0.63	2.13	0.68	0.23	2.06	1.03	0.74	1.44	0.60	1.03	0.74	1.44	0.60	
		Sulphur Creek	2.89	1.64	5.10	1.18	0.55	2.56	0.49	0.14	1.78	1.01	0.65	1.59	0.54	1.01	0.65	1.59	0.54	
		Camas Creek	1.01	0.58	1.75	0.97	0.47	1.98	0.98	0.19	5.14	0.98	0.65	1.49	0.46	0.98	0.65	1.49	0.46	
		Loon Creek	1.29	0.75	2.24	1.36	0.66	2.82	1.25	0.55	2.85	1.06	0.75	1.49	0.66	1.06	0.75	1.49	0.66	
		Chamberlain Creek																		
		Lower Middle Fork Salmon (below Ind. Cr.)																		
		Upper Middle Fork Salmon (above Ind. Cr.)																		
	Upper Salmon	Lemhi River	1.41	0.91	2.20	1.42	0.83	2.42	1.72	0.71	4.19	0.99	0.64	1.53	0.47	0.99	0.64	1.53	0.47	
		Valley Creek	1.33	0.87	2.02	1.33	0.76	2.32	1.44	0.60	3.48	1.02	0.69	1.51	0.55	1.02	0.69	1.51	0.55	
		Yankee Fork	1.09	0.63	1.88	0.96	0.45	2.05	0.66	0.14	3.07	1.07	0.67	1.68	0.66	1.07	0.67	1.68	0.66	
		Upper Salmon River (above Redfish L.)	2.11	1.44	3.09	2.12	1.18	3.81	2.26	0.97	5.28	1.01	0.72	1.43	0.54	0.95	0.68	1.34	0.36	
		North Fork Salmon River																		
		Lower Salmon River (below Redfish L.)	1.51	1.11	2.05	1.49	0.94	2.39	2.26	1.17	4.35	0.98	0.72	1.33	0.43	0.98	0.72	1.33	0.43	
		East Fork Salmon River	1.33	0.84	2.12	1.32	0.67	2.58	2.32	0.87	6.14	0.99	0.66	1.49	0.48	0.97	0.63	1.48	0.42	
		Pahsimeroi River	0.93	0.49	1.77	0.88	0.38	2.05	2.25	1.42	3.57									
		Panther - Extirpated																		
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.41	0.85	2.34	1.13	0.70	1.84	0.85	0.33	2.18	0.93	0.59	1.47	0.32	0.88	0.59	1.32	0.20	
		Methow R.	1.45	0.93	2.25	1.32	0.75	2.30	0.47	0.14	1.55	1.03	0.59	1.80	0.57	0.95	0.59	1.54	0.39	
		Entiat R.	2.00	1.41	2.83	1.38	0.94	2.03	1.16	0.54	2.48	1.00	0.74	1.34	0.49	0.95	0.73	1.24	0.28	
		Okanogan R. (extirpated)																		
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				1.01	0.57	1.51				1.14	0.96	1.37	0.95	0.99	0.84	1.18	0.47	
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				1.07	0.61	1.60				1.16	0.97	1.38	0.96	1.01	0.85	1.20	0.55	
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest							1.38	1.03	1.84									
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest							1.47	1.10	1.95									

Table 4. Continued.

PROSPECTIVE		Warm PDO (Poor) Climate														
			Productivity								BRT Trend					
ESU	MPG	Population	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	1980-current trend	1980-current trend Lower95	1980-current trend Upper95	1990-current trend	1990-current trend Lower95	1990-current trend Upper95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.94	0.33	2.68	0.41	0.80	0.30	2.12	0.21	0.91	0.84	0.98	0.95	0.80	1.14
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	1.05	0.81	1.38	0.76	0.94	0.60	1.48	0.31	0.96	0.91	1.02	1.09	0.98	1.21
		Lostine/Wallowa Rivers	1.03	0.76	1.41	0.66	0.94	0.61	1.46	0.30	0.97	0.92	1.02	1.07	0.99	1.15
		Minam River	0.99	0.82	1.18	0.38	0.92	0.65	1.32	0.22	1.01	0.96	1.06	1.02	0.94	1.12
		Imnaha River	1.00	0.53	1.86	0.49	0.77	0.43	1.40	0.10	0.93	0.89	0.97	1.00	0.92	1.09
		Wenaha River	1.06	1.02	1.10	0.99	0.96	0.83	1.10	0.16	1.06	1.01	1.12	1.09	1.00	1.18
		Upper Grande Ronde	0.95	0.84	1.07	0.10	0.84	0.58	1.20	0.08	0.96	0.91	1.01	0.95	0.84	1.07
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	0.97	0.14	6.93	0.44	0.85	0.12	6.14	0.24	1.00	0.96	1.04	0.99	0.89	1.09
		Secesh River	1.00	0.58	1.73	0.50	0.99	0.57	1.71	0.47	0.99	0.96	1.03	1.02	0.93	1.12
		East Fork S. Fork Salmon (including Johns	0.93	0.20	4.37	0.34	0.92	0.20	4.15	0.31	0.97	0.92	1.02	0.95	0.83	1.10
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	1.02	0.08	>10	0.53	1.02	0.08	>10	0.53	0.97	0.90	1.04	1.04	0.87	1.24
		Bear Valley/Elk Creek	1.00	0.10	>10	0.51	1.00	0.10	>10	0.51	1.00	0.93	1.07	1.05	0.88	1.25
		Marsh Creek	1.00	0.11	9.18	0.50	1.00	0.11	9.18	0.50	0.95	0.87	1.04	0.98	0.76	1.27
		Sulphur Creek	0.87	0.09	8.22	0.29	0.87	0.09	8.22	0.29	0.97	0.89	1.05	0.91	0.74	1.13
		Camas Creek	1.07	0.04	>10	0.58	1.07	0.04	>10	0.58	0.94	0.88	1.01	1.07	0.91	1.26
		Loon Creek									1.01	0.93	1.09	1.13	0.88	1.44
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	1.04	0.21	5.07	0.60	1.04	0.21	5.07	0.60	0.95	0.89	1.01	1.04	0.90	1.20
		Valley Creek	1.09	0.20	6.01	0.68	1.09	0.20	6.01	0.68	0.98	0.91	1.05	1.07	0.93	1.24
		Yankee Fork	1.08	0.03	>10	0.59	1.08	0.03	>10	0.59	1.05	0.96	1.15	1.08	0.87	1.35
		Upper Salmon River (above Redfish L.)	1.00	0.44	2.28	0.50	0.93	0.41	2.13	0.38	0.98	0.93	1.03	1.04	0.93	1.16
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	0.99	0.58	1.68	0.47	0.99	0.58	1.68	0.47	0.95	0.91	1.00	1.01	0.91	1.11
		East Fork Salmon River	1.02	0.41	2.51	0.53	0.98	0.37	2.59	0.47	0.96	0.89	1.03	1.07	0.93	1.24
		Pahsimeroi River														
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.01	0.02	>10	0.51	0.91	0.03	>10	0.40	0.95	0.89	1.02	1.00	0.83	1.20
		Methow R.	0.98	0.01	>10	0.49	0.87	0.01	>10	0.37	1.00	0.89	1.13	0.91	0.64	1.31
		Entiat R.	1.06	0.07	>10	0.58	0.99	0.09	>10	0.48	1.05	1.00	1.11	1.06	0.92	1.23
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest									1.15	1.11	1.19			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest									1.16	1.13	1.20			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	1.21	0.91	1.59	0.95	1.03	0.81	1.30	0.67				1.26	1.19	1.34
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	1.22	0.93	1.62	0.96	1.04	0.82	1.32	0.74				1.28	1.20	1.35

Table 5. Detailed prospective survival gap estimates for Chinook salmon ESUs under historical ocean climate assumptions. Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

PROSPECTIVE		Historical Climate															
			Survival Gap For Productivity ≥ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.60	0.91	0.40	0.69	1.51	0.31	0.51	2.56	0.10	0.80	3.49	0.39	0.55	>10	0.00
		Asotin - Functionally Extirpated															
	Grande Ronde / Imnaha	Catherine Creek	0.79	1.52	0.41	0.36	0.58	0.22	0.48	2.19	0.10	0.87	6.22	0.19	0.32	1.08	0.10
		Lostine/Wallowa Rivers	0.69	1.21	0.39	0.42	0.73	0.24	0.44	1.53	0.12	0.64	2.88	0.38	0.62	1.06	0.36
		Minam River	0.54	0.92	0.32	0.49	0.82	0.30	0.35	1.08	0.11	0.47	2.01	0.37	0.44	0.98	0.19
		Imnaha River	0.88	1.29	0.60	0.83	1.60	0.43	0.51	2.05	0.13	1.06	3.16	0.48	0.32	0.38	0.27
		Wenaha River	0.57	0.93	0.35	0.49	0.76	0.32	0.31	1.06	0.09	0.53	2.64	0.28	0.36	1.44	0.09
		Upper Grande Ronde	1.05	1.86	0.59	0.85	1.43	0.51	0.43	1.09	0.17	0.85	3.67	0.30	0.36	0.80	0.16
		Big Sheep Creek - Functionally Extirpated															
		Lookingglass- Functionally Extirpated															
	South Fork Salmon	South Fork Salmon Mainstem	0.60	0.89	0.41	1.01	1.93	0.53	0.36	1.21	0.11	0.54	1.99	0.47	0.47	>10	0.00
		Secesh River	0.44	0.64	0.30	0.40	0.84	0.19	0.39	1.05	0.15	0.41	1.07	0.44	0.41	4.89	0.03
		East Fork S. Fork Salmon (including Johnson)	0.54	0.78	0.37	0.89	1.73	0.46	0.41	0.94	0.18	0.43	0.98	0.43	0.56	>10	0.00
		Little Salmon River (including Rapid R.)															
	Middle Fork Salmon	Big Creek	0.43	0.79	0.24	0.53	1.45	0.19	0.35	1.61	0.08	0.35	1.61	0.37	0.38	>10	0.00
		Bear Valley/Elk Creek	0.39	0.64	0.24	0.49	1.17	0.21	0.33	1.49	0.07	0.33	1.49	0.42	0.41	>10	0.00
		Marsh Creek	0.55	1.01	0.30	0.94	2.84	0.31	0.36	1.64	0.08	0.36	1.64	0.24	0.41	>10	0.00
		Sulphur Creek	0.54	1.17	0.25	1.31	4.75	0.36	0.39	2.92	0.05	0.39	2.92	0.40	0.76	>10	0.00
		Camas Creek	0.66	1.35	0.33	0.66	3.44	0.12	0.44	2.83	0.07	0.44	2.83	0.53	0.30	>10	0.00
		Loon Creek	0.47	0.98	0.23	0.51	1.17	0.23									
		Chamberlain Creek															
		Lower Middle Fork Salmon (below Ind. Cr.)															
		Upper Middle Fork Salmon (above Ind. Cr.)															
	Upper Salmon	Lemhi River	0.45	0.78	0.27	0.37	0.91	0.15	0.44	3.08	0.06	0.44	3.08	0.49	0.35	>10	0.00
		Valley Creek	0.48	0.85	0.28	0.45	1.07	0.18	0.38	2.24	0.07	0.38	2.24	0.40	0.28	>10	0.00
		Yankee Fork	0.67	1.42	0.31	0.97	4.52	0.21	0.31	2.42	0.04	0.31	2.42	0.40	0.29	>10	0.00
		Upper Salmon River (above Redfish L.)	0.30	0.55	0.17	0.28	0.66	0.12	0.39	1.82	0.08	0.51	2.37	0.44	0.41	>10	0.01
		North Fork Salmon River															
		Lower Salmon River (below Redfish L.)	0.43	0.69	0.27	0.28	0.55	0.15	0.45	1.76	0.12	0.45	1.76	0.47	0.43	4.68	0.04
		East Fork Salmon River	0.49	0.95	0.25	0.28	0.74	0.10	0.42	2.63	0.07	0.48	3.31	0.52	0.38	>10	0.01
		Pahsimeroi River	0.73	1.70	0.31	0.29	0.45	0.18									
		Panther - Extirpated															
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.59	0.97	0.37	0.79	2.04	0.31	0.55	4.26	0.07	0.69	4.23	0.39	0.59	>10	0.00
		Methow R.	0.51	0.90	0.29	1.44	4.76	0.43	0.34	4.06	0.03	0.49	4.22	0.37	0.66	>10	0.00
		Entiat R.	0.49	0.72	0.33	0.58	1.25	0.27	0.40	1.51	0.10	0.50	1.65	0.31	0.47	>10	0.00
		Okanogan R. (extirpated)															
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	1.08	1.74	0.66				0.55	1.22	0.25	1.02	2.20	0.48			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	1.01	1.64	0.62				0.52	1.15	0.23	0.96	2.06	0.45			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest				0.73	0.97	0.54							0.43	1.50	0.12
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest				0.68	0.91	0.51							0.40	1.41	0.12

Table 5. Continued.

PROSPECTIVE		Historical Climate														
			Productivity ≥ 1.0			TRT Gap			Framework Gap		Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Adjusted 25% Gap	Adjusted 5% Gap	Adjusted 1% Gap	High	Low	1980-current trend	1980-current trend Upper95	1980-current trend Lower95	1990-current trend (not b-t-c adjusted)	1990-current trend Upper95	1990-current trend Lower95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.15	>10	0.01	0.65	0.97	1.51	0.63	0.55	0.64	0.91	0.45	0.54	1.15	0.23
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	0.54	4.13	0.07	0.46	0.68	1.06	0.67	0.49	0.49	0.63	0.37	0.28	0.46	0.17
		Lostine/Wallowa Rivers	1.10	5.55	0.22	0.52	0.79	0.98	0.82	0.67	0.47	0.60	0.37	0.31	0.42	0.22
		Minam River	0.59	2.89	0.12	0.65	0.87	1.27	0.61	0.53	0.40	0.48	0.32	0.37	0.55	0.25
		Imnaha River	0.49	0.93	0.26	0.60	0.89	1.39	0.85	0.69	0.57	0.69	0.46	0.41	0.61	0.28
		Wenaha River	0.55	3.93	0.08	0.54	0.84	1.32	0.73	0.57	0.31	0.39	0.25	0.28	0.41	0.20
		Upper Grande Ronde				0.52	0.81	1.26	0.76	0.52	0.50	0.63	0.39	0.53	0.91	0.30
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	0.85	>10	0.00	0.54	0.69	1.00	0.78	0.67	0.41	0.49	0.35	0.43	0.69	0.27
		Secesh River	0.43	5.06	0.04	0.55	0.75	1.18	0.75	0.65	0.42	0.50	0.35	0.37	0.56	0.25
		East Fork S. Fork Salmon (including Johnson)	0.59	>10	0.00	0.68	1.22	1.42	0.72	0.64	0.47	0.59	0.38	0.51	0.97	0.27
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	0.38	>10	0.00	0.57	1.22	1.37	0.80	0.68	0.48	0.67	0.34	0.34	0.75	0.16
		Bear Valley/Elk Creek	0.41	>10	0.00	0.54	0.87	1.05	0.64	0.60	0.42	0.57	0.31	0.33	0.72	0.15
		Marsh Creek	0.41	>10	0.00	0.66	1.15	2.50	1.03	0.81	0.51	0.76	0.34	0.45	1.44	0.14
		Sulphur Creek	0.76	>10	0.00	0.64	1.26	2.40	0.97	0.78	0.47	0.70	0.32	0.62	1.62	0.24
		Camas Creek	0.30	>10	0.00	0.75	1.40	3.04	0.97	0.77	0.53	0.74	0.39	0.30	0.63	0.14
		Loon Creek				0.63	1.09	2.38	1.01	0.80	0.40	0.57	0.27	0.24	0.71	0.08
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	0.35	>10	0.00	0.58	0.99	1.08	0.64	0.57	0.53	0.70	0.40	0.35	0.67	0.18
		Valley Creek	0.28	>10	0.00	0.62	1.07	2.32	0.88	0.71	0.45	0.63	0.33	0.30	0.58	0.15
		Yankee Fork	0.29	>10	0.00	0.70	1.31	2.85	0.84	0.64	0.33	0.50	0.22	0.29	0.78	0.11
		Upper Salmon River (above Redfish L.)	0.56	>10	0.01	0.46	0.66	0.77	0.63	0.52	0.45	0.57	0.35	0.35	0.58	0.21
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	0.43	4.68	0.04	0.56	1.22	1.30	1.12	0.78	0.51	0.64	0.41	0.40	0.63	0.25
		East Fork Salmon River	0.45	>10	0.01	0.61	0.94	1.11	0.60	0.57	0.50	0.70	0.36	0.30	0.58	0.16
		Pahsimeroi River				0.76	1.09	1.58	1.00	0.55						
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.90	>10	0.00	0.62	0.77	0.91	0.60	0.54	0.75	1.01	0.56	0.61	1.39	0.27
		Methow R.	1.13	>10	0.00	0.59	0.76	1.02	0.46	0.42	0.61	1.03	0.36	0.91	4.61	0.18
		Entiat R.	0.63	>10	0.00	0.61	0.85	1.07	0.47	0.42	0.48	0.60	0.38	0.46	0.89	0.24
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				0.90	1.02	1.11	1.00	0.92	0.54	0.63	0.46			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				0.85	0.96	1.04	0.94	0.87	0.51	0.59	0.44			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	0.88	2.58	0.30	0.90	0.92	1.07	1.08	1.01				0.35	0.46	0.27
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	0.83	2.42	0.29	0.85	0.86	1.01	1.02	0.95				0.33	0.43	0.25

Table 5. Continued.

PROSPECTIVE		Historical Climate																
			Gap For 24- Year Extinction ≤ 5%								Gap For 100- Year Extinction ≤ 5%							
			Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions				Extinction - Based On Current Adjustment				Extinction - Based On Prospective Actions			
ESU	MPG	Population	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)	Gap (QET=1)	Gap (QET=10)	Gap (QET=30)	Gap (QET=50)
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	0.19	0.33	0.50	0.66	0.14	0.25	0.37	0.49	0.34	0.50	0.72	0.93	0.25	0.37	0.53	0.69
		Asotin - Functionally Extirpated																
	Grande Ronde / Imnaha	Catherine Creek	0.62	1.06	1.49	1.88	0.44	0.75	1.05	1.33	1.28	1.91	2.70	3.37	0.91	1.35	1.91	2.39
		Lostine/Wallowa Rivers	0.28	0.51	0.74	0.93	0.24	0.43	0.63	0.79	0.57	0.85	1.21	1.53	0.49	0.73	1.03	1.31
		Minam River	0.13	0.25	0.39	0.52	0.12	0.22	0.34	0.46	0.25	0.38	0.56	0.75	0.22	0.33	0.49	0.65
		Imnaha River	0.25	0.41	0.58	0.71	0.21	0.36	0.50	0.61	0.51	0.69	0.90	1.08	0.44	0.59	0.77	0.93
		Wenaha River	0.24	0.41	0.60	0.74	0.21	0.36	0.52	0.65	0.47	0.66	0.92	1.14	0.41	0.58	0.80	0.99
		Upper Grande Ronde	0.26	0.53	0.90	1.27	0.19	0.38	0.63	0.90	0.44	0.79	1.25	1.77	0.31	0.56	0.88	1.25
		Big Sheep Creek - Functionally Extirpated																
		Lookingglass- Functionally Extirpated																
	South Fork Salmon	South Fork Salmon Mainstem	0.10	0.16	0.22	0.27	0.08	0.14	0.19	0.23	0.20	0.25	0.30	0.36	0.17	0.22	0.26	0.31
		Secesh River	0.19	0.31	0.42	0.51	0.17	0.27	0.36	0.44	0.39	0.50	0.61	0.71	0.34	0.43	0.53	0.61
		East Fork S. Fork Salmon (including Johnson)	0.24	0.38	0.49	0.57	0.20	0.33	0.43	0.49	0.51	0.60	0.69	0.76	0.44	0.53	0.60	0.66
		Little Salmon River (including Rapid R.)																
	Middle Fork Salmon	Big Creek	0.25	0.58	1.11	1.63	0.22	0.50	0.96	1.40	0.49	1.00	1.92	2.83	0.42	0.86	1.65	2.43
		Bear Valley/Elk Creek	0.16	0.32	0.54	0.76	0.14	0.28	0.47	0.66	0.31	0.52	0.85	1.20	0.27	0.45	0.74	1.05
		Marsh Creek	0.54	1.10	1.88	2.59	0.47	0.96	1.63	2.25	1.12	2.01	3.35	4.62	0.98	1.74	2.92	4.01
		Sulphur Creek	0.18	0.64	1.61	2.57	0.15	0.56	1.40	2.23	0.31	1.11	2.83	4.61	0.27	0.97	2.46	4.01
		Camas Creek																
		Loon Creek																
		Chamberlain Creek																
		Lower Middle Fork Salmon (below Ind. Cr.)																
		Upper Middle Fork Salmon (above Ind. Cr.)																
	Upper Salmon	Lemhi River																
		Valley Creek	0.19	0.77	1.97	3.23	0.17	0.66	1.70	2.78	0.34	1.31	3.31	5.46	0.30	1.13	2.85	4.70
		Yankee Fork																
		Upper Salmon River (above Redfish L.)	0.04	0.13	0.28	0.44	0.03	0.10	0.22	0.34	0.07	0.18	0.41	0.65	0.05	0.14	0.31	0.50
		North Fork Salmon River																
		Lower Salmon River (below Redfish L.)	0.11	0.34	0.82	1.31	0.10	0.30	0.71	1.13	0.19	0.53	1.30	2.06	0.17	0.46	1.12	1.78
		East Fork Salmon River																
		Pahsimeroi River																
		Panther - Extirpated																
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	0.07	0.16	0.27	0.35	0.06	0.13	0.22	0.29	0.25	0.45	0.75	1.01	0.20	0.37	0.61	0.83
		Methow R.																
		Entiat R.	0.16	0.32	0.53	0.75	0.11	0.22	0.36	0.51	0.29	0.47	0.78	1.09	0.20	0.32	0.53	0.74
		Okanogan R. (extirpated)																
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest																
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest																

Table 6. Detailed prospective productivity estimates for Chinook salmon ESUs under historical ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

PROSPECTIVE		Historical Climate																		
			Productivity																	
ESU	MPG	Population	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Upper 95% CI Intrinsic Productivity: 20-yr SAR adj. and delimited	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 20-yr non-SAR adj.; non-delimited	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI R/S: 10-yr non-SAR adj.; non-delimited	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.82	1.36	2.43	1.67	1.10	2.52	1.46	0.66	3.21	1.48	1.04	2.12	0.98	1.34	0.97	1.86	0.97
		Asotin - Functionally Extirpated																	
	Grande Ronde / Imnaha	Catherine Creek	2.60	1.78	3.80	1.27	0.66	2.46	2.80	1.71	4.57	1.50	1.07	2.11	0.99	1.32	0.85	2.04	0.92
		Lostine/Wallowa Rivers	1.58	1.08	2.31	1.45	0.83	2.56	2.39	1.37	4.15	1.54	1.16	2.03	0.99	1.41	1.01	1.97	0.98
		Minam River	2.37	1.66	3.37	1.86	1.09	3.17	2.02	1.22	3.36	1.62	1.26	2.08	1.00	1.51	1.09	2.10	0.99
		Imnaha River	1.54	1.25	1.89	1.14	0.78	1.68	1.21	0.62	2.35	1.48	1.09	2.01	0.99	1.26	0.99	1.61	0.97
		Wenaha River	1.95	1.40	2.72	1.75	1.08	2.85	2.03	1.32	3.11	1.65	1.26	2.17	1.00	1.47	1.03	2.11	0.98
		Upper Grande Ronde	1.23	0.78	1.95	0.95	0.54	1.69	1.17	0.70	1.96	1.54	1.25	1.90	1.00	1.33	0.96	1.84	0.96
		Big Sheep Creek - Functionally Extirpated																	
		Lookingglass- Functionally Extirpated																	
	South Fork Salmon	South Fork Salmon Mainstem	2.31	1.62	3.28	1.66	1.13	2.45	0.99	0.52	1.89	1.61	1.22	2.10	0.99	1.47	1.10	1.96	0.99
		Secesh River	2.32	1.84	2.92	2.30	1.56	3.38	2.51	1.20	5.28	1.57	1.26	1.95	1.00	1.56	1.26	1.94	1.00
		East Fork S. Fork Salmon (including Johns	1.96	1.20	3.19	1.85	1.27	2.68	1.13	0.58	2.20	1.56	1.29	1.88	1.00	1.54	1.28	1.86	1.00
		Little Salmon River (including Rapid R.)																	
	Middle Fork Salmon	Big Creek	2.35	1.63	3.38	2.31	1.27	4.21	1.89	0.69	5.17	1.61	1.15	2.26	0.99	1.61	1.15	2.26	0.99
		Bear Valley/Elk Creek	2.77	2.02	3.80	2.57	1.57	4.22	2.04	0.86	4.85	1.63	1.17	2.28	0.99	1.63	1.17	2.28	0.99
		Marsh Creek	1.93	1.28	2.89	1.81	0.99	3.32	1.06	0.35	3.20	1.60	1.15	2.24	0.99	1.60	1.15	2.24	0.99
		Sulphur Creek	4.50	2.55	7.94	1.84	0.86	3.98	0.76	0.21	2.78	1.58	1.01	2.47	0.98	1.58	1.01	2.47	0.98
		Camas Creek	1.57	0.91	2.72	1.51	0.74	3.08	1.53	0.29	8.01	1.53	1.01	2.32	0.98	1.53	1.01	2.32	0.98
		Loon Creek	2.01	1.17	3.48	2.12	1.02	4.39	1.95	0.86	4.43	1.65	1.17	2.32	0.99	1.65	1.17	2.32	0.99
		Chamberlain Creek																	
		Lower Middle Fork Salmon (below Ind. Cr.)																	
		Upper Middle Fork Salmon (above Ind. Cr.)																	
	Upper Salmon	Lemhi River	2.20	1.41	3.42	2.20	1.29	3.77	2.68	1.10	6.52	1.54	0.99	2.38	0.97	1.54	0.99	2.38	0.97
		Valley Creek	2.06	1.36	3.14	2.06	1.18	3.61	2.25	0.93	5.41	1.58	1.07	2.34	0.98	1.58	1.07	2.34	0.98
		Yankee Fork	1.69	0.98	2.93	1.50	0.70	3.20	1.03	0.22	4.78	1.66	1.05	2.62	0.98	1.66	1.05	2.62	0.98
		Upper Salmon River (above Redfish L.)	3.29	2.24	4.81	3.29	1.83	5.93	3.52	1.51	8.22	1.58	1.12	2.22	0.99	1.49	1.05	2.09	0.98
		North Fork Salmon River																	
		Lower Salmon River (below Redfish L.)	2.35	1.72	3.20	2.33	1.46	3.71	3.51	1.82	6.76	1.52	1.13	2.06	0.99	1.52	1.13	2.06	0.99
		East Fork Salmon River	2.07	1.30	3.30	2.05	1.05	4.02	3.60	1.36	9.56	1.55	1.03	2.32	0.98	1.50	0.98	2.31	0.97
		Pahsimeroi River	1.45	0.77	2.76	1.37	0.59	3.19	3.51	2.22	5.55								
		Panther - Extirpated																	
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	2.09	1.26	3.48	1.68	1.04	2.74	1.26	0.49	3.24	1.44	0.92	2.28	0.96	1.37	0.92	2.06	0.96
		Methow R.	2.15	1.38	3.34	1.95	1.12	3.41	0.70	0.21	2.31	1.61	0.93	2.80	0.96	1.48	0.92	2.40	0.96
		Entiat R.	2.97	2.10	4.21	2.05	1.39	3.01	1.72	0.80	3.68	1.55	1.15	2.09	0.99	1.47	1.13	1.92	0.99
		Okanogan R. (extirpated)																	
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest				1.01	0.57	1.51				1.14	0.96	1.37	0.95	0.99	0.84	1.18	0.47
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest				1.07	0.61	1.60				1.16	0.97	1.38	0.96	1.01	0.85	1.20	0.55
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest							1.38	1.03	1.84								
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest							1.47	1.10	1.95								

Table 6. Continued.

PROSPECTIVE		Historical Climate														
			Productivity								BRT Trend					
ESU	MPG	Population	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	1980-current trend	1980-current trend Lower95	1980-current trend Upper95	1990-current trend	1990-current trend Lower95	1990-current trend Upper95
Snake River Spring/ Summer Chinook Salmon	Lower Snake	Tucannon	1.46	0.51	4.17	0.87	1.24	0.47	3.30	0.78	1.41	1.30	1.52	1.49	1.24	1.78
		Asotin - Functionally Extirpated														
	Grande Ronde / Imnaha	Catherine Creek	1.64	1.25	2.15	0.99	1.46	0.93	2.30	0.97	1.50	1.41	1.59	1.69	1.52	1.88
		Lostine/Wallowa Rivers	1.61	1.18	2.19	0.99	1.46	0.95	2.27	0.97	1.51	1.43	1.59	1.66	1.55	1.79
		Minam River	1.53	1.28	1.84	1.00	1.44	1.01	2.05	0.98	1.57	1.50	1.64	1.59	1.46	1.74
		Imnaha River	1.55	0.83	2.90	0.95	1.20	0.66	2.18	0.84	1.45	1.39	1.52	1.56	1.43	1.70
		Wenaha River	1.64	1.58	1.71	1.00	1.49	1.29	1.72	1.00	1.65	1.57	1.74	1.69	1.56	1.84
		Upper Grande Ronde	1.48	1.31	1.67	1.00	1.30	0.91	1.87	0.96	1.49	1.42	1.57	1.47	1.30	1.67
		Big Sheep Creek - Functionally Extirpated														
		Lookingglass- Functionally Extirpated														
	South Fork Salmon	South Fork Salmon Mainstem	1.51	0.21	>10	0.89	1.32	0.18	9.55	0.84	1.56	1.50	1.62	1.54	1.39	1.70
		Secesh River	1.56	0.90	2.70	0.96	1.54	0.89	2.67	0.96	1.55	1.49	1.61	1.59	1.45	1.74
		East Fork S. Fork Salmon (including Johns	1.46	0.31	6.81	0.90	1.43	0.32	6.46	0.90	1.51	1.44	1.59	1.48	1.29	1.71
		Little Salmon River (including Rapid R.)														
	Middle Fork Salmon	Big Creek	1.58	0.13	>10	0.87	1.58	0.13	>10	0.87	1.50	1.40	1.62	1.62	1.36	1.93
		Bear Valley/Elk Creek	1.56	0.15	>10	0.87	1.56	0.15	>10	0.87	1.55	1.45	1.66	1.64	1.38	1.95
		Marsh Creek	1.56	0.17	>10	0.88	1.56	0.17	>10	0.88	1.48	1.36	1.62	1.53	1.18	1.98
		Sulphur Creek	1.36	0.14	>10	0.83	1.36	0.14	>10	0.83	1.51	1.38	1.64	1.42	1.15	1.75
		Camas Creek	1.67	0.07	>10	0.85	1.67	0.07	>10	0.85	1.47	1.37	1.58	1.67	1.41	1.97
		Loon Creek									1.57	1.45	1.70	1.76	1.38	2.24
		Chamberlain Creek														
		Lower Middle Fork Salmon (below Ind. Cr.)														
		Upper Middle Fork Salmon (above Ind. Cr.)														
	Upper Salmon	Lemhi River	1.62	0.33	7.89	0.92	1.62	0.33	7.89	0.92	1.47	1.38	1.57	1.62	1.40	1.87
		Valley Creek	1.69	0.31	9.36	0.92	1.69	0.31	9.36	0.92	1.52	1.42	1.63	1.67	1.44	1.93
		Yankee Fork	1.68	0.05	>10	0.84	1.68	0.05	>10	0.84	1.63	1.49	1.79	1.69	1.35	2.10
		Upper Salmon River (above Redfish L.)	1.56	0.68	3.55	0.93	1.45	0.64	3.32	0.90	1.53	1.45	1.61	1.62	1.44	1.81
		North Fork Salmon River														
		Lower Salmon River (below Redfish L.)	1.54	0.91	2.61	0.96	1.54	0.91	2.61	0.96	1.48	1.41	1.56	1.57	1.42	1.74
		East Fork Salmon River	1.58	0.64	3.91	0.92	1.53	0.58	4.04	0.90	1.49	1.38	1.61	1.67	1.44	1.93
		Pahsimeroi River														
		Panther - Extirpated														
Upper Columbia Spring Chinook	Eastern Cascades	Wenatchee R.	1.49	0.03	>10	0.79	1.36	0.04	>10	0.76	1.41	1.32	1.51	1.48	1.23	1.78
		Methow R.	1.46	0.01	>10	0.75	1.29	0.02	>10	0.71	1.48	1.32	1.67	1.36	0.95	1.94
		Entiat R.	1.57	0.10	>10	0.86	1.47	0.13	>10	0.85	1.56	1.49	1.64	1.57	1.36	1.82
		Okanogan R. (extirpated)														
Snake River Fall Chinook Salmon	Main Stem and Lower Tributaries	Lower Mainstem Fall Chinook 1977-1999 with Allowable Future Harvest									1.15	1.11	1.19			
		Lower Mainstem Fall Chinook 1977-1999 with Expected Future Harvest									1.16	1.13	1.20			
		Lower Mainstem Fall Chinook 1990-1999 with Allowable Future Harvest	1.21	0.91	1.59	0.95	1.03	0.81	1.30	0.67				1.26	1.19	1.34
		Lower Mainstem Fall Chinook 1990-1999 with Expected Future Harvest	1.22	0.93	1.62	0.96	1.04	0.82	1.32	0.74				1.28	1.20	1.35

Table 7. Detailed prospective survival gap estimates for steelhead DPSs under recent ocean climate assumptions Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

Prospective - Recent Climate			Survival Gap For Productivity $\geq$ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
		Low Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.11	1.73	0.71	1.54	2.62	0.91	0.29	0.91	0.09	1.07	3.41	0.34	0.66	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	2.15	3.04	1.51	2.55	3.90	1.67	0.31	1.07	0.09	2.71	6.13	1.19	0.63	>10	0.01
		Entiat (Summer A)	1.36	1.90	0.97	1.27	1.66	0.97	0.56	1.75	0.18	1.82	4.14	0.80	0.61	>10	0.01
		Okanogan (Summer A)	4.44	6.38	3.09	4.92	7.39	3.28									
		High Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.11	1.73	0.71	1.54	2.62	0.91	0.29	0.91	0.09	1.07	3.41	0.34	0.66	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	1.62	2.29	1.14	2.55	3.90	1.67	0.24	0.80	0.07	2.04	4.63	0.90	0.63	>10	0.01
		Entiat (Summer A)	0.86	1.20	0.61	1.27	1.66	0.97	0.35	1.10	0.11	1.15	2.61	0.50	0.61	>10	0.01
		Okanogan (Summer A)	3.17	4.55	2.20	4.92	7.39	3.28									
		Allowable Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
	Average "B-Run" Populations (only 13 years)		1.16	1.77	0.76	1.14	1.88	0.70	0.93	7.31	0.12	0.93	7.31	0.12	0.88	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.74	1.45	0.38	0.74	1.63	0.33	0.64	>10	0.02	0.64	>10	0.02	0.60	>10	0.00
		Asotin (A)	0.74	1.44	0.38	0.74	1.64	0.34	0.64	>10	0.02	0.64	>10	0.02	0.61	>10	0.00
	Imnaha River	Imnaha R. (A)	0.62	0.96	0.40	0.64	1.08	0.38	0.70	2.26	0.22	0.70	2.26	0.22	0.76	4.11	0.14
	Grande Ronde	Upper Mainstem (A)	0.92	1.32	0.64	1.02	1.33	0.78	0.91	1.94	0.42	1.05	2.26	0.48	0.87	1.45	0.51
		Lower Mainstem (A)	0.82	1.61	0.42	0.77	1.69	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Joseph Cr. (A)	0.68	1.01	0.45	0.62	0.84	0.46	0.69	2.13	0.22	0.69	2.13	0.22	0.80	2.44	0.26
		Wallowa R. (A)	0.69	0.94	0.50	0.55	0.72	0.43	0.72	2.17	0.24	0.73	2.24	0.24	0.58	6.74	0.05
	Clearwater River	Lower Mainstem (A)	0.81	1.58	0.42	0.77	1.71	0.35	0.70	>10	0.02	0.70	>10	0.02	0.63	>10	0.00
		Lolo Creek (A & B)-assume B	1.01	1.54	0.66	1.00	1.64	0.61	0.81	6.35	0.10	0.81	6.35	0.10	0.77	>10	0.00
		Lochsa River (B)	0.94	1.43	0.62	0.93	1.53	0.57	0.75	5.91	0.09	0.75	5.91	0.09	0.72	>10	0.00
		Selway River (B)	1.08	1.64	0.71	1.07	1.76	0.65	0.86	6.78	0.11	0.86	6.78	0.11	0.82	>10	0.00
		South Fork (B)	0.95	1.44	0.62	0.95	1.56	0.58	0.76	5.96	0.10	0.76	5.96	0.10	0.73	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.83	1.62	0.42	0.77	1.71	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Chamberlain Cr. (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Secesh River (B)	1.03	1.57	0.68	1.02	1.67	0.62	0.83	6.51	0.10	0.83	6.51	0.10	0.78	>10	0.00
		South Fork Salmon (B)	1.09	1.66	0.71	1.07	1.77	0.65	0.87	6.86	0.11	0.87	6.86	0.11	0.83	>10	0.00
		Panther Creek (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Lower Middle Fork Tribs (B)	1.07	1.64	0.70	1.06	1.74	0.64	0.86	6.76	0.11	0.86	6.76	0.11	0.82	>10	0.00
		Upper Middle Fork Tribs (B)	1.09	1.67	0.72	1.08	1.77	0.66	0.87	6.90	0.11	0.87	6.90	0.11	0.83	>10	0.00
		North Fork (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Lemhi River (A)	0.80	1.57	0.41	0.75	1.66	0.34	0.69	>10	0.02	0.69	>10	0.02	0.61	>10	0.00
		Pahsimeroi River (A)	0.72	1.40	0.37	0.71	1.57	0.32	0.62	>10	0.02	0.62	>10	0.02	0.58	>10	0.00
		East Fork Salmon (A)	0.81	1.58	0.42	0.76	1.67	0.34	0.70	>10	0.02	0.70	>10	0.02	0.62	>10	0.00
		Upper Mainstem (A)	0.78	1.52	0.40	0.73	1.61	0.33	0.67	>10	0.02	0.67	>10	0.02	0.60	>10	0.00

Table 7. Continued.

Prospective - Recent Climate

ESU	MPG	Population	Productivity ≥ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend ≥ 1.0					
			12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	High	Low	1980-current trend	Upper 95% CI	Lower 95% CI	1990-current trend	Upper 95% CI	Lower 95% CI
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.99	>10	0.10	0.46	0.56	0.67	0.71	0.61	0.33	0.38	0.24	0.59	0.78	0.45
		Wenatchee - Hatch =.3 (Summer A)				0.46	0.55	0.67								
		Methow (Summer A)	4.81	>10	0.55	1.69	1.97	2.37	0.91	0.75	0.35	0.40	0.26	0.56	0.79	0.40
		Entiat (Summer A)	2.13	9.68	0.47	1.56	1.97	2.45	1.41	1.17	0.59	0.68	0.43	0.55	0.72	0.42
		Okanogan (Summer A)				3.05	3.51	4.24	0.75	0.62						
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.99	>10	0.10	0.46	0.56	0.67	0.71	0.61	0.33	0.38	0.24	0.59	0.78	0.45
		Wenatchee - Hatch =.3 (Summer A)				0.46	0.55	0.67								
		Methow (Summer A)	4.81	>10	0.55	1.27	1.48	1.79	0.68	0.57	0.26	0.30	0.19	0.56	0.79	0.40
		Entiat (Summer A)	2.13	9.68	0.47	0.99	1.24	1.55	0.89	0.74	0.37	0.43	0.27	0.55	0.72	0.42
		Okanogan (Summer A)				2.17	2.50	3.02	0.53	0.44						
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
	Average "B-Run" Populations (only 13 years)		0.88	>10	0.00	1.13	1.60	1.69	1.32	1.14	1.12	1.49	0.61	0.96	1.50	0.61
	Lower Snake	Tucannon (A, but below LGR)	0.60	>10	0.00	0.79	1.50	1.50	1.09	0.96	0.76	1.09	0.33	0.61	1.05	0.35
		Asotin (A)	0.61	>10	0.00	0.79	1.48	1.48	1.08	0.96	0.75	1.08	0.33	0.62	1.06	0.36
	Imnaha River	Imnaha R. (A)	0.76	4.11	0.14	0.89	1.67	1.67	1.22	1.08	0.80	0.96	0.51	0.73	1.04	0.51
	Grande Ronde	Upper Mainstem (A)	1.07	1.81	0.63	0.85	0.95	0.95	0.50	0.69	0.91	1.06	0.64	0.83	1.06	0.66
		Lower Mainstem (A)	0.63	>10	0.00	0.88	1.65	1.65	1.20	1.07	0.84	1.20	0.37	0.63	1.10	0.37
		Joseph Cr. (A)	0.80	2.44	0.26	0.31	0.35	0.39	0.44	0.58	0.80	0.96	0.53	0.72	0.96	0.54
		Wallowa R. (A)	0.59	7.39	0.05	0.86	1.63	1.63	1.19	1.05	0.78	0.91	0.39	0.55	0.75	0.40
	Clearwater River	Lower Mainstem (A)	0.63	>10	0.00	0.86	1.63	1.63	1.19	1.05	0.83	1.19	0.36	0.64	1.11	0.37
		Lolo Creek (A & B)-assume B	0.77	>10	0.00	0.98	1.39	1.47	1.15	0.99	0.98	1.29	0.53	0.84	1.31	0.53
		Lochsa River (B)	0.72	>10	0.00	0.92	1.30	1.37	1.07	0.93	0.91	1.20	0.49	0.78	1.22	0.50
		Selway River (B)	0.82	>10	0.00	1.05	1.49	1.56	1.23	1.06	1.04	1.38	0.57	0.90	1.40	0.57
		South Fork (B)	0.73	>10	0.00	0.92	1.31	1.38	1.08	0.93	0.92	1.21	0.50	0.79	1.24	0.51
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	0.63	>10	0.00	0.88	1.66	1.66	1.21	1.07	0.84	1.21	0.37	0.64	1.11	0.37
		Chamberlain Cr. (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Secesh River (B)	0.78	>10	0.00	1.01	1.43	1.50	1.18	1.02	1.00	1.32	0.54	0.85	1.33	0.54
		South Fork Salmon (B)	0.83	>10	0.00	1.06	1.51	1.58	1.24	1.07	1.06	1.40	0.57	0.90	1.41	0.57
		Panther Creek (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Lower Middle Fork Tribs (B)	0.82	>10	0.00	1.05	1.48	1.56	1.22	1.06	1.04	1.38	0.56	0.89	1.39	0.57
		Upper Middle Fork Tribs (B)	0.83	>10	0.00	1.07	1.51	1.59	1.25	1.08	1.06	1.40	0.58	0.91	1.41	0.58
		North Fork (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Lemhi River (A)	0.61	>10	0.00	0.86	1.62	1.62	1.18	1.04	0.82	1.18	0.36	0.62	1.08	0.36
		Pahsimeroi River (A)	0.58	>10	0.00	0.76	1.44	1.44	1.05	0.93	0.73	1.05	0.32	0.59	1.02	0.34
		East Fork Salmon (A)	0.62	>10	0.00	0.86	1.63	1.63	1.19	1.05	0.83	1.19	0.36	0.63	1.09	0.36
		Upper Mainstem (A)	0.60	>10	0.00	0.83	1.57	1.57	1.14	1.01	0.80	1.14	0.35	0.60	1.04	0.35

Table 7. Continued.

Prospective - Recent Climate

ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
			Survival Gap For Productivity $\geq$ 1.0														
		Expected Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
	Average "B-Run" Populations (only 13 years)		1.10	1.68	0.72	1.09	1.79	0.66	0.88	6.96	0.11	0.88	6.96	0.11	0.84	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.74	1.45	0.38	0.74	1.63	0.33	0.64	>10	0.02	0.64	>10	0.02	0.60	>10	0.00
		Asotin (A)	0.74	1.44	0.38	0.74	1.64	0.34	0.64	>10	0.02	0.64	>10	0.02	0.61	>10	0.00
	Imnaha River	Imnaha R. (A)	0.62	0.96	0.40	0.64	1.08	0.38	0.70	2.26	0.22	0.70	2.26	0.22	0.76	4.11	0.14
	Grande Ronde	Upper Mainstem (A)	0.92	1.32	0.64	1.02	1.33	0.78	0.91	1.94	0.42	1.05	2.26	0.48	0.87	1.45	0.51
		Lower Mainstem (A)	0.82	1.61	0.42	0.77	1.69	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Joseph Cr. (A)	0.68	1.01	0.45	0.62	0.84	0.46	0.69	2.13	0.22	0.69	2.13	0.22	0.80	2.44	0.26
		Wallowa R. (A)	0.69	0.94	0.50	0.55	0.72	0.43	0.72	2.17	0.24	0.73	2.24	0.24	0.58	6.74	0.05
	Clearwater River	Lower Mainstem (A)	0.81	1.58	0.42	0.77	1.71	0.35	0.70	>10	0.02	0.70	>10	0.02	0.63	>10	0.00
		Lolo Creek (A & B)-assume B	0.96	1.46	0.63	0.95	1.56	0.58	0.77	6.05	0.10	0.77	6.05	0.10	0.73	>10	0.00
		Lochsa River (B)	0.89	1.36	0.59	0.89	1.46	0.54	0.71	5.63	0.09	0.71	5.63	0.09	0.68	>10	0.00
		Selway River (B)	1.02	1.56	0.67	1.02	1.67	0.62	0.82	6.45	0.10	0.82	6.45	0.10	0.78	>10	0.00
		South Fork (B)	0.90	1.37	0.59	0.90	1.48	0.55	0.72	5.67	0.09	0.72	5.67	0.09	0.69	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.83	1.62	0.42	0.77	1.71	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Chamberlain Cr. (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Secesh River (B)	0.98	1.50	0.64	0.97	1.59	0.59	0.79	6.19	0.10	0.79	6.19	0.10	0.75	>10	0.00
		South Fork Salmon (B)	1.04	1.58	0.68	1.02	1.68	0.62	0.83	6.53	0.10	0.83	6.53	0.10	0.79	>10	0.00
		Panther Creek (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Lower Middle Fork Tribs (B)	1.02	1.56	0.67	1.01	1.66	0.61	0.82	6.43	0.10	0.82	6.43	0.10	0.78	>10	0.00
		Upper Middle Fork Tribs (B)	1.04	1.59	0.68	1.03	1.69	0.62	0.83	6.56	0.11	0.83	6.56	0.11	0.79	>10	0.00
		North Fork (A)	0.83	1.62	0.43	0.77	1.71	0.35	0.72	>10	0.02	0.72	>10	0.02	0.63	>10	0.00
		Lemhi River (A)	0.80	1.57	0.41	0.75	1.66	0.34	0.69	>10	0.02	0.69	>10	0.02	0.61	>10	0.00
		Pahsimeroi River (A)	0.72	1.40	0.37	0.71	1.57	0.32	0.62	>10	0.02	0.62	>10	0.02	0.58	>10	0.00
		East Fork Salmon (A)	0.81	1.58	0.42	0.76	1.67	0.34	0.70	>10	0.02	0.70	>10	0.02	0.62	>10	0.00
		Upper Mainstem (A)	0.78	1.52	0.40	0.73	1.61	0.33	0.67	>10	0.02	0.67	>10	0.02	0.60	>10	0.00
Mid Columbia Steelhead	Yakima	Upper Yakima	0.70	1.04	0.48	0.51	0.79	0.33	0.68	2.78	0.16	0.69	2.88	0.17	0.51	>10	0.00
		Naches	0.71	1.04	0.48	0.52	0.82	0.33	0.66	2.86	0.15	0.71	3.10	0.16	0.50	>10	0.00
		Toppenish	0.49	0.81	0.30	0.33	0.56	0.19	0.49	2.52	0.09	0.53	2.74	0.10	0.36	>10	0.00
		Satus	0.84	1.16	0.60	0.72	1.11	0.47	0.80	2.42	0.27	0.87	2.65	0.29	0.70	>10	0.00
	Eastern Cascades	Deschutes W.	0.90	1.23	0.66	0.71	1.12	0.45	0.76	2.19	0.26	0.96	2.59	0.36	0.59	2.66	0.13
		Deschutes E.				0.70	1.24	0.39							0.57	>10	0.03
		Klickitat															
		Fifteenmile Cr.	0.77	1.07	0.55	0.48	0.70	0.33	0.79	2.10	0.30	0.79	2.10	0.30	0.49	1.60	0.15
		Rock Cr.															
		White Salmon - Extirpated															
	Umatilla/Walla Walla	Umatilla	0.79	1.02	0.61	0.87	1.06	0.71	0.64	1.49	0.27	0.80	1.75	0.36	0.61	>10	0.00
		Walla-Walla															
		Touchet															
	John Day	Lower Mainstem	0.64	1.06	0.39	0.54	1.09	0.27	0.76	3.68	0.16	0.80	3.73	0.17	0.69	>10	0.05
		North Fork	0.68	1.02	0.46	0.48	0.65	0.35	0.79	2.24	0.28	0.82	2.27	0.29	0.61	1.18	0.31
		Upper Mainstem	0.75	1.11	0.50	1.01	1.65	0.61	0.82	2.58	0.26	0.85	2.62	0.27	0.99	7.47	0.13
		Middle Fork	0.68	0.98	0.47	0.81	1.41	0.46	0.77	2.23	0.27	0.80	2.27	0.28	0.87	9.27	0.08
		South Fork	0.79	1.23	0.51	0.78	1.49	0.40	0.82	3.09	0.22	0.84	3.11	0.23	0.73	>10	0.03

Table 7. Continued.

Prospective - Recent Climate

			Productivity ≥ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	High	Low	1980-current trend	Upper 95% CI	Lower 95% CI	1990-current trend	Upper 95% CI	Lower 95% CI
		Expected Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
	Average "B-Run" Populations (only 13 years)		0.84	>10	0.00	1.08	1.53	1.61	1.26	1.09	1.07	1.42	0.58	0.91	1.43	0.58
	Lower Snake	Tucannon (A, but below LGR)	0.60	>10	0.00	0.79	1.50	1.50	1.09	0.96	0.76	1.09	0.33	0.61	1.05	0.35
		Asotin (A)	0.61	>10	0.00	0.79	1.48	1.48	1.08	0.96	0.75	1.08	0.33	0.62	1.06	0.36
	Imnaha River	Imnaha R. (A)	0.76	4.11	0.14	0.89	1.67	1.67	1.22	1.08	0.80	0.96	0.51	0.73	1.04	0.51
	Grande Ronde	Upper Mainstem (A)	1.07	1.81	0.63	0.85	0.95	0.95	0.50	0.69	0.91	1.06	0.64	0.83	1.06	0.66
		Lower Mainstem (A)	0.63	>10	0.00	0.88	1.65	1.65	1.20	1.07	0.84	1.20	0.37	0.63	1.10	0.37
		Joseph Cr. (A)	0.80	2.44	0.26	0.31	0.35	0.39	0.44	0.58	0.80	0.96	0.53	0.72	0.96	0.54
		Wallowa R. (A)	0.59	7.39	0.05	0.86	1.63	1.63	1.19	1.05	0.78	0.91	0.39	0.55	0.75	0.40
	Clearwater River	Lower Mainstem (A)	0.63	>10	0.00	0.86	1.63	1.63	1.19	1.05	0.83	1.19	0.36	0.64	1.11	0.37
		Lolo Creek (A & B)-assume B	0.73	>10	0.00	0.94	1.33	1.40	1.09	0.95	0.93	1.23	0.50	0.80	1.25	0.51
		Lochsa River (B)	0.68	>10	0.00	0.87	1.24	1.30	1.02	0.88	0.87	1.15	0.47	0.74	1.16	0.47
		Selway River (B)	0.78	>10	0.00	1.00	1.42	1.49	1.17	1.01	0.99	1.31	0.54	0.85	1.33	0.54
		South Fork (B)	0.69	>10	0.00	0.88	1.24	1.31	1.03	0.89	0.87	1.15	0.47	0.76	1.18	0.48
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	0.63	>10	0.00	0.88	1.66	1.66	1.21	1.07	0.84	1.21	0.37	0.64	1.11	0.37
		Chamberlain Cr. (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Secesh River (B)	0.75	>10	0.00	0.96	1.36	1.43	1.12	0.97	0.95	1.26	0.52	0.81	1.27	0.52
		South Fork Salmon (B)	0.79	>10	0.00	1.01	1.43	1.51	1.18	1.02	1.00	1.33	0.54	0.86	1.34	0.55
		Panther Creek (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Lower Middle Fork Tribs (B)	0.78	>10	0.00	1.00	1.41	1.49	1.16	1.01	0.99	1.31	0.54	0.85	1.32	0.54
		Upper Middle Fork Tribs (B)	0.79	>10	0.00	1.02	1.44	1.51	1.19	1.03	1.01	1.34	0.55	0.86	1.35	0.55
		North Fork (A)	0.63	>10	0.00	0.89	1.67	1.67	1.22	1.08	0.85	1.22	0.37	0.64	1.11	0.37
		Lemhi River (A)	0.61	>10	0.00	0.86	1.62	1.62	1.18	1.04	0.82	1.18	0.36	0.62	1.08	0.36
		Pahsimeroi River (A)	0.58	>10	0.00	0.76	1.44	1.44	1.05	0.93	0.73	1.05	0.32	0.59	1.02	0.34
		East Fork Salmon (A)	0.62	>10	0.00	0.86	1.63	1.63	1.19	1.05	0.83	1.19	0.36	0.63	1.09	0.36
		Upper Mainstem (A)	0.60	>10	0.00	0.83	1.57	1.57	1.14	1.01	0.80	1.14	0.35	0.60	1.04	0.35
Mid Columbia Steelhead	Yakima	Upper Yakima	0.53	>10	0.00	0.80	1.55	1.64	1.25	1.06	0.70	0.89	0.36	0.52	0.71	0.39
		Naches	0.55	>10	0.00	0.75	1.46	1.56	1.10	0.97	0.67	0.85	0.34	0.50	0.66	0.38
		Toppenish	0.39	>10	0.00	0.72	1.08	1.08	0.94	0.87	0.49	0.66	0.21	0.33	0.48	0.23
		Satus	0.77	>10	0.00	0.71	1.80	1.80	0.95	0.88	0.81	1.00	0.43	0.64	0.87	0.48
	Eastern Cascades	Deschutes W.	0.82	3.51	0.19	0.94	1.47	1.59	1.08	0.99	0.85	1.00	0.41	0.57	0.77	0.43
		Deschutes E.	0.94	>10	0.06	0.43	0.53	0.64	0.74	0.76				0.53	0.82	0.34
		Klickitat														
		Fifteenmile Cr.	0.49	1.60	0.15	0.89	0.71	0.87	1.13	1.04	0.79	0.97	0.48	0.52	0.68	0.39
		Rock Cr.														
		White Salmon - Extirpated														
	Umatilla/Walla Walla	Umatilla	0.90	>10	0.01	0.51	0.81	0.81	0.78	0.77	0.73	0.83	0.43	0.59	0.76	0.46
		Walla-Walla				0.66	0.97	1.05	0.72	0.72						
		Touchet														
	John Day	Lower Mainstem	0.75	>10	0.05	0.80	0.89	0.89	0.86	0.84	0.89	1.08	0.44	0.70	1.07	0.46
		North Fork	0.64	1.21	0.34	0.34	0.41	0.49	0.56	0.62	0.83	1.00	0.41	0.56	0.73	0.43
		Upper Mainstem	1.04	7.42	0.15	0.78	1.09	1.09	0.89	0.86	1.00	1.18	0.69	1.00	1.37	0.72
		Middle Fork	0.91	9.34	0.09	0.80	0.86	0.86	0.89	0.86	0.93	1.09	0.62	0.92	1.31	0.65
		South Fork	0.77	>10	0.04	0.77	0.95	0.95	0.92	0.87	0.99	1.18	0.53	0.80	1.13	0.56

Table 8. Detailed prospective productivity estimates for steelhead DPSs under recent ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

Prospective - Recent Climate

			Productivity																
ESU	**MPG**	**Population**	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Low Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.16	1.47	3.17	0.90	0.58	1.41	0.65	0.38	1.10	1.32	1.02	1.70	0.98	0.98	0.76	1.27	0.44
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.60	0.33	1.11	0.47	0.33	0.66	0.39	0.26	0.60	1.29	0.99	1.69	0.97	0.80	0.67	0.96	0.01
		Entiat (Summer A)	0.68	0.45	1.03	0.74	0.53	1.03	0.79	0.60	1.03	1.14	0.88	1.47	0.89	0.88	0.73	1.05	0.06
		Okanogan (Summer A)	0.34	0.18	0.64	0.23	0.16	0.32	0.20	0.14	0.30								
		High Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.16	1.47	3.17	0.90	0.58	1.41	0.65	0.38	1.10	1.32	1.02	1.70	0.98	0.98	0.76	1.27	0.44
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.80	0.43	1.46	0.62	0.44	0.87	0.39	0.26	0.60	1.38	1.05	1.80	0.98	0.85	0.71	1.02	0.04
		Entiat (Summer A)	1.08	0.72	1.63	1.17	0.83	1.64	0.79	0.60	1.03	1.26	0.98	1.62	0.97	0.97	0.81	1.16	0.33
		Okanogan (Summer A)	0.47	0.25	0.90	0.32	0.22	0.45	0.20	0.14	0.30								
		Allowable Harvest Assumption:																	
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
	Average "B-Run" Populations (only 13 years)		0.92	0.71	1.19	0.86	0.57	1.32	0.87	0.53	1.44	1.02	0.64	1.61	0.56	1.02	0.64	1.61	0.56
	Lower Snake	Tucannon (A, but below LGR)	1.63	0.78	3.43	1.34	0.69	2.63	1.36	0.61	2.99	1.10	0.52	2.34	0.69	1.10	0.52	2.34	0.69
		Asotin (A)	1.65	0.78	3.46	1.36	0.69	2.65	1.34	0.61	2.96	1.11	0.52	2.35	0.69	1.11	0.52	2.35	0.69
	Imnaha River	Imnaha R. (A)	3.34	2.53	4.40	1.60	1.04	2.48	1.57	0.93	2.66	1.08	0.83	1.41	0.78	1.08	0.83	1.41	0.78
	Grande Ronde	Upper Mainstem (A)	2.68	1.66	4.34	1.09	0.76	1.56	0.98	0.75	1.29	1.02	0.86	1.21	0.63	0.99	0.83	1.17	0.44
		Lower Mainstem (A)	1.48	0.70	3.10	1.22	0.62	2.38	1.30	0.59	2.87	1.08	0.51	2.29	0.65	1.08	0.51	2.29	0.65
		Joseph Cr. (A)	3.03	2.35	3.90	1.48	0.99	2.22	1.60	1.20	2.15	1.09	0.85	1.40	0.79	1.09	0.85	1.40	0.79
		Wallowa R. (A)	2.60	1.83	3.68	1.45	1.06	1.98	1.81	1.40	2.35	1.07	0.84	1.37	0.79	1.07	0.84	1.37	0.78
	Clearwater River	Lower Mainstem (A)	1.50	0.71	3.14	1.23	0.63	2.41	1.29	0.59	2.85	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
		Lolo Creek (A & B)-assume B	1.06	0.82	1.37	0.99	0.65	1.51	1.00	0.61	1.65	1.05	0.66	1.66	0.65	1.05	0.66	1.66	0.65
		Lochsa River (B)	1.14	0.88	1.47	1.07	0.70	1.63	1.08	0.65	1.77	1.07	0.67	1.69	0.69	1.07	0.67	1.69	0.69
		Selway River (B)	0.99	0.77	1.28	0.93	0.61	1.42	0.94	0.57	1.54	1.03	0.65	1.64	0.61	1.03	0.65	1.64	0.61
		South Fork (B)	1.13	0.88	1.46	1.06	0.69	1.61	1.06	0.64	1.74	1.06	0.67	1.69	0.69	1.06	0.67	1.69	0.69
		North Fork - (Extirpated)																	
	Salmon River	Little Salmon/Rapid (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.29	0.59	2.85	1.08	0.51	2.29	0.65	1.08	0.51	2.29	0.65
		Chamberlain Cr. (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Secesh River (B)	1.04	0.80	1.34	0.97	0.64	1.48	0.98	0.60	1.62	1.04	0.66	1.65	0.64	1.04	0.66	1.65	0.64
		South Fork Salmon (B)	0.98	0.76	1.27	0.92	0.60	1.40	0.93	0.57	1.53	1.03	0.65	1.63	0.60	1.03	0.65	1.63	0.60
		Panther Creek (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Lower Middle Fork Tribs (B)	1.00	0.77	1.29	0.93	0.61	1.42	0.95	0.57	1.56	1.03	0.65	1.64	0.61	1.03	0.65	1.64	0.61
		Upper Middle Fork Tribs (B)	0.98	0.76	1.26	0.91	0.60	1.39	0.93	0.56	1.52	1.03	0.65	1.63	0.60	1.03	0.65	1.63	0.60
		North Fork (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Lemhi River (A)	1.51	0.72	3.17	1.24	0.64	2.43	1.33	0.60	2.93	1.09	0.51	2.30	0.66	1.09	0.51	2.30	0.66
		Pahsimeroi River (A)	1.69	0.81	3.56	1.40	0.71	2.73	1.41	0.64	3.10	1.11	0.52	2.36	0.70	1.11	0.52	2.36	0.70
		East Fork Salmon (A)	1.50	0.71	3.14	1.23	0.63	2.41	1.32	0.60	2.90	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
		Upper Mainstem (A)	1.56	0.74	3.27	1.28	0.66	2.50	1.37	0.62	3.02	1.09	0.51	2.32	0.67	1.09	0.51	2.32	0.67

Table 8. Continued.

Prospective - Recent Climate

			Productivity								BRT Trend					
ESU	**MPG**	**Population**	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	**1980-current trend**	Lower 95% CI	Upper 95% CI	**1990-current trend**	Lower 95% CI	Upper 95% CI
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.10	0.02	2.58	0.73	0.86	0.44	1.68	0.22	2.67	2.58	2.86	1.46	1.38	1.56
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.11	0.03	2.58	0.71	0.71	0.43	1.14	0.04	2.32	2.25	2.48	1.48	1.37	1.60
		Entiat (Summer A)	1.11	0.03	2.60	0.77	0.85	0.60	1.18	0.08	1.48	1.44	1.59	1.54	1.45	1.63
		Okanogan (Summer A)														
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.10	0.02	2.58	0.73	0.86	0.44	1.68	0.22	2.67	2.58	2.86	1.46	1.38	1.56
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.11	0.03	2.58	0.71	0.71	0.43	1.14	0.04	3.08	2.98	3.29	1.48	1.37	1.60
		Entiat (Summer A)	1.11	0.03	2.60	0.77	0.85	0.60	1.18	0.08	2.35	2.28	2.52	1.54	1.45	1.63
		Okanogan (Summer A)														
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.11	0.05	23.84	0.63	1.11	0.05	23.84	0.63	1.12	1.04	1.35	1.19	1.05	1.34
	Average "B-Run" Populations (only 13 years)		1.03	0.15	6.87	0.56	1.03	0.15	6.87	0.56	1.03	0.97	1.18	1.07	0.97	1.18
	Lower Snake	Tucannon (A, but below LGR)	*1.12*	*0.05*	*24.10*	*0.64*	*1.12*	*0.05*	*24.10*	*0.64*	*1.25*	*1.16*	*1.51*	*1.25*	*1.11*	*1.41*
		Asotin (A)	*1.12*	*0.05*	*24.05*	*0.64*	*1.12*	*0.05*	*24.05*	*0.64*	*1.27*	*1.17*	*1.52*	*1.24*	*1.10*	*1.40*
	Imnaha River	Imnaha R. (A)	1.06	0.73	1.55	0.72	1.06	0.73	1.55	0.72	1.14	1.09	1.26	1.16	1.07	1.25
	Grande Ronde	Upper Mainstem (A)	1.03	0.92	1.16	0.82	0.99	0.88	1.11	0.32	1.16	1.12	1.25	1.16	1.10	1.22
		Lower Mainstem (A)	*1.11*	*0.05*	*23.90*	*0.63*	*1.11*	*0.05*	*23.90*	*0.63*	*1.13*	*1.05*	*1.36*	*1.20*	*1.06*	*1.36*
		Joseph Cr. (A)	1.05	0.82	1.34	0.76	1.05	0.82	1.34	0.76	1.19	1.14	1.30	1.19	1.12	1.27
		Wallowa R. (A)	1.13	0.65	1.94	0.89	1.12	0.64	1.97	0.88	1.16	1.12	1.36	1.24	1.15	1.33
	Clearwater River	Lower Mainstem (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.15*	*1.06*	*1.38*	*1.19*	*1.05*	*1.34*
		Lolo Creek (A & B)-assume B	*1.06*	*0.16*	*7.08*	*0.62*	*1.06*	*0.16*	*7.08*	*0.62*	*1.19*	*1.12*	*1.36*	*1.22*	*1.11*	*1.35*
		Lochsa River (B)	*1.08*	*0.16*	*7.20*	*0.65*	*1.08*	*0.16*	*7.20*	*0.65*	*1.28*	*1.20*	*1.46*	*1.31*	*1.19*	*1.45*
		Selway River (B)	*1.04*	*0.16*	*6.98*	*0.59*	*1.04*	*0.16*	*6.98*	*0.59*	*1.11*	*1.05*	*1.28*	*1.14*	*1.04*	*1.26*
		South Fork (B)	*1.07*	*0.16*	*7.17*	*0.64*	*1.07*	*0.16*	*7.17*	*0.64*	*1.27*	*1.19*	*1.45*	*1.29*	*1.17*	*1.43*
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.13*	*1.04*	*1.36*	*1.19*	*1.05*	*1.34*
		Chamberlain Cr. (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Secesh River (B)	*1.06*	*0.16*	*7.05*	*0.61*	*1.06*	*0.16*	*7.05*	*0.61*	*1.16*	*1.09*	*1.33*	*1.20*	*1.09*	*1.33*
		South Fork Salmon (B)	*1.04*	*0.16*	*6.97*	*0.59*	*1.04*	*0.16*	*6.97*	*0.59*	*1.10*	*1.03*	*1.26*	*1.14*	*1.03*	*1.26*
		Panther Creek (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Lower Middle Fork Tribs (B)	*1.05*	*0.16*	*6.99*	*0.59*	*1.05*	*0.16*	*6.99*	*0.59*	*1.12*	*1.05*	*1.28*	*1.15*	*1.05*	*1.28*
		Upper Middle Fork Tribs (B)	*1.04*	*0.16*	*6.96*	*0.59*	*1.04*	*0.16*	*6.96*	*0.59*	*1.10*	*1.03*	*1.25*	*1.13*	*1.02*	*1.25*
		North Fork (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Lemhi River (A)	*1.11*	*0.05*	*24.00*	*0.63*	*1.11*	*0.05*	*24.00*	*0.63*	*1.16*	*1.07*	*1.40*	*1.23*	*1.08*	*1.38*
		Pahsimeroi River (A)	*1.13*	*0.05*	*24.31*	*0.65*	*1.13*	*0.05*	*24.31*	*0.65*	*1.30*	*1.20*	*1.57*	*1.30*	*1.15*	*1.46*
		East Fork Salmon (A)	*1.11*	*0.05*	*23.95*	*0.63*	*1.11*	*0.05*	*23.95*	*0.63*	*1.15*	*1.06*	*1.38*	*1.21*	*1.07*	*1.37*
		Upper Mainstem (A)	*1.12*	*0.05*	*24.16*	*0.64*	*1.12*	*0.05*	*24.16*	*0.64*	*1.19*	*1.10*	*1.44*	*1.26*	*1.12*	*1.42*

Table 8. Continued.

Prospective - Recent Climate

			Productivity															
ESU	MPG	Population	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Expected Harvest Assumption:																	
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
	Average "B-Run" Populations (only 13 years)		0.97	0.75	1.25	0.91	0.59	1.38	0.92	0.56	1.51	1.03	0.65	1.63	0.59	1.03	0.65	1.63	0.59
	Lower Snake	Tucannon (A, but below LGR)	1.63	0.78	3.43	1.34	0.69	2.63	1.36	0.61	2.99	1.10	0.52	2.34	0.69	1.10	0.52	2.34	0.69
		Asotin (A)	1.65	0.78	3.46	1.36	0.69	2.65	1.34	0.61	2.96	1.11	0.52	2.35	0.69	1.11	0.52	2.35	0.69
	Imnaha River	Imnaha R. (A)	3.34	2.53	4.40	1.60	1.04	2.48	1.57	0.93	2.66	1.08	0.83	1.41	0.78	1.08	0.83	1.41	0.78
	Grande Ronde	Upper Mainstem (A)	2.68	1.66	4.34	1.09	0.76	1.56	0.98	0.75	1.29	1.02	0.86	1.21	0.63	0.99	0.83	1.17	0.44
		Lower Mainstem (A)	1.48	0.70	3.10	1.22	0.62	2.38	1.30	0.59	2.87	1.08	0.51	2.29	0.65	1.08	0.51	2.29	0.65
		Joseph Cr. (A)	3.03	2.35	3.90	1.48	0.99	2.22	1.60	1.20	2.15	1.09	0.85	1.40	0.79	1.09	0.85	1.40	0.79
		Wallowa R. (A)	2.60	1.83	3.68	1.45	1.06	1.98	1.81	1.40	2.35	1.07	0.84	1.37	0.79	1.07	0.84	1.37	0.78
	Clearwater River	Lower Mainstem (A)	1.50	0.71	3.14	1.23	0.63	2.41	1.29	0.59	2.85	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
		Lolo Creek (A & B)-assume B	1.11	0.86	1.44	1.04	0.68	1.59	1.05	0.64	1.73	1.06	0.67	1.68	0.68	1.06	0.67	1.68	0.68
		Lochsa River (B)	1.20	0.93	1.54	1.12	0.73	1.71	1.13	0.69	1.86	1.08	0.68	1.71	0.72	1.08	0.68	1.71	0.72
		Selway River (B)	1.04	0.81	1.35	0.98	0.64	1.49	0.98	0.60	1.62	1.05	0.66	1.66	0.64	1.05	0.66	1.66	0.64
		South Fork (B)	1.19	0.92	1.53	1.11	0.73	1.69	1.11	0.67	1.83	1.08	0.68	1.70	0.72	1.08	0.68	1.70	0.72
		North Fork - (Extirpated)																	
	Salmon River	Little Salmon/Rapid (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.29	0.59	2.85	1.08	0.51	2.29	0.65	1.08	0.51	2.29	0.65
		Chamberlain Cr. (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Secesh River (B)	1.09	0.84	1.40	1.02	0.67	1.55	1.03	0.63	1.70	1.06	0.67	1.67	0.67	1.06	0.67	1.67	0.67
		South Fork Salmon (B)	1.03	0.80	1.33	0.97	0.63	1.47	0.98	0.59	1.61	1.04	0.66	1.65	0.63	1.04	0.66	1.65	0.63
		Panther Creek (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Lower Middle Fork Tribs (B)	1.05	0.81	1.35	0.98	0.64	1.49	0.99	0.60	1.63	1.05	0.66	1.66	0.64	1.05	0.66	1.66	0.64
		Upper Middle Fork Tribs (B)	1.03	0.80	1.33	0.96	0.63	1.46	0.97	0.59	1.60	1.04	0.66	1.65	0.63	1.04	0.66	1.65	0.63
		North Fork (A)	1.46	0.70	3.07	1.20	0.62	2.35	1.29	0.59	2.85	1.08	0.51	2.28	0.64	1.08	0.51	2.28	0.64
		Lemhi River (A)	1.51	0.72	3.17	1.24	0.64	2.43	1.33	0.60	2.93	1.09	0.51	2.30	0.66	1.09	0.51	2.30	0.66
		Pahsimeroi River (A)	1.69	0.81	3.56	1.40	0.71	2.73	1.41	0.64	3.10	1.11	0.52	2.36	0.70	1.11	0.52	2.36	0.70
		East Fork Salmon (A)	1.50	0.71	3.14	1.23	0.63	2.41	1.32	0.60	2.90	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
		Upper Mainstem (A)	1.56	0.74	3.27	1.28	0.66	2.50	1.37	0.62	3.02	1.09	0.51	2.32	0.67	1.09	0.51	2.32	0.67
Mid Columbia Steelhead	Yakima	Upper Yakima	1.55	1.06	2.28	1.42	0.96	2.10	1.95	1.26	3.02	1.09	0.80	1.49	0.78	1.09	0.79	1.49	0.76
		Naches	1.55	1.01	2.36	1.42	0.96	2.09	1.91	1.22	2.99	1.10	0.79	1.52	0.78	1.08	0.78	1.49	0.74
		Toppenish	2.21	1.25	3.92	2.02	1.24	3.32	3.04	1.77	5.21	1.17	0.81	1.69	0.87	1.15	0.80	1.66	0.85
		Satus	1.94	1.48	2.54	1.20	0.86	1.67	1.39	0.90	2.15	1.05	0.82	1.34	0.72	1.03	0.81	1.32	0.64
	Eastern Cascades	Deschutes W.	1.26	0.96	1.67	1.11	0.81	1.51	1.40	0.89	2.20	1.06	0.84	1.35	0.75	1.01	0.81	1.26	0.54
		Deschutes E.							1.43	0.81	2.54								
		Klickitat																	
		Fifteenmile Cr.	2.02	1.40	2.93	1.30	0.94	1.81	2.10	1.44	3.07	1.05	0.85	1.31	0.75	1.05	0.85	1.31	0.75
		Rock Cr.																	
		White Salmon - Extirpated																	
	Umatilla/Walla Walla	Umatilla	2.02	1.49	2.73	1.26	0.98	1.64	1.15	0.95	1.41	1.11	0.92	1.34	0.89	1.05	0.88	1.25	0.77
		Walla-Walla																	
		Touchet																	
	John Day	Lower Mainstem	3.74	2.43	5.76	1.56	0.95	2.55	1.86	0.92	3.75	1.06	0.75	1.51	0.67	1.05	0.75	1.48	0.65
		North Fork	3.02	2.04	4.48	1.47	0.98	2.19	2.09	1.53	2.85	1.05	0.84	1.33	0.71	1.05	0.83	1.31	0.70
		Upper Mainstem	2.69	1.44	5.01	1.34	0.90	2.00	0.99	0.60	1.63	1.04	0.81	1.34	0.67	1.04	0.81	1.33	0.65
		Middle Fork	3.06	2.31	4.07	1.47	1.02	2.11	1.24	0.71	2.16	1.06	0.84	1.34	0.73	1.05	0.83	1.33	0.71
		South Fork	2.63	1.62	4.26	1.26	0.81	1.97	1.29	0.67	2.47	1.05	0.78	1.41	0.65	1.04	0.78	1.39	0.63

Table 8. Continued.

Prospective - Recent Climate			Productivity								BRT Trend					
ESU	**MPG**	**Population**	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	**1980-current trend**	Lower 95% CI	Upper 95% CI	**1990-current trend**	Lower 95% CI	Upper 95% CI
		Expected Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.11	0.05	23.84	0.63	1.11	0.05	23.84	0.63	1.12	1.04	1.35	1.19	1.05	1.34
	Average "B-Run" Populations (only 13 years)		1.04	0.16	6.95	0.58	1.04	0.16	6.95	0.58	1.09	1.02	1.24	1.12	1.02	1.24
	Lower Snake	Tucannon (A, but below LGR)	*1.12*	*0.05*	*24.10*	*0.64*	*1.12*	*0.05*	*24.10*	*0.64*	*1.25*	*1.16*	*1.51*	*1.25*	*1.11*	*1.41*
		Asotin (A)	*1.12*	*0.05*	*24.05*	*0.64*	*1.12*	*0.05*	*24.05*	*0.64*	*1.27*	*1.17*	*1.52*	*1.24*	*1.10*	*1.40*
	Imnaha River	Imnaha R. (A)	1.06	0.73	1.55	0.72	1.06	0.73	1.55	0.72	1.14	1.09	1.26	1.16	1.07	1.25
	Grande Ronde	Upper Mainstem (A)	1.03	0.92	1.16	0.82	0.99	0.88	1.11	0.32	1.16	1.12	1.25	1.16	1.10	1.22
		Lower Mainstem (A)	*1.11*	*0.05*	*23.90*	*0.63*	*1.11*	*0.05*	*23.90*	*0.63*	*1.13*	*1.05*	*1.36*	*1.20*	*1.06*	*1.36*
		Joseph Cr. (A)	1.05	0.82	1.34	0.76	1.05	0.82	1.34	0.76	1.19	1.14	1.30	1.19	1.12	1.27
		Wallowa R. (A)	1.13	0.65	1.94	0.89	1.12	0.64	1.97	0.88	1.16	1.12	1.36	1.24	1.15	1.33
	Clearwater River	Lower Mainstem (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.15*	*1.06*	*1.38*	*1.19*	*1.05*	*1.34*
		Lolo Creek (A & B)-assume B	*1.07*	*0.16*	*7.16*	*0.64*	*1.07*	*0.16*	*7.16*	*0.64*	*1.25*	*1.17*	*1.43*	*1.28*	*1.16*	*1.42*
		Lochsa River (B)	*1.09*	*0.16*	*7.28*	*0.66*	*1.09*	*0.16*	*7.28*	*0.66*	*1.34*	*1.26*	*1.54*	*1.38*	*1.25*	*1.52*
		Selway River (B)	*1.06*	*0.16*	*7.06*	*0.61*	*1.06*	*0.16*	*7.06*	*0.61*	*1.17*	*1.10*	*1.34*	*1.20*	*1.09*	*1.33*
		South Fork (B)	*1.08*	*0.16*	*7.25*	*0.66*	*1.08*	*0.16*	*7.25*	*0.66*	*1.33*	*1.25*	*1.53*	*1.36*	*1.23*	*1.50*
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.13*	*1.04*	*1.36*	*1.19*	*1.05*	*1.34*
		Chamberlain Cr. (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Secesh River (B)	*1.07*	*0.16*	*7.13*	*0.63*	*1.07*	*0.16*	*7.13*	*0.63*	*1.22*	*1.15*	*1.40*	*1.26*	*1.14*	*1.39*
		South Fork Salmon (B)	*1.05*	*0.16*	*7.05*	*0.61*	*1.05*	*0.16*	*7.05*	*0.61*	*1.16*	*1.09*	*1.33*	*1.19*	*1.08*	*1.32*
		Panther Creek (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Lower Middle Fork Tribs (B)	*1.06*	*0.16*	*7.07*	*0.61*	*1.06*	*0.16*	*7.07*	*0.61*	*1.17*	*1.10*	*1.34*	*1.21*	*1.10*	*1.34*
		Upper Middle Fork Tribs (B)	*1.05*	*0.16*	*7.04*	*0.61*	*1.05*	*0.16*	*7.04*	*0.61*	*1.15*	*1.08*	*1.32*	*1.19*	*1.08*	*1.31*
		North Fork (A)	*1.11*	*0.05*	*23.84*	*0.63*	*1.11*	*0.05*	*23.84*	*0.63*	*1.12*	*1.04*	*1.35*	*1.19*	*1.05*	*1.34*
		Lemhi River (A)	*1.11*	*0.05*	*24.00*	*0.63*	*1.11*	*0.05*	*24.00*	*0.63*	*1.16*	*1.07*	*1.40*	*1.23*	*1.08*	*1.38*
		Pahsimeroi River (A)	*1.13*	*0.05*	*24.31*	*0.65*	*1.13*	*0.05*	*24.31*	*0.65*	*1.30*	*1.20*	*1.57*	*1.30*	*1.15*	*1.46*
		East Fork Salmon (A)	*1.11*	*0.05*	*23.95*	*0.63*	*1.11*	*0.05*	*23.95*	*0.63*	*1.15*	*1.06*	*1.38*	*1.21*	*1.07*	*1.37*
		Upper Mainstem (A)	*1.12*	*0.05*	*24.16*	*0.64*	*1.12*	*0.05*	*24.16*	*0.64*	*1.19*	*1.10*	*1.44*	*1.26*	*1.12*	*1.42*
Mid Columbia Steelhead	Yakima	Upper Yakima	1.16	0.32	4.21	0.58	1.15	0.31	4.24	0.80	1.39	1.32	1.62	1.38	1.29	1.47
		Naches	1.16	0.29	4.67	0.57	1.14	0.28	4.66	0.78	1.41	1.34	1.63	1.40	1.31	1.48
		Toppenish	1.26	0.24	6.48	0.59	1.23	0.23	6.49	0.82	1.51	1.41	1.83	1.53	1.41	1.66
		Satus	1.08	0.31	3.91	0.71	1.06	0.29	3.88	0.67	1.35	1.29	1.55	1.32	1.24	1.41
	Eastern Cascades	Deschutes W.	1.13	0.80	1.57	0.87	1.04	0.76	1.44	0.69	1.20	1.16	1.41	1.27	1.19	1.36
		Deschutes E.	1.13	0.58	2.23	0.74	1.01	0.55	1.86	0.53				1.32	1.20	1.46
		Klickitat														
		Fifteenmile Cr.	1.17	0.90	1.53	0.94	1.17	0.90	1.53	0.94	1.15	1.09	1.28	1.48	1.39	1.58
		Rock Cr.														
		White Salmon - Extirpated														
	Umatilla/Walla Walla	Umatilla	1.12	0.37	3.35	0.79	1.02	0.38	2.75	0.59	1.35	1.31	1.52	1.33	1.26	1.40
		Walla-Walla														
		Touchet														
	John Day	Lower Mainstem	1.09	0.59	1.98	0.69	1.07	0.59	1.94	0.66	1.22	1.17	1.43	1.24	1.13	1.36
		North Fork	1.12	0.96	1.29	0.96	1.10	0.96	1.27	0.95	1.24	1.19	1.45	1.31	1.23	1.39
		Upper Mainstem	1.00	0.64	1.57	0.51	0.99	0.64	1.53	0.47	1.20	1.15	1.30	1.15	1.08	1.24
		Middle Fork	1.03	0.61	1.75	0.59	1.02	0.61	1.71	0.56	1.21	1.17	1.33	1.17	1.08	1.27
		South Fork	1.07	0.53	2.15	0.65	1.06	0.53	2.10	0.62	1.21	1.17	1.39	1.22	1.13	1.32

Table 9. Detailed prospective survival gap estimates for steelhead DPSs under warm PDO (poor) ocean climate assumptions. Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

Prospective - Warm PDO (Poor) Climate																	
			Survival Gap For Productivity ≥ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
		Low Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.13	1.76	0.72	1.58	2.68	0.93	0.30	0.93	0.09	1.09	3.48	0.34	0.67	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	2.19	3.10	1.55	2.60	3.98	1.70	0.32	1.09	0.10	2.76	6.25	1.21	0.64	>10	0.01
		Entiat (Summer A)	1.38	1.94	0.99	1.30	1.69	0.99	0.57	1.79	0.18	1.86	4.22	0.82	0.63	>10	0.01
		Okanogan (Summer A)	4.53	6.51	3.16	5.02	7.54	3.35									
		High Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.13	1.76	0.72	1.58	2.68	0.93	0.30	0.93	0.09	1.09	3.48	0.34	0.67	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	1.65	2.34	1.17	2.60	3.98	1.70	0.24	0.82	0.07	2.08	4.72	0.92	0.64	>10	0.01
		Entiat (Summer A)	0.87	1.22	0.62	1.30	1.69	0.99	0.36	1.13	0.12	1.17	2.66	0.52	0.63	>10	0.01
		Okanogan (Summer A)	3.23	4.64	2.25	5.02	7.54	3.35									
		Allowable Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
	Average "B-Run" Populations (only 13 years)		1.18	1.80	0.78	1.17	1.92	0.71	0.95	7.46	0.12	0.95	7.46	0.12	0.90	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.76	1.48	0.39	0.75	1.66	0.34	0.65	>10	0.02	0.65	>10	0.02	0.61	>10	0.00
		Asotin (A)	0.75	1.47	0.38	0.76	1.68	0.34	0.65	>10	0.02	0.65	>10	0.02	0.62	>10	0.00
	Imnaha River	Imnaha R. (A)	0.64	0.98	0.41	0.65	1.10	0.38	0.71	2.30	0.22	0.71	2.30	0.22	0.77	4.20	0.14
	Grande Ronde	Upper Mainstem (A)	0.94	1.35	0.65	1.04	1.36	0.79	0.93	1.98	0.43	1.07	2.31	0.49	0.88	1.48	0.52
		Lower Mainstem (A)	0.84	1.64	0.43	0.78	1.73	0.35	0.72	>10	0.02	0.72	>10	0.02	0.64	>10	0.00
		Joseph Cr. (A)	0.69	1.03	0.46	0.64	0.85	0.47	0.70	2.17	0.23	0.70	2.17	0.23	0.82	2.49	0.27
		Wallowa R. (A)	0.70	0.96	0.51	0.56	0.73	0.43	0.74	2.21	0.25	0.74	2.29	0.24	0.60	6.87	0.05
	Clearwater River	Lower Mainstem (A)	0.83	1.62	0.42	0.79	1.74	0.36	0.71	>10	0.02	0.71	>10	0.02	0.64	>10	0.00
		Lolo Creek (A & B)-assume B	1.03	1.57	0.67	1.02	1.68	0.62	0.82	6.48	0.10	0.82	6.48	0.10	0.79	>10	0.00
		Lochsa River (B)	0.96	1.46	0.63	0.95	1.56	0.58	0.77	6.04	0.10	0.77	6.04	0.10	0.73	>10	0.00
		Selway River (B)	1.10	1.67	0.72	1.09	1.79	0.66	0.88	6.92	0.11	0.88	6.92	0.11	0.84	>10	0.00
		South Fork (B)	0.96	1.47	0.63	0.97	1.59	0.59	0.77	6.08	0.10	0.77	6.08	0.10	0.74	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.84	1.65	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Chamberlain Cr. (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Secesh River (B)	1.05	1.61	0.69	1.04	1.71	0.63	0.84	6.64	0.11	0.84	6.64	0.11	0.80	>10	0.00
		South Fork Salmon (B)	1.11	1.69	0.73	1.10	1.80	0.67	0.89	7.00	0.11	0.89	7.00	0.11	0.84	>10	0.00
		Panther Creek (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Lower Middle Fork Tribs (B)	1.09	1.67	0.72	1.08	1.78	0.66	0.87	6.90	0.11	0.87	6.90	0.11	0.83	>10	0.00
		Upper Middle Fork Tribs (B)	1.12	1.70	0.73	1.10	1.81	0.67	0.89	7.04	0.11	0.89	7.04	0.11	0.85	>10	0.00
		North Fork (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Lemhi River (A)	0.82	1.60	0.42	0.77	1.69	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Pahsimeroi River (A)	0.73	1.43	0.37	0.73	1.60	0.33	0.63	>10	0.02	0.63	>10	0.02	0.59	>10	0.00
		East Fork Salmon (A)	0.83	1.62	0.42	0.78	1.71	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Upper Mainstem (A)	0.80	1.56	0.41	0.75	1.64	0.34	0.69	>10	0.02	0.69	>10	0.02	0.61	>10	0.00

Table 9. Continued.

Prospective - Warm PDO (Poor) Climate

			Productivity ≥ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend ≥ 1.0					
ESU	**MPG**	**Population**	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	**High**	**Low**	**1980-current trend**	**Upper 95% CI**	**Lower 95% CI**	**1990-current trend**	**Upper 95% CI**	**Lower 95% CI**
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.03	>10	0.10	0.47	0.57	0.69	0.72	0.62	0.34	0.39	0.25	0.60	0.79	0.46
		Wenatchee - Hatch =.3 (Summer A)				0.47	0.56	0.68								
		Methow (Summer A)	4.91	>10	0.56	1.72	2.01	2.42	0.92	0.77	0.35	0.41	0.26	0.57	0.81	0.40
		Entiat (Summer A)	2.17	9.88	0.48	1.60	2.01	2.50	1.44	1.20	0.60	0.69	0.44	0.56	0.73	0.43
		Okanogan (Summer A)				3.11	3.58	4.33	0.76	0.63						
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.03	>10	0.10	0.47	0.57	0.69	0.72	0.62	0.34	0.39	0.25	0.60	0.79	0.46
		Wenatchee - Hatch =.3 (Summer A)				0.47	0.56	0.68								
		Methow (Summer A)	4.91	>10	0.56	1.30	1.51	1.83	0.70	0.58	0.27	0.31	0.20	0.57	0.81	0.40
		Entiat (Summer A)	2.17	9.88	0.48	1.01	1.27	1.58	0.91	0.76	0.38	0.44	0.28	0.56	0.73	0.43
		Okanogan (Summer A)				2.22	2.55	3.09	0.54	0.45						
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
	Average "B-Run" Populations (only 13 years)		0.90	>10	0.00	1.15	1.64	1.72	1.35	1.17	1.15	1.52	0.62	0.98	1.53	0.62
	Lower Snake	Tucannon (A, but below LGR)	0.61	>10	0.00	0.81	1.53	1.53	1.11	0.98	0.77	1.11	0.34	0.62	1.08	0.36
		Asotin (A)	0.62	>10	0.00	0.80	1.51	1.51	1.10	0.98	0.77	1.10	0.33	0.63	1.09	0.36
	Imnaha River	Imnaha R. (A)	0.77	4.20	0.14	0.90	1.71	1.71	1.24	1.10	0.82	0.98	0.52	0.74	1.06	0.52
	Grande Ronde	Upper Mainstem (A)	1.09	1.84	0.65	0.87	0.97	0.97	0.51	0.70	0.93	1.08	0.66	0.85	1.08	0.67
		Lower Mainstem (A)	0.64	>10	0.00	0.89	1.69	1.69	1.23	1.09	0.86	1.23	0.37	0.65	1.12	0.37
		Joseph Cr. (A)	0.82	2.49	0.27	0.31	0.36	0.40	0.45	0.59	0.82	0.98	0.54	0.74	0.98	0.55
		Wallowa R. (A)	0.60	7.54	0.05	0.88	1.67	1.67	1.21	1.07	0.80	0.93	0.40	0.56	0.77	0.40
	Clearwater River	Lower Mainstem (A)	0.64	>10	0.00	0.88	1.67	1.67	1.21	1.07	0.85	1.21	0.37	0.65	1.13	0.38
		Lolo Creek (A & B)-assume B	0.79	>10	0.00	1.00	1.42	1.50	1.17	1.01	1.00	1.32	0.54	0.86	1.34	0.55
		Lochsa River (B)	0.73	>10	0.00	0.93	1.32	1.39	1.09	0.94	0.93	1.23	0.50	0.80	1.24	0.51
		Selway River (B)	0.84	>10	0.00	1.07	1.52	1.60	1.25	1.08	1.06	1.41	0.58	0.92	1.43	0.58
		South Fork (B)	0.74	>10	0.00	0.94	1.33	1.40	1.10	0.95	0.94	1.24	0.51	0.81	1.27	0.52
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	0.64	>10	0.00	0.90	1.70	1.70	1.24	1.09	0.86	1.24	0.38	0.65	1.13	0.38
		Chamberlain Cr. (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
		Secesh River (B)	0.80	>10	0.00	1.03	1.46	1.53	1.20	1.04	1.02	1.35	0.55	0.87	1.36	0.56
		South Fork Salmon (B)	0.84	>10	0.00	1.08	1.54	1.62	1.27	1.10	1.08	1.42	0.58	0.92	1.44	0.59
		Panther Creek (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
		Lower Middle Fork Tribs (B)	0.83	>10	0.00	1.07	1.51	1.59	1.25	1.08	1.06	1.40	0.58	0.91	1.41	0.58
		Upper Middle Fork Tribs (B)	0.85	>10	0.00	1.09	1.54	1.62	1.27	1.10	1.08	1.43	0.59	0.92	1.44	0.59
		North Fork (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
		Lemhi River (A)	0.63	>10	0.00	0.87	1.65	1.65	1.20	1.06	0.84	1.20	0.36	0.63	1.10	0.37
		Pahsimeroi River (A)	0.59	>10	0.00	0.78	1.47	1.47	1.07	0.95	0.75	1.07	0.32	0.60	1.04	0.35
		East Fork Salmon (A)	0.63	>10	0.00	0.88	1.67	1.67	1.21	1.07	0.85	1.21	0.37	0.64	1.11	0.37
		Upper Mainstem (A)	0.61	>10	0.00	0.85	1.60	1.60	1.17	1.03	0.81	1.17	0.35	0.62	1.07	0.36

Table 9. Continued.

Prospective - Warm PDO (Poor) Climate

			Survival Gap For Productivity ≥ 1.0														
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
		Expected Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
	Average "B-Run" Populations (only 13 years)		1.13	1.72	0.74	1.11	1.83	0.68	0.90	7.10	0.11	0.90	7.10	0.11	0.86	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.76	1.48	0.39	0.75	1.66	0.34	0.65	>10	0.02	0.65	>10	0.02	0.61	>10	0.00
		Asotin (A)	0.75	1.47	0.38	0.76	1.68	0.34	0.65	>10	0.02	0.65	>10	0.02	0.62	>10	0.00
	Imnaha River	Imnaha R. (A)	0.64	0.98	0.41	0.65	1.10	0.38	0.71	2.30	0.22	0.71	2.30	0.22	0.77	4.20	0.14
	Grande Ronde	Upper Mainstem (A)	0.94	1.35	0.65	1.04	1.36	0.79	0.93	1.98	0.43	1.07	2.31	0.49	0.88	1.48	0.52
		Lower Mainstem (A)	0.84	1.64	0.43	0.78	1.73	0.35	0.72	>10	0.02	0.72	>10	0.02	0.64	>10	0.00
		Joseph Cr. (A)	0.69	1.03	0.46	0.64	0.85	0.47	0.70	2.17	0.23	0.70	2.17	0.23	0.82	2.49	0.27
		Wallowa R. (A)	0.70	0.96	0.51	0.56	0.73	0.43	0.74	2.21	0.25	0.74	2.29	0.24	0.60	6.87	0.05
	Clearwater River	Lower Mainstem (A)	0.83	1.62	0.42	0.79	1.74	0.36	0.71	>10	0.02	0.71	>10	0.02	0.64	>10	0.00
		Lolo Creek (A & B)-assume B	0.98	1.49	0.64	0.97	1.60	0.59	0.78	6.17	0.10	0.78	6.17	0.10	0.75	>10	0.00
		Lochsa River (B)	0.91	1.39	0.60	0.90	1.49	0.55	0.73	5.74	0.09	0.73	5.74	0.09	0.70	>10	0.00
		Selway River (B)	1.04	1.59	0.68	1.04	1.71	0.63	0.84	6.58	0.11	0.84	6.58	0.11	0.80	>10	0.00
		South Fork (B)	0.92	1.40	0.60	0.92	1.51	0.56	0.73	5.79	0.09	0.73	5.79	0.09	0.71	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.84	1.65	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Chamberlain Cr. (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Secesh River (B)	1.00	1.53	0.66	0.99	1.63	0.60	0.80	6.32	0.10	0.80	6.32	0.10	0.76	>10	0.00
		South Fork Salmon (B)	1.06	1.61	0.69	1.04	1.71	0.63	0.85	6.66	0.11	0.85	6.66	0.11	0.80	>10	0.00
		Panther Creek (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Lower Middle Fork Tribs (B)	1.04	1.59	0.68	1.03	1.69	0.62	0.83	6.56	0.11	0.83	6.56	0.11	0.79	>10	0.00
		Upper Middle Fork Tribs (B)	1.06	1.62	0.70	1.05	1.72	0.64	0.85	6.70	0.11	0.85	6.70	0.11	0.81	>10	0.00
		North Fork (A)	0.85	1.66	0.43	0.79	1.74	0.36	0.73	>10	0.02	0.73	>10	0.02	0.64	>10	0.00
		Lemhi River (A)	0.82	1.60	0.42	0.77	1.69	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Pahsimeroi River (A)	0.73	1.43	0.37	0.73	1.60	0.33	0.63	>10	0.02	0.63	>10	0.02	0.59	>10	0.00
		East Fork Salmon (A)	0.83	1.62	0.42	0.78	1.71	0.35	0.71	>10	0.02	0.71	>10	0.02	0.63	>10	0.00
		Upper Mainstem (A)	0.80	1.56	0.41	0.75	1.64	0.34	0.69	>10	0.02	0.69	>10	0.02	0.61	>10	0.00
Mid Columbia Steelhead	Yakima	Upper Yakima	0.72	1.06	0.49	0.52	0.81	0.34	0.69	2.83	0.17	0.71	2.94	0.17	0.53	>10	0.00
		Naches	0.72	1.06	0.49	0.53	0.84	0.34	0.68	2.92	0.16	0.73	3.17	0.17	0.51	>10	0.00
		Toppenish	0.50	0.83	0.31	0.34	0.58	0.20	0.50	2.57	0.10	0.54	2.80	0.10	0.37	>10	0.00
		Satus	0.85	1.19	0.61	0.73	1.13	0.47	0.82	2.47	0.27	0.89	2.70	0.29	0.72	>10	0.00
	Eastern Cascades	Deschutes W.	0.92	1.26	0.67	0.73	1.14	0.46	0.77	2.23	0.27	0.98	2.64	0.37	0.60	2.72	0.13
		Deschutes E.				0.71	1.26	0.40							0.58	>10	0.03
		Klickitat															
		Fifteenmile Cr.	0.78	1.09	0.56	0.49	0.71	0.33	0.81	2.14	0.31	0.81	2.14	0.31	0.50	1.63	0.15
		Rock Cr.															
		White Salmon - Extirpated															
	Umatilla/Walla Walla	Umatilla	0.81	1.05	0.62	0.88	1.08	0.72	0.65	1.52	0.28	0.81	1.78	0.37	0.62	>10	0.00
		Walla-Walla															
		Touchet															
	John Day	Lower Mainstem	0.66	1.08	0.40	0.55	1.11	0.27	0.78	3.76	0.16	0.81	3.81	0.17	0.71	>10	0.05
		North Fork	0.70	1.04	0.47	0.49	0.67	0.36	0.81	2.29	0.29	0.83	2.31	0.30	0.62	1.21	0.32
		Upper Mainstem	0.76	1.14	0.51	1.03	1.69	0.63	0.84	2.63	0.27	0.86	2.68	0.28	1.01	7.63	0.13
		Middle Fork	0.69	1.00	0.48	0.82	1.44	0.47	0.79	2.28	0.27	0.81	2.31	0.29	0.88	9.45	0.08
		South Fork	0.81	1.26	0.52	0.79	1.52	0.41	0.84	3.15	0.22	0.86	3.17	0.23	0.75	>10	0.03

Table 9. Continued.

Prospective - Warm PDO (Poor) Climate

			Productivity ≥ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	High	Low	1980-current trend	Upper 95% CI	Lower 95% CI	1990-current trend	Upper 95% CI	Lower 95% CI
		Expected Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
Snake River Steelhead	Average "B-Run" Populations (only 13 years)		0.86	>10	0.00	1.10	1.56	1.64	1.28	1.11	1.09	1.44	0.59	0.93	1.46	0.59
Snake River Steelhead	Lower Snake	Tucannon (A, but below LGR)	0.61	>10	0.00	0.81	1.53	1.53	1.11	0.98	0.77	1.11	0.34	0.62	1.08	0.36
Snake River Steelhead	Lower Snake	Asotin (A)	0.62	>10	0.00	0.80	1.51	1.51	1.10	0.98	0.77	1.10	0.33	0.63	1.09	0.36
Snake River Steelhead	Imnaha River	Imnaha R. (A)	0.77	4.20	0.14	0.90	1.71	1.71	1.24	1.10	0.82	0.98	0.52	0.74	1.06	0.52
Snake River Steelhead	Grande Ronde	Upper Mainstem (A)	1.09	1.84	0.65	0.87	0.97	0.97	0.51	0.70	0.93	1.08	0.66	0.85	1.08	0.67
Snake River Steelhead	Grande Ronde	Lower Mainstem (A)	0.64	>10	0.00	0.89	1.69	1.69	1.23	1.09	0.86	1.23	0.37	0.65	1.12	0.37
Snake River Steelhead	Grande Ronde	Joseph Cr. (A)	0.82	2.49	0.27	0.31	0.36	0.40	0.45	0.59	0.82	0.98	0.54	0.74	0.98	0.55
Snake River Steelhead	Grande Ronde	Wallowa R. (A)	0.60	7.54	0.05	0.88	1.67	1.67	1.21	1.07	0.80	0.93	0.40	0.56	0.77	0.40
Snake River Steelhead	Clearwater River	Lower Mainstem (A)	0.64	>10	0.00	0.88	1.67	1.67	1.21	1.07	0.85	1.21	0.37	0.65	1.13	0.38
Snake River Steelhead	Clearwater River	Lolo Creek (A & B)-assume B	0.75	>10	0.00	0.95	1.35	1.42	1.12	0.97	0.95	1.26	0.51	0.81	1.27	0.52
Snake River Steelhead	Clearwater River	Lochsa River (B)	0.70	>10	0.00	0.89	1.26	1.33	1.04	0.90	0.88	1.17	0.48	0.76	1.18	0.48
Snake River Steelhead	Clearwater River	Selway River (B)	0.80	>10	0.00	1.02	1.44	1.52	1.19	1.03	1.01	1.34	0.55	0.87	1.36	0.56
Snake River Steelhead	Clearwater River	South Fork (B)	0.71	>10	0.00	0.90	1.27	1.34	1.05	0.91	0.89	1.18	0.48	0.77	1.20	0.49
Snake River Steelhead	Clearwater River	North Fork - (Extirpated)														
Snake River Steelhead	Salmon River	Little Salmon/Rapid (A)	0.64	>10	0.00	0.90	1.70	1.70	1.24	1.09	0.86	1.24	0.38	0.65	1.13	0.38
Snake River Steelhead	Salmon River	Chamberlain Cr. (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
Snake River Steelhead	Salmon River	Secesh River (B)	0.76	>10	0.00	0.98	1.39	1.46	1.14	0.99	0.97	1.29	0.53	0.83	1.30	0.53
Snake River Steelhead	Salmon River	South Fork Salmon (B)	0.80	>10	0.00	1.03	1.46	1.54	1.21	1.04	1.03	1.36	0.56	0.88	1.37	0.56
Snake River Steelhead	Salmon River	Panther Creek (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
Snake River Steelhead	Salmon River	Lower Middle Fork Tribs (B)	0.79	>10	0.00	1.02	1.44	1.52	1.19	1.03	1.01	1.34	0.55	0.86	1.35	0.55
Snake River Steelhead	Salmon River	Upper Middle Fork Tribs (B)	0.81	>10	0.00	1.04	1.47	1.55	1.21	1.05	1.03	1.36	0.56	0.88	1.37	0.56
Snake River Steelhead	Salmon River	North Fork (A)	0.64	>10	0.00	0.90	1.71	1.71	1.24	1.10	0.87	1.24	0.38	0.65	1.13	0.38
Snake River Steelhead	Salmon River	Lemhi River (A)	0.63	>10	0.00	0.87	1.65	1.65	1.20	1.06	0.84	1.20	0.36	0.63	1.10	0.37
Snake River Steelhead	Salmon River	Pahsimeroi River (A)	0.59	>10	0.00	0.78	1.47	1.47	1.07	0.95	0.75	1.07	0.32	0.60	1.04	0.35
Snake River Steelhead	Salmon River	East Fork Salmon (A)	0.63	>10	0.00	0.88	1.67	1.67	1.21	1.07	0.85	1.21	0.37	0.64	1.11	0.37
Snake River Steelhead	Salmon River	Upper Mainstem (A)	0.61	>10	0.00	0.85	1.60	1.60	1.17	1.03	0.81	1.17	0.35	0.62	1.07	0.36
Mid Columbia Steelhead	Yakima	Upper Yakima	0.54	>10	0.00	0.82	1.58	1.67	1.27	1.08	0.72	0.91	0.36	0.54	0.72	0.40
Mid Columbia Steelhead	Yakima	Naches	0.56	>10	0.00	0.76	1.49	1.59	1.12	0.99	0.69	0.86	0.35	0.51	0.67	0.39
Mid Columbia Steelhead	Yakima	Toppenish	0.39	>10	0.00	0.74	1.10	1.10	0.96	0.89	0.50	0.68	0.21	0.34	0.49	0.23
Mid Columbia Steelhead	Yakima	Satus	0.78	>10	0.00	0.73	1.84	1.84	0.97	0.89	0.82	1.02	0.44	0.66	0.89	0.48
Mid Columbia Steelhead	Eastern Cascades	Deschutes W.	0.84	3.58	0.20	0.96	1.50	1.62	1.11	1.01	0.87	1.02	0.42	0.59	0.79	0.44
Mid Columbia Steelhead	Eastern Cascades	Deschutes E.	0.96	>10	0.06	0.44	0.54	0.65	0.76	0.78				0.54	0.84	0.34
Mid Columbia Steelhead	Eastern Cascades	Klickitat														
Mid Columbia Steelhead	Eastern Cascades	Fifteenmile Cr.	0.50	1.63	0.15	0.91	0.72	0.89	1.15	1.07	0.80	0.99	0.49	0.53	0.70	0.40
Mid Columbia Steelhead	Eastern Cascades	Rock Cr.														
Mid Columbia Steelhead	Eastern Cascades	White Salmon - Extirpated														
Mid Columbia Steelhead	Umatilla/Walla Walla	Umatilla	0.92	>10	0.01	0.52	0.83	0.83	0.80	0.78	0.74	0.85	0.44	0.60	0.77	0.47
Mid Columbia Steelhead	Umatilla/Walla Walla	Walla-Walla				0.68	0.99	1.07	0.73	0.73						
Mid Columbia Steelhead	Umatilla/Walla Walla	Touchet														
Mid Columbia Steelhead	John Day	Lower Mainstem	0.76	>10	0.05	0.81	0.90	0.90	0.88	0.86	0.91	1.10	0.45	0.72	1.09	0.47
Mid Columbia Steelhead	John Day	North Fork	0.66	1.23	0.35	0.34	0.42	0.50	0.57	0.64	0.85	1.02	0.42	0.57	0.74	0.44
Mid Columbia Steelhead	John Day	Upper Mainstem	1.06	7.57	0.15	0.79	1.11	1.11	0.90	0.87	1.02	1.20	0.71	1.02	1.40	0.74
Mid Columbia Steelhead	John Day	Middle Fork	0.93	9.53	0.09	0.81	0.88	0.88	0.91	0.88	0.95	1.12	0.63	0.94	1.33	0.66
Mid Columbia Steelhead	John Day	South Fork	0.79	>10	0.04	0.78	0.97	0.97	0.94	0.89	1.01	1.21	0.54	0.81	1.16	0.57

Table 10. Detailed prospective productivity estimates for steelhead DPSs under warm PDO (poor) ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

Prospective - Warm PDO (Poor) Climate

			Productivity															
ESU	MPG	Population	Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Low Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.11	1.44	3.10	0.89	0.57	1.38	0.63	0.37	1.08	1.29	1.00	1.67	0.98	0.97	0.75	1.25	0.36
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.59	0.32	1.08	0.46	0.32	0.65	0.38	0.25	0.59	1.27	0.97	1.66	0.96	0.79	0.66	0.94	0.01
		Entiat (Summer A)	0.67	0.44	1.01	0.72	0.52	1.01	0.77	0.59	1.01	1.12	0.87	1.44	0.85	0.86	0.71	1.03	0.04
		Okanogan (Summer A)	0.33	0.17	0.63	0.22	0.15	0.32	0.20	0.13	0.30								
		High Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.11	1.44	3.10	0.89	0.57	1.38	0.63	0.37	1.08	1.29	1.00	1.67	0.98	0.97	0.75	1.25	0.36
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.78	0.42	1.44	0.61	0.43	0.86	0.38	0.25	0.59	1.35	1.03	1.77	0.98	0.84	0.70	1.00	0.03
		Entiat (Summer A)	1.06	0.70	1.60	1.15	0.82	1.61	0.77	0.59	1.01	1.24	0.96	1.59	0.96	0.95	0.79	1.14	0.24
		Okanogan (Summer A)	0.46	0.24	0.88	0.31	0.22	0.44	0.20	0.13	0.30								
		Allowable Harvest Assumption:																	
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
	Average "B-Run" Populations (only 13 years)		0.90	0.70	1.17	0.85	0.55	1.29	0.86	0.52	1.41	1.00	0.63	1.58	0.49	1.00	0.63	1.58	0.49
	Lower Snake	Tucannon (A, but below LGR)	1.60	0.76	3.36	1.32	0.67	2.57	1.33	0.60	2.93	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
		Asotin (A)	1.61	0.77	3.39	1.33	0.68	2.60	1.32	0.60	2.90	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
	Imnaha River	Imnaha R. (A)	3.27	2.48	4.32	1.57	1.02	2.43	1.54	0.91	2.61	1.06	0.82	1.38	0.72	1.06	0.82	1.38	0.72
	Grande Ronde	Upper Mainstem (A)	2.63	1.62	4.26	1.06	0.74	1.53	0.96	0.74	1.26	1.00	0.85	1.19	0.51	0.97	0.82	1.15	0.32
		Lower Mainstem (A)	1.45	0.69	3.04	1.19	0.61	2.33	1.28	0.58	2.82	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
		Joseph Cr. (A)	2.97	2.30	3.82	1.45	0.97	2.17	1.57	1.17	2.11	1.06	0.83	1.37	0.74	1.06	0.83	1.37	0.74
		Wallowa R. (A)	2.55	1.80	3.61	1.42	1.04	1.94	1.77	1.37	2.30	1.05	0.83	1.35	0.73	1.05	0.82	1.35	0.72
	Clearwater River	Lower Mainstem (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.27	0.57	2.79	1.06	0.50	2.25	0.62	1.06	0.50	2.25	0.62
		Lolo Creek (A & B)-assume B	1.04	0.80	1.34	0.97	0.64	1.48	0.98	0.60	1.61	1.03	0.65	1.63	0.59	1.03	0.65	1.63	0.59
		Lochsa River (B)	1.12	0.86	1.44	1.04	0.68	1.59	1.05	0.64	1.73	1.04	0.66	1.65	0.64	1.04	0.66	1.65	0.64
		Selway River (B)	0.97	0.75	1.26	0.91	0.60	1.39	0.92	0.56	1.51	1.01	0.64	1.61	0.54	1.01	0.64	1.61	0.54
		South Fork (B)	1.11	0.86	1.43	1.04	0.68	1.58	1.04	0.63	1.70	1.04	0.66	1.65	0.63	1.04	0.66	1.65	0.63
		North Fork - (Extirpated)																	
	Salmon River	Little Salmon/Rapid (A)	1.44	0.68	3.02	1.18	0.61	2.31	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
		Chamberlain Cr. (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
		Secesh River (B)	1.01	0.79	1.31	0.95	0.62	1.45	0.96	0.59	1.58	1.02	0.65	1.62	0.57	1.02	0.65	1.62	0.57
		South Fork Salmon (B)	0.96	0.75	1.24	0.90	0.59	1.37	0.91	0.55	1.50	1.01	0.64	1.60	0.54	1.01	0.64	1.60	0.54
		Panther Creek (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
		Lower Middle Fork Tribs (B)	0.98	0.76	1.26	0.91	0.60	1.39	0.93	0.56	1.52	1.01	0.64	1.61	0.55	1.01	0.64	1.61	0.55
		Upper Middle Fork Tribs (B)	0.96	0.74	1.24	0.90	0.59	1.37	0.91	0.55	1.49	1.01	0.64	1.60	0.53	1.01	0.64	1.60	0.53
		North Fork (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
		Lemhi River (A)	1.48	0.71	3.11	1.22	0.62	2.38	1.30	0.59	2.87	1.06	0.50	2.26	0.62	1.06	0.50	2.26	0.62
		Pahsimeroi River (A)	1.66	0.79	3.49	1.37	0.70	2.67	1.38	0.63	3.04	1.09	0.51	2.31	0.67	1.09	0.51	2.31	0.67
		East Fork Salmon (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.29	0.59	2.85	1.06	0.50	2.25	0.62	1.06	0.50	2.25	0.62
		Upper Mainstem (A)	1.52	0.73	3.20	1.26	0.64	2.45	1.34	0.61	2.96	1.07	0.50	2.27	0.63	1.07	0.50	2.27	0.63

Table 10. Continued.

Prospective - Warm PDO (Poor) Climate																
			Productivity								BRT Trend					
ESU	MPG	Population	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	1980-current trend	Lower 95% CI	Upper 95% CI	1990-current trend	Lower 95% CI	Upper 95% CI
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.07	0.02	2.53	0.69	0.84	0.43	1.64	0.19	2.62	2.53	2.80	1.43	1.35	1.53
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.09	0.03	2.53	0.68	0.69	0.43	1.12	0.04	2.28	2.20	2.44	1.45	1.35	1.57
		Entiat (Summer A)	1.09	0.03	2.55	0.73	0.83	0.59	1.16	0.07	1.45	1.41	1.56	1.50	1.42	1.60
		Okanogan (Summer A)														
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.07	0.02	2.53	0.69	0.84	0.43	1.64	0.19	2.62	2.53	2.80	1.43	1.35	1.53
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.09	0.03	2.53	0.68	0.69	0.43	1.12	0.04	3.02	2.92	3.23	1.45	1.35	1.57
		Entiat (Summer A)	1.09	0.03	2.55	0.73	0.83	0.59	1.16	0.07	2.31	2.23	2.47	1.50	1.42	1.60
		Okanogan (Summer A)														
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.01	1.32	1.17	1.03	1.32
	Average "B-Run" Populations (only 13 years)		1.01	0.15	6.74	0.52	1.01	0.15	6.74	0.52	1.01	0.95	1.16	1.05	0.95	1.16
	Lower Snake	Tucannon (A, but below LGR)	1.10	0.05	23.62	0.62	1.10	0.05	23.62	0.62	1.23	1.13	1.48	1.22	1.08	1.38
		Asotin (A)	1.09	0.05	23.57	0.61	1.09	0.05	23.57	0.61	1.24	1.14	1.49	1.21	1.07	1.37
	Imnaha River	Imnaha R. (A)	1.04	0.72	1.52	0.66	1.04	0.72	1.52	0.66	1.11	1.07	1.23	1.13	1.05	1.22
	Grande Ronde	Upper Mainstem (A)	1.01	0.90	1.14	0.65	0.97	0.86	1.08	0.16	1.13	1.10	1.22	1.13	1.08	1.19
		Lower Mainstem (A)	1.09	0.05	23.42	0.61	1.09	0.05	23.42	0.61	1.11	1.03	1.34	1.18	1.04	1.33
		Joseph Cr. (A)	1.03	0.80	1.32	0.67	1.03	0.80	1.32	0.67	1.17	1.12	1.28	1.17	1.10	1.25
		Wallowa R. (A)	1.10	0.64	1.90	0.87	1.10	0.63	1.93	0.86	1.14	1.10	1.33	1.21	1.13	1.30
	Clearwater River	Lower Mainstem (A)	1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.13	1.04	1.36	1.17	1.03	1.32
		Lolo Creek (A & B)-assume B	1.04	0.15	6.94	0.58	1.04	0.15	6.94	0.58	1.17	1.10	1.33	1.20	1.08	1.32
		Lochsa River (B)	1.06	0.16	7.05	0.61	1.06	0.16	7.05	0.61	1.25	1.18	1.43	1.29	1.16	1.42
		Selway River (B)	1.02	0.15	6.84	0.55	1.02	0.15	6.84	0.55	1.09	1.03	1.25	1.12	1.01	1.24
		South Fork (B)	1.05	0.16	7.03	0.60	1.05	0.16	7.03	0.60	1.24	1.17	1.42	1.26	1.14	1.40
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.02	1.33	1.17	1.03	1.32
		Chamberlain Cr. (A)	1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.01	1.32	1.17	1.03	1.32
		Secesh River (B)	1.03	0.15	6.91	0.57	1.03	0.15	6.91	0.57	1.14	1.07	1.30	1.18	1.06	1.30
		South Fork Salmon (B)	1.02	0.15	6.83	0.55	1.02	0.15	6.83	0.55	1.08	1.01	1.24	1.11	1.01	1.23
		Panther Creek (A)	1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.01	1.32	1.17	1.03	1.32
		Lower Middle Fork Tribs (B)	1.03	0.15	6.85	0.55	1.03	0.15	6.85	0.55	1.09	1.03	1.25	1.13	1.02	1.25
		Upper Middle Fork Tribs (B)	1.02	0.15	6.82	0.54	1.02	0.15	6.82	0.54	1.07	1.01	1.23	1.11	1.00	1.23
		North Fork (A)	1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.01	1.32	1.17	1.03	1.32
		Lemhi River (A)	1.09	0.05	23.52	0.61	1.09	0.05	23.52	0.61	1.14	1.05	1.37	1.20	1.06	1.36
		Pahsimeroi River (A)	1.11	0.05	23.82	0.63	1.11	0.05	23.82	0.63	1.28	1.18	1.53	1.27	1.13	1.43
		East Fork Salmon (A)	1.09	0.05	23.47	0.61	1.09	0.05	23.47	0.61	1.13	1.04	1.36	1.19	1.05	1.34
		Upper Mainstem (A)	1.10	0.05	23.67	0.62	1.10	0.05	23.67	0.62	1.17	1.08	1.41	1.24	1.09	1.40

Table 10. Continued.

Prospective - Warm PDO (Poor) Climate

ESU	MPG	Population	Productivity: Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Expected Harvest Assumption:																	
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Average "B-Run" Populations (only 13 years)		0.95	0.74	1.23	0.89	0.58	1.35	0.90	0.55	1.48	1.01	0.64	1.60	0.53	1.01	0.64	1.60	0.53
Snake River Steelhead	Lower Snake	Tucannon (A, but below LGR)	1.60	0.76	3.36	1.32	0.67	2.57	1.33	0.60	2.93	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
Snake River Steelhead	Lower Snake	Asotin (A)	1.61	0.77	3.39	1.33	0.68	2.60	1.32	0.60	2.90	1.08	0.51	2.30	0.65	1.08	0.51	2.30	0.65
Snake River Steelhead	Imnaha River	Imnaha R. (A)	3.27	2.48	4.32	1.57	1.02	2.43	1.54	0.91	2.61	1.06	0.82	1.38	0.72	1.06	0.82	1.38	0.72
Snake River Steelhead	Grande Ronde	Upper Mainstem (A)	2.63	1.62	4.26	1.06	0.74	1.53	0.96	0.74	1.26	1.00	0.85	1.19	0.51	0.97	0.82	1.15	0.32
Snake River Steelhead	Grande Ronde	Lower Mainstem (A)	1.45	0.69	3.04	1.19	0.61	2.33	1.28	0.58	2.82	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Grande Ronde	Joseph Cr. (A)	2.97	2.30	3.82	1.45	0.97	2.17	1.57	1.17	2.11	1.06	0.83	1.37	0.74	1.06	0.83	1.37	0.74
Snake River Steelhead	Grande Ronde	Wallowa R. (A)	2.55	1.80	3.61	1.42	1.04	1.94	1.77	1.37	2.30	1.05	0.83	1.35	0.73	1.05	0.82	1.35	0.72
Snake River Steelhead	Clearwater River	Lower Mainstem (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.27	0.57	2.79	1.06	0.50	2.25	0.62	1.06	0.50	2.25	0.62
Snake River Steelhead	Clearwater River	Lolo Creek (A & B)-assume B	1.09	0.85	1.41	1.02	0.67	1.56	1.03	0.63	1.70	1.04	0.66	1.65	0.62	1.04	0.66	1.65	0.62
Snake River Steelhead	Clearwater River	Lochsa River (B)	1.17	0.91	1.51	1.10	0.72	1.67	1.11	0.67	1.82	1.06	0.67	1.67	0.67	1.06	0.67	1.67	0.67
Snake River Steelhead	Clearwater River	Selway River (B)	1.02	0.79	1.32	0.96	0.63	1.46	0.96	0.59	1.59	1.02	0.65	1.62	0.58	1.02	0.65	1.62	0.58
Snake River Steelhead	Clearwater River	South Fork (B)	1.16	0.90	1.50	1.09	0.71	1.66	1.09	0.66	1.79	1.05	0.67	1.67	0.67	1.05	0.67	1.67	0.67
Snake River Steelhead	Clearwater River	North Fork - (Extirpated)																	
Snake River Steelhead	Salmon River	Little Salmon/Rapid (A)	1.44	0.68	3.02	1.18	0.61	2.31	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Salmon River	Chamberlain Cr. (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Salmon River	Secesh River (B)	1.07	0.83	1.38	1.00	0.65	1.52	1.01	0.62	1.66	1.03	0.65	1.64	0.61	1.03	0.65	1.64	0.61
Snake River Steelhead	Salmon River	South Fork Salmon (B)	1.01	0.78	1.31	0.95	0.62	1.44	0.96	0.58	1.58	1.02	0.65	1.62	0.57	1.02	0.65	1.62	0.57
Snake River Steelhead	Salmon River	Panther Creek (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Salmon River	Lower Middle Fork Tribs (B)	1.03	0.79	1.32	0.96	0.63	1.46	0.97	0.59	1.60	1.03	0.65	1.62	0.58	1.03	0.65	1.62	0.58
Snake River Steelhead	Salmon River	Upper Middle Fork Tribs (B)	1.01	0.78	1.30	0.94	0.62	1.44	0.95	0.58	1.57	1.02	0.65	1.62	0.57	1.02	0.65	1.62	0.57
Snake River Steelhead	Salmon River	North Fork (A)	1.43	0.68	3.00	1.18	0.60	2.30	1.27	0.57	2.79	1.06	0.50	2.24	0.61	1.06	0.50	2.24	0.61
Snake River Steelhead	Salmon River	Lemhi River (A)	1.48	0.71	3.11	1.22	0.62	2.38	1.30	0.59	2.87	1.06	0.50	2.26	0.62	1.06	0.50	2.26	0.62
Snake River Steelhead	Salmon River	Pahsimeroi River (A)	1.66	0.79	3.49	1.37	0.70	2.67	1.38	0.63	3.04	1.09	0.51	2.31	0.67	1.09	0.51	2.31	0.67
Snake River Steelhead	Salmon River	East Fork Salmon (A)	1.47	0.70	3.08	1.21	0.62	2.36	1.29	0.59	2.85	1.06	0.50	2.25	0.62	1.06	0.50	2.25	0.62
Snake River Steelhead	Salmon River	Upper Mainstem (A)	1.52	0.73	3.20	1.26	0.64	2.45	1.34	0.61	2.96	1.07	0.50	2.27	0.63	1.07	0.50	2.27	0.63
Mid Columbia Steelhead	Yakima	Upper Yakima	1.52	1.04	2.23	1.39	0.94	2.06	1.91	1.24	2.96	1.07	0.78	1.46	0.73	1.06	0.77	1.46	0.71
Mid Columbia Steelhead	Yakima	Naches	1.52	0.99	2.31	1.39	0.94	2.05	1.87	1.19	2.93	1.07	0.78	1.49	0.73	1.06	0.76	1.46	0.68
Mid Columbia Steelhead	Yakima	Toppenish	2.17	1.22	3.84	1.98	1.21	3.25	2.98	1.74	5.11	1.15	0.80	1.65	0.84	1.13	0.78	1.63	0.82
Mid Columbia Steelhead	Yakima	Satus	1.90	1.45	2.49	1.17	0.84	1.63	1.36	0.88	2.11	1.03	0.81	1.32	0.64	1.01	0.79	1.29	0.55
Mid Columbia Steelhead	Eastern Cascades	Deschutes W.	1.24	0.94	1.64	1.09	0.80	1.48	1.37	0.88	2.16	1.04	0.82	1.32	0.68	0.99	0.79	1.23	0.44
Mid Columbia Steelhead	Eastern Cascades	Deschutes E.							1.41	0.79	2.49								
Mid Columbia Steelhead	Eastern Cascades	Klickitat																	
Mid Columbia Steelhead	Eastern Cascades	Fifteenmile Cr.	1.98	1.37	2.87	1.28	0.92	1.77	2.06	1.41	3.01	1.03	0.83	1.28	0.66	1.03	0.83	1.28	0.66
Mid Columbia Steelhead	Eastern Cascades	Rock Cr.																	
Mid Columbia Steelhead	Eastern Cascades	White Salmon - Extirpated																	
Mid Columbia Steelhead	Umatilla/Walla Walla	Umatilla	1.98	1.46	2.68	1.24	0.96	1.60	1.13	0.93	1.38	1.08	0.90	1.31	0.85	1.03	0.87	1.23	0.67
Mid Columbia Steelhead	Umatilla/Walla Walla	Walla-Walla																	
Mid Columbia Steelhead	Umatilla/Walla Walla	Touchet																	
Mid Columbia Steelhead	John Day	Lower Mainstem	3.67	2.39	5.64	1.52	0.93	2.50	1.82	0.90	3.68	1.04	0.73	1.48	0.62	1.03	0.73	1.45	0.59
Mid Columbia Steelhead	John Day	North Fork	2.96	2.00	4.39	1.44	0.96	2.14	2.05	1.50	2.79	1.03	0.82	1.30	0.64	1.03	0.82	1.29	0.61
Mid Columbia Steelhead	John Day	Upper Mainstem	2.64	1.42	4.91	1.31	0.88	1.96	0.97	0.59	1.59	1.02	0.79	1.32	0.59	1.02	0.79	1.31	0.57
Mid Columbia Steelhead	John Day	Middle Fork	3.00	2.26	3.99	1.44	1.00	2.07	1.21	0.70	2.11	1.04	0.82	1.31	0.66	1.03	0.82	1.30	0.63
Mid Columbia Steelhead	John Day	South Fork	2.58	1.59	4.18	1.24	0.80	1.93	1.26	0.66	2.42	1.02	0.76	1.38	0.58	1.02	0.76	1.36	0.56

Table 10. Continued.

Prospective - Warm PDO (Poor) Climate

ESU	MPG	Population	Productivity								BRT Trend					
			12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	**1980-current trend**	Lower 95% CI	Upper 95% CI	**1990-current trend**	Lower 95% CI	Upper 95% CI
		Expected Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.09	0.05	23.37	0.60	1.09	0.05	23.37	0.60	1.10	1.01	1.32	1.17	1.03	1.32
Snake River Steelhead	Average "B-Run" Populations (only 13 years)		1.02	0.15	6.81	0.54	1.02	0.15	6.81	0.54	1.06	1.00	1.22	1.10	1.00	1.21
Snake River Steelhead	Lower Snake	Tucannon (A, but below LGR)	*1.10*	*0.05*	*23.62*	*0.62*	*1.10*	*0.05*	*23.62*	*0.62*	*1.23*	*1.13*	*1.48*	*1.22*	*1.08*	*1.38*
Snake River Steelhead	Lower Snake	Asotin (A)	*1.09*	*0.05*	*23.57*	*0.61*	*1.09*	*0.05*	*23.57*	*0.61*	*1.24*	*1.14*	*1.49*	*1.21*	*1.07*	*1.37*
Snake River Steelhead	Imnaha River	Imnaha R. (A)	1.04	0.72	1.52	0.66	1.04	0.72	1.52	0.66	1.11	1.07	1.23	1.13	1.05	1.22
Snake River Steelhead	Grande Ronde	Upper Mainstem (A)	1.01	0.90	1.14	0.65	0.97	0.86	1.08	0.16	1.13	1.10	1.22	1.13	1.08	1.19
Snake River Steelhead	Grande Ronde	Lower Mainstem (A)	*1.09*	*0.05*	*23.42*	*0.61*	*1.09*	*0.05*	*23.42*	*0.61*	*1.11*	*1.03*	*1.34*	*1.18*	*1.04*	*1.33*
Snake River Steelhead	Grande Ronde	Joseph Cr. (A)	1.03	0.80	1.32	0.67	1.03	0.80	1.32	0.67	1.17	1.12	1.28	1.17	1.10	1.25
Snake River Steelhead	Grande Ronde	Wallowa R. (A)	1.10	0.64	1.90	0.87	1.10	0.63	1.93	0.86	1.14	1.10	1.33	1.21	1.13	1.30
Snake River Steelhead	Clearwater River	Lower Mainstem (A)	*1.09*	*0.05*	*23.37*	*0.60*	*1.09*	*0.05*	*23.37*	*0.60*	*1.13*	*1.04*	*1.36*	*1.17*	*1.03*	*1.32*
Snake River Steelhead	Clearwater River	Lolo Creek (A & B)-assume B	*1.05*	*0.16*	*7.02*	*0.60*	*1.05*	*0.16*	*7.02*	*0.60*	*1.22*	*1.15*	*1.40*	*1.26*	*1.14*	*1.39*
Snake River Steelhead	Clearwater River	Lochsa River (B)	*1.07*	*0.16*	*7.13*	*0.63*	*1.07*	*0.16*	*7.13*	*0.63*	*1.31*	*1.24*	*1.51*	*1.35*	*1.22*	*1.49*
Snake River Steelhead	Clearwater River	Selway River (B)	*1.03*	*0.15*	*6.91*	*0.57*	*1.03*	*0.15*	*6.91*	*0.57*	*1.15*	*1.08*	*1.31*	*1.18*	*1.07*	*1.30*
Snake River Steelhead	Clearwater River	South Fork (B)	*1.06*	*0.16*	*7.10*	*0.62*	*1.06*	*0.16*	*7.10*	*0.62*	*1.31*	*1.23*	*1.50*	*1.33*	*1.20*	*1.47*
Snake River Steelhead	Clearwater River	North Fork - (Extirpated)														
Snake River Steelhead	Salmon River	Little Salmon/Rapid (A)	*1.09*	*0.05*	*23.37*	*0.60*	*1.09*	*0.05*	*23.37*	*0.60*	*1.10*	*1.02*	*1.33*	*1.17*	*1.03*	*1.32*
Snake River Steelhead	Salmon River	Chamberlain Cr. (A)	*1.09*	*0.05*	*23.37*	*0.60*	*1.09*	*0.05*	*23.37*	*0.60*	*1.10*	*1.01*	*1.32*	*1.17*	*1.03*	*1.32*
Snake River Steelhead	Salmon River	Secesh River (B)	*1.05*	*0.16*	*6.99*	*0.59*	*1.05*	*0.16*	*6.99*	*0.59*	*1.20*	*1.12*	*1.37*	*1.23*	*1.12*	*1.36*
Snake River Steelhead	Salmon River	South Fork Salmon (B)	*1.03*	*0.15*	*6.91*	*0.57*	*1.03*	*0.15*	*6.91*	*0.57*	*1.13*	*1.07*	*1.30*	*1.17*	*1.06*	*1.29*
Snake River Steelhead	Salmon River	Panther Creek (A)	*1.09*	*0.05*	*23.37*	*0.60*	*1.09*	*0.05*	*23.37*	*0.60*	*1.10*	*1.01*	*1.32*	*1.17*	*1.03*	*1.32*
Snake River Steelhead	Salmon River	Lower Middle Fork Tribs (B)	*1.04*	*0.15*	*6.93*	*0.58*	*1.04*	*0.15*	*6.93*	*0.58*	*1.15*	*1.08*	*1.32*	*1.19*	*1.08*	*1.31*
Snake River Steelhead	Salmon River	Upper Middle Fork Tribs (B)	*1.03*	*0.15*	*6.90*	*0.57*	*1.03*	*0.15*	*6.90*	*0.57*	*1.13*	*1.06*	*1.29*	*1.17*	*1.06*	*1.29*
Snake River Steelhead	Salmon River	North Fork (A)	*1.09*	*0.05*	*23.37*	*0.60*	*1.09*	*0.05*	*23.37*	*0.60*	*1.10*	*1.01*	*1.32*	*1.17*	*1.03*	*1.32*
Snake River Steelhead	Salmon River	Lemhi River (A)	*1.09*	*0.05*	*23.52*	*0.61*	*1.09*	*0.05*	*23.52*	*0.61*	*1.14*	*1.05*	*1.37*	*1.20*	*1.06*	*1.36*
Snake River Steelhead	Salmon River	Pahsimeroi River (A)	*1.11*	*0.05*	*23.82*	*0.63*	*1.11*	*0.05*	*23.82*	*0.63*	*1.28*	*1.18*	*1.53*	*1.27*	*1.13*	*1.43*
Snake River Steelhead	Salmon River	East Fork Salmon (A)	*1.09*	*0.05*	*23.47*	*0.61*	*1.09*	*0.05*	*23.47*	*0.61*	*1.13*	*1.04*	*1.36*	*1.19*	*1.05*	*1.34*
Snake River Steelhead	Salmon River	Upper Mainstem (A)	*1.10*	*0.05*	*23.67*	*0.62*	*1.10*	*0.05*	*23.67*	*0.62*	*1.17*	*1.08*	*1.41*	*1.24*	*1.09*	*1.40*
Mid Columbia Steelhead	Yakima	Upper Yakima	1.14	0.31	4.12	0.57	1.13	0.31	4.15	0.78	1.37	1.30	1.59	1.35	1.27	1.44
Mid Columbia Steelhead	Yakima	Naches	1.14	0.28	4.58	0.57	1.12	0.27	4.57	0.75	1.38	1.31	1.60	1.37	1.29	1.46
Mid Columbia Steelhead	Yakima	Toppenish	1.23	0.24	6.35	0.59	1.21	0.23	6.36	0.81	1.48	1.38	1.79	1.50	1.38	1.63
Mid Columbia Steelhead	Yakima	Satus	1.06	0.30	3.83	0.66	1.04	0.28	3.80	0.61	1.33	1.26	1.52	1.29	1.21	1.38
Mid Columbia Steelhead	Eastern Cascades	Deschutes W.	1.10	0.79	1.54	0.83	1.02	0.74	1.41	0.61	1.18	1.13	1.38	1.25	1.17	1.33
Mid Columbia Steelhead	Eastern Cascades	Deschutes E.	1.11	0.56	2.19	0.71	0.99	0.54	1.82	0.48				1.30	1.17	1.43
Mid Columbia Steelhead	Eastern Cascades	Klickitat														
Mid Columbia Steelhead	Eastern Cascades	Fifteenmile Cr.	1.15	0.88	1.50	0.92	1.15	0.88	1.50	0.92	1.12	1.07	1.25	1.45	1.36	1.54
Mid Columbia Steelhead	Eastern Cascades	Rock Cr.														
Mid Columbia Steelhead	Eastern Cascades	White Salmon - Extirpated														
Mid Columbia Steelhead	Umatilla/Walla Walla	Umatilla	1.10	0.37	3.28	0.76	1.00	0.37	2.70	0.51	1.32	1.29	1.49	1.30	1.23	1.37
Mid Columbia Steelhead	Umatilla/Walla Walla	Walla-Walla														
Mid Columbia Steelhead	Umatilla/Walla Walla	Touchet														
Mid Columbia Steelhead	John Day	Lower Mainstem	1.06	0.58	1.94	0.65	1.05	0.58	1.90	0.61	1.20	1.15	1.40	1.22	1.11	1.34
Mid Columbia Steelhead	John Day	North Fork	1.10	0.94	1.27	0.94	1.08	0.94	1.24	0.93	1.22	1.17	1.42	1.28	1.21	1.36
Mid Columbia Steelhead	John Day	Upper Mainstem	0.98	0.63	1.54	0.44	0.97	0.63	1.50	0.40	1.17	1.13	1.27	1.13	1.05	1.21
Mid Columbia Steelhead	John Day	Middle Fork	1.01	0.60	1.71	0.53	1.00	0.60	1.68	0.50	1.19	1.14	1.30	1.15	1.06	1.24
Mid Columbia Steelhead	John Day	South Fork	1.05	0.52	2.11	0.61	1.04	0.52	2.05	0.58	1.19	1.14	1.36	1.20	1.11	1.30

Table 11. Detailed prospective survival gap estimates for steelhead DPSs under historical ocean climate assumptions. Estimates less than or equal to 1.0 represent no additional survival gap for the condition identified for each column; estimates greater than 1.0 represent the proportional change in density-independent survival that would be necessary to achieve the condition identified in each column.

Prospective - Historical

			Survival Gap For Productivity ≥ 1.0															
ESU	MPG	Population	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
		Low Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	0.96	1.50	0.62	1.34	2.28	0.79	0.25	0.79	0.08	0.93	2.97	0.29	0.57	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	1.87	2.64	1.32	2.22	3.39	1.45	0.27	0.93	0.08	2.35	5.33	1.03	0.55	>10	0.01
		Entiat (Summer A)	1.18	1.65	0.84	1.11	1.44	0.85	0.49	1.52	0.16	1.58	3.60	0.70	0.53	>10	0.01
		Okanogan (Summer A)	3.86	5.55	2.69	4.28	6.42	2.85									
		High Hatchery Assumptions:															
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	0.96	1.50	0.62	1.34	2.28	0.79	0.25	0.79	0.08	0.93	2.97	0.29	0.57	>10	0.01
		Wenatchee - Hatch =.3 (Summer A)															
		Methow (Summer A)	1.41	1.99	0.99	2.22	3.39	1.45	0.21	0.70	0.06	1.78	4.02	0.78	0.55	>10	0.01
		Entiat (Summer A)	0.74	1.04	0.53	1.11	1.44	0.85	0.31	0.96	0.10	1.00	2.27	0.44	0.53	>10	0.01
		Okanogan (Summer A)	2.75	3.96	1.92	4.28	6.42	2.85									
		Allowable Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
	Average "B-Run" Populations (only 13 years)		0.97	1.49	0.64	0.96	1.58	0.58	0.78	6.14	0.10	0.78	6.14	0.10	0.74	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.62	1.22	0.32	0.62	1.37	0.28	0.54	>10	0.02	0.54	>10	0.02	0.51	>10	0.00
		Asotin (A)	0.62	1.21	0.32	0.63	1.38	0.28	0.53	>10	0.02	0.53	>10	0.02	0.51	>10	0.00
	Imnaha River	Imnaha R. (A)	0.52	0.81	0.34	0.54	0.91	0.32	0.59	1.90	0.18	0.59	1.90	0.18	0.64	3.45	0.12
	Grande Ronde	Upper Mainstem (A)	0.77	1.11	0.54	0.85	1.12	0.65	0.76	1.63	0.35	0.88	1.90	0.41	0.73	1.22	0.43
		Lower Mainstem (A)	0.69	1.35	0.35	0.64	1.42	0.29	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Joseph Cr. (A)	0.57	0.85	0.38	0.52	0.70	0.39	0.58	1.79	0.19	0.58	1.79	0.19	0.67	2.05	0.22
		Wallowa R. (A)	0.58	0.79	0.42	0.46	0.60	0.36	0.61	1.82	0.20	0.61	1.88	0.20	0.49	5.66	0.04
	Clearwater River	Lower Mainstem (A)	0.68	1.33	0.35	0.65	1.44	0.30	0.59	>10	0.02	0.59	>10	0.02	0.53	>10	0.00
		Lolo Creek (A & B)-assume B	0.85	1.29	0.56	0.84	1.38	0.51	0.68	5.34	0.09	0.68	5.34	0.09	0.65	>10	0.00
		Lochsa River (B)	0.79	1.20	0.52	0.78	1.29	0.48	0.63	4.97	0.08	0.63	4.97	0.08	0.60	>10	0.00
		Selway River (B)	0.90	1.38	0.59	0.90	1.48	0.55	0.72	5.70	0.09	0.72	5.70	0.09	0.69	>10	0.00
		South Fork (B)	0.79	1.21	0.52	0.80	1.31	0.48	0.64	5.01	0.08	0.64	5.01	0.08	0.61	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Chamberlain Cr. (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Secesh River (B)	0.87	1.32	0.57	0.86	1.41	0.52	0.69	5.47	0.09	0.69	5.47	0.09	0.66	>10	0.00
		South Fork Salmon (B)	0.91	1.40	0.60	0.90	1.48	0.55	0.73	5.77	0.09	0.73	5.77	0.09	0.70	>10	0.00
		Panther Creek (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Lower Middle Fork Tribs (B)	0.90	1.37	0.59	0.89	1.46	0.54	0.72	5.68	0.09	0.72	5.68	0.09	0.69	>10	0.00
		Upper Middle Fork Tribs (B)	0.92	1.40	0.60	0.91	1.49	0.55	0.73	5.79	0.09	0.73	5.79	0.09	0.70	>10	0.00
		North Fork (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Lemhi River (A)	0.67	1.32	0.35	0.63	1.39	0.29	0.58	>10	0.02	0.58	>10	0.02	0.52	>10	0.00
		Pahsimeroi River (A)	0.60	1.18	0.31	0.60	1.32	0.27	0.52	>10	0.02	0.52	>10	0.02	0.49	>10	0.00
		East Fork Salmon (A)	0.68	1.33	0.35	0.64	1.41	0.29	0.59	>10	0.02	0.59	>10	0.02	0.52	>10	0.00
		Upper Mainstem (A)	0.66	1.28	0.34	0.61	1.35	0.28	0.57	>10	0.02	0.57	>10	0.02	0.50	>10	0.00

Table 11. Continued.

Prospective - Historical																
			Productivity ≥ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend ≥ 1.0					
ESU	MPG	Population	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	High	Low	1980-current trend	Upper 95% CI	Lower 95% CI	1990-current trend	Upper 95% CI	Lower 95% CI
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.73	>10	0.08	0.40	0.48	0.58	0.62	0.53	0.29	0.33	0.21	0.51	0.68	0.39
		Wenatchee - Hatch =.3 (Summer A)				0.40	0.48	0.58								
		Methow (Summer A)	4.18	>10	0.48	1.47	1.71	2.06	0.79	0.65	0.30	0.35	0.22	0.49	0.69	0.34
		Entiat (Summer A)	1.85	8.42	0.41	1.36	1.71	2.13	1.23	1.02	0.51	0.59	0.37	0.48	0.63	0.36
		Okanogan (Summer A)				2.65	3.05	3.69	0.65	0.54						
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.73	>10	0.08	0.40	0.48	0.58	0.62	0.53	0.29	0.33	0.21	0.51	0.68	0.39
		Wenatchee - Hatch =.3 (Summer A)				0.40	0.48	0.58								
		Methow (Summer A)	4.18	>10	0.48	1.11	1.29	1.56	0.59	0.49	0.23	0.26	0.17	0.49	0.69	0.34
		Entiat (Summer A)	1.85	8.42	0.41	0.86	1.08	1.35	0.77	0.64	0.32	0.37	0.24	0.48	0.63	0.36
		Okanogan (Summer A)				1.89	2.18	2.63	0.46	0.38						
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
	Average "B-Run" Populations (only 13 years)		0.74	>10	0.00	0.95	1.35	1.42	1.11	0.96	0.95	1.25	0.51	0.81	1.26	0.51
	Lower Snake	Tucannon (A, but below LGR)	0.51	>10	0.00	0.67	1.26	1.26	0.91	0.81	0.64	0.91	0.28	0.51	0.89	0.30
		Asotin (A)	0.51	>10	0.00	0.66	1.25	1.25	0.91	0.80	0.63	0.91	0.28	0.52	0.89	0.30
	Imnaha River	Imnaha R. (A)	0.64	3.45	0.12	0.74	1.40	1.40	1.02	0.91	0.68	0.81	0.43	0.61	0.87	0.43
	Grande Ronde	Upper Mainstem (A)	0.90	1.52	0.53	0.72	0.80	0.80	0.42	0.58	0.76	0.89	0.54	0.70	0.89	0.55
		Lower Mainstem (A)	0.53	>10	0.00	0.74	1.39	1.39	1.01	0.90	0.71	1.01	0.31	0.53	0.92	0.31
		Joseph Cr. (A)	0.67	2.05	0.22	0.26	0.29	0.33	0.37	0.49	0.67	0.81	0.44	0.61	0.81	0.46
		Wallowa R. (A)	0.50	6.21	0.04	0.73	1.37	1.37	1.00	0.88	0.66	0.77	0.33	0.46	0.63	0.33
	Clearwater River	Lower Mainstem (A)	0.53	>10	0.00	0.73	1.37	1.37	1.00	0.88	0.70	1.00	0.30	0.54	0.93	0.31
		Lolo Creek (A & B)-assume B	0.65	>10	0.00	0.83	1.17	1.23	0.97	0.84	0.82	1.09	0.45	0.70	1.10	0.45
		Lochsa River (B)	0.60	>10	0.00	0.77	1.09	1.15	0.90	0.78	0.76	1.01	0.41	0.66	1.02	0.42
		Selway River (B)	0.69	>10	0.00	0.88	1.25	1.32	1.03	0.89	0.88	1.16	0.48	0.75	1.18	0.48
		South Fork (B)	0.61	>10	0.00	0.77	1.10	1.16	0.91	0.78	0.77	1.02	0.42	0.67	1.04	0.43
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	0.53	>10	0.00	0.74	1.40	1.40	1.02	0.90	0.71	1.02	0.31	0.54	0.93	0.31
		Chamberlain Cr. (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Secesh River (B)	0.66	>10	0.00	0.85	1.20	1.26	0.99	0.86	0.84	1.11	0.46	0.72	1.12	0.46
		South Fork Salmon (B)	0.70	>10	0.00	0.89	1.27	1.33	1.04	0.90	0.89	1.17	0.48	0.76	1.18	0.48
		Panther Creek (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Lower Middle Fork Tribs (B)	0.69	>10	0.00	0.88	1.25	1.31	1.03	0.89	0.87	1.16	0.47	0.75	1.17	0.48
		Upper Middle Fork Tribs (B)	0.70	>10	0.00	0.90	1.27	1.34	1.05	0.91	0.89	1.18	0.48	0.76	1.19	0.49
		North Fork (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Lemhi River (A)	0.52	>10	0.00	0.72	1.36	1.36	0.99	0.88	0.69	0.99	0.30	0.52	0.90	0.30
		Pahsimeroi River (A)	0.49	>10	0.00	0.64	1.21	1.21	0.88	0.78	0.61	0.88	0.27	0.49	0.85	0.29
		East Fork Salmon (A)	0.52	>10	0.00	0.73	1.37	1.37	1.00	0.88	0.70	1.00	0.30	0.53	0.91	0.31
		Upper Mainstem (A)	0.50	>10	0.00	0.70	1.32	1.32	0.96	0.85	0.67	0.96	0.29	0.51	0.88	0.29

Table 11. Continued.

Prospective - Historical

			Survival Gap For Productivity ≥ 1.0														
ESU	**MPG**	**Population**	Average R/S: 20-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=0	Upper 95% CI	Lower 95% CI	20-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	12-yr lambda, HF=0	Upper 95% CI	Lower 95% CI
		Expected Harvest Assumption:															
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
	Average "B-Run" Populations (only 13 years)		0.93	1.41	0.61	0.91	1.50	0.56	0.74	5.85	0.09	0.74	5.85	0.09	0.71	>10	0.00
	Lower Snake	Tucannon (A, but below LGR)	0.62	1.22	0.32	0.62	1.37	0.28	0.54	>10	0.02	0.54	>10	0.02	0.51	>10	0.00
		Asotin (A)	0.62	1.21	0.32	0.63	1.38	0.28	0.53	>10	0.02	0.53	>10	0.02	0.51	>10	0.00
	Imnaha River	Imnaha R. (A)	0.52	0.81	0.34	0.54	0.91	0.32	0.59	1.90	0.18	0.59	1.90	0.18	0.64	3.45	0.12
	Grande Ronde	Upper Mainstem (A)	0.77	1.11	0.54	0.85	1.12	0.65	0.76	1.63	0.35	0.88	1.90	0.41	0.73	1.22	0.43
		Lower Mainstem (A)	0.69	1.35	0.35	0.64	1.42	0.29	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Joseph Cr. (A)	0.57	0.85	0.38	0.52	0.70	0.39	0.58	1.79	0.19	0.58	1.79	0.19	0.67	2.05	0.22
		Wallowa R. (A)	0.58	0.79	0.42	0.46	0.60	0.36	0.61	1.82	0.20	0.61	1.88	0.20	0.49	5.66	0.04
	Clearwater River	Lower Mainstem (A)	0.68	1.33	0.35	0.65	1.44	0.30	0.59	>10	0.02	0.59	>10	0.02	0.53	>10	0.00
		Lolo Creek (A & B)-assume B	0.81	1.23	0.53	0.80	1.31	0.49	0.64	5.08	0.08	0.64	5.08	0.08	0.62	>10	0.00
		Lochsa River (B)	0.75	1.14	0.49	0.74	1.22	0.45	0.60	4.73	0.08	0.60	4.73	0.08	0.57	>10	0.00
		Selway River (B)	0.86	1.31	0.56	0.85	1.41	0.52	0.69	5.42	0.09	0.69	5.42	0.09	0.66	>10	0.00
		South Fork (B)	0.76	1.15	0.50	0.76	1.25	0.46	0.60	4.77	0.08	0.60	4.77	0.08	0.58	>10	0.00
		North Fork - (Extirpated)															
	Salmon River	Little Salmon/Rapid (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Chamberlain Cr. (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Secesh River (B)	0.83	1.26	0.54	0.81	1.34	0.49	0.66	5.20	0.08	0.66	5.20	0.08	0.63	>10	0.00
		South Fork Salmon (B)	0.87	1.33	0.57	0.86	1.41	0.52	0.70	5.49	0.09	0.70	5.49	0.09	0.66	>10	0.00
		Panther Creek (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Lower Middle Fork Tribs (B)	0.86	1.31	0.56	0.85	1.39	0.51	0.69	5.41	0.09	0.69	5.41	0.09	0.65	>10	0.00
		Upper Middle Fork Tribs (B)	0.87	1.33	0.57	0.86	1.42	0.52	0.70	5.51	0.09	0.70	5.51	0.09	0.67	>10	0.00
		North Fork (A)	0.70	1.36	0.36	0.65	1.44	0.30	0.60	>10	0.02	0.60	>10	0.02	0.53	>10	0.00
		Lemhi River (A)	0.67	1.32	0.35	0.63	1.39	0.29	0.58	>10	0.02	0.58	>10	0.02	0.52	>10	0.00
		Pahsimeroi River (A)	0.60	1.18	0.31	0.60	1.32	0.27	0.52	>10	0.02	0.52	>10	0.02	0.49	>10	0.00
		East Fork Salmon (A)	0.68	1.33	0.35	0.64	1.41	0.29	0.59	>10	0.02	0.59	>10	0.02	0.52	>10	0.00
		Upper Mainstem (A)	0.66	1.28	0.34	0.61	1.35	0.28	0.57	>10	0.02	0.57	>10	0.02	0.50	>10	0.00
Mid Columbia Steelhead	Yakima	Upper Yakima	0.63	0.94	0.43	0.46	0.71	0.30	0.61	2.50	0.15	0.62	2.60	0.15	0.46	>10	0.00
		Naches	0.64	0.94	0.43	0.47	0.74	0.30	0.60	2.58	0.14	0.64	2.79	0.15	0.45	>10	0.00
		Toppenish	0.44	0.73	0.27	0.30	0.51	0.17	0.44	2.27	0.09	0.47	2.47	0.09	0.32	>10	0.00
		Satus	0.75	1.05	0.54	0.65	1.00	0.42	0.72	2.18	0.24	0.79	2.38	0.26	0.63	>10	0.00
	Eastern Cascades	Deschutes W.	0.81	1.11	0.59	0.64	1.01	0.41	0.68	1.97	0.24	0.87	2.34	0.32	0.53	2.40	0.12
		Deschutes E.				0.63	1.11	0.35							0.51	>10	0.02
		Klickitat															
		Fifteenmile Cr.	0.69	0.96	0.50	0.43	0.63	0.29	0.71	1.89	0.27	0.71	1.89	0.27	0.44	1.44	0.13
		Rock Cr.															
		White Salmon - Extirpated															
	Umatilla/Walla Walla	Umatilla	0.71	0.92	0.55	0.78	0.95	0.64	0.57	1.34	0.24	0.72	1.57	0.33	0.55	>10	0.00
		Walla-Walla															
		Touchet															
	John Day	Lower Mainstem	0.58	0.95	0.35	0.49	0.98	0.24	0.69	3.32	0.14	0.72	3.36	0.15	0.62	9.38	0.04
		North Fork	0.61	0.92	0.41	0.43	0.59	0.32	0.72	2.02	0.25	0.74	2.04	0.27	0.55	1.06	0.28
		Upper Mainstem	0.67	1.00	0.45	0.91	1.49	0.55	0.74	2.32	0.24	0.76	2.36	0.25	0.89	6.73	0.12
		Middle Fork	0.61	0.88	0.43	0.73	1.27	0.42	0.70	2.01	0.24	0.72	2.04	0.25	0.78	8.35	0.07
		South Fork	0.71	1.11	0.46	0.70	1.35	0.36	0.74	2.78	0.19	0.76	2.80	0.20	0.66	>10	0.03

Table 11. Continued.

Prospective - Historical

			Productivity $\geq$ 1.0			TRT Survival Gap			Framework Gap		Survival Gap For BRT Trend $\geq$ 1.0					
ESU	**MPG**	**Population**	12-yr lambda, HF=1	Upper 95% CI	Lower 95% CI	Observed 25% Gap	Observed 5% Gap	Observed 1% Gap	**High**	**Low**	**1980-current trend**	**Upper 95% CI**	**Lower 95% CI**	**1990-current trend**	**Upper 95% CI**	**Lower 95% CI**
		Expected Harvest Assumption:														
Snake River Steelhead		Average "A-Run" Populations (only 14 years)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Average "B-Run" Populations (only 13 years)	0.71	>10	0.00	0.90	1.28	1.35	1.06	0.91	0.90	1.19	0.49	0.77	1.20	0.49
	Lower Snake	Tucannon (A, but below LGR)	0.51	>10	0.00	0.67	1.26	1.26	0.91	0.81	0.64	0.91	0.28	0.51	0.89	0.30
		Asotin (A)	0.51	>10	0.00	0.66	1.25	1.25	0.91	0.80	0.63	0.91	0.28	0.52	0.89	0.30
	Imnaha River	Imnaha R. (A)	0.64	3.45	0.12	0.74	1.40	1.40	1.02	0.91	0.68	0.81	0.43	0.61	0.87	0.43
	Grande Ronde	Upper Mainstem (A)	0.90	1.52	0.53	0.72	0.80	0.80	0.42	0.58	0.76	0.89	0.54	0.70	0.89	0.55
		Lower Mainstem (A)	0.53	>10	0.00	0.74	1.39	1.39	1.01	0.90	0.71	1.01	0.31	0.53	0.92	0.31
		Joseph Cr. (A)	0.67	2.05	0.22	0.26	0.29	0.33	0.37	0.49	0.67	0.81	0.44	0.61	0.81	0.46
		Wallowa R. (A)	0.50	6.21	0.04	0.73	1.37	1.37	1.00	0.88	0.66	0.77	0.33	0.46	0.63	0.33
	Clearwater River	Lower Mainstem (A)	0.53	>10	0.00	0.73	1.37	1.37	1.00	0.88	0.70	1.00	0.30	0.54	0.93	0.31
		Lolo Creek (A & B)-assume B	0.62	>10	0.00	0.79	1.11	1.17	0.92	0.80	0.78	1.03	0.42	0.67	1.05	0.43
		Lochsa River (B)	0.57	>10	0.00	0.73	1.04	1.09	0.86	0.74	0.73	0.96	0.39	0.62	0.97	0.40
		Selway River (B)	0.66	>10	0.00	0.84	1.19	1.25	0.98	0.85	0.83	1.10	0.45	0.72	1.12	0.46
		South Fork (B)	0.58	>10	0.00	0.74	1.05	1.10	0.86	0.75	0.73	0.97	0.40	0.64	0.99	0.41
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	0.53	>10	0.00	0.74	1.40	1.40	1.02	0.90	0.71	1.02	0.31	0.54	0.93	0.31
		Chamberlain Cr. (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Secesh River (B)	0.63	>10	0.00	0.80	1.14	1.20	0.94	0.81	0.80	1.06	0.43	0.68	1.07	0.44
		South Fork Salmon (B)	0.66	>10	0.00	0.85	1.20	1.27	0.99	0.86	0.84	1.12	0.46	0.72	1.13	0.46
		Panther Creek (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Lower Middle Fork Tribs (B)	0.65	>10	0.00	0.84	1.19	1.25	0.98	0.85	0.83	1.10	0.45	0.71	1.11	0.45
		Upper Middle Fork Tribs (B)	0.67	>10	0.00	0.85	1.21	1.27	1.00	0.86	0.85	1.12	0.46	0.72	1.13	0.46
		North Fork (A)	0.53	>10	0.00	0.74	1.41	1.41	1.02	0.91	0.71	1.02	0.31	0.54	0.93	0.31
		Lemhi River (A)	0.52	>10	0.00	0.72	1.36	1.36	0.99	0.88	0.69	0.99	0.30	0.52	0.90	0.30
		Pahsimeroi River (A)	0.49	>10	0.00	0.64	1.21	1.21	0.88	0.78	0.61	0.88	0.27	0.49	0.85	0.29
		East Fork Salmon (A)	0.52	>10	0.00	0.73	1.37	1.37	1.00	0.88	0.70	1.00	0.30	0.53	0.91	0.31
		Upper Mainstem (A)	0.50	>10	0.00	0.70	1.32	1.32	0.96	0.85	0.67	0.96	0.29	0.51	0.88	0.29
Mid Columbia Steelhead	Yakima	Upper Yakima	0.47	>10	0.00	0.72	1.40	1.47	1.13	0.95	0.63	0.80	0.32	0.47	0.64	0.35
		Naches	0.49	>10	0.00	0.68	1.32	1.40	0.99	0.87	0.61	0.76	0.31	0.45	0.59	0.34
		Toppenish	0.35	>10	0.00	0.65	0.97	0.97	0.85	0.78	0.44	0.60	0.19	0.30	0.44	0.21
		Satus	0.69	>10	0.00	0.64	1.62	1.62	0.86	0.79	0.73	0.90	0.39	0.58	0.78	0.43
	Eastern Cascades	Deschutes W.	0.74	3.16	0.17	0.85	1.33	1.43	0.98	0.89	0.77	0.90	0.37	0.52	0.69	0.38
		Deschutes E.	0.85	>10	0.06	0.39	0.48	0.58	0.67	0.69				0.47	0.74	0.30
		Klickitat														
		Fifteenmile Cr.	0.44	1.44	0.13	0.80	0.64	0.79	1.01	0.94	0.71	0.87	0.43	0.47	0.61	0.35
		Rock Cr.														
		White Salmon - Extirpated														
	Umatilla/Walla Walla	Umatilla	0.81	>10	0.01	0.46	0.73	0.73	0.70	0.69	0.65	0.75	0.39	0.53	0.68	0.42
		Walla-Walla				0.60	0.87	0.94	0.65	0.65						
		Touchet														
	John Day	Lower Mainstem	0.67	9.92	0.05	0.72	0.80	0.80	0.78	0.76	0.80	0.97	0.40	0.63	0.96	0.42
		North Fork	0.58	1.09	0.31	0.30	0.37	0.45	0.50	0.56	0.75	0.90	0.37	0.50	0.66	0.39
		Upper Mainstem	0.94	6.68	0.13	0.70	0.98	0.98	0.80	0.77	0.90	1.06	0.62	0.90	1.24	0.65
		Middle Fork	0.82	8.41	0.08	0.72	0.78	0.78	0.80	0.78	0.83	0.99	0.56	0.83	1.18	0.58
		South Fork	0.70	>10	0.03	0.69	0.86	0.86	0.83	0.79	0.89	1.07	0.48	0.72	1.02	0.51

Table 12. Detailed prospective productivity estimates for steelhead DPSs under historical ocean climate assumptions. Estimates greater than 1.0 indicate expected population growth; estimates less than 1.0 indicate expected declines.

Prospective - Historical Climate

ESU	MPG	Population	Productivity: Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Low Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.48	1.69	3.64	1.04	0.67	1.62	0.74	0.44	1.27	1.51	1.18	1.95	0.99	1.13	0.88	1.47	0.87
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.69	0.38	1.27	0.54	0.38	0.76	0.45	0.29	0.69	1.49	1.13	1.95	0.99	0.92	0.77	1.11	0.14
		Entiat (Summer A)	0.78	0.52	1.18	0.85	0.60	1.19	0.90	0.69	1.18	1.31	1.02	1.69	0.98	1.01	0.84	1.21	0.54
		Okanogan (Summer A)	0.39	0.20	0.74	0.26	0.18	0.37	0.23	0.16	0.35								
		High Hatchery Assumptions:																	
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	2.48	1.69	3.64	1.04	0.67	1.62	0.74	0.44	1.27	1.51	1.18	1.95	0.99	1.13	0.88	1.47	0.87
		Wenatchee - Hatch =.3 (Summer A)																	
		Methow (Summer A)	0.92	0.50	1.68	0.71	0.50	1.01	0.45	0.29	0.69	1.58	1.21	2.07	1.00	0.98	0.82	1.18	0.39
		Entiat (Summer A)	1.24	0.82	1.88	1.34	0.96	1.89	0.90	0.69	1.18	1.45	1.12	1.87	0.99	1.12	0.93	1.34	0.91
		Okanogan (Summer A)	0.54	0.29	1.03	0.36	0.25	0.52	0.23	0.16	0.35								
		Allowable Harvest Assumption:																	
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
	Average "B-Run" Populations (only 13 years)		1.10	0.85	1.42	1.03	0.67	1.57	1.04	0.63	1.71	1.21	0.76	1.92	0.89	1.21	0.76	1.92	0.89
	Lower Snake	Tucannon (A, but below LGR)	1.94	0.93	4.08	1.60	0.82	3.13	1.61	0.73	3.56	1.31	0.62	2.79	0.87	1.31	0.62	2.79	0.87
		Asotin (A)	1.96	0.93	4.12	1.61	0.83	3.15	1.60	0.72	3.52	1.32	0.62	2.79	0.87	1.32	0.62	2.79	0.87
	Imnaha River	Imnaha R. (A)	3.97	3.01	5.24	1.91	1.24	2.95	1.87	1.10	3.17	1.29	0.99	1.67	0.97	1.29	0.99	1.67	0.97
	Grande Ronde	Upper Mainstem (A)	3.19	1.97	5.17	1.29	0.90	1.85	1.17	0.90	1.53	1.22	1.03	1.44	0.98	1.18	0.99	1.40	0.97
		Lower Mainstem (A)	1.76	0.84	3.69	1.45	0.74	2.83	1.55	0.70	3.42	1.28	0.61	2.73	0.86	1.28	0.61	2.73	0.86
		Joseph Cr. (A)	3.60	2.79	4.64	1.76	1.17	2.64	1.91	1.42	2.56	1.29	1.01	1.66	0.98	1.29	1.01	1.66	0.98
		Wallowa R. (A)	3.09	2.18	4.38	1.73	1.26	2.36	2.15	1.66	2.79	1.28	1.00	1.63	0.98	1.28	0.99	1.64	0.97
	Clearwater River	Lower Mainstem (A)	1.78	0.85	3.74	1.47	0.75	2.87	1.54	0.70	3.39	1.29	0.61	2.73	0.86	1.29	0.61	2.73	0.86
		Lolo Creek (A & B)-assume B	1.26	0.98	1.63	1.18	0.77	1.80	1.19	0.72	1.96	1.25	0.79	1.98	0.91	1.25	0.79	1.98	0.91
		Lochsa River (B)	1.36	1.05	1.75	1.27	0.83	1.93	1.28	0.78	2.10	1.27	0.80	2.01	0.92	1.27	0.80	2.01	0.92
		Selway River (B)	1.18	0.92	1.53	1.11	0.73	1.69	1.11	0.68	1.83	1.23	0.78	1.95	0.90	1.23	0.78	1.95	0.90
		South Fork (B)	1.35	1.04	1.74	1.26	0.83	1.92	1.26	0.76	2.07	1.27	0.80	2.01	0.92	1.27	0.80	2.01	0.92
		North Fork - (Extirpated)																	
	Salmon River	Little Salmon/Rapid (A)	1.75	0.83	3.67	1.44	0.74	2.81	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Chamberlain Cr. (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Secesh River (B)	1.23	0.95	1.59	1.15	0.76	1.76	1.17	0.71	1.92	1.24	0.78	1.97	0.91	1.24	0.78	1.97	0.91
		South Fork Salmon (B)	1.17	0.90	1.51	1.09	0.72	1.67	1.11	0.67	1.82	1.23	0.78	1.94	0.90	1.23	0.78	1.94	0.90
		Panther Creek (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Lower Middle Fork Tribs (B)	1.19	0.92	1.53	1.11	0.73	1.69	1.13	0.68	1.85	1.23	0.78	1.95	0.90	1.23	0.78	1.95	0.90
		Upper Middle Fork Tribs (B)	1.16	0.90	1.50	1.09	0.71	1.66	1.10	0.67	1.81	1.23	0.77	1.94	0.90	1.23	0.77	1.94	0.90
		North Fork (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Lemhi River (A)	1.80	0.86	3.78	1.48	0.76	2.89	1.58	0.72	3.49	1.29	0.61	2.74	0.86	1.29	0.61	2.74	0.86
		Pahsimeroi River (A)	2.02	0.96	4.23	1.66	0.85	3.25	1.67	0.76	3.69	1.32	0.62	2.81	0.88	1.32	0.62	2.81	0.88
		East Fork Salmon (A)	1.78	0.85	3.74	1.47	0.75	2.87	1.57	0.71	3.45	1.29	0.61	2.73	0.86	1.29	0.61	2.73	0.86
		Upper Mainstem (A)	1.85	0.88	3.89	1.52	0.78	2.98	1.63	0.74	3.59	1.30	0.61	2.76	0.86	1.30	0.61	2.76	0.86

Table 12. Continued.

Prospective - Historical Climate

			Productivity								BRT Trend					
ESU	**MPG**	**Population**	12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	**1980-current trend**	Lower 95% CI	Upper 95% CI	**1990-current trend**	Lower 95% CI	Upper 95% CI
		Low Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.26	0.02	2.96	0.90	0.99	0.51	1.93	0.47	3.07	2.97	3.28	1.68	1.58	1.79
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.28	0.03	2.96	0.87	0.81	0.50	1.31	0.10	2.67	2.58	2.86	1.70	1.58	1.84
		Entiat (Summer A)	1.28	0.03	2.99	0.91	0.97	0.69	1.36	0.38	1.71	1.65	1.83	1.77	1.66	1.87
		Okanogan (Summer A)														
		High Hatchery Assumptions:														
Upper Columbia River Steelhead	Eastern Cascades	Wenatchee - Hatch =1 (Summer A)	1.26	0.02	2.96	0.90	0.99	0.51	1.93	0.47	3.07	2.97	3.28	1.68	1.58	1.79
		Wenatchee - Hatch =.3 (Summer A)														
		Methow (Summer A)	1.28	0.03	2.96	0.87	0.81	0.50	1.31	0.10	3.54	3.42	3.79	1.70	1.58	1.84
		Entiat (Summer A)	1.28	0.03	2.99	0.91	0.97	0.69	1.36	0.38	2.71	2.62	2.90	1.77	1.66	1.87
		Okanogan (Summer A)														
		Allowable Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.33	1.23	1.61	1.42	1.25	1.60
	Average "B-Run" Populations (only 13 years)		1.22	0.18	8.18	0.80	1.22	0.18	8.18	0.80	1.23	1.16	1.41	1.27	1.15	1.40
	Lower Snake	Tucannon (A, but below LGR)	*1.33*	*0.06*	*28.68*	*0.78*	*1.33*	*0.06*	*28.68*	*0.78*	*1.49*	*1.38*	*1.80*	*1.49*	*1.32*	*1.68*
		Asotin (A)	*1.33*	*0.06*	*28.62*	*0.78*	*1.33*	*0.06*	*28.62*	*0.78*	*1.51*	*1.39*	*1.81*	*1.47*	*1.30*	*1.66*
	Imnaha River	Imnaha R. (A)	1.27	0.87	1.84	0.94	1.27	0.87	1.84	0.94	1.35	1.30	1.50	1.38	1.27	1.49
	Grande Ronde	Upper Mainstem (A)	1.23	1.10	1.38	0.99	1.17	1.04	1.32	0.99	1.38	1.33	1.49	1.38	1.31	1.45
		Lower Mainstem (A)	*1.32*	*0.06*	*28.44*	*0.77*	*1.32*	*0.06*	*28.44*	*0.77*	*1.35*	*1.25*	*1.62*	*1.43*	*1.27*	*1.61*
		Joseph Cr. (A)	1.25	0.98	1.60	0.97	1.25	0.98	1.60	0.97	1.42	1.36	1.55	1.42	1.33	1.51
		Wallowa R. (A)	1.34	0.78	2.31	0.95	1.34	0.76	2.34	0.95	1.39	1.34	1.62	1.47	1.37	1.58
	Clearwater River	Lower Mainstem (A)	*1.32*	*0.06*	*28.38*	*0.77*	*1.32*	*0.06*	*28.38*	*0.77*	*1.37*	*1.26*	*1.65*	*1.42*	*1.25*	*1.60*
		Lolo Creek (A & B)-assume B	*1.26*	*0.19*	*8.43*	*0.82*	*1.26*	*0.19*	*8.43*	*0.82*	*1.41*	*1.33*	*1.62*	*1.45*	*1.32*	*1.61*
		Lochsa River (B)	*1.28*	*0.19*	*8.56*	*0.83*	*1.28*	*0.19*	*8.56*	*0.83*	*1.52*	*1.43*	*1.74*	*1.56*	*1.41*	*1.73*
		Selway River (B)	*1.24*	*0.19*	*8.30*	*0.81*	*1.24*	*0.19*	*8.30*	*0.81*	*1.33*	*1.25*	*1.52*	*1.36*	*1.23*	*1.50*
		South Fork (B)	*1.28*	*0.19*	*8.53*	*0.82*	*1.28*	*0.19*	*8.53*	*0.82*	*1.51*	*1.42*	*1.73*	*1.53*	*1.39*	*1.70*
		North Fork - (Extirpated)														
	Salmon River	Little Salmon/Rapid (A)	*1.32*	*0.06*	*28.38*	*0.77*	*1.32*	*0.06*	*28.38*	*0.77*	*1.34*	*1.24*	*1.61*	*1.42*	*1.25*	*1.60*
		Chamberlain Cr. (A)	*1.32*	*0.06*	*28.38*	*0.77*	*1.32*	*0.06*	*28.38*	*0.77*	*1.33*	*1.23*	*1.61*	*1.42*	*1.25*	*1.60*
		Secesh River (B)	*1.26*	*0.19*	*8.39*	*0.82*	*1.26*	*0.19*	*8.39*	*0.82*	*1.38*	*1.30*	*1.58*	*1.43*	*1.29*	*1.58*
		South Fork Salmon (B)	*1.24*	*0.19*	*8.30*	*0.81*	*1.24*	*0.19*	*8.30*	*0.81*	*1.31*	*1.23*	*1.50*	*1.35*	*1.23*	*1.50*
		Panther Creek (A)	*1.32*	*0.06*	*28.38*	*0.77*	*1.32*	*0.06*	*28.38*	*0.77*	*1.33*	*1.23*	*1.61*	*1.42*	*1.25*	*1.60*
		Lower Middle Fork Tribs (B)	*1.25*	*0.19*	*8.32*	*0.81*	*1.25*	*0.19*	*8.32*	*0.81*	*1.33*	*1.25*	*1.52*	*1.37*	*1.24*	*1.52*
		Upper Middle Fork Tribs (B)	*1.24*	*0.18*	*8.29*	*0.81*	*1.24*	*0.18*	*8.29*	*0.81*	*1.30*	*1.23*	*1.49*	*1.35*	*1.22*	*1.49*
		North Fork (A)	*1.32*	*0.06*	*28.38*	*0.77*	*1.32*	*0.06*	*28.38*	*0.77*	*1.33*	*1.23*	*1.61*	*1.42*	*1.25*	*1.60*
		Lemhi River (A)	*1.33*	*0.06*	*28.56*	*0.77*	*1.33*	*0.06*	*28.56*	*0.77*	*1.38*	*1.27*	*1.66*	*1.46*	*1.29*	*1.65*
		Pahsimeroi River (A)	*1.34*	*0.06*	*28.92*	*0.78*	*1.34*	*0.06*	*28.92*	*0.78*	*1.55*	*1.43*	*1.86*	*1.54*	*1.37*	*1.74*
		East Fork Salmon (A)	*1.32*	*0.06*	*28.50*	*0.77*	*1.32*	*0.06*	*28.50*	*0.77*	*1.37*	*1.26*	*1.65*	*1.44*	*1.28*	*1.63*
		Upper Mainstem (A)	*1.33*	*0.06*	*28.75*	*0.78*	*1.33*	*0.06*	*28.75*	*0.78*	*1.42*	*1.31*	*1.71*	*1.50*	*1.33*	*1.69*

Table 12. Continued.

Prospective - Historical Climate

ESU	MPG	Population	Productivity															
			Intrinsic Productivity: 20-yr SAR adj. and delimited	Lower 95% CI	Upper 95% CI	Average R/S: 20-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	Average R/S: 10-yr non-SAR adj.; non-delimited	Lower 95% CI	Upper 95% CI	20-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	20-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)
		Expected Harvest Assumption:																	
Snake River Steelhead		Average "A-Run" Populations (only 14 years)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Average "B-Run" Populations (only 13 years)	1.15	0.89	1.49	1.08	0.71	1.64	1.09	0.66	1.80	1.22	0.77	1.94	0.90	1.22	0.77	1.94	0.90
	Lower Snake	Tucannon (A, but below LGR)	1.94	0.93	4.08	1.60	0.82	3.13	1.61	0.73	3.56	1.31	0.62	2.79	0.87	1.31	0.62	2.79	0.87
		Asotin (A)	1.96	0.93	4.12	1.61	0.83	3.15	1.60	0.72	3.52	1.32	0.62	2.79	0.87	1.32	0.62	2.79	0.87
	Imnaha River	Imnaha R. (A)	3.97	3.01	5.24	1.91	1.24	2.95	1.87	1.10	3.17	1.29	0.99	1.67	0.97	1.29	0.99	1.67	0.97
	Grande Ronde	Upper Mainstem (A)	3.19	1.97	5.17	1.29	0.90	1.85	1.17	0.90	1.53	1.22	1.03	1.44	0.98	1.18	0.99	1.40	0.97
		Lower Mainstem (A)	1.76	0.84	3.69	1.45	0.74	2.83	1.55	0.70	3.42	1.28	0.61	2.73	0.86	1.28	0.61	2.73	0.86
		Joseph Cr. (A)	3.60	2.79	4.64	1.76	1.17	2.64	1.91	1.42	2.56	1.29	1.01	1.66	0.98	1.29	1.01	1.66	0.98
		Wallowa R. (A)	3.09	2.18	4.38	1.73	1.26	2.36	2.15	1.66	2.79	1.28	1.00	1.63	0.98	1.28	0.99	1.64	0.97
	Clearwater River	Lower Mainstem (A)	1.78	0.85	3.74	1.47	0.75	2.87	1.54	0.70	3.39	1.29	0.61	2.73	0.86	1.29	0.61	2.73	0.86
		Lolo Creek (A & B)-assume B	1.33	1.03	1.71	1.24	0.81	1.89	1.25	0.76	2.06	1.26	0.80	2.00	0.92	1.26	0.80	2.00	0.92
		Lochsa River (B)	1.42	1.10	1.84	1.33	0.87	2.03	1.34	0.82	2.21	1.28	0.81	2.03	0.93	1.28	0.81	2.03	0.93
		Selway River (B)	1.24	0.96	1.60	1.16	0.76	1.77	1.17	0.71	1.93	1.24	0.79	1.97	0.91	1.24	0.79	1.97	0.91
		South Fork (B)	1.41	1.09	1.82	1.32	0.87	2.02	1.32	0.80	2.17	1.28	0.81	2.03	0.93	1.28	0.81	2.03	0.93
		North Fork - (Extirpated)																	
	Salmon River	Little Salmon/Rapid (A)	1.75	0.83	3.67	1.44	0.74	2.81	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Chamberlain Cr. (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Secesh River (B)	1.29	1.00	1.67	1.21	0.79	1.85	1.23	0.75	2.02	1.26	0.79	1.99	0.92	1.26	0.79	1.99	0.92
		South Fork Salmon (B)	1.23	0.95	1.58	1.15	0.75	1.75	1.16	0.71	1.92	1.24	0.78	1.97	0.91	1.24	0.78	1.97	0.91
		Panther Creek (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Lower Middle Fork Tribs (B)	1.25	0.97	1.61	1.17	0.76	1.78	1.18	0.72	1.94	1.25	0.79	1.97	0.91	1.25	0.79	1.97	0.91
		Upper Middle Fork Tribs (B)	1.22	0.95	1.58	1.14	0.75	1.74	1.16	0.70	1.91	1.24	0.78	1.96	0.91	1.24	0.78	1.96	0.91
		North Fork (A)	1.74	0.83	3.65	1.43	0.73	2.80	1.54	0.70	3.39	1.28	0.60	2.72	0.85	1.28	0.60	2.72	0.85
		Lemhi River (A)	1.80	0.86	3.78	1.48	0.76	2.89	1.58	0.72	3.49	1.29	0.61	2.74	0.86	1.29	0.61	2.74	0.86
		Pahsimeroi River (A)	2.02	0.96	4.23	1.66	0.85	3.25	1.67	0.76	3.69	1.32	0.62	2.81	0.88	1.32	0.62	2.81	0.88
		East Fork Salmon (A)	1.78	0.85	3.74	1.47	0.75	2.87	1.57	0.71	3.45	1.29	0.61	2.73	0.86	1.29	0.61	2.73	0.86
		Upper Mainstem (A)	1.85	0.88	3.89	1.52	0.78	2.98	1.63	0.74	3.59	1.30	0.61	2.76	0.86	1.30	0.61	2.76	0.86
Mid Columbia Steelhead	Yakima	Upper Yakima	1.72	1.17	2.53	1.58	1.07	2.33	2.17	1.40	3.35	1.21	0.88	1.66	0.93	1.20	0.88	1.65	0.92
		Naches	1.72	1.12	2.62	1.57	1.06	2.32	2.12	1.35	3.32	1.22	0.88	1.68	0.92	1.20	0.86	1.66	0.91
		Toppenish	2.46	1.39	4.35	2.25	1.37	3.68	3.38	1.97	5.79	1.30	0.90	1.87	0.95	1.28	0.89	1.84	0.94
		Satus	2.15	1.64	2.82	1.33	0.95	1.85	1.55	1.00	2.39	1.17	0.91	1.49	0.93	1.14	0.89	1.46	0.91
	Eastern Cascades	Deschutes W.	1.40	1.06	1.86	1.23	0.90	1.68	1.56	0.99	2.45	1.18	0.93	1.49	0.94	1.12	0.90	1.39	0.89
		Deschutes E.							1.59	0.90	2.82								
		Klickitat																	
		Fifteenmile Cr.	2.24	1.55	3.25	1.45	1.04	2.01	2.33	1.59	3.41	1.17	0.94	1.45	0.95	1.17	0.94	1.45	0.95
		Rock Cr.																	
		White Salmon - Extirpated																	
	Umatilla/Walla Walla	Umatilla	2.24	1.65	3.03	1.40	1.08	1.82	1.28	1.05	1.56	1.23	1.02	1.48	0.98	1.17	0.98	1.39	0.97
		Walla-Walla																	
		Touchet																	
	John Day	Lower Mainstem	4.16	2.70	6.39	1.73	1.05	2.83	2.06	1.02	4.17	1.18	0.83	1.67	0.87	1.17	0.83	1.65	0.86
		North Fork	3.35	2.26	4.98	1.63	1.09	2.43	2.32	1.70	3.16	1.17	0.93	1.47	0.93	1.16	0.93	1.46	0.93
		Upper Mainstem	2.99	1.60	5.56	1.49	1.00	2.22	1.10	0.67	1.81	1.16	0.90	1.49	0.91	1.15	0.90	1.48	0.90
		Middle Fork	3.40	2.56	4.52	1.63	1.13	2.34	1.37	0.79	2.39	1.18	0.93	1.49	0.94	1.17	0.93	1.47	0.93
		South Fork	2.92	1.80	4.73	1.40	0.90	2.19	1.43	0.74	2.75	1.16	0.86	1.56	0.88	1.15	0.86	1.54	0.88

Table 12. Continued.

Prospective - Historical Climate

ESU	MPG	Population	Productivity: 12-yr lambda, HF=0	Lower 95% CI	Upper 95% CI	Prob (>1)	12-yr lambda, HF=1	Lower 95% CI	Upper 95% CI	Prob (>1)	BRT Trend: 1980-current trend	Lower 95% CI	Upper 95% CI	1990-current trend	Lower 95% CI	Upper 95% CI
		Expected Harvest Assumption:														
Snake River Steelhead	Average "A-Run" Populations (only 14 years)		1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.33	1.23	1.61	1.42	1.25	1.60
Snake River Steelhead	Average "B-Run" Populations (only 13 years)		1.24	0.18	8.27	0.81	1.24	0.18	8.27	0.81	1.29	1.21	1.48	1.33	1.21	1.47
Snake River Steelhead	Lower Snake	Tucannon (A, but below LGR)	1.33	0.06	28.68	0.78	1.33	0.06	28.68	0.78	1.49	1.38	1.80	1.49	1.32	1.68
Snake River Steelhead	Lower Snake	Asotin (A)	1.33	0.06	28.62	0.78	1.33	0.06	28.62	0.78	1.51	1.39	1.81	1.47	1.30	1.66
Snake River Steelhead	Imnaha River	Imnaha R. (A)	1.27	0.87	1.84	0.94	1.27	0.87	1.84	0.94	1.35	1.30	1.50	1.38	1.27	1.49
Snake River Steelhead	Grande Ronde	Upper Mainstem (A)	1.23	1.10	1.38	0.99	1.17	1.04	1.32	0.99	1.38	1.33	1.49	1.38	1.31	1.45
Snake River Steelhead	Grande Ronde	Lower Mainstem (A)	1.32	0.06	28.44	0.77	1.32	0.06	28.44	0.77	1.35	1.25	1.62	1.43	1.27	1.61
Snake River Steelhead	Grande Ronde	Joseph Cr. (A)	1.25	0.98	1.60	0.97	1.25	0.98	1.60	0.97	1.42	1.36	1.55	1.42	1.33	1.51
Snake River Steelhead	Grande Ronde	Wallowa R. (A)	1.34	0.78	2.31	0.95	1.34	0.76	2.34	0.95	1.39	1.34	1.62	1.47	1.37	1.58
Snake River Steelhead	Clearwater River	Lower Mainstem (A)	1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.37	1.26	1.65	1.42	1.25	1.60
Snake River Steelhead	Clearwater River	Lolo Creek (A & B)-assume B	1.28	0.19	8.52	0.82	1.28	0.19	8.52	0.82	1.49	1.40	1.70	1.53	1.38	1.69
Snake River Steelhead	Clearwater River	Lochsa River (B)	1.30	0.19	8.66	0.83	1.30	0.19	8.66	0.83	1.60	1.50	1.83	1.64	1.49	1.81
Snake River Steelhead	Clearwater River	Selway River (B)	1.26	0.19	8.40	0.82	1.26	0.19	8.40	0.82	1.39	1.31	1.60	1.43	1.29	1.58
Snake River Steelhead	Clearwater River	South Fork (B)	1.29	0.19	8.63	0.83	1.29	0.19	8.63	0.83	1.58	1.49	1.82	1.61	1.46	1.78
Snake River Steelhead	Clearwater River	North Fork - (Extirpated)														
Snake River Steelhead	Salmon River	Little Salmon/Rapid (A)	1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.34	1.24	1.61	1.42	1.25	1.60
Snake River Steelhead	Salmon River	Chamberlain Cr. (A)	1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.33	1.23	1.61	1.42	1.25	1.60
Snake River Steelhead	Salmon River	Secesh River (B)	1.27	0.19	8.49	0.82	1.27	0.19	8.49	0.82	1.45	1.36	1.66	1.50	1.36	1.66
Snake River Steelhead	Salmon River	South Fork Salmon (B)	1.25	0.19	8.39	0.81	1.25	0.19	8.39	0.81	1.38	1.29	1.58	1.42	1.29	1.57
Snake River Steelhead	Salmon River	Panther Creek (A)	1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.33	1.23	1.61	1.42	1.25	1.60
Snake River Steelhead	Salmon River	Lower Middle Fork Tribs (B)	1.26	0.19	8.41	0.82	1.26	0.19	8.41	0.82	1.40	1.31	1.60	1.44	1.31	1.59
Snake River Steelhead	Salmon River	Upper Middle Fork Tribs (B)	1.25	0.19	8.38	0.81	1.25	0.19	8.38	0.81	1.37	1.29	1.57	1.41	1.28	1.56
Snake River Steelhead	Salmon River	North Fork (A)	1.32	0.06	28.38	0.77	1.32	0.06	28.38	0.77	1.33	1.23	1.61	1.42	1.25	1.60
Snake River Steelhead	Salmon River	Lemhi River (A)	1.33	0.06	28.56	0.77	1.33	0.06	28.56	0.77	1.38	1.27	1.66	1.46	1.29	1.65
Snake River Steelhead	Salmon River	Pahsimeroi River (A)	1.34	0.06	28.92	0.78	1.34	0.06	28.92	0.78	1.55	1.43	1.86	1.54	1.37	1.74
Snake River Steelhead	Salmon River	East Fork Salmon (A)	1.32	0.06	28.50	0.77	1.32	0.06	28.50	0.77	1.37	1.26	1.65	1.44	1.28	1.63
Snake River Steelhead	Salmon River	Upper Mainstem (A)	1.33	0.06	28.75	0.78	1.33	0.06	28.75	0.78	1.42	1.31	1.71	1.50	1.33	1.69
Mid Columbia Steelhead	Yakima	Upper Yakima	1.29	0.35	4.67	0.63	1.28	0.35	4.71	0.88	1.55	1.47	1.80	1.53	1.44	1.64
Mid Columbia Steelhead	Yakima	Naches	1.29	0.32	5.18	0.62	1.27	0.31	5.18	0.86	1.56	1.49	1.81	1.55	1.46	1.65
Mid Columbia Steelhead	Yakima	Toppenish	1.39	0.27	7.19	0.63	1.37	0.26	7.21	0.87	1.67	1.57	2.03	1.70	1.56	1.84
Mid Columbia Steelhead	Yakima	Satus	1.20	0.34	4.34	0.84	1.18	0.32	4.31	0.82	1.50	1.43	1.73	1.47	1.37	1.57
Mid Columbia Steelhead	Eastern Cascades	Deschutes W.	1.25	0.89	1.75	0.95	1.16	0.84	1.60	0.91	1.33	1.29	1.57	1.41	1.32	1.51
Mid Columbia Steelhead	Eastern Cascades	Deschutes E.	1.26	0.64	2.48	0.86	1.13	0.61	2.07	0.75				1.47	1.33	1.62
Mid Columbia Steelhead	Eastern Cascades	Klickitat														
Mid Columbia Steelhead	Eastern Cascades	Fifteenmile Cr.	1.30	1.00	1.69	0.97	1.30	1.00	1.69	0.97	1.27	1.21	1.42	1.64	1.54	1.75
Mid Columbia Steelhead	Eastern Cascades	Rock Cr.														
Mid Columbia Steelhead	Eastern Cascades	White Salmon - Extirpated														
Mid Columbia Steelhead	Umatilla/Walla Walla	Umatilla	1.24	0.41	3.71	0.88	1.14	0.42	3.05	0.83	1.50	1.46	1.69	1.47	1.39	1.55
Mid Columbia Steelhead	Umatilla/Walla Walla	Walla-Walla														
Mid Columbia Steelhead	Umatilla/Walla Walla	Touchet														
Mid Columbia Steelhead	John Day	Lower Mainstem	1.20	0.66	2.20	0.84	1.18	0.65	2.15	0.83	1.36	1.30	1.59	1.38	1.26	1.51
Mid Columbia Steelhead	John Day	North Fork	1.24	1.07	1.44	0.99	1.22	1.06	1.41	0.99	1.38	1.32	1.61	1.45	1.37	1.54
Mid Columbia Steelhead	John Day	Upper Mainstem	1.11	0.71	1.74	0.79	1.10	0.71	1.70	0.78	1.33	1.28	1.44	1.28	1.19	1.38
Mid Columbia Steelhead	John Day	Middle Fork	1.15	0.68	1.94	0.81	1.13	0.68	1.90	0.80	1.34	1.30	1.47	1.30	1.20	1.41
Mid Columbia Steelhead	John Day	South Fork	1.19	0.59	2.39	0.80	1.18	0.59	2.33	0.79	1.35	1.29	1.54	1.36	1.26	1.47

Figure 1. Probability that median population growth rate (lambda) of SR spring/summer Chinook salmon will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

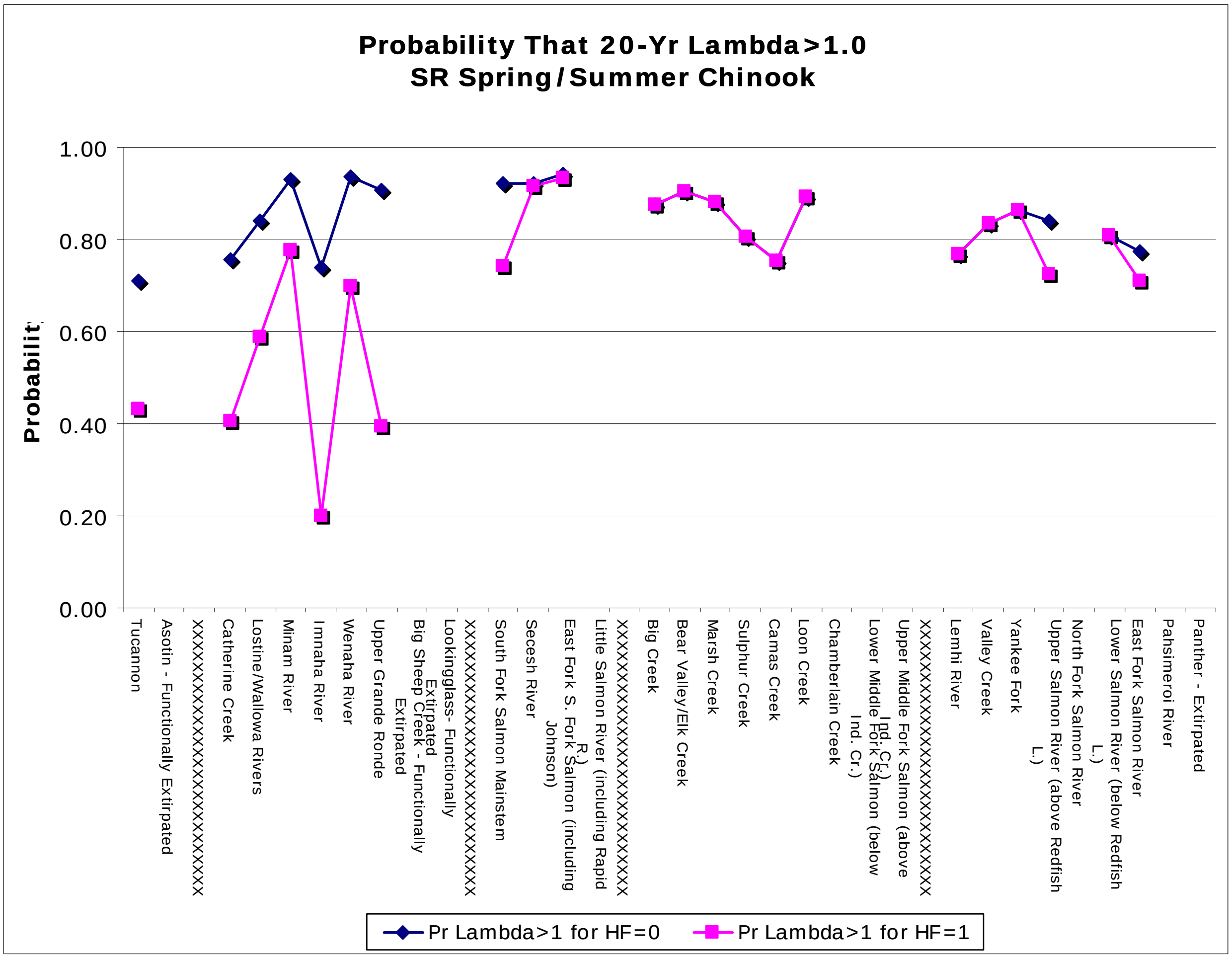


Figure 2. Probability that median population growth rate (lambda) of UCR spring Chinook salmon will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

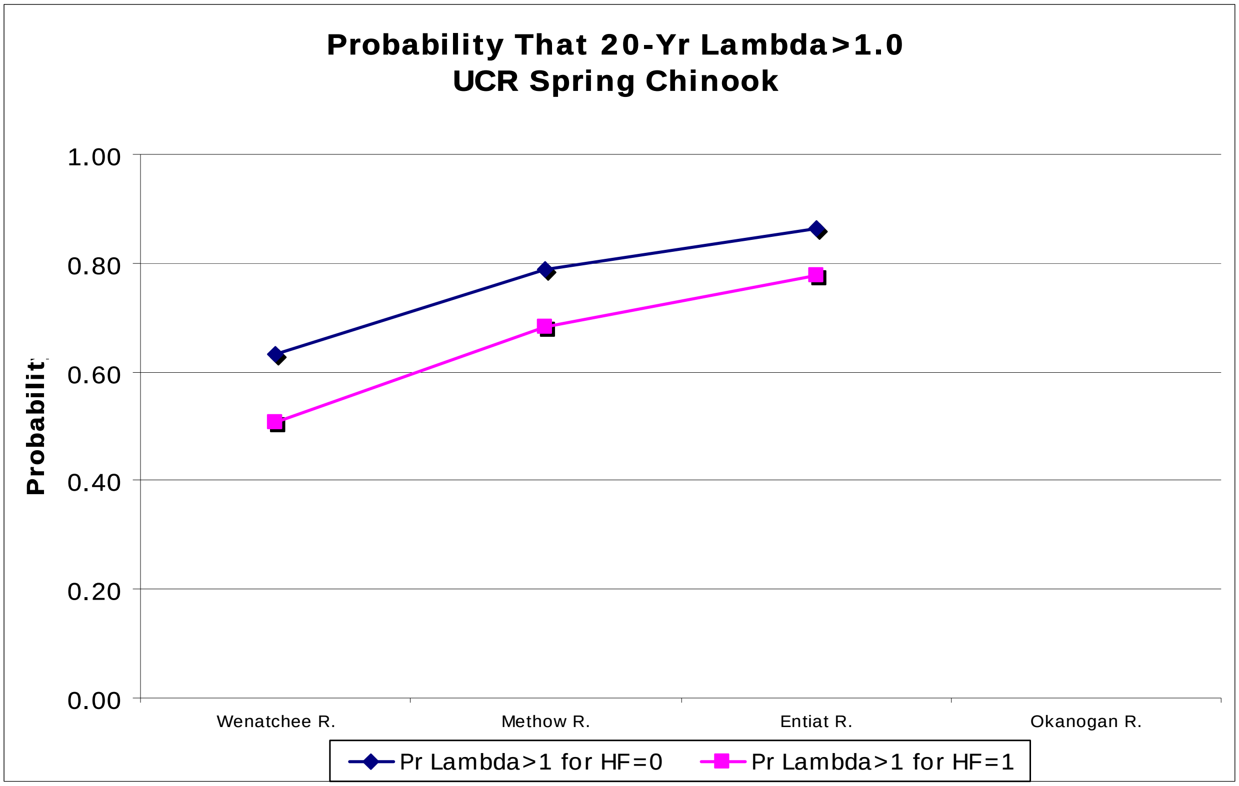


Figure 3. Probability that median population growth rate (lambda) of SR fall Chinook salmon will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

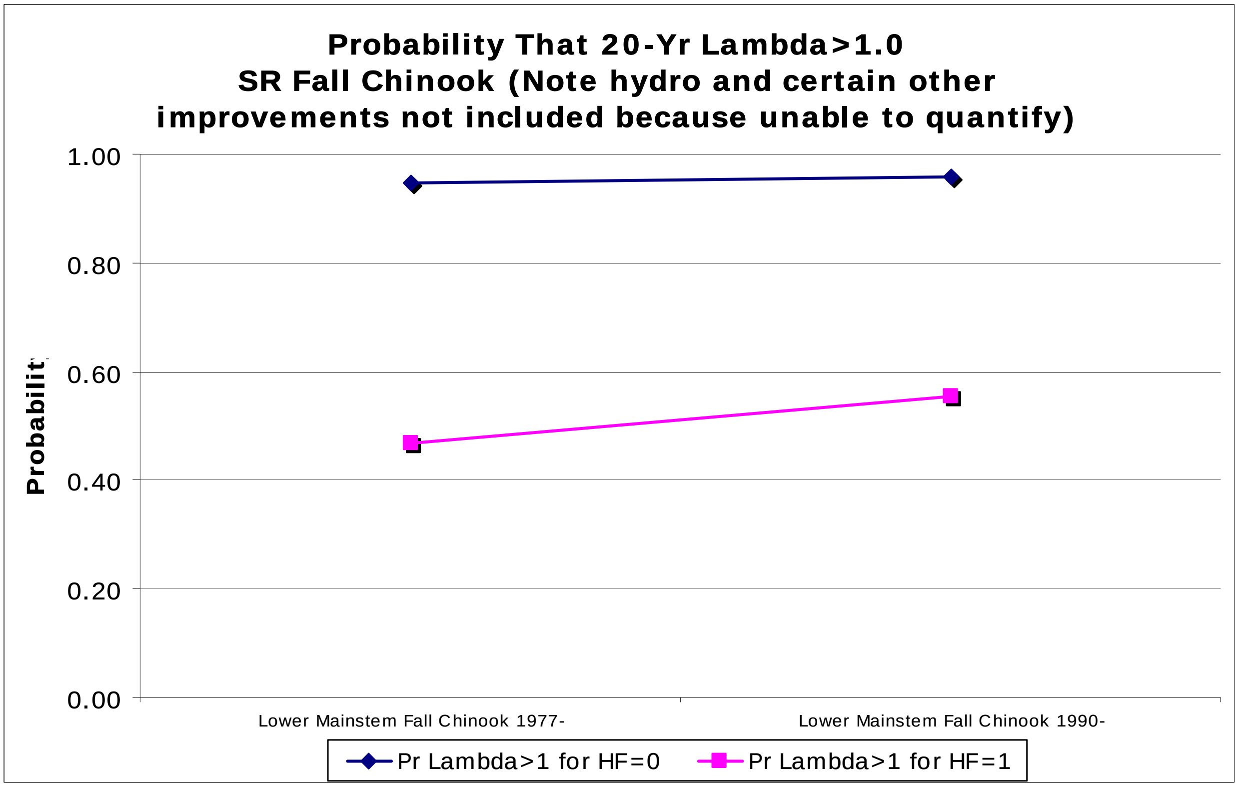


Figure 4. Probability that median population growth rate (lambda) of SR steelhead will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

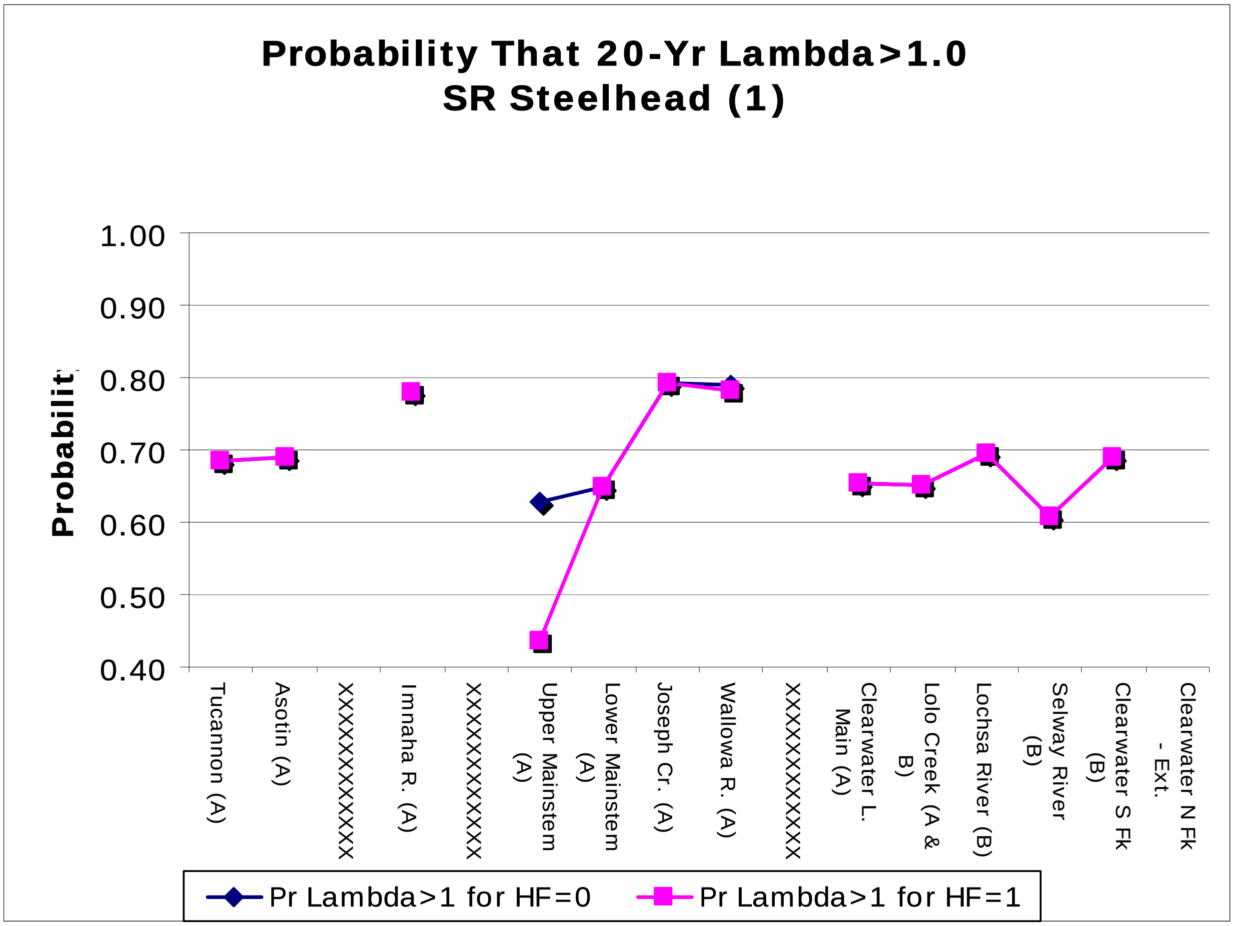


Figure 4. Continued.

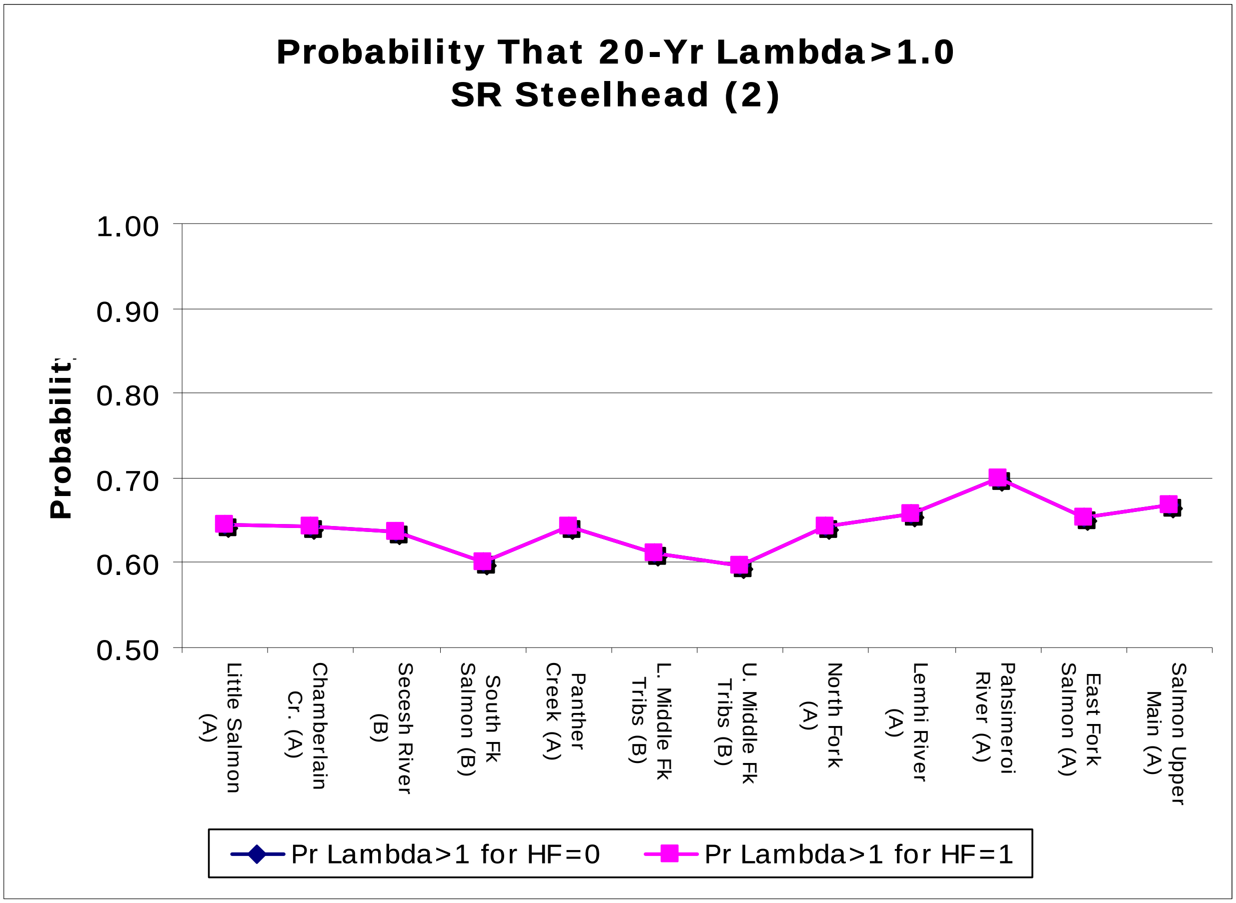


Figure 5. Probability that median population growth rate (lambda) of UCR steelhead will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

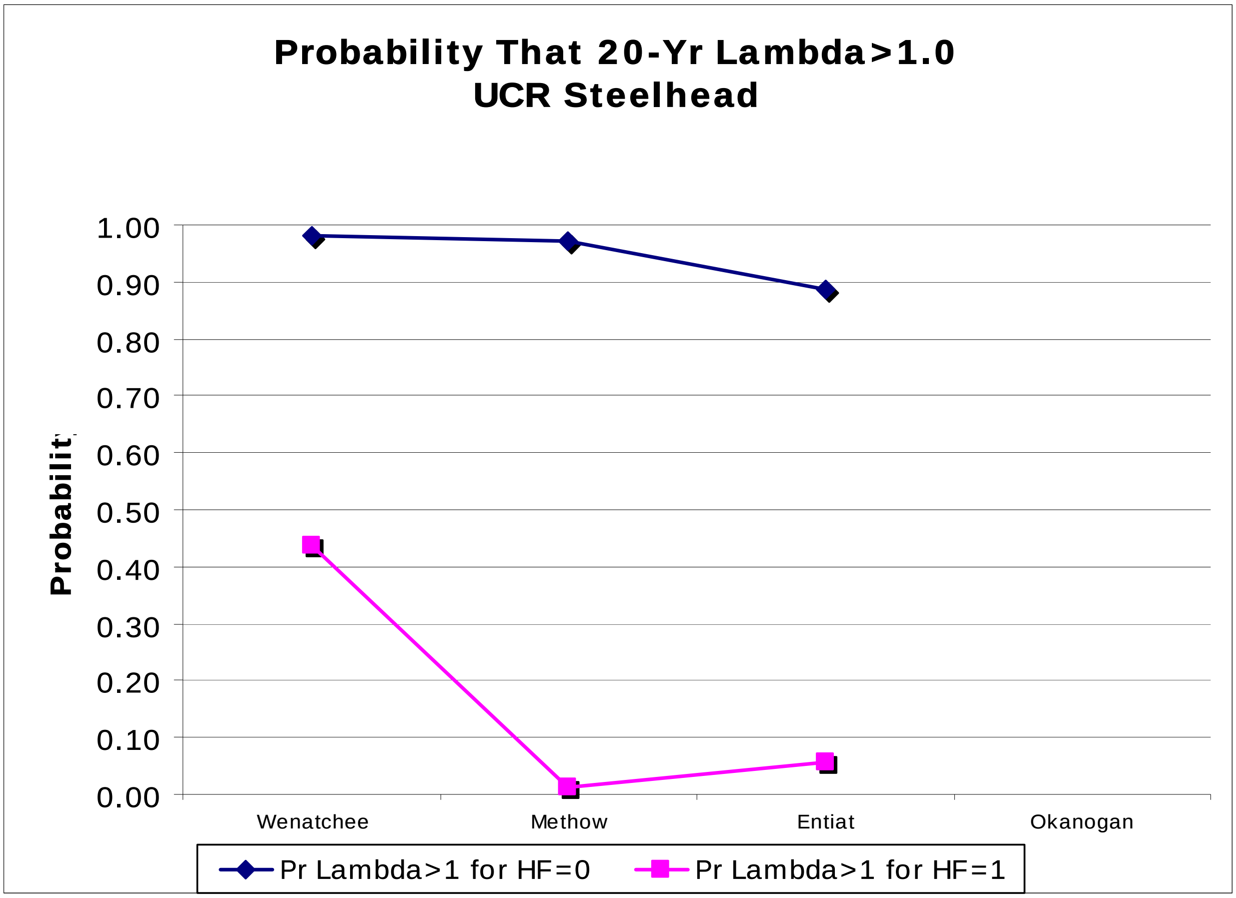


Figure 6. Probability that median population growth rate (lambda) of MCR steelhead will be greater than 1.0 after implementation of prospective actions. Probability estimate is derived from base period variance.

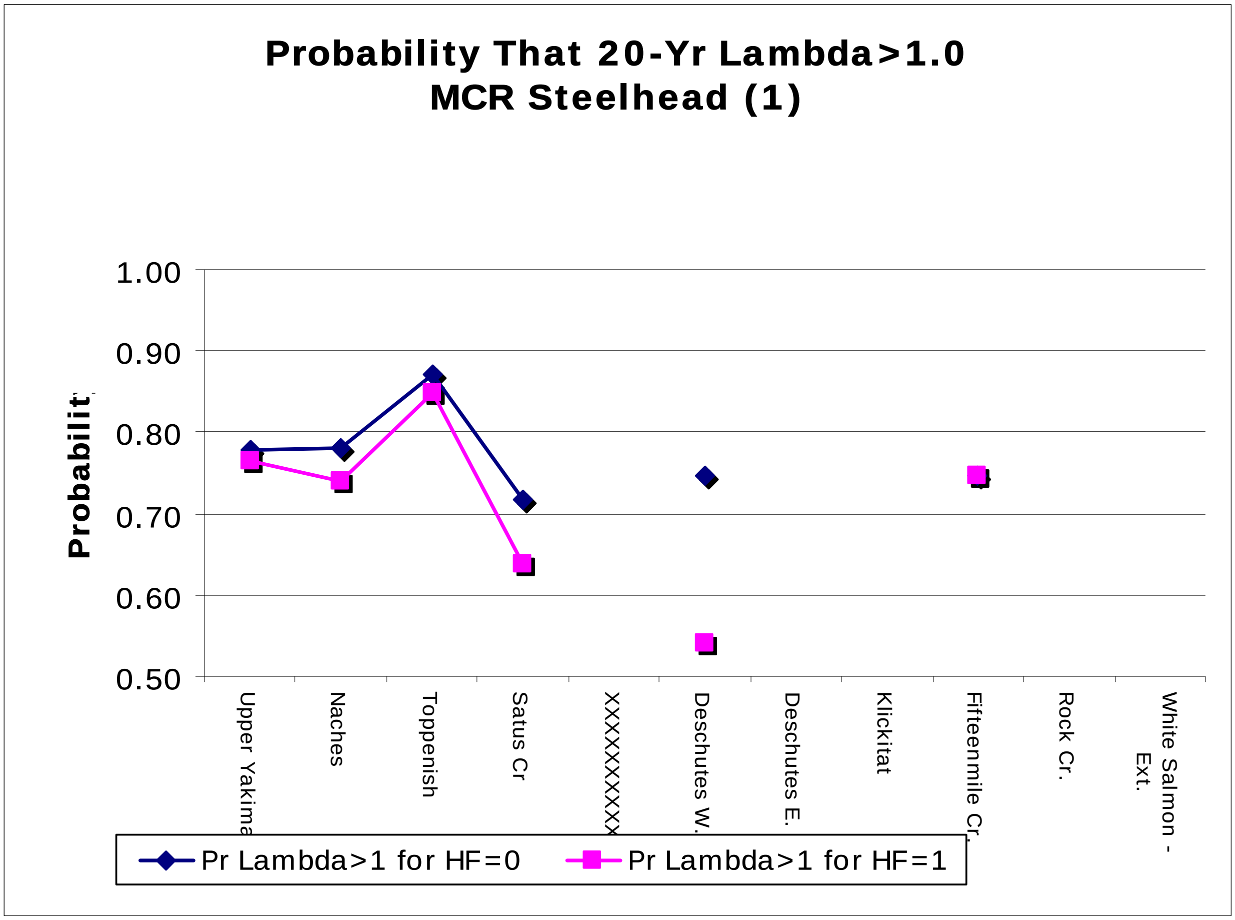


Figure 6. Continued.

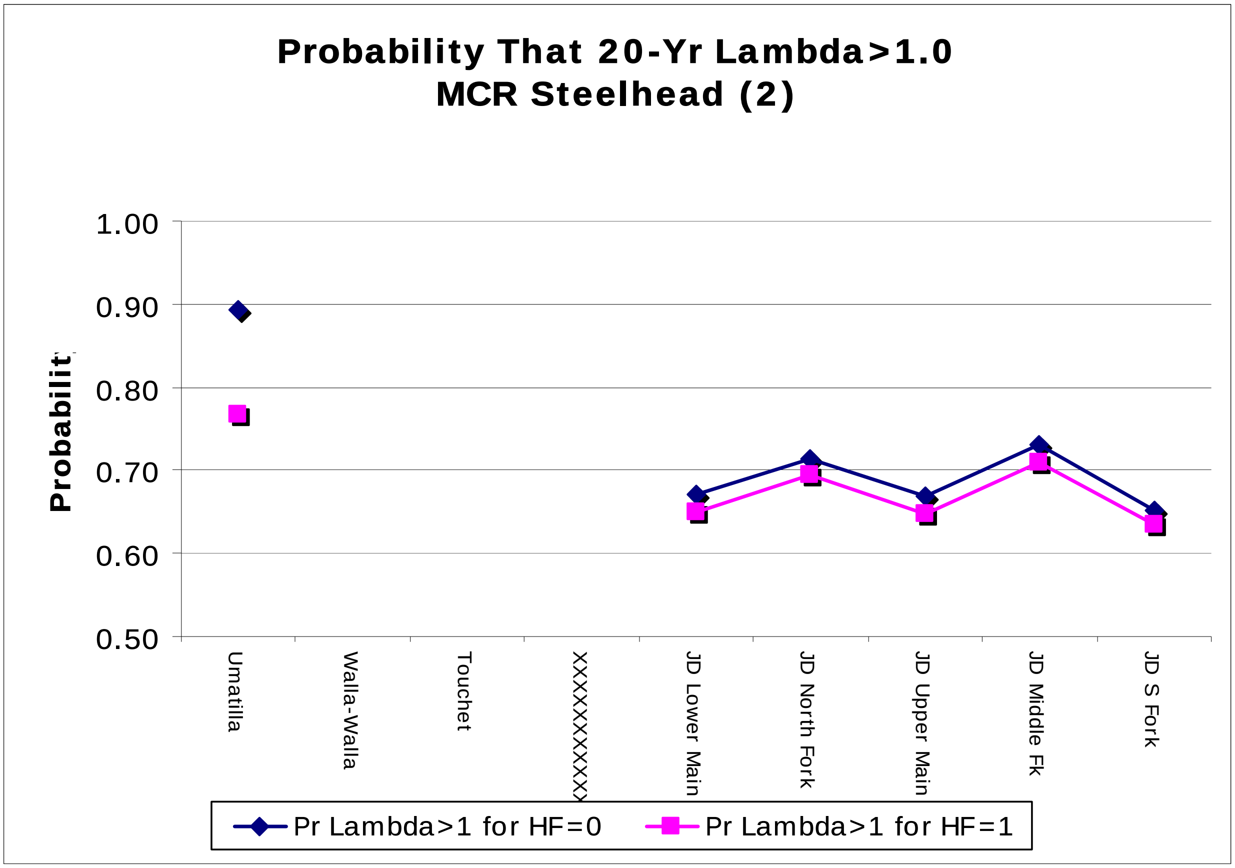
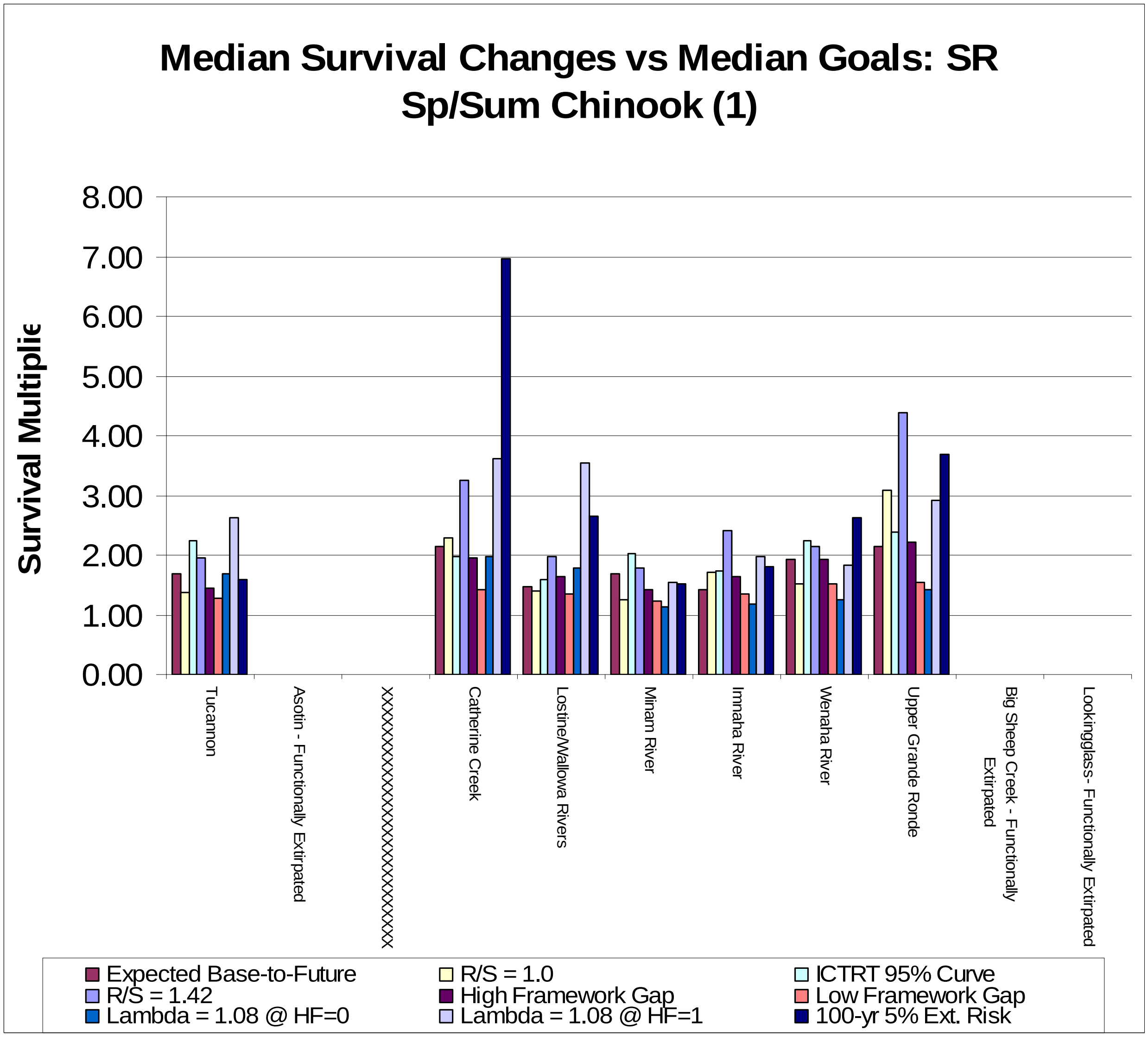


Figure 7. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for SR spring/summer Chinook salmon. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.



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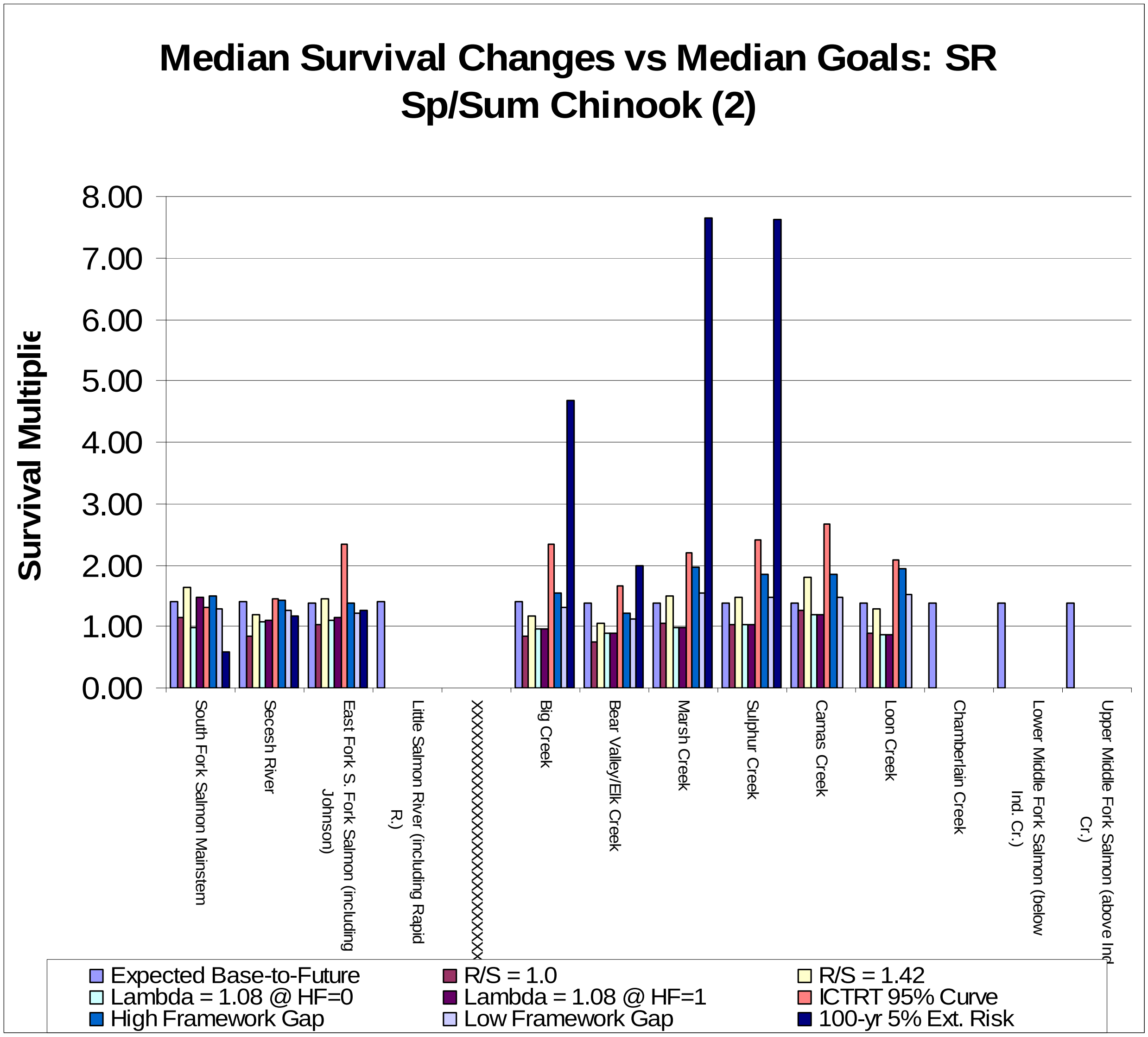

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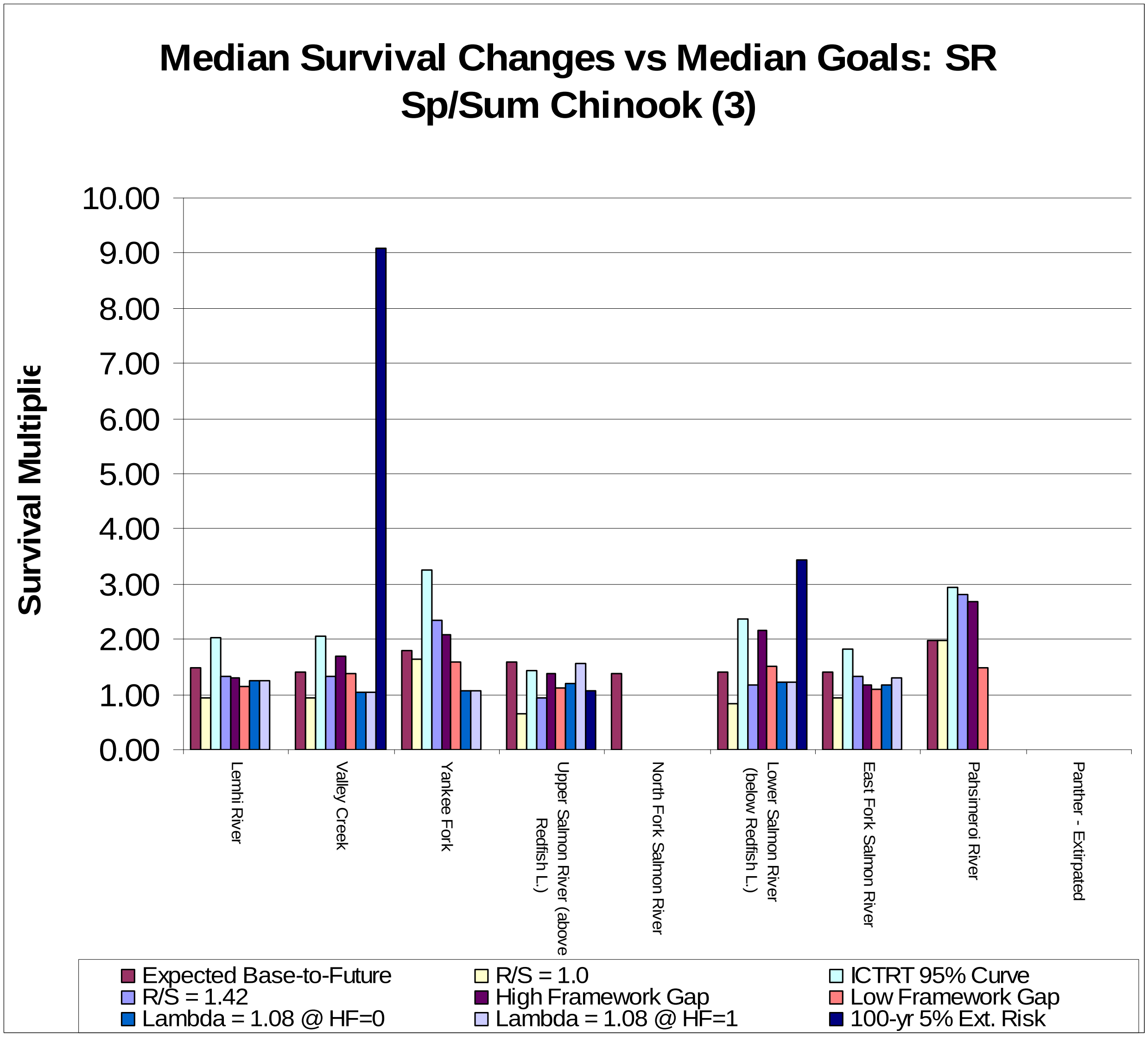


Figure 8. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for UCR spring Chinook salmon. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.

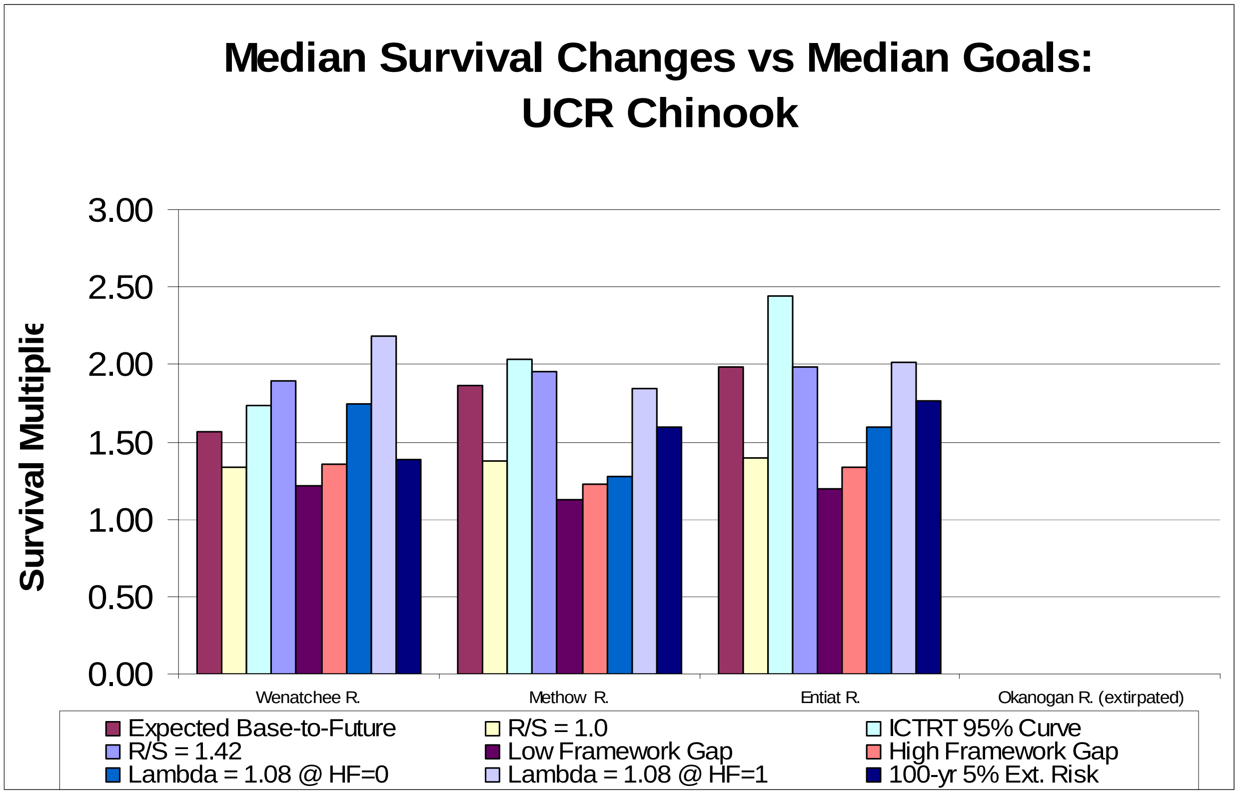


Figure 9. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for SR fall Chinook salmon. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.

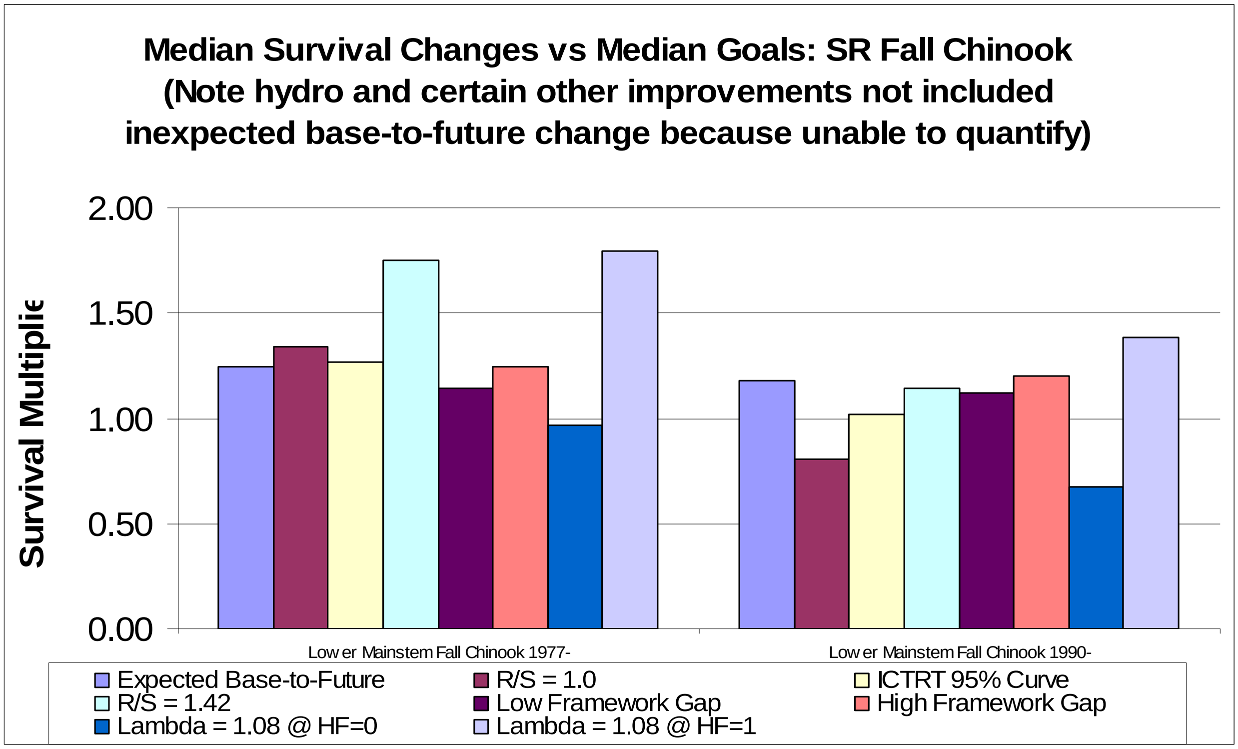
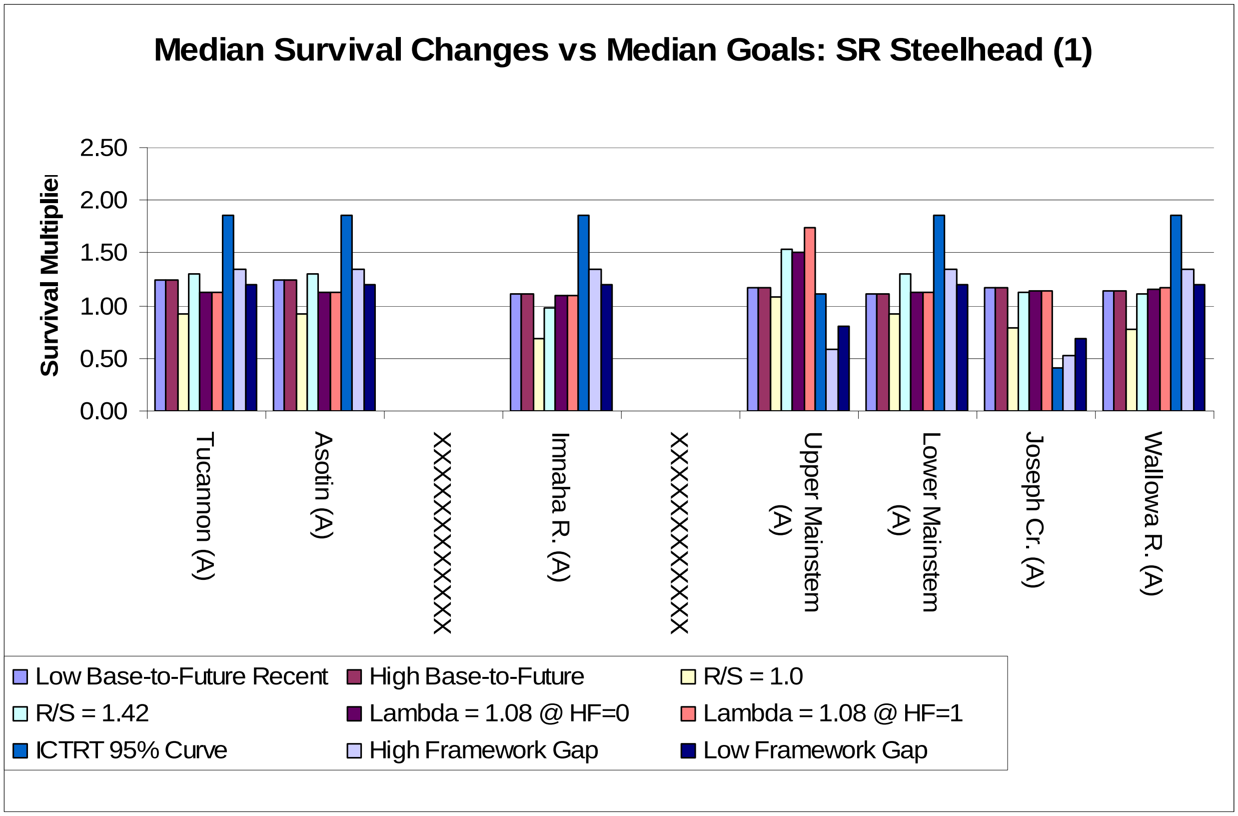


Figure 10. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for SR steelhead. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.



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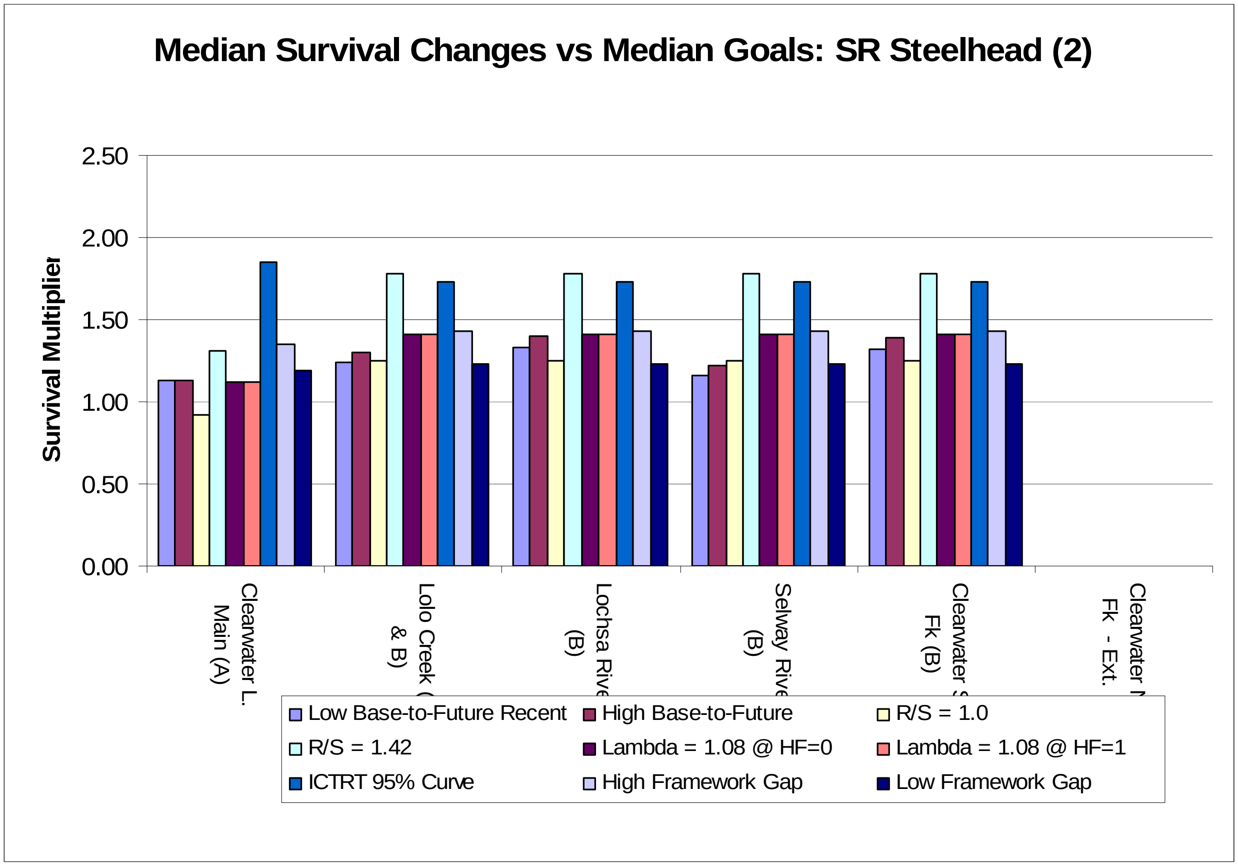


Figure 10. Continued.

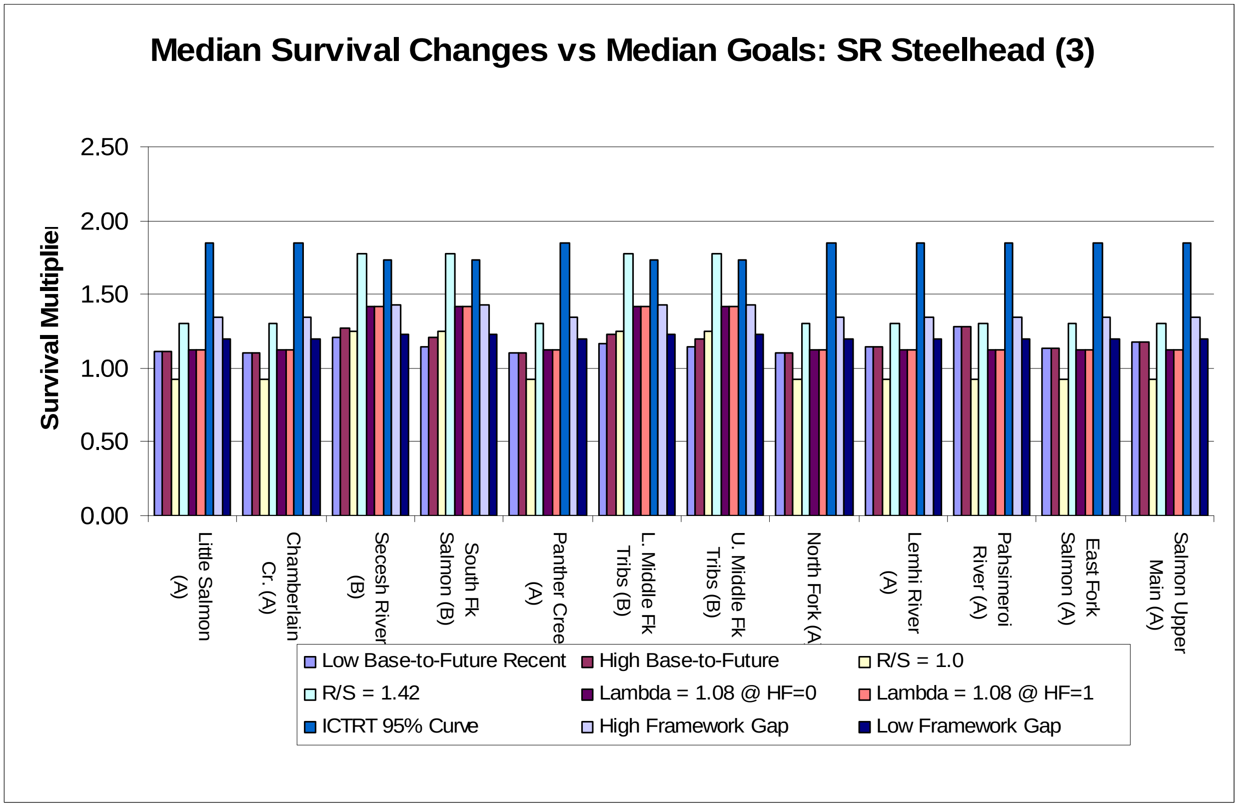


Figure 11. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for UCR steelhead. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.

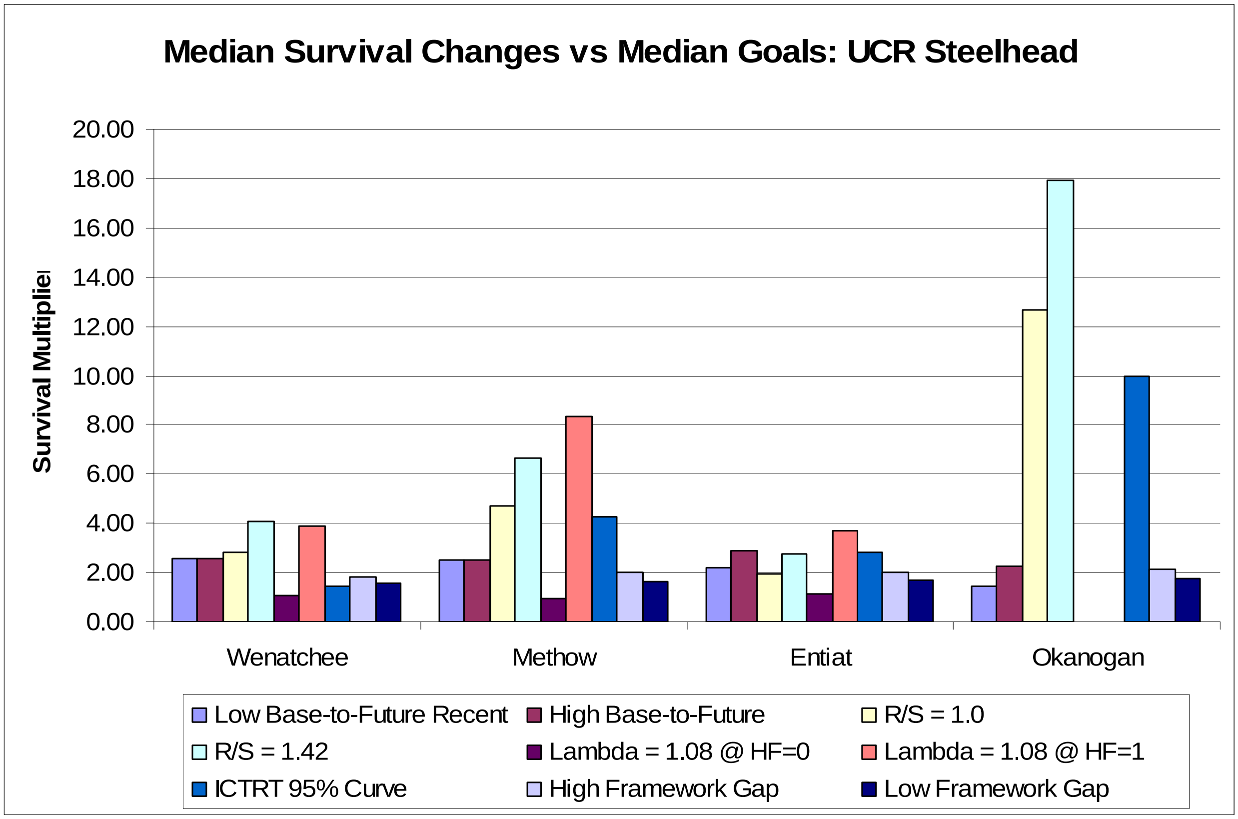
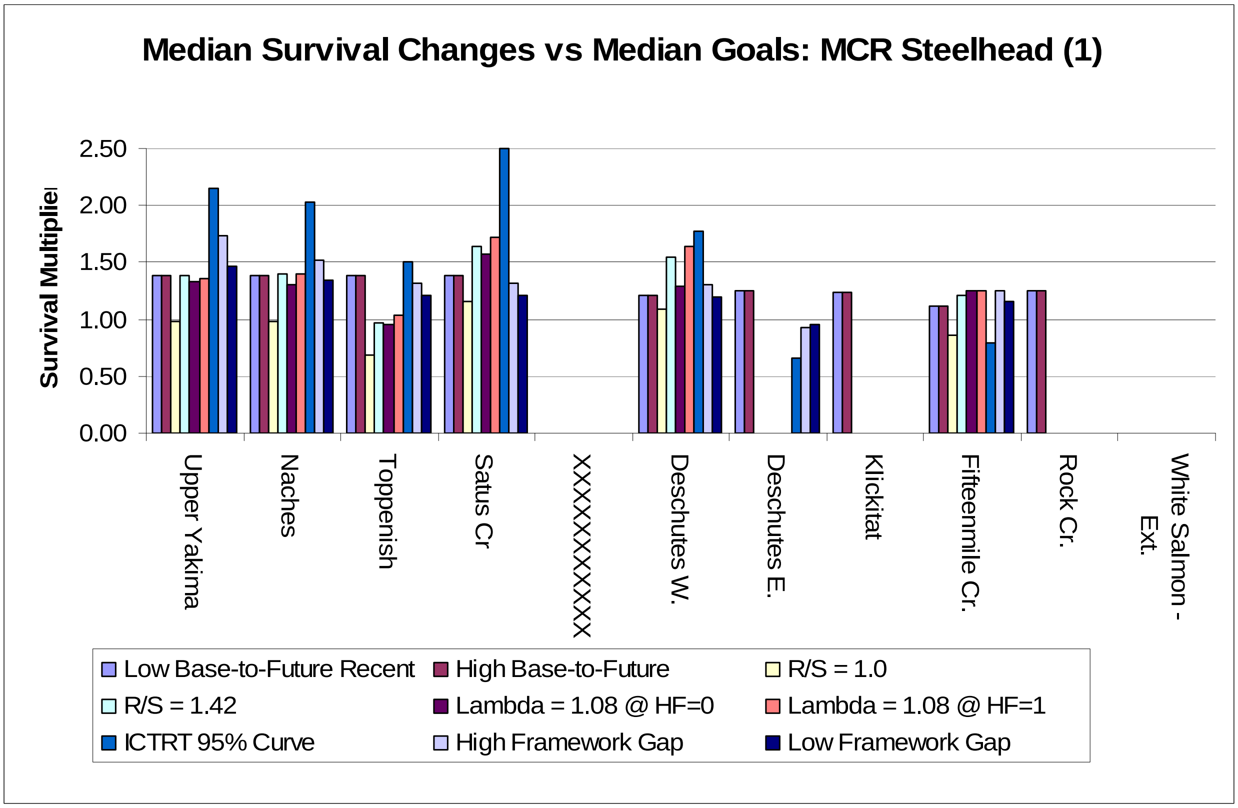


Figure 12. Comparison of alternative metrics or standards recommended in comments on the October 2007 draft biological opinion for MCR steelhead. Each metric is described in SCA Section 7.1.1. Bars represent the needed survival improvement from average base period survival that is needed to meet the standard, except for the left-most bar, which represents the expected survival improvement after implementing the Prospective Actions.



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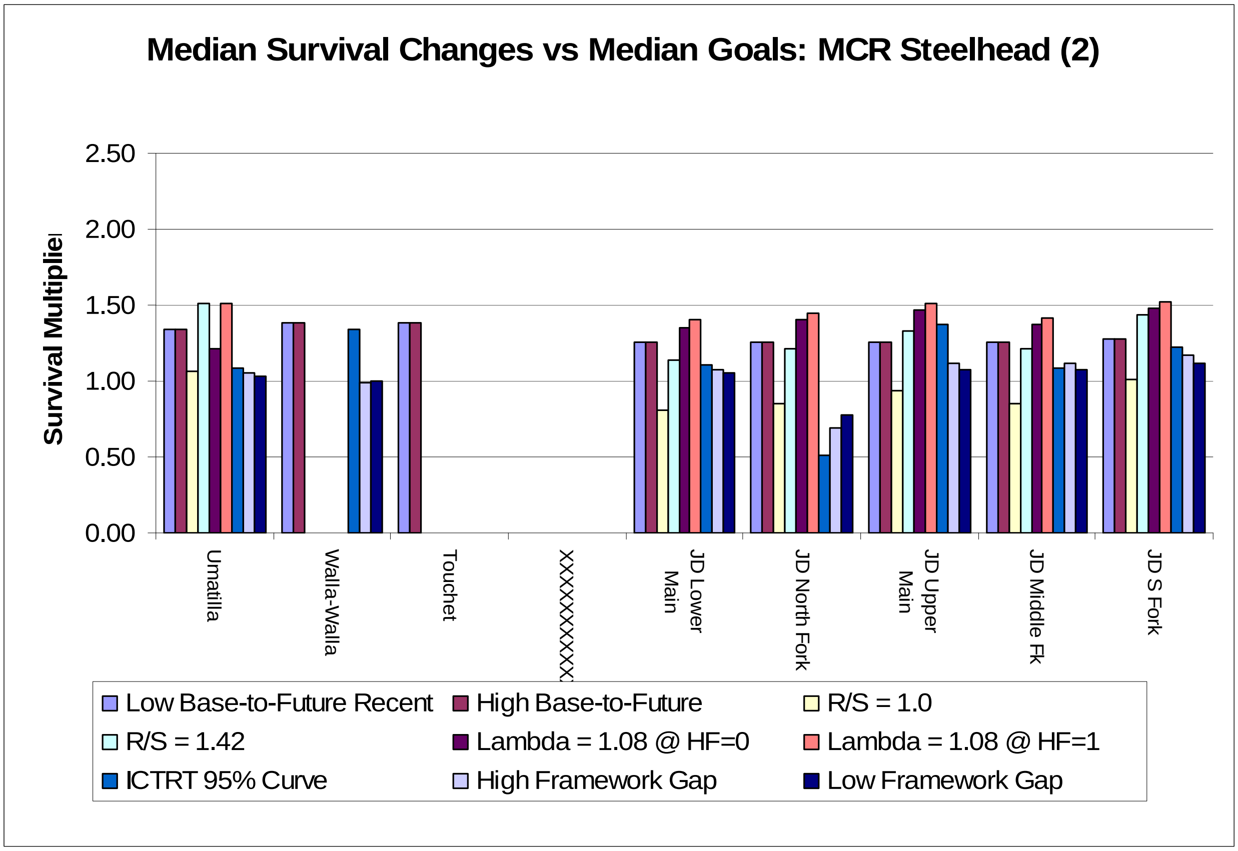

Aggregate Analysis

Attachment 1

Analytical methods for population viability analysis of endangered salmon

ESUs of the interior Columbia River Basin

March 19, 2008

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Executive summary

Extinction probability and trend estimates were developed for several chinook and steelhead salmon populations in the Columbia River Basin. The extinction probability approach used spawner-recruit (SR) functions which were fit to SR data from brood years 1978 to the present (most recently available observation). The estimated SR production functions were used to estimate extinction probabilities by population simulation. Alternative quasi-extinction thresholds of 1, 10, 30, and 50 spawners were used. In the projections, extinction was assumed to occur when spawner counts fell below the quasi-extinction threshold over four consecutive years. Survival gaps, defined as the change in life-cycle survival needed to achieve a 5% extinction probability risk, were developed for spring/summer chinook populations. BRT trend and mean log(R/S) estimates and associated confidence intervals were developed for all salmon populations analyzed.

Introduction

Population viability analysis is used to gauge the likelihood of extinction of endangered salmon populations in the Columbia River Basin. The 2000 Federal Columbia River Power System (FCRPS) BiOp used the Dennis et al. (1991) model to estimate the probability of absolute extinction (the population falling below 1 individual). The model was estimated using a procedure that accounted for measurement error (Holmes 2001). This method was used as a large-scale, multi-species risk assessment of anadromous salmonids in the Columbia River Basin (McClure et al. 2003).

An important element in the estimation of extinction risks is the production function that is used. The production function is the mathematical rule that describes how spawners in one year are related to adult returns in subsequent years. The models described in Holmes (2001) and McClure et al. (2003), which were used in the 2000 BiOp, were linear. That is, it was assumed that the mean population growth rate was constant regardless of spawner abundance. This assumption is contrary to most fisheries models, such as the Ricker or Beverton-Holt, which assume that the population growth rate declines as spawner numbers increase (Hilborn and Walters 1992). The most recent estimates used by the Interior Columbia Basin Technical Recovery Team (ICTRT) use nonlinear production functions. The nonlinear models include the assumption that populations cannot grow indefinitely, that is, they must level off as spawner numbers increase. Linear production functions do not include this assumption.

The nonlinear model used by the ICTRT for estimating extinction risks was the hockey stick model (Barrowman and Myers 2000). The more traditional models, such as Beverton-Holt and Ricker, assume that survival increases with declining spawning population until the last spawner disappears (Hilborn and Walters 1992). For these models, as spawner abundance declines, the number of recruits produced per spawner actually increases. From the perspective of population viability analysis, this assumption of increased survival at low population size may overestimate the resilience of a population and thus lead to underestimates of extinction probability. The hockey stick model addresses this concern by assuming constant recruits produced per spawner when spawner numbers fall below a threshold (Barrowman and Myers 2000). The hockey stick model, however, introduces important estimation difficulties because the likelihood function includes "kinks" where the derivative is not defined and it often exhibits multiple local maxima. Ideally, for the purposes of estimation, the likelihood function would be smooth (without kinks) and have a single maximum value.

This report details an approach to estimating extinction probabilities, survival gaps, and abundance trends. When estimating extinction probability, the hockey stick production model was not used because of the numerical and statistical difficulties involved (described above). Instead, the Beverton-Holt and Ricker productions were used. Parameter estimates for these production functions were obtained by maximizing the likelihood function. The production function estimates were then used to obtain extinction probabilities by projecting forward spawner abundances 24 years and 100 years into the future. This procedure was applied to salmon populations from the listed Snake River Spring/Summer Chinook and Upper Columbia River Spring/Summer Chinook Salmon ESUs and to the Snake River Steelhead, Upper Columbia River Steelhead, and Mid-Columbia River Steelhead. The time horizon was set at 24 and 100 years, and the quasi-extinction threshold (the spawner level below which extinction was assumed to occur) (QET) was set at 1, 10, 30, and 50 spawners.

Survival gaps, defined as the change in life-cycle survival needed to achieve a 5% extinction probability risk, were developed for spring/summer chinook populations. BRT trend and mean log(R/S) estimates and associated confidence intervals were developed for all salmon populations analyzed.

Data

Spawner recruit data for two spring/summer chinook ESUs, three Steelhead ESUs and on fall chinook ESU were used. A list of populations analyzed is presented in Tables 1-3.

Spring/summer chinook ESUs

The data used were Snake River and Upper Columbia River stream-type chinook spawner-recruit data (Matheson 2006), which were updated to include more recent estimates. Spawner estimates were estimates of annual abundance of salmon arriving at the spawning grounds. Recruitment refers to adult progeny returning to the spawning grounds.

Steelhead ESUs

The data used were Snake River, Mid-Columbia, and Upper Columbia River spawner-recruit data (Matheson 2006), updated to include more recent estimates.

Fall Chinook

The data used were Snake River Fall Chinook spawner-recruit estimates (Matheson 2006), updated to include more recent estimates.

Population viability analysis

The underlying production functions used in the population projections were the Beverton-Holt and Ricker (Hilborn and Walters 1992). The Beverton-Holt model was applied to spring/summer chinook salmon populations and the Ricker model was applied to steelhead and fall chinook populations. The Beverton-Holt model was used for the spring/summer chinook populations because preliminary work showed that it yielded extinction probability estimates that were similar to the hockey stick model used by the Interior Columbia Basin TRT. The Beverton-Holt model was not applied to the steelhead and fall chinook populations because valid parameter estimates could not be found for about half of the steelhead populations or the fall chinook population. For these populations, the Ricker model was used because it is guaranteed to yield maximum likelihood estimates.

The Beverton-Holt model takes the mathematical form:

(1) $$R_t = S_t \exp(a + \phi_t)/(1 + bS_t)\text{,}$$ **(Beverton-Holt)**

where R_t is recruitment (the adult progeny of fish spawning in year t); S_t represents the number of spawners in brood year *t*; a is the intrinsic productivity, which is the maximum log recruits per spawner; ϕ_t is a stochastic error term, which follows an autoregressive process of order 1; and *b* is the parameter that describes density dependent growth.

The Ricker model takes the mathematical form

(2) $$R_t = S_t \exp(a - bS + \phi_t)\text{,}$$ **(Ricker)**

where R_t is recruitment (the adult progeny of fish spawning in year t); S_t represents the number of spawners in brood year *t*; a is the intrinsic productivity, which is the maximum log recruits per spawner; ϕ_t is a stochastic error term, which follows an autoregressive process of order 1; and *b* is the parameter that describes density dependent growth.

The autoregressive process was used for the error term because lag-1 autocorrelation was evident in the data and extinction probabilities are known to be influenced by autocorrelation (Wichmann et al. 2005). The autoregressive order 1 process is described by:

(3) $$\phi_{t+1} = \alpha\phi_t + \varepsilon_{t+1}\text{,}$$

where α is the autoregressive parameter, which, according to the Yule-Walker equations, is equivalent to the lag-1 autocorrelation coefficient (Box et al. 1994); and ε_{t+1} is an independent and normally distributed random error term with mean zero and variance σ^2. The ε_t process will be referred to as the white noise process. (The ϕ_t errors represent a red noise process because the errors are positively correlated). The initial production function error, ϕ_1, is set equal to ε_1 (i.e., it is normally distributed with mean zero and variance σ^2).
The parameters were estimated by maximizing the likelihood function. The log likelihood function was formed by taking the natural log of the joint distribution of the white noise errors, ε_t:

$$l = -\frac{n}{2}\log\left(2\pi\sigma^2\right) - \frac{1}{2\sigma^2}\sum_{t=1}^{n}\varepsilon_t^2 =$$
$$= -\frac{n}{2}\log\left(2\pi\sigma^2\right) - \frac{1}{2\sigma^2}\left\{\left(y_1 - f(a,b,S_1)\right)^2 + \sum_{t=1}^{n-1}\left(y_{t+1} - f(a,b,S_{t+1}) - \alpha\left(y_t - f(a,b,S_t)\right)\right)^2\right\}$$

where n was the number of spawner-recruit observations; y_t represents $\log(R_t / S_t)$; and $f(a,b,S_t)$ was $a - \log(1+bS_t)$ when the Beverton-Holt production function was used, or equal to $a - bS_t$ when the Ricker production function was used. Notice that when the autoregressive parameter, α, is equal to zero, the likelihood function is reduced to the usual likelihood function with uncorrelated errors. Altogether, there were four parameters estimated from this likelihood function: a, b, α, and σ^2. Because the model is nonlinear in the parameters, interior maximum likelihood estimates were not guaranteed to exist.

The nonlinear regression was conducted using the routine *nls* from the R statistical package, which uses a Gauss-Newton algorithm for calculating maximum likelihood estimates (R Development Core Team 2005). Standard errors and *p*-values were calculated for the parameter estimates and correlations between the parameter estimates were also calculated.

Extinction probabilities

Once the Beverton-Holt or Ricker parameters were estimated the production functions were used to estimate probabilities of extinction by projecting spawner numbers into the future (Tables 1-3). In each simulation of a population, $N = 4000$ 24-year and 100-year sequences of spawners were generated. Once the spawner series was initialized, the stochastic production function was used to build a series of future spawners by allocating recruits to the appropriate spawners. A fixed age structure of recruits was assumed in the population projections. Age structure was set to the average age structure from 1978 to present (the year of most recently available data).

The extinction probability was estimated as the fraction of the 4000 sequences in which spawners fell below the quasi-extinction threshold (QET) for four consecutive years. Extinction probability estimates were obtained using alternative values of QET (1, 10, 30, and 50), and with alternative time horizons of 24 and 100 years. If, during a population projection, the total number of spawners fell below 10, then number of recruits was set to zero (i.e. the reproductive failure threshold was set at 10 spawners). In the case where QET=1, a reproductive failure threshold of 2 spawners was used.

Using the Beverton-Holt production function, the projections took the following mathematical form:

(4) $$R_t^* = S_t^* \exp(\hat{a} + \phi_t^*)/(1+\hat{b}S_t^*)$$

(5) $$S_t^* = \sum_{\tau=1}^{5} \overline{p}_\tau R_{t-\tau}^* ,$$

where R_t^* was the simulated number of recruits generated from spawners in brood year *t*; S_t^* was the simulated number of spawners in brood year *t*; $\hat{a}$ was the maximum likelihood estimate of the Beverton-Holt density-independent parameter a; ϕ_t^* represented a random draw from the autoregressive error model; $\hat{b}$ was the maximum likelihood estimate of the Beverton-Holt density-dependent parameter b; τ represented age of returning adults; and $\overline{p}_\tau$ represented the average fraction of adults returning at age τ. The projections were initialized by setting the first five spawner numbers in the sequence equal to the most recently available 5 spawner observations.

A similar method was used when the Ricker model was employed, but in that case the population projections were accomplished using the relationship

(6) $$R_t^* = S_t^* \exp(\hat{a} - \hat{b}S_t^* + \phi_t^*)$$

instead of the Beverton-Holt spawner-recruit relationship.

Supplementation

In the extinction probability analysis described above, it was assumed that the relative reproductive effectiveness of hatchery-born spawners was equal to that of the wild-born spawners and that supplementation would not continue into the future. As an alternative, some extinction runs were conducted under the assumptions that reproductive effectiveness of hatchery-born spawners could differ from that of wild-born spawners and that supplementation would continue at some level into the future (Tables 4-6).

Within this framework, which recognizes supplementation and differential reproductive effectiveness of hatchery-born spawners, the following model is fit to the retrospective data,

(7) $$R_t = S_t (f_t + (1 - f_t) e_t) \exp(a + \phi_t) / (1 + bS_t)$$

where f_t represents the fraction of wild-born spawners and e_t represents the relative reproductive success of hatchery-born spawners. In the special case where $e_t = 0$, note that none of the hatchery-born spawners contributes to the progeny (recruits). In the case where $e_t = 1$, the model reduces to the model introduced in equation 1.

This supplementation model produces different point estimates of the Beverton-Holt parameters than the original model. Therefore, extinction probability estimates will change. Inclusion of supplementation in the future will also alter extinction probabilities by adding spawners and thereby decreasing the probability that spawner abundance will fall below QET. The population projections with supplementation take the form

(8) $$R_t^* = S_t^*(f_t^* + (1 - f_t^*)e_t^*)\exp(\hat{a} + \phi_t^*)/(1 - \hat{b}S_t^*)$$

(9) $$S_t^* = \left(\sum_{\tau=1}^{5} \overline{p}_\tau R_{t-\tau}^*\right) + H^*{}_t$$

where e_t^* represents the future values of the relative reproductive effectiveness of hatchery-born spawners, f_t^* represents the future fraction of wild-born spawners, and S_t^* represents the total number of (wild + hatchery-born) spawners. ϕ_t^* represents a random draw from the autoregressive error model, $\hat{b}$ is the maximum likelihood estimate of the Beverton-Holt density-dependent parameter b, and H_t^* represents future supplementation in year t.

Extinction occurred when the total spawners fall below QET 4 years running. That is, when total spawners fell below QET for four consecutive years within the time horizon. A similar methodology was used when the Ricker model was used instead of the Beverton-Holt model.

Survival gap calculations

Estimates of increase in survival to achieve acceptable extinction risk, known as a "gap," were developed for spring/summer chinook (Table 7). In the population viability analysis, extinction probability was considered as a function of abundance and productivity. Generally, as abundance and productivity (Beverton-Holt *a*) parameters increase, extinction probability decreases. Whenever extinction probability was above 5 percent, a survival gap was considered to exist. That is, a gap exists when productivity must increase in order to reduce extinction risk to 5 percent or less. The gap was quantified by calculating the increase in productivity necessary to achieve the 5 percent extinction risk target. Extinction probability was considered as a function of productivity, which was denoted $P(a)$. $P(a)$ is the probability of extinction when the Beverton-Holt production parameter is set to a. A necessary step in calculating the gap is to find the value of a that makes

(10) $$f(a) = P(a) - 0.05$$

equal to zero. This is a root finding problem in numerical analysis. The root in this case is the value of the Beverton-Holt *a* parameter that yields an extinction probability of 5 percent. To solve this problem, the bisection method was used, which cannot fail once an interval that contains a root is identified (Press et al. 1992). The bisection algorithm was *rtbis*, and the bracketing routine (which identifies an interval that contains the root) was *zbrac* (Press et al. 1992).

Once the root a^* was found numerically, the survival gap was calculated as

(11) $$gap = \exp(a^* - \hat{a}),$$

where $\hat{a}$ represented the maximum likelihood estimate of the Beverton-Holt *a* parameter. The gap is the survival multiplier needed achieve a 5 percent extinction risk. When the multiplier is at or below one, no increase in survival is necessary (extinction risk is already at or below 5 percent), but when the multiplier is above one, an increase is necessary to achieve 5 percent risk. Finding an accurate gap estimate required increasing the number of trajectories used in the extinction probability estimates from 4,000 to 10,000.

The underlying assumption that allowed this gap calculation was that the intrinsic productivity, or recruits per spawner at very low abundance given by $\exp(a)$ was proportional to survival. Thus, $\exp(a) = k \cdot s$ where k is a constant and s represents survival. If s_0 represents current survival and s^* represents the survival necessary to achieve the 5 percent target, then the survival gap is

(12) $$gap = \frac{s^*}{s_0} = \frac{\exp(a^*)/k}{\exp(\hat{a})/k} = \exp(a^* - \hat{a})$$

Extinction probability confidence intervals

Extinction probabilities suffer from high uncertainty, especially over long time horizons (e.g., 100 years). Fieberg and Ellner (2000) demonstrated that reliable extinction probability estimates were possible for short-term time horizons (10 percent-20 percent as long as the time series used for model fitting) only. Using 20 percent as a guide, it follows that 24-year extinction probabilities should be estimated using about 100 years of data. Time series of that duration are not available for Columbia River Basin salmonid populations. This analysis and others (the ICTRT, for example) use much shorter time series of data, generally 20 years. Thus, the imprecision of the extinction probability estimates is due, in part, to a lack of data.
To quantify the uncertainty surrounding the estimates, confidence intervals were constructed. Confidence intervals that are narrow (e.g. 0.50 to 0.51), indicate high reliability of extinction probability estimates. Confidence intervals that are wide (e.g., spanning 0 to 1), indicate low reliability of extinction probability estimates. That is, data from the same population process, generally yield very different inferences about the extinction probability. Wide confidence intervals are a common problem with the estimation of extinction probabilities, especially for

populations that are highly variable with a paucity of data. Furthermore, confidence intervals are wide because extinction probability usually declines sharply with increasing intrinsic productivity (Botsford and Brittnacher 1998). Therefore any uncertainty in the intrinsic productivity parameter (which depends strongly on the error variance), will be greatly magnified in the estimation of extinction probability.

Bootstrapping was used to estimate confidence intervals for extinction probabilities (Efron and Tibshirani 1993). Bootstrapping proceeded by building an empirical distribution of 1000 bootstrap replications of an extinction probability estimate, then using the 0.025 and 0.975 quantiles of the distribution as confidence limits. Each of the bootstrap extinction probability estimates was based on a replication of the production function parameter estimates derived from a synthetic data set. If the replication of the autoregressive parameter exceeded one, it was set to one. Replications with a negative *b* parameter were ignored. Synthetic data sets were constructed by resampling the original data set with replacement. Maximum likelihood estimates were obtained for each synthetic data set. Replications of extinction probability were then obtained by evaluating the extinction probability at these maximum likelihood estimates.

These methods were applied to steelhead and Snake River fall chinook populations (using the Ricker production function) and spring/summer chinook salmon populations (using the Beverton-Holt production function).

BRT trend

Trends in natural spawner abundance were calculated to infer whether population abundances tend to be (on average) increasing, decreasing or remaining the same (Tables 8-10). Trend was calculated as the slope of the regression of the abundance index (log transformed) versus time. Two alternative time periods were considered: 1980 to present and 1990 to present. “Present” is considered to be the year of the most recently available observation. One was added to the natural spawner abundance before log transforming the data to avoid taking the log of zero, which is undefined. Trend was reported as the exponential function of the estimated slope of the regression line. A trend greater than 1.0 indicates population increase, a trend less than 1.0 indicates population decrease, and a trend of 1.0 indicates that, on average, population numbers are not changing. The regression equation was

(13) $$\ln(N_t + 1) = \beta_0 + \beta_1 t + \varepsilon_t ,$$

where N_t was the natural spawners in brood year t, β_0 is the intercept regression parameter, β_1 was the slope regression parameter, and ε_t was the random error term of the regression. The regression parameter estimates, $\hat{\beta}_0$ and $\hat{\beta}_1$ were obtained through a least squares fit to the data. The trend estimate was then defined as $\exp(\hat{\beta}_1)$.

Developing confidence intervals for $\exp(\beta_1)$ using the usual regression procedures was not possible because the regression residuals were not independent and not identically distributed. This is a drawback for this estimate of trend because the usual desirable statistical properties of maximum likelihood estimators (low bias and relatively high precision) do not apply. Therefore, a bootstrapping approach was developed to estimating confidence intervals. This involved creating synthetic population data sets and applying the trend estimation procedure to each of these synthetic data sets. This yielded a set of trend replications. The confidence intervals were constructed by setting the confidence limits equal to the 0.025 and 0.975 quantiles of the empirical distribution of the trend replications (Efron and Tibshirani 1993).

Assumptions about the relative reproductive success of hatchery-born spawners and the extent of supplementation can influence the synthetic population data. It was assumed that the relative reproductive success of hatchery born spawners equaled one and that the fraction of hatchery-born spawners followed the same trajectory as in the retrospective data.

Because the BRT trend estimator was not based on maximum likelihood theory, it is not guaranteed to possess optimal statistical properties (i.e. low bias and relatively high precision). This stems from the fact that the errors in the regression of log(natural spawners+1) against time are serially dependent and are not normally distributed. In some cases the bias of the estimator is quite severe, and in one case, the bootstrap confidence interval does not contain the BRT trend estimate. Therefore, it is important to use this estimate of trend in the context of other estimates, such as mean log(R/S).

Mean log(R/S)

Another useful measure of the productivity of a salmon population is the mean log(R/S) (Tables 11-13). When this estimate is greater than zero, it implies that the population is increasing. When it is below zero, it implies that the population is decreasing. The mean of the log(R/S) was calculated in the usual way,

(14) $$\text{mean}\log(R/S) = \sum_{t=1}^{n}\log(R_t / S_t)/n,$$

where n represents the total number of log(R/S) observations.

Because there is first-order serial dependence in the time series of log recruits-per-spawner, log(R/S), it is inappropriate to use the usual standard error calculation for mean log(R/S). Instead, a bootstrap technique was used to simulate the times series while respecting autocorrelation in the residuals.

Synthetic (bootstrap) data sets for constructing bootstrap confidence intervals were generated by using the model

(15) $$y_t^* = \hat{\mu} + \varepsilon_t^*$$

where y_t^* represents a synthetic observation of log(R/S), $\hat{\mu}$ represents the mean log(R/S) calculated from the data set, and ε_t^* is a residual was modeled as a serially correlated random process of order 1.

A set of 1000 bootstrap replications of mean log(R/S) were then obtained by taking the mean of each of the 1000 synthetic data sets. Standard error was estimated as the standard deviation of the 1000 replications, and 95 percent confidence limits are estimated as the 0.025 and 0.975 quantiles of the 1000 replications.

Acknowledgements

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Table 1a. Spring/summer chinook Confidence limits on extinction probabilities (Prob) (updated with "Chinook datasets 11_14_07 for dist.xls"). The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 24 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Beverton-Holt model. The column "ngood" represents the number of valid replicates of the parameter estimates. "nbadb" represents the number of replications with b less than zero, and "nbadalpha" represents the number of replicates with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent five years of spawner observations. Spawner numbers do not include jacks.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Tucannon Spring Chinook	0.00	0.00	0.13	1	2	9	33	905
Tucannon Spring Chinook	0.00	0.00	0.30	10	10	9	33	905
Tucannon Spring Chinook	0.02	0.00	0.55	30	10	9	33	905
Tucannon Spring Chinook	0.07	0.00	0.71	50	10	9	33	905
Lostine River Chinook	0.00	0.00	0.46	1	2	38	42	838
Lostine River Chinook	0.03	0.00	0.62	10	10	38	42	838
Lostine River Chinook	0.10	0.00	0.74	30	10	38	42	838
Lostine River Chinook	0.18	0.00	0.81	50	10	38	42	838
Grande Ronde Upper Mainstem Chinook	0.00	0.00	0.11	1	2	6	2	946
Grande Ronde Upper Mainstem Chinook	0.09	0.00	0.57	10	10	6	2	946
Grande Ronde Upper Mainstem Chinook	0.41	0.01	0.89	30	10	6	2	946
Grande Ronde Upper Mainstem Chinook	0.70	0.07	0.97	50	10	6	2	946
Catherine Creek Chinook	0.09	0.00	0.77	1	2	169	135	778
Catherine Creek Chinook	0.23	0.00	0.90	10	10	169	135	778
Catherine Creek Chinook	0.37	0.00	0.96	30	10	169	135	778
Catherine Creek Chinook	0.45	0.01	0.98	50	10	169	135	778
Imnaha River Chinook	0.00	0.00	0.22	1	2	0	16	971
Imnaha River Chinook	0.01	0.00	0.45	10	10	0	16	971
Imnaha River Chinook	0.04	0.00	0.66	30	10	0	16	971
Imnaha River Chinook	0.09	0.00	0.73	50	10	0	16	971
Minam River Chinook	0.00	0.00	0.31	1	2	2	53	937
Minam River Chinook	0.00	0.00	0.42	10	10	2	53	937
Minam River Chinook	0.02	0.00	0.57	30	10	2	53	937
Minam River Chinook	0.06	0.00	0.68	50	10	2	53	937
Wenaha River Chinook	0.00	0.00	0.35	1	2	10	45	970
Wenaha River Chinook	0.04	0.00	0.57	10	10	10	45	970
Wenaha River Chinook	0.15	0.00	0.74	30	10	10	45	970

Wenaha River Chinook	0.26	0.00	0.83	50	10	10	45	970
South Fork Salmon Mainstem	0.00	0.00	0.00	1	2	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.02	10	10	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.07	30	10	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.13	50	10	91	0	763
Secesh River Chinook	0.00	0.00	0.17	1	2	195	40	776
Secesh River Chinook	0.00	0.00	0.26	10	10	195	40	776
Secesh River Chinook	0.01	0.00	0.35	30	10	195	40	776
Table 1a. (Continued)								
Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Secesh River Chinook	0.02	0.00	0.42	50	10	195	40	776
South Fork Salmon East Fork (inc Johnson Cr.)	0.00	0.00	0.02	1	2	353	15	623
South Fork Salmon East Fork (inc Johnson Cr.)	0.00	0.00	0.14	10	10	353	15	623
South Fork Salmon East Fork (inc Johnson Cr.)	0.01	0.00	0.33	30	10	353	15	623
South Fork Salmon East Fork (inc Johnson Cr.)	0.04	0.00	0.48	50	10	353	15	623
Big Creek Chinook	0.00	0.00	0.60	1	2	22	36	868
Big Creek Chinook	0.04	0.00	0.80	10	10	22	36	868
Big Creek Chinook	0.20	0.00	0.89	30	10	22	36	868
Big Creek Chinook	0.37	0.00	0.93	50	10	22	36	868
Bear Valley Creek	0.00	0.00	0.40	1	2	1	53	982
Bear Valley Creek	0.00	0.00	0.53	10	10	1	53	982
Bear Valley Creek	0.03	0.00	0.63	30	10	1	53	982
Bear Valley Creek	0.09	0.00	0.71	50	10	1	53	982
Marsh Creek Chinook	0.03	0.00	0.64	1	2	92	33	814
Marsh Creek Chinook	0.21	0.00	0.82	10	10	92	33	814
Marsh Creek Chinook	0.43	0.00	0.92	30	10	92	33	814
Marsh Creek Chinook	0.56	0.00	0.95	50	10	92	33	814
Sulphur Creek*	0.00	0.00	0.65	1	2	8	43	797
Sulphur Creek*	0.06	0.00	0.79	10	10	8	43	797
Sulphur Creek*	0.33	0.00	0.88	30	10	8	43	797
Sulphur Creek*	0.55	0.00	0.92	50	10	8	43	797
Valley Creek Chinook	0.00	0.00	0.32	1	2	1	58	720
Valley Creek Chinook	0.12	0.00	0.76	10	10	1	58	720
Valley Creek Chinook	0.50	0.01	0.96	30	10	1	58	720
Valley Creek Chinook	0.75	0.07	0.99	50	10	1	58	720
Lower Mainstem Salmon River (SRLMA)	0.00	0.00	0.41	1	2	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.00	0.00	0.80	10	10	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.13	0.00	0.97	30	10	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.37	0.00	0.99	50	10	1	116	865

Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.37	1	2	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.53	10	10	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.64	30	10	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.71	50	10	20	9	871
Wenatchee River Chinook	0.00	0.00	0.42	1	2	7	191	919
Wenatchee River Chinook	0.00	0.00	0.64	10	10	7	191	919
Wenatchee River Chinook	0.01	0.00	0.78	30	10	7	191	919
Wenatchee River Chinook	0.02	0.00	0.82	50	10	7	191	919
Entiat River Chinook	0.00	0.00	0.18	1	2	11	35	942
Entiat River Chinook	0.01	0.00	0.42	10	10	11	35	942
Entiat River Chinook	0.07	0.00	0.69	30	10	11	35	942
Entiat River Chinook	0.19	0.00	0.82	50	10	11	35	942
To increase the accuracy of the Sulphur Creek extinction probability estimates, 10,000 trajectories were used instead of 4,000.								

Table 1b. Confidence limits on extinction probabilities (Prob) (updated with "Chinook datasets 11_14_07 for dist.xls"). The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 100 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Beverton-Holt model. The column "ngood" represents the number of valid replicates of the parameter estimates. "nbadb" represents the number of replicates with b less than zero, and "nbadalpha" represents the number of replicates with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent five years of spawner observations. Spawner numbers do not include jacks.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Tucannon Spring Chinook	0.00	0.00	0.76	1	2	9	33	905
Tucannon Spring Chinook	0.01	0.00	0.96	10	10	9	33	905
Tucannon Spring Chinook	0.14	0.00	0.99	30	10	9	33	905
Tucannon Spring Chinook	0.35	0.00	1.00	50	10	9	33	905
Lostine River Chinook	0.04	0.00	0.98	1	2	38	42	838
Lostine River Chinook	0.23	0.00	1.00	10	10	38	42	838
Lostine River Chinook	0.48	0.00	1.00	30	10	38	42	838
Lostine River Chinook	0.67	0.00	1.00	50	10	38	42	838
Grande Ronde Upper Mainstem Chinook	0.03	0.00	0.88	1	2	6	2	946
Grande Ronde Upper Mainstem Chinook	0.58	0.00	1.00	10	10	6	2	946
Grande Ronde Upper Mainstem Chinook	0.95	0.06	1.00	30	10	6	2	946
Grande Ronde Upper Mainstem Chinook	1.00	0.34	1.00	50	10	6	2	946
Catherine Creek Chinook	0.55	0.00	1.00	1	2	169	135	778
Catherine Creek Chinook	0.76	0.00	1.00	10	10	169	135	778

Catherine Creek Chinook	0.87	0.01	1.00	30	10	169	135	778
Catherine Creek Chinook	0.93	0.04	1.00	50	10	169	135	778
Imnaha River Chinook	0.01	0.00	0.94	1	2	0	16	971
Imnaha River Chinook	0.10	0.00	0.99	10	10	0	16	971
Imnaha River Chinook	0.29	0.00	1.00	30	10	0	16	971
Imnaha River Chinook	0.45	0.00	1.00	50	10	0	16	971
Minam River Chinook	0.00	0.00	0.74	1	2	2	53	937
Minam River Chinook	0.01	0.00	0.89	10	10	2	53	937
Minam River Chinook	0.10	0.00	0.97	30	10	2	53	937
Minam River Chinook	0.28	0.00	0.99	50	10	2	53	937
Wenaha River Chinook	0.09	0.00	0.96	1	2	10	45	970
Wenaha River Chinook	0.33	0.00	0.99	10	10	10	45	970
Wenaha River Chinook	0.63	0.00	1.00	30	10	10	45	970
Wenaha River Chinook	0.80	0.00	1.00	50	10	10	45	970
South Fork Salmon Mainstem	0.00	0.00	0.22	1	2	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.48	10	10	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.63	30	10	91	0	763
South Fork Salmon Mainstem	0.00	0.00	0.76	50	10	91	0	763
Secesh River Chinook	0.00	0.00	0.70	1	2	195	40	776
Secesh River Chinook	0.01	0.00	0.84	10	10	195	40	776
Secesh River Chinook	0.06	0.00	0.92	30	10	195	40	776
Secesh River Chinook	0.13	0.00	0.95	50	10	195	40	776
South Fork Salmon East Fork (inc Johnson Cr.)	0.01	0.00	0.63	1	2	353	15	623
South Fork Salmon East Fork (inc Johnson Cr.)	0.05	0.00	0.86	10	10	353	15	623
Table 1b. (Continued)								
Population	**Prob**	**Lower95**	**Upper95**	**QET**	**RFT**	**nbadb**	**nbadalpha**	**ngood**
South Fork Salmon East Fork (inc Johnson Cr.)	0.15	0.00	0.94	30	10	353	15	623
South Fork Salmon East Fork (inc Johnson Cr.)	0.28	0.00	0.98	50	10	353	15	623
Big Creek Chinook	0.02	0.00	0.99	1	2	22	36	868
Big Creek Chinook	0.23	0.00	1.00	10	10	22	36	868
Big Creek Chinook	0.65	0.00	1.00	30	10	22	36	868
Big Creek Chinook	0.87	0.00	1.00	50	10	22	36	868
Bear Valley Creek	0.00	0.00	0.84	1	2	1	53	982
Bear Valley Creek	0.02	0.00	0.95	10	10	1	53	982
Bear Valley Creek	0.19	0.00	0.99	30	10	1	53	982
Bear Valley Creek	0.40	0.00	1.00	50	10	1	53	982
Marsh Creek Chinook	0.37	0.00	1.00	1	2	92	33	814
Marsh Creek Chinook	0.78	0.00	1.00	10	10	92	33	814
Marsh Creek Chinook	0.95	0.00	1.00	30	10	92	33	814

Marsh Creek Chinook	0.98	0.02	1.00	50	10	92	33	814
Sulphur Creek*	0.01	0.00	0.98	1	2	8	43	797
Sulphur Creek*	0.28	0.00	1.00	10	10	8	43	797
Sulphur Creek*	0.81	0.00	1.00	30	10	8	43	797
Sulphur Creek*	0.96	0.00	1.00	50	10	8	43	797
Valley Creek Chinook	0.01	0.00	0.83	1	2	1	58	720
Valley Creek Chinook	0.46	0.00	1.00	10	10	1	58	720
Valley Creek Chinook	0.96	0.05	1.00	30	10	1	58	720
Valley Creek Chinook	1.00	0.29	1.00	50	10	1	58	720
Lower Mainstem Salmon River (SRLMA)	0.00	0.00	0.91	1	2	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.03	0.00	1.00	10	10	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.47	0.00	1.00	30	10	1	116	865
Lower Mainstem Salmon River (SRLMA)	0.85	0.00	1.00	50	10	1	116	865
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.89	1	2	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.96	10	10	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	0.99	30	10	20	9	871
Upper Mainstem Salmon River (SRUMA)	0.00	0.00	1.00	50	10	20	9	871
Wenatchee River Chinook	0.01	0.00	0.90	1	2	7	191	919
Wenatchee River Chinook	0.03	0.00	0.95	10	10	7	191	919
Wenatchee River Chinook	0.09	0.00	0.99	30	10	7	191	919
Wenatchee River Chinook	0.14	0.00	1.00	50	10	7	191	919
Entiat River Chinook	0.00	0.00	0.89	1	2	11	35	942
Entiat River Chinook	0.03	0.00	0.98	10	10	11	35	942
Entiat River Chinook	0.28	0.00	1.00	30	10	11	35	942
Entiat River Chinook	0.64	0.00	1.00	50	10	11	35	942
To increase the accuracy of the Sulphur Creek extinction probability estimates, 10,000 trajectories were used instead of 4,000.								

Table 2a. Confidence limits on extinction probabilities (Prob) for steelhead (updated with "Sthd datasets 1_22_08 for dist.xls") . The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 24 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Ricker model. The column "ngood" represents the number of valid replicates of the parameter estimates. "nbadb" represents the number of replicates with b less than zero, and "nbadalpha" represents the number of replicates with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent six spawner observations.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Average A-run steelhead population	0.05	0.00	0.28	1	2	3	315	842
Average A-run steelhead population	0.10	0.00	0.37	10	10	3	315	842

Average A-run steelhead population	0.16	0.00	0.44	30	10	3	315	842
Average A-run steelhead population	0.21	0.00	0.49	50	10	3	315	842
Average B-run steelhead population	0.00	0.00	0.18	1	2	7	173	917
Average B-run steelhead population	0.02	0.00	0.29	10	10	7	173	917
Average B-run steelhead population	0.03	0.00	0.36	30	10	7	173	917
Average B-run steelhead population	0.05	0.00	0.41	50	10	7	173	917
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.00	1	2	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.00	10	10	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.00	30	10	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.01	50	10	0	8	995
Wallowa River Steelhead	0.00	0.00	0.04	1	2	0	100	987
Wallowa River Steelhead	0.00	0.00	0.15	10	10	0	100	987
Wallowa River Steelhead	0.00	0.00	0.31	30	10	0	100	987
Wallowa River Steelhead	0.00	0.00	0.45	50	10	0	100	987
Joseph Creek Steelhead	0.00	0.00	0.03	1	2	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.10	10	10	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.15	30	10	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.19	50	10	5	12	974
Imnaha River Steelhead (Camp Creek)	0.00	0.00	0.34	1	2	0	113	992
Imnaha River Steelhead (Camp Creek)	0.00	0.00	0.53	10	10	0	113	992
Imnaha River Steelhead (Camp Creek)	0.13	0.00	0.82	30	10	0	113	992
Imnaha River Steelhead (Camp Creek)	0.53	0.03	0.96	50	10	0	113	992
John Day Lower Mainstem	0.00	0.00	0.21	1	2	0	55	994
John Day Lower Mainstem	0.00	0.00	0.29	10	10	0	55	994
John Day Lower Mainstem	0.00	0.00	0.35	30	10	0	55	994
John Day Lower Mainstem	0.00	0.00	0.38	50	10	0	55	994
John Day North Fork	0.00	0.00	0.01	1	2	0	25	997
John Day North Fork	0.00	0.00	0.02	10	10	0	25	997
John Day North Fork	0.00	0.00	0.04	30	10	0	25	997
John Day North Fork	0.00	0.00	0.07	50	10	0	25	997
John Day Upper Mainstem	0.00	0.00	0.36	1	2	0	121	965
John Day Upper Mainstem	0.00	0.00	0.43	10	10	0	121	965
John Day Upper Mainstem	0.00	0.00	0.61	30	10	0	121	965
John Day Upper Mainstem	0.00	0.00	0.67	50	10	0	121	965
John Day Middle Fork	0.00	0.00	0.16	1	2	0	128	989
John Day Middle Fork	0.00	0.00	0.28	10	10	0	128	989
John Day Middle Fork	0.00	0.00	0.38	30	10	0	128	989
Table 2a. (Continued)								
Population	**Prob**	**Lower95**	**Upper95**	**QET**	**RFT**	**nbadb**	**nbadalpha**	**ngood**

John Day Middle Fork	0.00	0.00	0.44	50	10	0	128	989
John Day South Fork	0.00	0.00	0.40	1	2	0	182	975
John Day South Fork	0.00	0.00	0.55	10	10	0	182	975
John Day South Fork	0.01	0.00	0.61	30	10	0	182	975
John Day South Fork	0.03	0.00	0.69	50	10	0	182	975
Umatilla River Steelhead	0.00	0.00	0.14	1	2	3	32	995
Umatilla River Steelhead	0.00	0.00	0.26	10	10	3	32	995
Umatilla River Steelhead	0.00	0.00	0.34	30	10	3	32	995
Umatilla River Steelhead	0.00	0.00	0.37	50	10	3	32	995
Walla Walla River Steelhead	0.00	0.00	0.11	1	2	29	97	909
Walla Walla River Steelhead	0.00	0.00	0.23	10	10	29	97	909
Walla Walla River Steelhead	0.00	0.00	0.31	30	10	29	97	909
Walla Walla River Steelhead	0.00	0.00	0.35	50	10	29	97	909
Fifteenmile Steelhead	0.00	0.00	0.22	1	2	0	130	980
Fifteenmile Steelhead	0.00	0.00	0.32	10	10	0	130	980
Fifteenmile Steelhead	0.00	0.00	0.40	30	10	0	130	980
Fifteenmile Steelhead	0.00	0.00	0.44	50	10	0	130	980
Deschutes Westside Steelhead	0.00	0.00	0.48	1	2	0	185	976
Deschutes Westside Steelhead	0.00	0.00	0.75	10	10	0	185	976
Deschutes Westside Steelhead	0.00	0.00	0.84	30	10	0	185	976
Deschutes Westside Steelhead	0.01	0.00	0.90	50	10	0	185	976
Deschutes Eastside Steelhead	0.42	0.00	1.00	1	2	4	800	762
Deschutes Eastside Steelhead	0.48	0.00	1.00	10	10	4	800	762
Deschutes Eastside Steelhead	0.51	0.00	1.00	30	10	4	800	762
Deschutes Eastside Steelhead	0.53	0.00	1.00	50	10	4	800	762
Satus Creek Steelhead	0.00	0.00	0.04	1	2	0	40	978
Satus Creek Steelhead	0.00	0.00	0.13	10	10	0	40	978
Satus Creek Steelhead	0.00	0.00	0.22	30	10	0	40	978
Satus Creek Steelhead	0.00	0.00	0.30	50	10	0	40	978
Toppenish Creek Steelhead	0.48	0.00	0.58	1	2	1	611	778
Toppenish Creek Steelhead	0.61	0.00	0.73	10	10	1	611	778
Toppenish Creek Steelhead	0.73	0.00	0.92	30	10	1	611	778
Toppenish Creek Steelhead	0.79	0.00	0.97	50	10	1	611	778
Naches River Steelhead	0.06	0.00	0.58	1	2	1	200	933
Naches River Steelhead	0.18	0.00	0.77	10	10	1	200	933
Naches River Steelhead	0.27	0.00	0.83	30	10	1	200	933
Naches River Steelhead	0.34	0.00	0.87	50	10	1	200	933
Upper Yakima River Steelhead	0.37	0.00	1.00	1	2	1	612	837
Upper Yakima River Steelhead	0.50	0.00	1.00	10	10	1	612	837

Upper Yakima River Steelhead	0.60	0.00	1.00	30	10	1	612	837
Upper Yakima River Steelhead	0.68	0.08	1.00	50	10	1	612	837
Upper Columbia Steelhead -- Wenatchee River	0.01	0.00	0.38	1	2	0	23	996
Upper Columbia Steelhead -- Wenatchee River	0.06	0.00	0.59	10	10	0	23	996
Upper Columbia Steelhead -- Wenatchee River	0.19	0.00	0.84	30	10	0	23	996
Upper Columbia Steelhead -- Wenatchee River	0.27	0.00	0.92	50	10	0	23	996
Upper Columbia Steelhead -- Methow River	0.00	0.00	0.82	1	2	0	36	996
Upper Columbia Steelhead -- Methow River	0.07	0.00	0.99	10	10	0	36	996
Upper Columbia Steelhead -- Methow River	0.28	0.00	1.00	30	10	0	36	996
Table 2a. (Continued)								
Population	**Prob**	**Lower95**	**Upper95**	**QET**	**RFT**	**nbadb**	**nbadalpha**	**ngood**
Upper Columbia Steelhead -- Methow River	0.47	0.02	1.00	50	10	0	36	996
Upper Columbia Steelhead -- Entiat River	0.53	0.00	0.67	1	2	0	263	988
Upper Columbia Steelhead -- Entiat River	0.80	0.00	0.95	10	10	0	263	988
Upper Columbia Steelhead -- Entiat River	0.95	0.01	1.00	30	10	0	263	988
Upper Columbia Steelhead -- Entiat River	0.99	0.10	1.00	50	10	0	263	988
Upper Columbia Steelhead -- Okanogan River	0.93	0.18	1.00	1	2	0	50	990
Upper Columbia Steelhead -- Okanogan River	1.00	0.56	1.00	10	10	0	50	990
Upper Columbia Steelhead -- Okanogan River	1.00	0.71	1.00	30	10	0	50	990
Upper Columbia Steelhead -- Okanogan River	1.00	0.77	1.00	50	10	0	50	990

Table 2b. Confidence limits on extinction probabilities (Prob) for steelhead updated with "Sthd datasets 1_22_08 for dist.xls". The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 100 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Ricker model. The column "ngood" represents the number of valid replications of the parameter estimates. "nbadb" represents the number of replications with b less than zero, and "nbadalpha" represents the number of replications with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent six spawner observations.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Average A-run steelhead population	0.32	0.00	0.73	1	2	3	315	842
Average A-run steelhead population	0.43	0.00	0.78	10	10	3	315	842
Average A-run steelhead population	0.53	0.00	0.81	30	10	3	315	842
Average A-run steelhead population	0.60	0.00	0.85	50	10	3	315	842
Average B-run steelhead population	0.04	0.00	0.63	1	2	7	173	917
Average B-run steelhead population	0.11	0.00	0.67	10	10	7	173	917
Average B-run steelhead population	0.18	0.00	0.74	30	10	7	173	917
Average B-run steelhead population	0.27	0.00	0.77	50	10	7	173	917

Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.00	1	2	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.02	10	10	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.04	30	10	0	8	995
Grande Ronde Upper Mainstem Steelhead	0.00	0.00	0.08	50	10	0	8	995
Wallowa River Steelhead	0.00	0.00	0.41	1	2	0	100	987
Wallowa River Steelhead	0.00	0.00	0.50	10	10	0	100	987
Wallowa River Steelhead	0.00	0.00	0.74	30	10	0	100	987
Wallowa River Steelhead	0.01	0.00	0.86	50	10	0	100	987
Joseph Creek Steelhead	0.00	0.00	0.47	1	2	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.57	10	10	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.62	30	10	5	12	974
Joseph Creek Steelhead	0.00	0.00	0.65	50	10	5	12	974
Imnaha River Steelhead (Camp Creek)	0.00	0.00	0.72	1	2	0	113	992
Imnaha River Steelhead (Camp Creek)	0.02	0.00	0.89	10	10	0	113	992
Imnaha River Steelhead (Camp Creek)	0.50	0.00	0.99	30	10	0	113	992
Imnaha River Steelhead (Camp Creek)	0.96	0.15	1.00	50	10	0	113	992
John Day Lower Mainstem	0.00	0.00	0.76	1	2	0	55	994
John Day Lower Mainstem	0.00	0.00	0.83	10	10	0	55	994
John Day Lower Mainstem	0.00	0.00	0.85	30	10	0	55	994
John Day Lower Mainstem	0.00	0.00	0.87	50	10	0	55	994
John Day North Fork	0.00	0.00	0.29	1	2	0	25	997
John Day North Fork	0.00	0.00	0.35	10	10	0	25	997
John Day North Fork	0.00	0.00	0.43	30	10	0	25	997
John Day North Fork	0.00	0.00	0.46	50	10	0	25	997
John Day Upper Mainstem	0.00	0.00	0.83	1	2	0	121	965
John Day Upper Mainstem	0.00	0.00	0.91	10	10	0	121	965
John Day Upper Mainstem	0.00	0.00	0.95	30	10	0	121	965
John Day Upper Mainstem	0.01	0.00	0.97	50	10	0	121	965
Table 2b. (Continued)								
Population	**Prob**	**Lower95**	**Upper95**	**QET**	**RFT**	**nbadb**	**nbadalpha**	**ngood**
John Day Middle Fork	0.00	0.00	0.65	1	2	0	128	989
John Day Middle Fork	0.00	0.00	0.71	10	10	0	128	989
John Day Middle Fork	0.00	0.00	0.76	30	10	0	128	989
John Day Middle Fork	0.00	0.00	0.78	50	10	0	128	989
John Day South Fork	0.00	0.00	0.84	1	2	0	182	975
John Day South Fork	0.02	0.00	0.88	10	10	0	182	975
John Day South Fork	0.09	0.00	0.92	30	10	0	182	975
John Day South Fork	0.14	0.00	0.93	50	10	0	182	975
Umatilla River Steelhead	0.00	0.00	0.63	1	2	3	32	995

Umatilla River Steelhead	0.00	0.00	0.69	10	10	3	32	995
Umatilla River Steelhead	0.00	0.00	0.74	30	10	3	32	995
Umatilla River Steelhead	0.00	0.00	0.76	50	10	3	32	995
Walla Walla River Steelhead	0.00	0.00	0.53	1	2	28	108	907
Walla Walla River Steelhead	0.00	0.00	0.59	10	10	28	108	907
Walla Walla River Steelhead	0.00	0.00	0.63	30	10	28	108	907
Walla Walla River Steelhead	0.00	0.00	0.66	50	10	28	108	907
Fifteenmile Steelhead	0.00	0.00	0.62	1	2	0	143	977
Fifteenmile Steelhead	0.00	0.00	0.7	10	10	0	143	977
Fifteenmile Steelhead	0.00	0.00	0.75	30	10	0	143	977
Fifteenmile Steelhead	0.01	0.00	0.79	50	10	0	143	977
Deschutes Westside Steelhead	0.00	0.00	0.82	1	2	0	174	982
Deschutes Westside Steelhead	0.00	0.00	0.92	10	10	0	174	982
Deschutes Westside Steelhead	0.02	0.00	0.97	30	10	0	174	982
Deschutes Westside Steelhead	0.04	0.00	0.98	50	10	0	174	982
Deschutes Eastside Steelhead	1.00	0.00	1.00	1	2	3	777	723
Deschutes Eastside Steelhead	1.00	0.00	1.00	10	10	3	777	723
Deschutes Eastside Steelhead	1.00	0.00	1.00	30	10	3	777	723
Deschutes Eastside Steelhead	1.00	0.00	1.00	50	10	3	777	723
Satus Creek Steelhead	0.00	0.00	0.58	1	2	1	49	988
Satus Creek Steelhead	0.00	0.00	0.68	10	10	1	49	988
Satus Creek Steelhead	0.00	0.00	0.79	30	10	1	49	988
Satus Creek Steelhead	0.00	0.00	0.87	50	10	1	49	988
Toppenish Creek Steelhead	0.94	0.00	0.98	1	2	5	583	777
Toppenish Creek Steelhead	0.98	0.00	1.00	10	10	5	583	777
Toppenish Creek Steelhead	0.99	0.00	1.00	30	10	5	583	777
Toppenish Creek Steelhead	1.00	0.00	1.00	50	10	5	583	777
Naches River Steelhead	0.50	0.00	0.92	1	2	2	228	949
Naches River Steelhead	0.64	0.00	0.99	10	10	2	228	949
Naches River Steelhead	0.74	0.00	1.00	30	10	2	228	949
Naches River Steelhead	0.78	0.00	1.00	50	10	2	228	949
Upper Yakima River Steelhead	0.99	0.00	1.00	1	2	0	619	849
Upper Yakima River Steelhead	0.99	0.00	1.00	10	10	0	619	849
Upper Yakima River Steelhead	1.00	0.00	1.00	30	10	0	619	849
Upper Yakima River Steelhead	1.00	0.07	1.00	50	10	0	619	849
Upper Columbia Steelhead -- Wenatchee River	0.62	0.00	1.00	1	2	0	7	989
Upper Columbia Steelhead -- Wenatchee River	0.83	0.00	1.00	10	10	0	7	989
Upper Columbia Steelhead -- Wenatchee River	0.91	0.00	1.00	30	10	0	7	989
Upper Columbia Steelhead -- Wenatchee River	0.95	0.00	1.00	50	10	0	7	989

Table 2b. (Continued)								
Population	**Prob**	**Lower95**	**Upper95**	**QET**	**RFT**	**nbadb**	**nbadalpha**	**ngood**
Upper Columbia Steelhead -- Methow River	0.66	0.00	1.00	1	2	0	41	994
Upper Columbia Steelhead -- Methow River	0.92	0.00	1.00	10	10	0	41	994
Upper Columbia Steelhead -- Methow River	0.98	0.02	1.00	30	10	0	41	994
Upper Columbia Steelhead -- Methow River	0.99	0.10	1.00	50	10	0	41	994
Upper Columbia Steelhead -- Entiat River	0.88	0.00	1.00	1	2	0	241	991
Upper Columbia Steelhead -- Entiat River	0.95	0.00	1.00	10	10	0	241	991
Upper Columbia Steelhead -- Entiat River	0.99	0.04	1.00	30	10	0	241	991
Upper Columbia Steelhead -- Entiat River	1.00	0.29	1.00	50	10	0	241	991
Upper Columbia Steelhead -- Okanogan River	1.00	0.89	1.00	1	2	0	51	994
Upper Columbia Steelhead -- Okanogan River	1.00	0.94	1.00	10	10	0	51	994
Upper Columbia Steelhead -- Okanogan River	1.00	0.96	1.00	30	10	0	51	994
Upper Columbia Steelhead -- Okanogan River	1.00	0.97	1.00	50	10	0	51	994

Table 3a. Snake River Fall chinook confidence limits on extinction probabilities (Prob) (updated with "Chinook datasets 11_14_07 for dist.xls"). The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 24 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Ricker model. The column "ngood" represents the number of valid replicates of the parameter estimates. "nbadb" represents the number of replications with b less than zero, and "nbadalpha" represents the number of replications with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent five years of spawner observations. Spawner numbers do not include jacks.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Snake River Fall Chinook	0.00	0.00	1.00	1	2	0	30	987
Snake River Fall Chinook	0.00	0.00	1.00	10	10	0	30	987
Snake River Fall Chinook	0.00	0.00	1.00	30	10	0	30	987
Snake River Fall Chinook	0.01	0.00	1.00	50	10	0	30	987

Table 3b. Snake River Fall chinook confidence limits on extinction probabilities ("Prob") (updated with "Chinook datasets 11_14_07 for dist.xls"). These are based on 1000 replicates of the estimation process. The lower confidence bound represents the 0.025 quantile of the 1000 extinction probability replications, while the upper limit represents the 0.975 quantile of the the 1000 extinction probability replications. Extinction probabilities were calculated over a time window of 100 years with various levels of quasi-extinction threshold (QET) and reproductive failure threshold (RFT). Note that less that 1000 replications were actually generated for each of the populations because some bootstrap samples resulted in invalid maximum likelihood estimates of the Ricker model. The column "ngood" represents the number of valid replicates of the parameter estimates." nbadb" represents the number of replicates with b less than zero, and nbadalpha represents the number of replicates with alpha greater than 1.0. Whenever a replication of alpha was greater than one, it was set equal to one. Extinction probabilities were based on 4000 population trajectories. The time period used was 1978-present. The population projections were initialized with the most recent five years of spawner observations. Spawner numbers do not include jacks.

Population	Prob	Lower95	Upper95	QET	RFT	nbadb	nbadalpha	ngood
Snake River Fall Chinook	0.04	0.00	1.00	1	2	0	30	987
Snake River Fall Chinook	0.15	0.00	1.00	10	10	0	30	987
Snake River Fall Chinook	0.24	0.00	1.00	30	10	0	30	987
Snake River Fall Chinook	0.33	0.00	1.00	50	10	0	30	987

Table 4. Spring/summer chinook extinction probabilities with supplementation in the future (updated with "Chinook datasets 11_14_07 for dist.xls"). Relative reproductive effectiveness of hatchery-born spawners was assumed to be 0.2 retrospectively and 0.45 in the future. Future fractions of wild-spawners were equal to the average from years 1996-present. Extinction probability results using Beverton-Holt production function and autoregressive process of order 1 for the errors. The autoregressive parameter was estimated using maximum likelihood. Populations analyzed were the Grande Ronde/ Imnaha populations from the Snake River Spring/Summer Chinook ESU and Upper Columbia Spring Chinook ESU. Extinction occurred when spawners fell below QET four years running. Reproductive failure occurred (zero recruits) whenever spawner abundance fell below 10. When QET was 1, the reproductive failure threshold was 2. Extinction probability estimates were based on 4000 population simulations.

	Time horizon = 24 years					Time horizon = 100 years			
Population	**QET = 1**	**QET = 10**	**QET = 30**	**QET = 50**		**QET = 1**	**QET = 10**	**QET = 30**	**QET = 50**
Lostine River Chinook	0.00	0.00	0.00	0.02		0.00	0.00	0.04	0.12
Grande Ronde Upper Mainstem Chinook	0.00	0.01	0.11	0.30		0.00	0.05	0.40	0.77
Catherine Creek Chinook	0.01	0.05	0.12	0.23		0.07	0.28	0.51	0.68
Imnaha River Chinook	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.01

Table 5. Extinction probabilities for Upper Columbia Steelhead with supplementation in the future (data updated with "Sthd datasets 1_22_08 for dist.xls"). Extinction probability results were obtained using the Ricker model with an autocorrelation in the residual errors. The reproductive failure threshold (RFT) was set at 10 except when QET=1, in which case RFT was set to 2. Extinction was calculated at four levels of quasi-extinction threshold (QET; 1,10,30,and 50), and three different time horizons (24 and 100 years). Relative reproductive success of hatchery-born spawners was 0.20 (historical) and 0.45 (future), and the future fraction of wild-born spawners was set to the recent 10-year average.

	24 year					100 year			
Population	**QET=1**	**QET=10**	**QET=30**	**QET=50**		**QET=1**	**QET=10**	**QET=30**	**QET=50**
Upper Columbia Steelhead -- Wenatchee	0.00	0.00	0.00	0.00		0.00	0.00	0.01	0.02

River									
Upper Columbia Steelhead -- Methow River	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.01
Upper Columbia Steelhead -- Entiat River*	0.01	0.06	0.17	0.30		0.10	0.29	0.54	0.72
Upper Columbia Steelhead -- Okanogan River	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00

* For the Entiat River, the future hatchery effectiveness was set to 0.20 instead of 0.45

Table 6. Extinction probabilities for Snake River Fall Chinook with supplementation in the future (updated with "Chinook datasets 11_14_07 for dist.xls"). The extinction probability results were obtained using the Ricker Model with autocorrelation in the residual errors. Reproductive failure threshold (RFT) was set at 10 except when QET=1, in which case RFT was set to 2. Extinction was calculated at four levels of quasi-extinction threshold (QET; 1,10,30,and 50), and three different time horizons (24, and 100 years). Relative reproductive success of hatchery-born spawners was assumed be 1. The most recent 10-year average fraction of wild spawners was used to project future supplementation.

	24 year					100 year			
Population	**QET=1**	**QET=10**	**QET=30**	**QET=50**		**QET=1**	**QET=10**	**QET=30**	**QET=50**
Snake River Fall Chinook	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00

Table 7a. Survival Gaps analysis for spring/summer chinook. The gaps or "needed survival increases" are presented as multipliers on current survival necessary to achieve 5% extinction risk over 24 years. When a quasi-extinction threshold of 1 was used, the reproductive failure threshold was 2, and when a quasi-extinction threshold of 10 or higher was used, the reproductive failure threshold was 10. Survival gaps were calculated from probabilities based on 10,000 population projections. An accuracy of 0.0001 was used in the bisection method to locate the Beverton-Holt a parameter resulting in 5% extinction probability. Data from "Chinook datasets 11_14_07 for dist.xls". The population projections were initialized with spawner observations from 2002-2006 for Tucannon and 2001-2005 for the remaining populations. Spawner and recruitment numbers do not include jacks.

	Needed survival increase			
Population	**QET=1**	**QET=10**	**QET=30**	**QET=50**
Tucannon Spring Chinook	0.33	0.57	0.86	1.13
Lostine River Chinook	0.49	0.87	1.27	1.60
Grande Ronde Upper Mainstem Chinook	0.55	1.11	1.87	2.65
Catherine Creek Chinook	1.28	2.18	3.07	3.88
Imnaha River Chinook	0.41	0.69	0.97	1.18
Minam River Chinook	0.27	0.50	0.79	1.06
Wenaha River Chinook	0.55	0.95	1.38	1.71
South Fork Salmon Mainstem	0.16	0.27	0.37	0.45
Secesh River Chinook	0.32	0.52	0.69	0.84
South Fork Salmon East Fork (inc Johnson Cr.)	0.39	0.63	0.81	0.94
Big Creek Chinook	0.42	0.96	1.84	2.70
Bear Valley Creek	0.27	0.53	0.90	1.26
Marsh Creek Chinook	0.89	1.82	3.11	4.28
Sulphur Creek	0.29	1.06	2.66	4.25
Valley Creek Chinook	0.32	1.28	3.28	5.37
Lower Mainstem Salmon River (SRLMA)	0.19	0.57	1.37	2.18
Upper Mainstem Salmon River (SRUMA)	0.07	0.21	0.47	0.74
Wenatchee River Chinook	0.13	0.29	0.49	0.65
Entiat River Chinook	0.32	0.63	1.04	1.47

Table 7b. Survival Gaps analysis for spring/summer chinook. The gaps or "needed survival increases" are presented as multipliers on current survival necessary to achieve 5% extinction risk over 100 years. When a quasi-extinction threshold of 1 was used, the reproductive failure threshold was 2, and when a quasi-extinction threshold of 10 or higher was used, the reproductive failure threshold was 10. Survival gaps were calculated from probabilities based on 10,000 projections. An accuracy of 0.0001 was used in the bisection method to locate the Beverton-Holt a parameter resulting in 5% extinction probability. Data from "Chinook datasets 11_14_07 for dist.xls". The population projections were initialized with spawner observations from 2002-2006 for Tucannon and 2001-2005 for the remaining populations. Spawner and recruitment numbers do not include jacks.

	Needed survival increase			
Population	**QET=1**	**QET=10**	**QET=30**	**QET=50**
Tucannon Spring Chinook	0.58	0.86	1.23	1.59
Lostine River Chinook	0.99	1.47	2.08	2.64
Grande Ronde Upper Mainstem Chinook	0.91	1.64	2.60	3.68
Catherine Creek Chinook	2.65	3.94	5.57	6.97
Imnaha River Chinook	0.85	1.15	1.50	1.81
Minam River Chinook	0.50	0.76	1.14	1.51
Wenaha River Chinook	1.09	1.53	2.12	2.62
South Fork Salmon Mainstem	0.33	0.42	0.50	0.59
Secesh River Chinook	0.65	0.83	1.01	1.17
South Fork Salmon East Fork (inc Johnson Cr.)	0.84	1.00	1.14	1.26
Big Creek Chinook	0.81	1.65	3.18	4.68
Bear Valley Creek	0.51	0.86	1.41	1.99
Marsh Creek Chinook	1.86	3.32	5.55	7.64
Sulphur Creek	0.52	1.84	4.68	7.63
Valley Creek Chinook	0.57	2.18	5.50	9.09
Lower Mainstem Salmon River (SRLMA)	0.32	0.89	2.16	3.43
Upper Mainstem Salmon River (SRUMA)	0.11	0.30	0.68	1.08
Wenatchee River Chinook	0.46	0.83	1.38	1.86
Entiat River Chinook	0.56	0.92	1.53	2.13

Table 8. Estimates of the log BRT trend for various spring/summer chinook populations (updated with "Chinook datasets 11_14_07.xls"). Estimates of standard error (SE) were obtained using bootstrapping. Synthetic data sets were generated using run reconstruction information, age structure, and lag-1 autocorrelation in the log(R/S) observations. The log(BRT trend estimate) was generated by regressing log(natural spawners+1) against time and using the slope of the ordinary least squares regression line. "Nobs" represents the number of spawner observations used in the least squares estimation. The SEs were based on 1000 replications. The confidence intervals were constructed for the log(BRT trend estimate) using bootstrapping.

Population	1980-present						1990-present				
	Estimate	SE	Lower95	Upper95	Nobs		Estimate	SE	Lower95	Upper95	Nobs
Tucannon Spring Chinook	-0.08	0.13	-0.09	0.43	27		0.01	0.23	-0.24	0.66	17
Lostine River Chinook	0.01	0.16	-0.19	0.43	26		0.15	0.24	-0.29	0.64	16
Grande Ronde Upper Mainstem Chinook	-0.07	0.11	-0.10	0.35	26		-0.01	0.15	-0.11	0.46	16
Catherine Creek Chinook	-0.07	0.17	-0.25	0.38	26		0.20	0.20	-0.23	0.59	16
Imnaha River Chinook	-0.03	0.12	-0.14	0.35	26		0.09	0.18	-0.16	0.55	16
Minam River Chinook	0.02	0.16	-0.20	0.41	26		0.12	0.26	-0.37	0.63	16
Wenaha River Chinook	0.04	0.13	-0.16	0.36	26		0.18	0.23	-0.28	0.58	16
South Fork Salmon Mainstem	0.05	0.09	-0.08	0.30	24		0.08	0.16	-0.27	0.34	14
Secesh River Chinook	0.04	0.10	-0.11	0.29	26		0.11	0.16	-0.16	0.46	16
South Fork Salmon East Fork (inc Johnson Cr.)	0.02	0.08	-0.09	0.21	24		0.04	0.16	-0.30	0.31	14
Big Creek Chinook	0.02	0.21	-0.25	0.51	25		0.13	0.28	-0.37	0.71	15
Bear Valley Creek	0.05	0.13	-0.16	0.37	24		0.15	0.27	-0.41	0.61	14
Camas Creek Chinook	-0.01	0.18	-0.16	0.56	25		0.18	0.32	-0.27	0.97	15
Loon Creek Chinook	0.06	0.13	-0.09	0.41	25		0.29	0.37	-0.48	0.92	15
Marsh Creek Chinook	0.00	0.17	-0.24	0.39	24		0.11	0.28	-0.47	0.54	14
Sulphur Creek	-0.01	0.16	-0.17	0.47	23		0.00	0.23	-0.41	0.47	14
Chamberlain Creek Chinook	0.03	0.33	-0.47	0.78	16		0.10	0.12	-0.14	0.33	12
Pahsimeroi Chinook	0.32	0.29	-0.22	0.87	20		0.29	0.27	-0.08	0.94	16
Lemhi River Chinook	-0.02	0.14	-0.17	0.36	24		0.12	0.20	-0.16	0.60	14
Valley Creek Chinook	0.02	0.13	-0.12	0.40	24		0.18	0.23	-0.30	0.61	14
Yankee Fork Salmon River	0.03	0.18	-0.19	0.50	23		0.12	0.35	-0.42	0.85	14

Lower Mainstem Salmon River (SRLMA)	0.00	0.15	-0.16	0.40	26		0.10	0.20	-0.19	0.58	16
Upper Salmon East Fork Chinook	0.01	0.23	-0.23	0.62	26		0.16	0.34	-0.38	0.95	16
Upper Mainstem Salmon River (SRUMA)	0.01	0.16	-0.08	0.54	26		0.11	0.24	-0.21	0.71	16
Wenatchee River Chinook	-0.11	0.17	-0.27	0.38	24		-0.02	0.28	-0.45	0.64	14
Methow River Chinook	-0.05	0.26	-0.06	0.97	22		-0.09	0.57	-0.37	1.82	12
Entiat River Chinook	-0.07	0.11	-0.20	0.24	24		0.01	0.23	-0.37	0.51	14

Table 9. Estimates of the log BRT trend for steelhead populations (updated with "Sthd datasets 1_22_08 for dist.xls"). Estimates of standard error (SE) were obtained using bootstrapping. Synthetic data sets were generated using run reconstruction information, age structure, and lag-1 autocorrelation in the log(R/S) observations. The log(BRT trend estimate) was generated by regressing log(natural spawners+1) against time and using the slope of the ordinary least squares regression line. "Nobs" represents the number of spawner observations used in the least squares estimation. The SEs were based on 1000 bootstrap replications. The confidence intervals were constructed for the log(BRT trend estimate) using bootstrapping.

Population	**1980-present**							**1990-present**			
	Estimate	**SE**	**Lower95**	**Upper95**	**Nobs**		**Estimate**	**SE**	**Lower95**	**Upper95**	**Nobs**
Average "A" run steelhead population	0.01	0.21	-0.34	0.48	19		0.08	0.28	-0.43	0.60	15
Average "B" run steelhead population	-0.04	0.09	-0.18	0.15	19		-0.01	0.13	-0.28	0.25	15
Grande Ronde Upper Mainstem Steelhead	-0.01	0.06	-0.07	0.18	27		0.01	0.03	-0.03	0.08	17
Wallowa River Steelhead	0.02	0.09	-0.21	0.14	26		0.08	0.06	-0.13	0.10	16
Joseph Creek Steelhead	0.01	0.13	-0.17	0.35	26		0.04	0.06	-0.04	0.18	16
Imnaha River Steelhead (Camp Creek)	0.03	0.12	-0.12	0.35	26		0.05	0.10	-0.09	0.30	16
John Day Lower Mainstem	-0.02	0.18	-0.27	0.44	26		0.04	0.19	-0.23	0.50	16
John Day North Fork	-0.01	0.09	-0.10	0.27	26		0.09	0.04	0.10	0.24	16
John Day Upper Mainstem	-0.05	0.10	-0.17	0.24	26		-0.04	0.10	-0.19	0.20	16
John Day Middle Fork	-0.03	0.10	-0.12	0.26	26		-0.02	0.13	-0.20	0.32	16
John Day South Fork	-0.05	0.11	-0.18	0.25	26		0.01	0.17	-0.29	0.38	16
Umatilla River Steelhead	0.01	0.06	-0.08	0.18	25		0.07	0.04	0.00	0.14	15
Walla Walla River Steelhead	-0.02	0.11	-0.15	0.29	12		-0.02	0.11	-0.17	0.26	12

Fifteenmile Steelhead	0.03	0.07	-0.07	0.19	21		0.08	0.06	0.01	0.25	16
Deschutes Westside Steelhead	-0.01	0.09	-0.12	0.23	26		0.09	0.09	-0.04	0.30	16
Deschutes Eastside Steelhead	0.10	0.18	-0.22	0.51	16		0.10	0.18	-0.19	0.52	16
Satus Creek Steelhead	-0.02	0.08	-0.14	0.15	20		0.05	0.08	-0.07	0.22	15
Toppenish Creek Steelhead	0.08	0.13	-0.14	0.38	20		0.19	0.11	0.02	0.46	15
Naches River Steelhead	0.02	0.13	-0.22	0.29	20		0.10	0.11	-0.10	0.34	15
Upper Yakima River Steelhead	0.00	0.12	-0.22	0.27	20		0.09	0.11	-0.08	0.32	15
Upper Columbia Steelhead -- Wenatchee River	0.04	0.14	-0.18	0.34	27		0.04	0.18	-0.26	0.41	17
Upper Columbia Steelhead -- Methow River	0.06	0.07	0.02	0.28	27		0.05	0.11	-0.13	0.30	17
Upper Columbia Steelhead -- Entiat River	0.04	0.07	0.01	0.27	27		0.05	0.07	-0.02	0.23	17
Upper Columbia Steelhead -- Okanogan River	0.03	0.09	-0.09	0.26	27		0.05	0.12	-0.18	0.31	17

Table 10. Estimates of the log BRT trend for Snake River fall chinook (updated with "Chinook datasets 11_14_07.xls") Estimates of standard error (SE) were obtained using bootstrapping. Synthetic data sets were generated using run reconstruction information, age structure, and lag-1 autocorrelation in the log(R/S) observations. The log(BRT trend estimate) was generated by regressing log(natural spawners+1) against time and using the slope of the ordinary least squares regression line. "Nobs" represents the number of spawner observations used in the least squares estimation. The SEs were based on 1000 replications. The confidence intervals were constructed for the log(BRT trend estimate) using bootstrapping.

	1980-present						1990-present				
Population	**Estimate**	**SE**	**Lower95**	**Upper95**	**Nobs**		**Estimate**	**SE**	**Lower95**	**Upper95**	**Nobs**
Snake River Fall Chinook	0.09	0.08	0.01	0.31	26		0.21	0.10	0.08	0.47	16

Table 11. Spring/summer chinook estimates of mean log(R/S) using spawner-recruit (updated with "Chinook datasets 11_14_07 for dist.xls"). Most recently available 20 years of data were used. Observations with fewer than 6 spawners were omitted. "Estimate" represents the mean log(R/S). "Boot SE" represents the bootstrap standard error, which takes serial dependence into account. The lower and upper limits of the bootstrap confidence interval are given by "Lower95" and "Upper95", respectively (1000 bootstrap replications used). Bootstrapping was accomplished using a parametric bootstrap procedure where residuals followed an AR(1) process. "Beta2" represents the variance of the error term in the AR(1) model, while "auto" represents the autoregressive parameter. "n" represents the number of observations used in the estimation. Spawner and recruitment estimates exclude jacks.

Population	Estimate	Boot SE	Lower95	Upper95	Beta2	auto	n
Tucannon Spring Chinook	-0.33	0.45	-1.18	0.61	0.72	0.59	20
Lostine River Chinook	-0.33	0.64	-1.57	0.87	1.22	0.63	20
Grande Ronde Upper Mainstem Chinook	-1.13	0.39	-1.91	-0.36	1.80	0.20	18
Catherine Creek Chinook	-0.83	0.88	-2.71	0.88	1.31	0.73	20
Imnaha River Chinook	-0.53	0.46	-1.44	0.33	0.54	0.66	20
Minam River Chinook	-0.22	0.58	-1.40	0.91	1.11	0.63	20
Wenaha River Chinook	-0.41	0.55	-1.52	0.63	0.93	0.62	20
South Fork Salmon Mainstem	-0.15	0.33	-0.77	0.51	0.79	0.44	20
Secesh River Chinook	0.18	0.39	-0.60	0.91	0.65	0.57	20
South Fork Salmon East Fork (inc Johnson Cr.)	-0.03	0.29	-0.59	0.55	0.78	0.35	20
Big Creek Chinook	0.19	0.91	-1.57	2.05	0.78	0.80	19
Bear Valley Creek	0.30	0.52	-0.71	1.35	1.06	0.57	20
Camas Creek Chinook	-0.10	0.60	-1.28	1.05	2.36	0.43	18
Loon Creek Chinook	0.11	0.54	-0.96	1.17	2.47	0.29	16
Marsh Creek Chinook	-0.05	0.69	-1.39	1.25	1.42	0.61	19
Sulphur Creek	-0.03	0.68	-1.30	1.28	2.50	0.47	17
Chamberlain Creek Chinook	0.28	1.59	-2.93	3.45	0.99	0.86	9
Pahsimeroi Chinook	-0.68	1.13	-2.96	1.46	1.28	0.78	15
Lemhi River Chinook	0.07	0.56	-0.97	1.22	1.23	0.58	20
Valley Creek Chinook	0.20	0.56	-0.87	1.27	1.47	0.52	19
Yankee Fork Salmon River	-0.50	0.96	-2.21	1.43	1.16	0.74	14

Lower Mainstem Salmon River (SRLMA)	0.19	0.63	-1.03	1.43	0.63	0.74	20
Upper Salmon East Fork Chinook	0.06	0.99	-1.91	1.98	1.09	0.79	20
Upper Mainstem Salmon River (SRUMA)	0.41	0.69	-0.88	1.80	1.31	0.64	20
Wenatchee River Chinook	-0.29	0.69	-1.60	1.10	0.60	0.78	20
Methow River Chinook	-0.39	0.56	-1.44	0.73	1.20	0.57	19
Entiat River Chinook	-0.33	0.44	-1.13	0.60	0.56	0.64	20

Table 12. Steelhead estimates of mean log(R/S) using spawner-recruit (updated with "Sthd datasets 1_22_08 for dist.xls"). Most recently available 20 years of data were used. "Estimate" represents the mean log(R/S) "Boot SE" represents the bootstrap standard error, which takes serial dependence into account. The lower and upper limits of the bootstrap confidence interval are given by "Lower95" and "Upper95", respectively. 1000 bootstrap replications were used for the confidence intervals and probability estimation. Bootstrapping was accomplished using a parametric bootstrap procedure where residuals followed an AR(1) process. "Beta2" represents the variance of the error term in the AR(1) model, while "auto" represents the autoregressive parameter. "n" represents the number of observations used in the estimation.

Population	Estimate	Boot SE	Lower95	Upper95	Beta2	auto	n
Average "A" run steelhead population	0.08	0.97	-1.75	2.00	0.58	0.82	13
Average "B" run steelhead population	-0.22	0.39	-1.00	0.55	0.49	0.54	13
Grande Ronde Upper Mainstem Steelhead	-0.08	0.31	-0.68	0.53	0.69	0.42	20
Wallowa River Steelhead	0.15	0.32	-0.47	0.77	0.38	0.60	20
Joseph Creek Steelhead	0.23	0.54	-0.87	1.24	0.48	0.74	20
Imnaha River Steelhead (Camp Creek)	0.37	0.51	-0.62	1.34	0.64	0.67	20
John Day Lower Mainstem	0.35	0.74	-1.08	1.80	0.73	0.76	20
John Day North Fork	0.16	0.42	-0.74	0.92	0.71	0.55	20
John Day Upper Mainstem	0.06	0.48	-0.90	0.95	0.54	0.69	20
John Day Middle Fork	0.16	0.45	-0.68	1.01	0.43	0.70	20
John Day South Fork	-0.01	0.53	-1.05	1.06	0.68	0.68	20
Umatilla River Steelhead	-0.06	0.28	-0.60	0.48	0.27	0.60	20
Walla Walla River Steelhead	0.16	0.44	-0.69	1.01	0.29	0.62	8

Fifteenmile Steelhead	0.16	0.29	-0.37	0.72	0.40	0.44	15
Deschutes Westside Steelhead	-0.09	0.37	-0.76	0.66	0.34	0.67	20
Deschutes Eastside Steelhead	0.19	0.78	-1.34	1.79	0.22	0.87	10
Satus Creek Steelhead	-0.15	0.32	-0.80	0.48	0.34	0.57	15
Toppenish Creek Steelhead	0.38	0.62	-0.86	1.66	0.51	0.73	15
Naches River Steelhead	0.02	0.58	-1.09	1.14	0.19	0.85	15
Upper Yakima River Steelhead	0.02	0.59	-1.13	1.15	0.19	0.85	15
Upper Columbia Steelhead -- Wenatchee River	-1.05	0.68	-2.38	0.28	0.43	0.81	20
Upper Columbia Steelhead -- Methow River	-1.54	0.35	-2.21	-0.85	0.52	0.58	20
Upper Columbia Steelhead -- Entiat River	-0.66	0.31	-1.24	-0.04	0.57	0.47	20
Upper Columbia Steelhead -- Okanogan River	-2.54	0.45	-3.37	-1.70	0.46	0.67	20

Table 13. Fall chinook estimates of mean log(R/S) using spawner-recruit (updated with "Chinook datasets 11_14_07 for dist.xls") . Most recently available 20 years of data were used. "Estimate" represents the mean log(R/S). "Boot SE" represents the bootstrap standard error, which takes serial dependence into account. The lower and upper limits of the bootstrap confidence interval are given by "Lower95" and "Upper95", respectively. 1000 bootstrap replications were used for the confidence intervals and probability estimation. Bootstrapping was accomplished using a parametric bootstrap procedure where residuals followed an AR(1) process. "Beta2" represents the variance of the error term in the AR(1) model, while "auto" represents the autoregressive parameter. "n" represents the number of observations used in the estimation.

Population	Estimate	Boot SE	Lower95	Upper95	Beta2	auto	n
Snake River Fall Chinook	-0.23	0.30	-0.80	0.38	0.55	0.46	20

Artificial Propagation for Pacific Salmon Appendix:

Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs Consistent with Conservation and Sustainable Fisheries Mandates

May 5, 2008

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Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks, & Recommendations for Operating Hatchery Programs Consistent with Conservation & Sustainable Fisheries Mandates

May 2008

NOAA's National Marine Fisheries Service
Hatcheries & Inland Fisheries
Salmon Recovery Division

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Executive Summary

There has been a growing reliance on hatcheries to sustain tribal, public and commercial fishing opportunity, and more recently, to help conserve Pacific salmon as the capacity of natural habitat to produce fish has been eroded. In the course of providing these benefits, there also is the potential for hatchery programs to increase the extinction risk and threaten the long-term viability of natural populations. In this paper we review key factors for assessing the benefits and risks of hatchery programs relative to the conservation of Pacific salmon and to Indian Treaty and sustainable fishery mandates. These key factors include: (1) population viability status and recovery goals, (2) the conservation of genetic resources, (3) hatchery effects on population viability, (4) research monitoring and evaluation, (5) hatchery effects on density-dependent processes, (6) hatchery weirs, and (7) compensation for impacts to Indian treaty, public, commercial and international fisheries. Impacts to habitat and corresponding reductions in production capacity and fish survival can prevent salmon and steelhead from achieving viability and from supporting sustainable fishery mandates. Hatchery programs will have a prominent role to play until degraded and blocked habitats are rehabilitated and restored. We recommend a strategy and supportive hatchery practices to serve harvest goals and a strategy and practices to serve salmon and steelhead conservation objectives. We conclude that hatchery programs can provide benefits for both sustainable fisheries and conservation purposes, with acceptable collateral risks, when the program is designed and operated based on a clear and feasible objective. The National Marine Fisheries Service (NMFS) will use this paper to help guide Endangered Species Act (ESA) and National Environmental Policy Act (NEPA) determinations, ESA recovery planning, and funding allocation decisions as they relate to the artificial propagation of Pacific salmon.

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1. Definitions

Abundance: An indicator or measure of how Pacific salmon are sustaining themselves without human intervention (i.e., separate from and not including any hatchery propagation subsidy). Abundance is natural-origin fish from either naturally spawning natural-origin fish or from naturally spawning hatchery-origin fish included in a salmon Evolutionarily Significant Unit (ESU) or steelhead DPS.

Allee Effects: Is the difficulty finding mates at low population or spawning aggregate abundance.

Captive Broodstock Hatchery Program: A supplementation program that first retains fish for their entire life-cycle before out-planting progeny (juveniles or adults) for reintroduction or supplementation purposes.

Compensation Hatchery Program: Hatchery programs designed to make up for or compensate for reductions in adult returns due to reduced habitat productivity (i.e., for degraded habitats and for habitat taken out of production and no longer accessible to Pacific salmon). They do not operate to conserve or improve Pacific salmon viability with two exceptions. First, Compensation Programs that use fish included in an ESU for broodstock, and that produce fish that mimic life history characteristics of the local natural population, can serve as a gene reserve in the event that fish are needed for conservation purposes. Second, either naturally spawning fish or carcasses from compensation hatchery programs can add important nutrients to streams and, thus, contribute to productivity.

Conservation: The act of preserving, increasing or restoring Pacific salmon viability. Under the Federal Endangered Species Act, "conservation" is defined as "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, *propagation*, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking" (ESA Sec. 3(3)) (emphasis added).

Conservation Hatchery Program: Programs designed to work together with habitat still capable of producing fish or in conjunction with initiatives to restore habitat productivity. Conservation Propagation programs are designed and operated to protect and promote Pacific salmon viability. Conservation programs follow practices that promote population dynamics and that promote survival under local environmental conditions. Conservation programs purposely seed habitats capable of producing fish or attempt to preserve populations until habitat productivity is restored. Conservation programs include reintroduction, supplementation, and captive broodstock programs

Delisting: Removing a species or Distinct Population Segment (DPS) from the list of threatened and endangered species after concluding that the measures provided pursuant to the ESA are no longer necessary and that the species or DPS is not likely to become endangered (the definition of a threatened species) within the foreseeable future throughout all or a significant portion of its range.

Demographic Stochasticity: A natural tendency for salmon and steelhead populations at low abundance to be highly variable and possibly going to zero.

Distinct Population Segment: Under the ESA, the term "species" includes any subspecies of fish or wildlife or plants, and any "distinct population segment" of any species or vertebrate fish or wildlife which interbreeds when mature (ESA Sec. 3(15)). The ESA thus considers a "distinct population segment" of vertebrates to be a "species". It does not however establish how distinctness should be determined. Under NMFS policy (NMFS 1991 II), for Pacific salmon, a population or group of populations will be considered a DPS if it represents an evolutionarily significant unit (ESU) of the biological species.

Educational Propagation Program: Programs designed and operated to inform and educate the public, and to provide opportunities for the public to participate in propagation initiatives.

Evolutionarily Significant Unit (ESU): For Chinook, coho, chum, sockeye, and pink salmon, a population or group of populations that is considered distinct because 1) they are substantially reproductively isolated from other con-specific groups and because 2) they represent an important component in the evolutionary legacy of the biological species. An ESU qualifies as a "species" under the Federal Endangered Species Act.

Experimental population: Any population, including eggs, propagules, or individuals of an endangered species or a threatened species authorized by the Secretaries (of Interior or Commerce depending on the species) for release outside the current range of such species if the Secretary determines that such release will further the conservation of such species (ESA section 10(j)).

Extant population: Existing populations of Pacific salmon.

Genetic Resources: The combination of natural-origin fish (NOF) and hatchery-origin fish (HOF) included in an ESU or steelhead DPS.

Hatchery: A facility that supports one or more hatchery programs.

Hatchery-Origin fish (HOF): Salmon or steelhead from parents (i.e., from either HOF or NOF parents) that were selected for broodstock and spawned artificially.

Hatchery Program: A group of fish that is handled separately and may have different spawning, rearing, marking and release strategies. The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004).

Hatchery Reform: Changes or improvements in practices to accomplish goals for the hatchery program.

Independent Population: Populations that are substantially reproductively isolated from other conspecific fish and that have population dynamics that are substantially independent from other groups. The exact level of reproductive isolation that is required for a population to have substantially independent dynamics is not well understood, but available scientific information indicates that substantial independence will occur when the proportion of a population that consists of migrants or non local fish is less than 10%.

Intrinsic Productivity: Intrinsic productivity is recruit to spawner (R/S) productivity when spawner abundance is low. R/S usually is calculated as an average productivity for all brood cycles during some specified time period. Intrinsic productivity however, considers a subset of those brood cycles with the lowest parental spawner abundance. Intrinsic productivity is an indication of resilience and the potential for a population to bounce-back and recover after periods of low abundance. Intrinsic productivity is expected to be higher than 1.0 because there should be little or no negative effect of density dependence when spawner abundance is low.

Integrated Hatchery Strategy: HOF are intended to be as similar as possible to local NOF. Processes that drive adaptation and fitness in the natural environment must dominate hatchery selection effects. The larger the ratio of NOF in the hatchery broodstock/ HOF spawning naturally + NOF in the hatchery broodstock, the greater the influence of the natural environment relative to the hatchery environment on selection. This ratio must exceed 0.5 in order for the natural environment to dominate or drive selection.

Integrated Fisheries Program: HOF are for harvest and are not intended to spawn naturally. HOF may also serve as a source of genetic resources to initiate a conservation program.

Lambda: Estimates trends in the abundance of natural spawners and counts hatchery-origin fish as both parental stock and recruits. Lambda does not help determine the ability of a population to sustain itself and grow in the absence of hatchery fish that subsidize natural spawning.

Limiting Factor: Any factor (anthropogenic or natural) that, by itself or in combination with other factors, slows or prevents anadromous salmonid population viability from improving.

Isolated Hatchery Strategy: HOF are intended to be dissimilar relative to local NOF and interactions between HOF and NOF are avoided (i.e., HOF are isolated from NOF). NOF are not used for hatchery broodstock and HOF are for harvest and not intended to spawn naturally.

Mitigation: In-kind replacement of what is lost or degraded. Impacts to habitat function (e.g., reduced habitat productivity) are mitigated by replacing or improving habitat function. Hatchery propagation can act as compensation, but it cannot mitigate for lost or degraded habitat.

Natural-Origin Fish (NOF): Fish originating from naturally spawning parents. This includes fish from naturally spawning natural-origin parents and fish from naturally spawning hatchery-origin parents.

Pacific Salmon: Any of the six species of the genus *Oncorhynchus* including *O. gorbuscha* (pink salmon), *O. keta* (chum salmon), *O. kisutch* (coho salmon), *O. nerka* (sockeye salmon), *O. tshawytscha* (Chinook salmon), and the anadromous form of *O. mykiss* (steelhead).

Proportion of Natural Influence (PNI): A measure of geneflow between hatchery-origin and natural origin fish. PNI is calculated as the percent natural-origin fish in the hatchery broodstock divided by the proportion of natural spawners comprised of hatchery-origin fish plus the percent natural-origin fish in the hatchery broodstock. Natural influence decreases and PNI approaches zero as the proportion of natural spawners comprised of hatchery-origin fish increases and as the proportion of hatchery broodstock comprised of natural-origin fish decreases.

Recovery: See the definition for delisting. For these purposes, Recovery occurs when an ESU or Steelhead DPS is determined to have improved such that it is not likely to become an endangered species within the foreseeable future, throughout all or a significant portion of its range, and is no longer in need of protection under the Endangered Species Act.

Returns or Recruits-per-Spawner (R/S): is a measure of whether a salmon or steelhead population is maintaining itself, declining, or growing. If 100 spawners produce 100 progeny that survive to maturity and successfully spawn, the R/S =1.0 and the population is maintaining or replacing itself. When R/S < 1.0, the population is declining.

Research Hatchery Programs: Programs designed to provide scientific information on the operation and performance of artificial propagation.

Returns: Pacific salmon returning to freshwater to reproduce.

Steelhead Distinct Population Segment (DPS): A group that is discrete from other groups and is significant to its taxon (species or subspecies). A group is discrete if it is markedly separated from other groups of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors. Significance is measured with respect to the taxon as opposed to the full species.

Supplementation Hatchery Program: Fish from supplementation programs are intended to spawn naturally. Supplementation programs include captive broodstock, egg-box, and juvenile release programs. Supplementation programs can preserve genetic resources and they can increase the number and distribution of natural spawners. Returns from supplementation programs that are surplus to conservation needs are available for other purposes (e.g., human consumption, stream fertilization, harvest, etc.).

2. Background

The origins and evolution of artificial propagation for Pacific salmon provides important context for analyzing the benefits and risks of hatchery programs. From their origin more than one hundred years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability.

The first hatcheries, beginning in the late 19th century provided additional fish for harvest purposes on top of large relatively healthy salmon and steelhead populations. It wasn't long before the role of hatcheries shifted to replacing losses in fish production attributable to water development and land use practices that blocked access to important production areas or that degraded habitat and reduced salmon and steelhead survival. Hatchery programs were tasked to maintain returns of adult salmon and steelhead, usually for cultural, social or economic purposes, because the capacity of habitat to produce salmon and steelhead was reduced. In the Columbia Basin for example, as development proceeded (e.g., construction of the Federal Columbia River Power System (FCRPS) between 1939 and 1975) and the capacity for the basin to produce fish declined, hatchery production increased. National Fish Hatcheries were constructed in the upper Columbia after federal dams blocked access to approximately 50 percent of the production area for the Upper Columbia spring Chinook salmon Evolutionarily Significant Unit (ESU) and the Upper Columbia steelhead Distinct Population Segment (DPS). In the Snake River, the Columbia's largest tributary, hatchery programs were expected to replace losses of fall Chinook salmon from inundation of their spawning habitat and from reduced survival during their migration to and from the ocean because of the four federal dams on the Lower Snake River. The scope and level of hatchery production increased greatly during this period as impacts from development and the requirement to compensate for those impacts increased.

A new role for hatcheries emerged during the 1980s and 1990s after salmon and steelhead populations declined to unprecedented low levels. Hatchery programs were still expected to compensate for impacts to tribal, public, and commercial fisheries, but they also became a tool to conserve genetic resources, and in some cases, to help improve viability as the factors limiting viability are addressed. Some hatchery programs changed their goals and practices and whole new programs were implemented, including substantial new research to assess the efficacy of artificial propagation as a tool to promote conservation. The role of individual hatchery programs in two areas of the Columbia Basin is illustrated in Figure 1. Today, because nearly 90 percent of the Chinook salmon and steelhead habitat originally available in the Columbia Basin has been lost or degraded (Brannon et al. 2002), fish produced by hatcheries comprise the vast majority of the annual returns to the basin (CBFWA 1990). Annual returns of salmon and steelhead would be reduced by up to ninety percent and there would be little or no tribal, public or commercial fishing opportunity without hatcheries.

Genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery as well as in fish spawned in the wild (NMFS 1991b; Hard et al. 1992). Natural production has been in decline for over a century and now the vast majority of returning adult salmon and steelhead are hatchery fish. For a list of hatchery fish included in salmon ESUs and steelhead DPSs, see NMFS (2003). Hatchery programs also can be used as a proactive tool to conserve the genetic resources of depressed natural populations and to reduce short-term extinction risk. Hatchery programs can preserve the raw materials (i.e., genetic resources) that ESU and steelhead DPS conservation depends on and buy time until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs can reduce the risk of extirpation, and thereby mitigate the immediacy of an ESU's extinction risk. In absence of hatchery programs like this, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether. Hatchery programs that only conserve genetic resources however "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or long-term (70 FR 37160; June 28, 2005). Furthermore, hatchery programs that conserve vital genetic resources are not without risk because the manner in which these programs are implemented can have significant impacts on the genetic structure and evolutionary trajectory of the target population by reducing population or ESU/DPS-level variability and patterns of local adaptation (ICTRT 2007). In fact, when hatchery programs are relied upon to conserve genetic resources and reduce short-term extinction risk, there likely is a trade-off between reducing short-term extinction risk and potentially increasing long-term genetic risk.

Population viability and reductions in threats are key measures of salmon and steelhead status relative to recovery. Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., hatchery supplementation). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish (i.e., F1 hatchery-origin fish). They are not however a proven technology for achieving sustained increases in adult production (NRC 1996), and the long-term benefits and risks of hatchery supplementation remain untested (Araki et al. 2007a). In the interim, it is important and necessary to follow a measured and well conceived application of hatchery supplementation as opposed to any widespread moratorium that could do more harm than good for fish. For an overview of the pros and cons/benefits and risks from existing hatchery operations see NMFS 2004a, NMFS 2006b and Hatchery Effects Appendix.

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. For example, in Puget Sound, eight Chinook salmon hatchery programs are specifically implemented to preserve native populations in their natal watersheds "where habitat needed to sustain the populations naturally at viable levels has been lost or degraded" (70 FR 37160; June 28, 2005). These hatchery programs deserve credit for helping "to preserve remaining genetic diversity, and likely have prevented the loss of several populations" (70 FR 37160; June 28, 2005). Until, however, the factors limiting Puget Sound Chinook salmon productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon viability may not be realized. Hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival or when access to spawning and rearing habitat is blocked. Under circumstances like these and in the short-term, the demographic risks of extinction likely exceed genetic and ecological risks to natural-origin fish from hatchery supplementation. Benefits like this should be considered *transitory* or short-term and do not contribute to survival rate changes necessary to meet ICTRT abundance and productivity viability criteria. Fixing the factors limiting viability is the key to improving viability. "The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery" (HSRG 2004). Salmon and steelhead populations that rely on hatchery production are not viable (McElhany et al. 2000).

In the course of providing these benefits, there also is the potential for hatchery programs to increase the extinction risk and threaten the long-term viability of natural populations. For almost four hundred hatchery programs up and down the West Coast, NMFS 2004a evaluates benefits and risks at two levels: at the population level and at the ESU or DPS level. For programs in the Interior Columbia (upstream from Bonneville Dam), the Hatchery Effects Appendix in the May 5, 2008 NMFS Biological Opinion for the Federal Columbia River Power System, with input provided by members of the Hatchery and Harvest Workgroup of the FCRPS collaboration; (1) summarized the major factors limiting salmon and steelhead recovery at the population scale, (2) provided an inventory of existing hatchery programs including their funding source(s) and the status of their regulatory compliance under the ESA and under the National Environmental Policy Act , (3) summarized the effects on salmon and steelhead viability from current hatchery operations, and (4) identified new opportunities or changes in hatchery programs likely to benefit population viability. As a follow-up to the Hatchery Effects Report, NMFS developed recommendations for determining hatchery effects, including an overview of hatchery programs in the upper Columbia and Snake River Basin and presented this paper to the Hatchery and Harvest Workgroup and to the Policy Workgroup in August of 2006. NMFS received comments and made edits to this paper to provide updated recommendations for assessing benefits and risks as a result of operating hatchery programs (NMFS 2007a.

Increasing knowledge and experience is another important factor in the application of hatchery supplementation. Hatchery supplementation is an "experimental" technology. It is relatively new and there is little data on long-term benefits and risks – study results for a single generation of Pacific salmon take a minimum of three to five years. The good news is that new information is emerging from ongoing research and important new research will be implemented as a result of NMFSs Biological Opinions. The reproductive fitness of hatchery fish and the effects of hatchery supplementation on population viability will be investigated for steelhead in the Methow River and for fall Chinook salmon in the Snake River. NMFS intends that the information emerging from ongoing and new studies will shape future decisions over hatchery supplementation up and down the west coast.

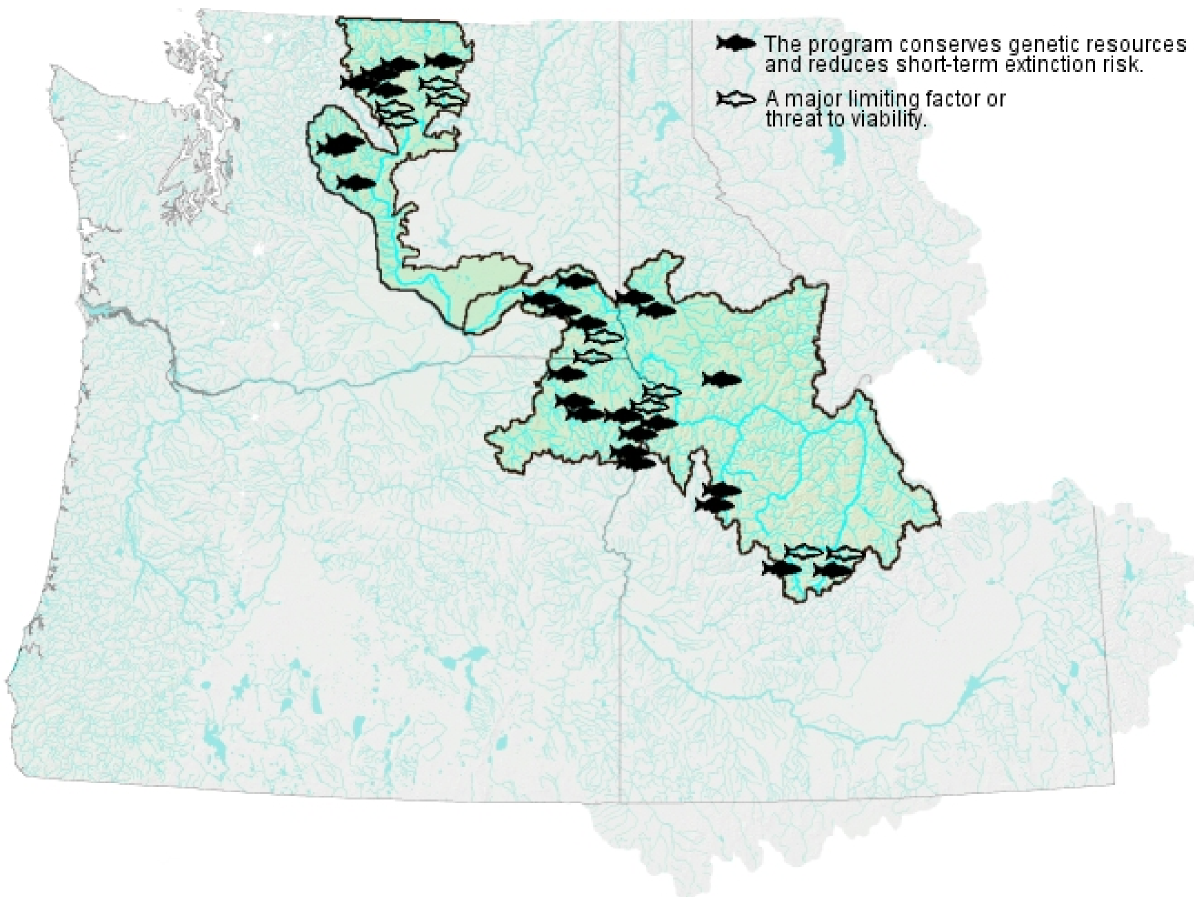


Figure 1. The role of hatchery programs in the upper Columbia and Snake River Basin. For identification and a description of the hatchery programs referenced below, see Table 4.

Hatchery programs are mitigation for factors limiting salmon and steelhead survival. The nearly two hundred programs that operate in the Columbia Basin are mitigation for Federal and public and private utility projects and the funding level and funding source for these programs is provided in Table 1.

Table 1. Estimated FY 2006 hatchery operation and maintenance funding for nearly 200 salmon and steelhead hatchery programs in the Columbia River Basin.

Funding Source	Annual Funding Level in millions of dollars
Bonneville Power Administration	$50.1
Utilities	$14.0
National Marine Fisheries Service, Federal Mitchell Act	$11.4
Corps of Engineers	$5.1
Bureau of Reclamation	$4.6
Oregon	$1.3
Federal Pacific Coast Salmon Restoration Fund	$1.0
Total	$87.5

3. Assessing the Benefits and Risks of Salmon and Steelhead Hatchery Programs

It is important and necessary to better understand the effects of hatchery programs. This paper offers a framework for determining the benefits and risks of existing hatchery programs and of alternative or proposed new hatchery actions. Seven factors are described here for assessing the benefits and risks of hatchery programs. These factors include: (1) population viability status and recovery goals, (2) the conservation of genetic resources, (3) effects, positive and negative, on population viability, (4) research monitoring and evaluation, (5) hatchery effects on density-dependent processes, (6) effects of hatchery weirs, and (7) compensation for impacts to Indian treaty, public, commercial and international fisheries.

3.1 Status and Viability Goals

3.1.1 *Status of the Fish*

Status of the fish at the population, major population group, and ESU or steelhead DPS scales is an important factor or consideration in assessing the benefits and risks of hatchery programs.

Status of the fish is determined by their level of viability and by threats to their survival. "Management actions ultimately need to be related to population and ESU viability" (McElhany et al. 2000). In general, the greater the viability of a fish population and the greater the protection from threats, the lesser the need and potential benefit of hatchery supplementation and the greater the risk tolerance of the fish to negative hatchery effects. For example, a viable population is at less risk from hatchery fish straying than a population at low viability with respect to protecting productivity and diversity. Conversely, direct hatchery supplementation confers fewer potential benefits to a population at high viability than to one at low viability.

Increasing viability must also be accompanied by a decreasing level of threat for population status to improve. This means that even as the viability of a population improves, continued hatchery supplementation may be important and beneficial until identified threats to a population's continued existence are addressed. For example, hatchery supplementation may be followed by only temporary increases in the abundance and spatial distribution of natural spawners and in the abundance of natural-origin fish unless known threats to the fish are alleviated. Changing environmental conditions (e.g., cycles in ocean productivity) also may lead to temporary increases in viability.

Hence, the level of viability and the level of threats are key components for assessing benefits and risks from existing and proposed new hatchery programs. One potentially useful guideline might be that hatchery effects pose the greatest benefits and risks when natural populations are below their critical threshold for viability and self-sustainability compared to natural populations that exceed those critical thresholds.

3.1.1 *Viability Goals*

Another important factor in assessing the benefits and risks of hatchery programs is the viability goal for salmon and steelhead populations. Recovery Plans are one place to find viability goals and these goals are determined in cooperation with Technical Recovery Teams (TRT). Viability goals are based on the importance of a population to ESU or steelhead DPS recovery and the viability goal for a population can range widely, from highly viable to maintaining minimum viability. The importance of a population and its corresponding viability goal depends on several factors including the potential size and any unique characteristics of the population. For example, larger populations in general stand a better chance of surviving or persisting during downturns in environmental conditions and unique life-history characteristics (e.g., populations including a summer-returning fish among populations where the spring-run characteristic dominates) decreases extinction risk by benefiting spatial distribution and diversity and acts to buffer a population against environmental variability. Populations like these likely must achieve a higher level of viability for an ESU or DPS to achieve recovery. Viability goal is a factor in a population's tolerance for negative effects. In general, the higher the viability goal, the lower tolerance to negative effects, including any risks posed by hatchery programs. For example, there should be a lower tolerance for stray hatchery-origin fish spawning together with a population that has a high viability goal. A higher level of hatchery strays could be acceptable for populations with a lower viability goal. The viability goal is thus a critical consideration in assessing the level of benefits and the potential risks from one or more hatchery programs. More than half of the 52 ESUs and steelhead DPSs up and down the West Coast are protected under the ESA and viability goals can be found in completed Recovery Plans.

3.2 Conservation of Genetic Resources

Natural production has been in decline for over a century and now the vast majority of returning adult salmon and steelhead are hatchery fish. Genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery as well as in fish spawned in the wild (NMFS 1991b; Hard et al. 1992). For a list of hatchery fish included in salmon ESUs and steelhead DPSs, see NMFS 2004b. Hatchery programs also can be used as a proactive tool to conserve the genetic resources of depressed natural populations and reduce ESU and steelhead DPS extinction risk. For example, in determining whether Lower Columbia River (LCR) coho salmon warranted listing under the ESA, NMFS concluded that "hatchery programs collectively mitigate the immediacy of extinction risk for the LCR coho ESU in-total in the short term", and this is an important benefit that hatchery programs can provide. However, hatchery programs that only conserve genetic resources "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or for the long-term (70 FR 37160; June 28, 2005). "Hatcheries are not a proven technology for achieving sustained increases in adult production" (NRC 1996), and the long-term effects of hatchery supplementation remain untested (Araki et al 2007a).

Hatchery programs preserve the raw materials (i.e., genetic resources) that ESU and steelhead DPS conservation depends on. In the absence of hatchery programs like these, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether. This beneficial effect, however, should be considered transitory because increasing dependence on hatchery intervention results in decreasing benefits and increasing risk. In fact, when hatchery programs are relied upon to conserve genetic resources and reduce short-term extinction risk, there likely is a trade-off between reducing short-term extinction risk and potentially increasing long-term genetic risk (ICTRT 2008). Hatchery supplementation programs, including captive-broodstock or safety-net programs, or hatchery programs that also function as gene reserves, fit into this category. In general, these hatchery programs can increase the number and spatial distribution of naturally spawning fish (i.e., F1 hatchery-origin fish), but, because they do not address the factors limiting viability (e.g., mainstem survival, habitat conditions, ocean productivity), increased population viability cannot be attributed to the program. For example, hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival, or when access to spawning and rearing habitat is blocked.

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. For example, in Puget Sound, eight Chinook salmon hatchery programs are specifically implemented to preserve natural populations in their natal watersheds "where habitat needed to sustain the populations naturally has been lost or degraded" (70 FR 37160; June 28, 2005). These hatchery programs benefit conservation of an ESU or steelhead DPS and have helped “to preserve remaining genetic diversity, and likely have prevented the loss of several populations” (NMFS 2005 III). Until however the factors limiting salmon and steelhead productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon and steelhead viability may not be realized.

Hatchery programs can buy time until the factors limiting salmon and steelhead viability are addressed. “The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery” (HSRG 2004). Without a hatchery program like this, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether. Under circumstances like these and in the short-term, the demographic risks of extinction exceed genetic and ecological risks from hatchery supplementation. Benefits from this category of effects should be considered *transitory* or short-term and do not contribute to survival rate changes necessary to meet ICTRT abundance and productivity viability criteria.

3.3 Effects on Population Viability

“The presence of well distributed self-sustaining natural populations that are ecologically and genetically diverse provides the most certain basis to determine that an ESU or steelhead DPS is not likely to become endangered in the Foreseeable future (i.e., whether a species is threatened or listing is not warranted)” (70 FR 37160; June 28, 2005). NMFS includes hatchery fish in assessing an ESU’s status in the context of their contributions to conserving natural-self-sustaining populations.

The primary criteria for determining the viability of salmon and steelhead populations are described by McElhany et al. (2000). These criteria are the abundance, productivity, spatial distribution and diversity of natural-origin fish (NOF). Hatchery origin fish (HOF) can benefit or harm salmon and steelhead viability. In determining the effects (positive or negative) of hatchery programs on salmon and steelhead viability, it is necessary then to determine their influence on these criteria. It is also is important to recognize that a single hatchery effect can and often does influence multiple viability criteria. For example, increases in NOF attributable to a hatchery program can benefit both abundance and spatial distribution while on the other hand, the removal of NOF for hatchery broodstock reduces abundance and can reduce productivity and spatial structure also. Ultimately, the number, nature and scale of hatchery programs must be consistent with the maintenance of naturally self-sustaining ESUs or steelhead DPSs. “A population that depends upon naturally spawning HOF for its survival is not viable” (McElhany et al. 2000).

The following guidance describes what to look for when assessing hatchery programs for their effects (i.e., benefits and risks) on parameters that determine salmon and steelhead population viability.

Abundance

Abundance is the number of fish produced by natural processes that have spent their entire life cycle in nature (i.e., natural-origin fish). This is often referred to as gravel-to-gravel survival or fish originating from naturally spawning parents that hatch from the gravel and that survive to spawn naturally themselves years later. The effect of a hatchery program on salmon and steelhead abundance should be determined by:

a. The proportion and number of natural-origin fish (NOF) removed from any population or spawning aggregate to provide hatchery broodstock (i.e., NOF that are taken into a hatchery instead of left to spawn naturally).

b. The proportion and number of NOF killed or injured by hatchery facilities (e.g., hatchery water intakes) and handling effects.

c. The reduction and loss of natural production caused by hatchery facilities that block, delay, or impede adult fish from returning to spawning areas (e.g., weirs, ladders or traps).

d. Sustained increases in NOF (compared to a condition absent or previous to hatchery intervention) attributable to successful reproduction of hatchery-origin fish intended to spawn naturally (i.e., hatchery supplementation). Eggs and juveniles released into streams and adult returns from these releases, serve to seed freshwater spawning and rearing areas. These naturally spawning hatchery-origin fish may reproduce successfully under natural conditions to increase the abundance of natural-origin juveniles and returning adults. Ultimately, the survival and natural reproductive success of natural-origin progeny (i.e., the progeny of naturally spawning parents, whether of natural-origin or hatchery-origin) determine the overall viability of any supplemented population.

e. The injury or mortality (i.e., from catch and release or from retention) of NOF or HOF intended to spawn naturally from fisheries targeting surplus HOF.

Productivity

Productivity, as a measure of salmon and steelhead viability for ESA purposes, is the adult-replacement rate of natural-origin fish spawning naturally. It is usually quantified or described by the ratio (R/S) or the number of adult-offspring recruits (R) per adult-parent spawners (S) of the previous generation. It is a measure that directly relates to the potential ability for a population or spawning aggregate to be self-sustaining. For example, the productivity measure used by the Interior Columbia Technical Recovery Team (ICTRT) is expressed in terms of recruits per spawner or the rate at which natural spawning adults in one generation are replaced by natural-origin natural spawning adults in the next generation. This measure of life-cycle productivity is affected by mortality and survival at all life stages combined. Consequently, there are only five situations where hatchery-origin fish spawning naturally can increase productivity: (1) if productivity is limited by the number of natural spawners (e.g., fish have difficulty finding mates or experience "Allee effects"), (2) the natural population has undergone inbreeding depression due to multiple generations of very low abundances (e.g., less than 20 spawning pairs per year for more than two generations) and the hatchery-origin fish are not of that same inbred stock, (3) habitat is being re-colonized via reintroductions using hatchery-origin fish, (4) HOF carcasses increase nutrients in spawning and rearing areas, and (5) naturally spawning HOF "clean" (i.e., reduction in fine sediments) spawning gravels. The effect of a hatchery program on salmon and steelhead productivity should be determined by:

a. The natural reproductive success of HOF spawning naturally relative to NOF spawning naturally.
b. The productivity of natural-origin progeny, otherwise referred to as fitness, derived from naturally spawning HOF (i.e., the life-cycle survival or replacement rate of progeny of naturally spawning HOF) relative to naturally spawning NOF.
c. The life history characteristics of naturally spawning HOF compared to naturally spawned NOF (e.g., age-of-return, size-at-return, spawn timing, fecundity, etc.).
d. In addition to a-c, the Proportion of Natural Influence (PNI) for hatchery programs that supplement natural spawning aggregates or populations of salmon and steelhead.
e. Competition for food or habitat between NOF and released HOF (i.e., density-dependent mechanisms).
f. Maintenance of within-population substructure (e.g., multiple spawning aggregates).
g. Whether hatchery facilities (e.g., weirs, ladders, diversions) affect escapement back to the area of origin, rates of natural straying, or dispersal of fish (adults and juveniles) into under-used habitats, especially when adult returns are large.
h. Competition for prime spawning areas and redd superimposition (another density-dependent mechanism, e.g., if large numbers of hatchery-origin adults with lower reproductive success displace natural-origin spawners).
i. Predation on juvenile NOF by released HOF.
j. Interbreeding between HOF and NOF that reduces reproductive genetic fitness of natural-origin adult recruits relative to the progeny of NOF only.
k. HOF nutrient contribution to freshwater rearing areas.
l. Changes in intrinsic productivity.

Spatial structure

Spatial structure is the range or distribution of NOF. Any viability evaluation must consider spatial structure within a population (or group of populations) because spatial structure affects extinction risk (McElhany et al. 2000). In general, HOF can increase spatial structure only when NOF (i.e., the progeny of naturally spawning hatchery-origin fish) expand their distribution and recolonize former range. The effect of hatchery programs on salmon and steelhead spatial structure should be determined by:

a. Whether reintroductions using HOF assist in reestablishing viable salmon and steelhead populations within their former range.
b. Whether hatchery supplementation slows any reduction in spatial structure.
c. Whether hatchery facilities (i.e., weirs, ladders, diversions, etc.) affect escapement back to the area of origin, rates of natural straying, or dispersal of fish (adults and juveniles) into under-used habitats, especially when adult returns are large.

d. Competition for prime spawning areas and redd superimposition.
e. Competition between HOF and NOF juveniles for rearing areas.
f. Predation on juvenile NOF by HOF.
g. Spawning between HOF and NOF that reduces reproductive genetic fitness and thereby reduces spatial structure via reduced abundance of natural-origin recruits in subsequent generations. (e.g., outbreeding depression).
h. HOF nutrient contribution to freshwater rearing areas.

Diversity

Diversity refers to the distribution of traits within and among populations of salmon and steelhead. These traits include anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, physiology and molecular genetic characteristics. Combinations of genetic and environmental factors largely cause phenotypic diversity. Variation or diversity in these and other traits is important to viability because 1. it allows fish to take advantage of a wider array of environments, 2. it spreads the risk (e.g., different ocean distribution patterns mean not all fish are at risk from local or regional varying ocean conditions) and 3. genetic diversity allows fish to adapt to changing environmental conditions. Hydropower, habitat, harvest, and hatchery factors can all affect diversity. In the case of hatchery programs, gene flow and local adaptation strongly influence patterns of diversity within and among salmon and steelhead populations. The effect of hatchery programs on salmon and steelhead diversity should be determined by:

a. The origin of hatchery broodstock (i.e., the source relative to the affected natural population), the number of generations in captivity, and evidence of domestication selection.
b. The similarity of HOF traits relative to NOF traits, relative survivals, and how the hatchery program affects effective population size.
c. Gene flow of HOF into a natural population or spawning aggregate. Natural rates of gene flow have helped salmon and steelhead to persist and adapt to local conditions. For groups of salmon and steelhead determined important to recovery (i.e., for groups that must maintain at least viable status), the natural or background level of gene flow (including duration) between spawning aggregates, between populations, between Distinct Population Segments and between Evolutionarily Significant Units should be maintained.
d. The extent to which a hatchery program preserves or builds salmon or steelhead genetic resources, including potential increases in life history diversity and the establishment of new, locally-adapted populations via habitat expansions and reintroductions.

3.4 Research, Monitoring and Evaluation

The Hatchery Fish Fraction of Natural Spawners

Valid estimates of the proportion of natural spawners comprised of HOF (i.e., the hatchery fish fraction of natural spawners) should be provided for individual spawning aggregates and populations. ESA authorization to operate a hatchery program and funding agreements should include a condition that valid hatchery fraction estimates must be calculated on an annual basis.

"Valid estimates of natural productivity are impossible to obtain for supplemented populations in which the abundance of naturally-produced and hatchery produced fish on the spawning grounds are not estimated separately" (McElhany et al. 2000). Average R/S provides the most realistic assessment of the likelihood that a population will trend toward recovery in the absence of continued hatchery programs (i.e., natural productivity). This is because the metric considers only the survival of NOF. This metric also requires the most data for each population, since brood-year specific estimates of hatchery fraction and age structure are necessary. For a number of populations, this requires assumptions and extrapolations from other populations or time periods.

The Spatial and Temporal Distribution of Hatchery Spawners

T*he spatial and temporal distribution of naturally spawning HOF must be monitored.* Understanding to what extent HOF spawn at the optimal time and in preferred habitats and to what extent HOF interbreed with NOF is crucial to assessing the benefits and risks of hatchery programs.

Hatchery Fish Fitness in Nature

Valid estimates of HOF fitness in nature are needed to assess the benefits and risks of hatchery programs that produce fish that spawn with NOF.
When HOF spawn naturally, "It is necessary to know or estimate the relative fitness of HOF compared to NOF in order to estimate natural productivity of the population" (Berejikian and Ford 2004). In the 2000 Federal Columbia River Power System Biological Opinion, NMFS estimated productivity (lambda) twice for 152 salmon and steelhead populations assuming that HOF in general were either 20% or 80% as fit as NOF. New information has become available since 2000, and it is now possible to assign HOF to fitness categories based on a common set of factors that studies show influence HOF fitness in the natural environment. This allows better estimates of lambda for natural populations where hatchery and natural fish co-occur in spawning areas. This is a new area of research and further studies are needed to improve the accuracy of hatchery fitness predictions including, replicate studies on other species subject to different hatchery practices and particularly on species with abbreviated freshwater life histories (e.g., ocean-type Chinook salmon).

Hatchery Affects on Density-Dependent Processes

Evaluating the factors that influence or drive density dependent effects under different freshwater conditions (e.g., hydrosystem) and ocean conditions is an important area of future research. Information gaps need to be filled to help managers make cost-effective decisions that serve both conservation and sustainable fisheries mandates. The significance of hatchery effects on density-dependent mechanisms and natural populations is largely unknown and this hampers the ability to assess the return from prospective investments in hatchery reform or the effects of additional hatchery production. In this section, we summarize how to provide additional insights into the effects of HOF on Pacific salmon viability and identify future research needs that would help inform management decisions.

Additional analyses incorporating more recent and broader ranging data from the Columbia River Basin may provide an example of how large-scale hatchery releases can affect natural populations through density-dependent mechanisms (Berejikian et al. 2007). The numbers of HOF released in the Columbia River Basin has steadily declined from the peak year of 1982, so adding years in which fewer HOF were released will improve the ability to quantify hatchery effects.

Tools that can be used to better understand potential effects on NOF growth and survival at each life stage and location in the life cycle are needed to help inform hatchery policy and management decisions and for recovery planning purposes in general. A model that explores direct competition for food and habitat and indirect mechanisms such as changes in the foraging activity of predators could provide important guidance. The first step would be to model salmon size and growth rates as functions of the physical (e.g., temperature, light, flow/currents) and biological (i.e. biomass and community composition of the prey base) environments. It would then be possible to estimate food demands to support natural fish relative to the supply. Next, data on the size and composition of the predator community (fish, birds, marine mammals) would be used to model predation risk for salmon and steelhead as a function of their species and size. Through "scenarios" that reflect various endpoints for hatchery release schedules, number of releases, and sizes of fish at the time of release, it would be possible to evaluate the (1) competitive effects of HOF with NOF for food, (2) effects of increased total prey biomass on predator foraging (including the possibility of predator "swamping"), and (3) the indirect effects of increased predator biomass on NOF due to increases in overall prey abundance (i.e. millions of hatchery smolts).

At the local level, additional data is needed to determine which ESUs, steelhead DPSs and Major Population Groups are affected by hatchery releases, is the growth and survival of NOF affected by just local hatcheries, or by the summed magnitude of hatchery releases across a larger landscape, and is NOF survival affected by hatchery releases of conspecifics only, or also by releases of heterospecifics? Studies that address these questions should incorporate important measures of ocean productivity (e.g., PDO, ENSO, spring transition date).

3.5 Hatchery Effects on Density-Dependent Processes

Evidence of HOF effects on density-dependent processes in freshwater and marine environments is presently insufficient to guide policy on the appropriate scale of hatchery releases (Berejikian et al. 2007). There is however, considerable interest and speculation over the issue of density-dependent effects on natural populations. For example, because of concerns for three salmon ESUs and one steelhead DPS, the Draft Snake River Salmon ESA Recovery Plan went so far as to propose a "limit on annual releases of anadromous fishes from Columbia Basin Hatcheries". This proposal however was tempered by the acknowledgement that there is little definitive information available to directly address the effects of ecological factors on the survival and growth of fish from natural populations of Pacific salmon (NMFS 1995c).

Pacific salmon at all abundance levels and at all life stages are subject to density-dependent processes. Many factors influence these processes including, changes in habitat quality and quantity, prey base, the abundance and distribution of predators, natural fluctuations in environmental conditions (e.g., summer stream flows and ocean productivity), and interactions among species and between natural and hatchery fish that depend on the same natural environments. The question is, how and to what extent do HOF, in combination with these and other factors, affect density-dependent processes and the growth and survival of NOF.

There is increasing evidence of density-dependent effects on salmon and steelhead growth and survival but the underlying factor or factors (e.g., HOF) remain poorly understood. For example, reduced growth and survival rates have been linked to high salmon abundance in the open ocean (e.g., Peterman 1984), but the role of HOF in reduced growth and survival rates remains unknown. Ruggerone et al. (2003) concluded that growth and survival of Bristol Bay sockeye salmon was inversely related to Asian pink salmon abundance but the contribution of hatchery reared Asian pink salmon to reduced growth and survival of sockeye salmon is unknown. Evidence of competition was apparent over the 45-year period of study, but the effect was most pronounced when survival rates and abundance levels were high for both species. Levin et al. (2001) tested the hypothesis that the sum of Chinook releases from Columbia Basin hatchery programs reduced the survival of natural-origin Chinook salmon from the Snake River Basin. The study concluded that releases of hatchery spring/summer Chinook salmon were not associated with natural-origin Chinook salmon survival, unless the data were divided post-hoc into years when the oyster condition index (a measure of near-shore ocean productivity; OCI) was low. There was a significant negative correlation between numbers of hatchery spring/summer Chinook released and natural-origin Snake River Chinook survival during low OCI. In contrast, Levin and Williams (2002) found no significant associations between the number of steelhead released from Snake River Basin hatchery programs and natural-origin Snake River steelhead regardless of ocean conditions (based on the El Niño-Southern Oscillation; ENSO). Survival of steelhead and Chinook salmon were not correlated with ENSO. However, there was a negative association between the number of hatchery steelhead released and natural-origin Chinook salmon survival. One likely explanation for the effect on Chinook occurs via predation from Caspian Terns that are attracted to the Columbia River estuary and feed on large aggregations of hatchery steelhead. For Oregon coastal coho salmon, Nickelson (2003) found a negative relationship between the average number of hatchery releases and population productivity (as estimated by the Ricker "a" parameter). The study did not determine how HOF reduced coho productivity but the author suggested that the likely effect occurs via predation, such that predators are attracted to large aggregations of hatchery coho and that NOF are thus more susceptible to piscivorous fish, birds, and mammals.

Another consideration is that ocean conditions, including spatial and temporal variations in ocean productivity, affect interactions among species and between hatchery and natural-origin salmon and steelhead. *Ruggerone and Goetz (2004)* suggested that abundant pink salmon protected hatchery Chinook salmon from predation during high ocean productivity but lead to competition-based mortality and reduced survival during poor ocean years. Evaluating the factors that influence or drive density dependent effects under different freshwater (e.g., hydrosystem) conditions and ocean conditions is an important area of future research because it will help managers make cost-effective decisions that serve conservation and sustainable fisheries mandates. In section 3.4, we summarize how to provide additional insights into the effects of HOF on natural salmon growth and survival.

Emerging data and analysis from ongoing studies is not going to be enough to guide decision-making processes that have important social, legal and economic implications. That's because the significance of hatchery effects on density-dependent mechanisms and natural populations is still largely unknown. This unknown hampers the ability to assess the return from potential investments in hatchery reform or the effects of additional hatchery production. There are practices that hatcheries can and should implement in the mean time to reduce potential affects on density-dependent mechanisms and corresponding threats to salmon and steelhead growth and survival. Hatchery programs that intend to supplement natural populations should:

1. monitor the accessibility, distribution, carrying capacity, and natural seeding level of spawning and rearing habitats in the area,
2. control the quantity of egg box and pre-smolt juvenile releases so that natural and hatchery fish combined do not exceed rearing habitat carrying capacity,
3. juvenile releases should mimic the size and condition of natural fish to avoid competitive advantages relative to natural fish,
4. juvenile releases should mimic the size and condition of natural fish to reduce hatchery fish residualism,
5. juvenile releases should mimic the size and condition of natural fish to reduce predation on natural or other hatchery fish,
6. acclimate hatchery smolts to improve the homing fidelity of adult returns and limit straying,
7. control HOF natural spawning to avoid superimposition of NOF spawning redds and to limit competitive interactions between the progeny of naturally spawning HOF and naturally spawning NOF,

8. control hatchery fish natural spawning so that rearing habitat carrying capacity is not exceeded, and
9. ensure that hatchery operations and structures allow unobstructed passage and distribution of juvenile and adult salmon and steelhead and that properly functioning habitat conditions are not degraded.

Practices that isolate or avoid interactions between HOF and NOF should be implemented for programs that produce fish exclusively for harvest purposes. Such practices include:

1. release fish at a size and condition factor that reduces residualism,
2. releasing fish away from populations that are important to salmon and steelhead recovery,
3. acclimate hatchery smolts to improve homing fidelity so that adult returns can be harvested and collected at hatchery facilities and so hatchery fish do not spawn naturally and produce offspring that compete with natural salmon and steelhead,
4. release fish at a size and condition factor that leads to their prompt emigration to the ocean, and
5. mark fish externally so they can be distinguished for harvest purposes and collected for hatchery broodstock.

3.6 Hatchery Weirs

The proper design and operation of hatchery weirs, including the monitoring of potential risk factors, can appreciably reduce the risks they pose to Pacific Salmon (Hevlin and Rainey 1993; NMFS 2008). Weirs are a tool for broodstock collection and for removing adult hatchery fish or for maintaining the appropriate level of hatchery fish that spawn naturally (i.e., supplementation hatchery programs). They can also assist in determining and tracking the status of Pacific salmon populations or spawning aggregates and in research projects, including hatchery effectiveness studies. These functions may be crucial to the operation of existing or prospective hatchery programs but weirs also pose risks that must be factored into design and implementation decisions.

Risk factors from the physical presence of a weir or trap include:

- Delaying upstream adult migration,
- Causing the fish to reject the weir or fishway structure, thus inducing spawning downstream of the trap (displaced spawning),
- Contributing to fallback of fish that have passed above the weir,
- Injuring or killing fish when they attempt to jump the barrier (Hevlin and Rainey 1993, Spence et al 1996), and
- Reducing the spatial distribution of juvenile salmon and steelhead seeking preferred habitats.

Potential risks from operating a weir or trap include:

- Physically harming the fish during their capture and retention whether in the fish holding area within a weir or trap, or by the snagging, netting or seining methods used for certain programs;
- Harming fish by holding them for long durations;
- Physically harming fish during handling; and
- Increasing their susceptibility to displacement downstream and predation, during the recovery period.

Other Considerations include:

- Aesthetic or visual effects,
- Changes to stream hydrology in the vicinity,
- Impacts to properly functioning habitat conditions, and
- Costs to construct, maintain, and operate the weir.

The installation and operation of weirs and traps are very dependent on water conditions at the trap site. High flows can delay the installation of a weir or make a trap inoperable. A weir or trap is usually operated in one of two modes. Continuously – where up to 100 percent of the run is collected and those fish not needed for broodstock are released upstream to spawn naturally, or periodically – where the weir is operated for a number of days each week to collect broodstock and otherwise left opened to provide fish unimpeded passage for the rest of the week. The mode of operation is established during the development of site-based broodstock collection protocols and can be adjusted based on in-season escapement estimates and environmental factors.

The potential impacts of weir rejection, fallback and injury from the operation of a weir or trap can be minimized by allowing unimpeded passage for a period each week. Trained hatchery personnel can reduce the impacts of weir or trap operation, by removing debris, preventing poaching and ensuring safe and proper facility operation. Delay and handling stress may also be reduced by holding fish for the shortest time possible, less than 24 hours, and any fish not needed for broodstock should be allowed to recover quickly from handling and be immediately released upstream to spawn naturally. However, it may be necessary to hold fish longer at the beginning and the end of the trapping season when the adult numbers are low.

There are alternatives to using weirs and a preferred option should be selected based on site-specific considerations. Beach seines, hook and line, gillnets and snorkeling are potential options for collecting hatchery broodstock and managing the escapement and natural spawning of HOF. All of these methods pose risks to NOF through injury, delaying their migration, changing their holding and spawning behavior, and increasing their susceptibility to predation and poaching. Some artificial production programs collect juveniles for their source of broodstock. Programs can collect developing eggs or fry by hydraulically sampling redds or collected emerging juvenile fish by capping redds (Shaklee et al. 1995; WDFW et al. 1995; Northwest Indian Fisheries Commission and WDFW 1998). Seines, screw traps and hand nets can also be used to collect juveniles. Each of these methods can adversely affect natural fish through handling or harming the juvenile fish that remain.

3.7 Hatchery Compensation for Impacts on Indian Treaty, Public, and Commercial Fisheries

Since time immemorial, the religion, economy and culture of Native Americans has depended on salmon and steelhead resources. These fisheries were so important that the United States signed treaties with many of the sovereign tribes that explicitly preserved Indian fishing rights. NMFS is committed to conserving salmon and steelhead in a manner that is fully consistent with the Government's treaty obligations and Indian trust responsibilities.

NOAA Fisheries' mission statement includes a strategic objective to "manage and rebuild fisheries to population levels that will support economically viable and sustainable harvests". The Policy for Conserving Species Listed or Proposed for Listing Under the ESA While Providing and Enhancing Recreational Fisheries Opportunities (NMFS and USFWS 1996), was jointly published by NMFS and the U.S. Fish and Wildlife Service on June 3, 1996. This policy was issued pursuant to Presidential Executive Order 12962, issued on June 7, 1995. That order requires Federal agencies, to the extent permitted by law, and where practicable and in cooperation with States and Tribes, to improve the quality, function, sustainable productivity, and distribution of aquatic resources for increased fishing opportunity. Among other actions, the order requires all Federal agencies to aggressively work to promote compatibility and reduce conflict between administration of the ESA and the management of fisheries.

Hatchery programs cannot restore habitat productivity but they are expected to compensate for impacts on cultural and economic values. From California to Canada, the vast majority of fisheries, including tribal treaty fishing, now depend on hatchery fish. In many places, hatchery fish are the only salmon or steelhead left to fish for and there would be little or no tribal or public fishing for salmon and steelhead without them. This function that hatchery programs serve constitutes a high positive value and benefit.

4. Operating Hatchery Programs Consistent with Conservation & Sustainable Fisheries Mandates

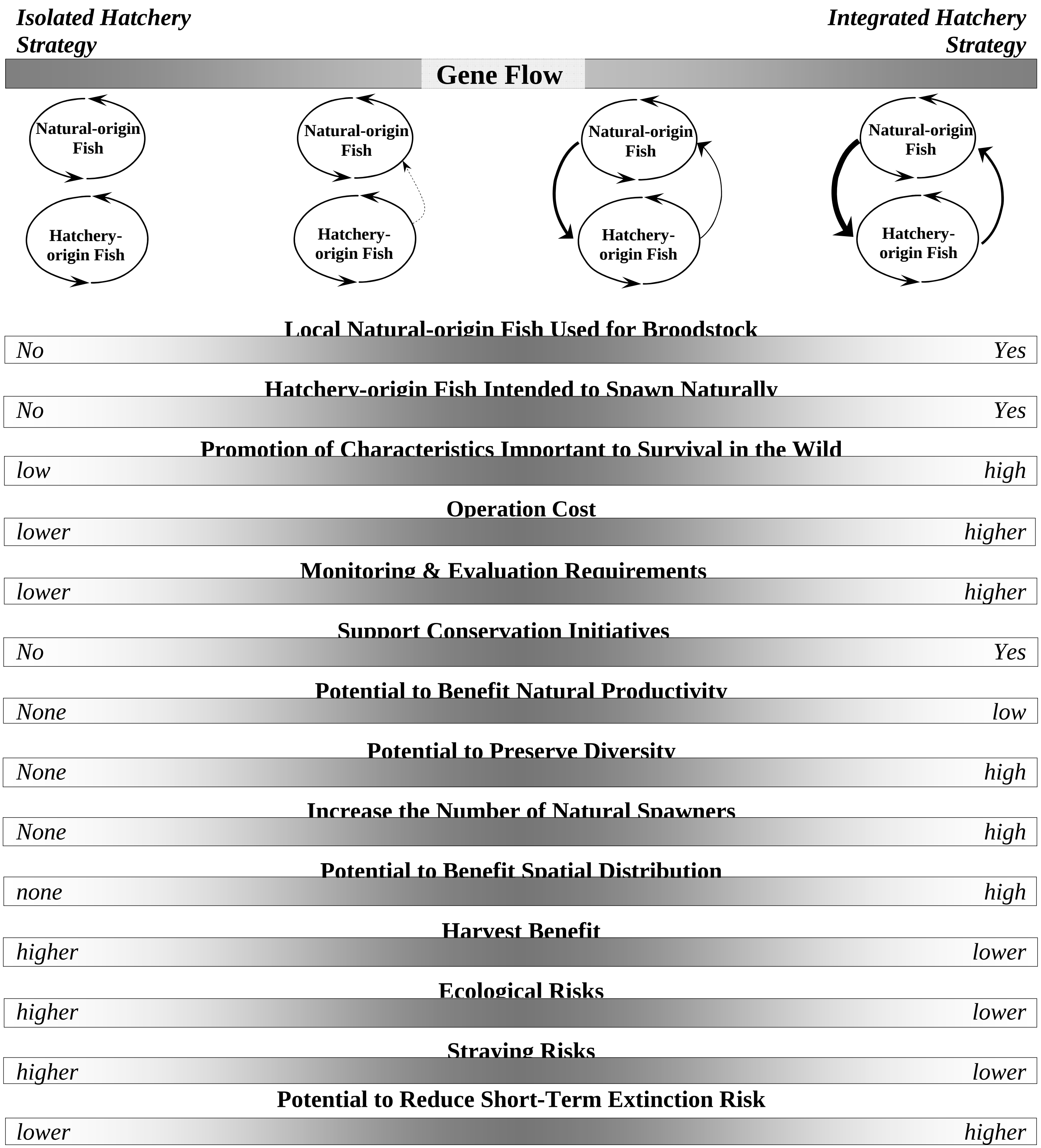
Implementation of the appropriate hatchery strategy, supportive hatchery practices, and accompanying monitoring, evaluation and reform, can benefit conservation and fishing opportunities with limited risks to salmon and steelhead viability.

There is no universal strategy or one-size-fits-all set of *prescriptive* "best management practices" that work well or can apply to all hatchery programs. Hatchery programs operate under a wide range of biological and environmental conditions and they are funded to serve different mandates (e.g.., International and Native American treaty obligations), public laws (e.g., the Water Resources Development Act of 1986 that authorizes the Lower Snake River Compensation Plan), and legal requirements (e.g., Federal Energy Regulatory Commission license agreements). The operation and management of every hatchery program is therefore unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004).

An alternative to assessing hatchery performance against a universal set of criteria (e.g., a specific Proportion Natural Influence: (PNI) threshold) is acknowledging a range of possible practices and corresponding effects, and assessing a particular program against this scale (Figure 2). The "Integrated Strategy" is recommended when HOF are intended to spawn naturally and the better integrated (i.e., moving to the right in Figure 2.) the greater the potential benefit. The "Isolated Strategy" is recommended when HOF are intended to be harvested and not intended to spawn naturally, and the better isolated (i.e., moving to the left in Figure 2) the greater the potential benefits (and lesser risks). For example, the better integrated it is (i.e., moving from left to right in Figure 2) the greater potential for a hatchery program to reduce short-term extinction risk for a target population. Conversely, the better a hatchery program isolates itself or limits interactions between HOF and NOF (e.g., limiting straying and competition between NOF and HOF), the lower are the risks or threats to salmon and steelhead viability.

Under the “isolated” strategy, hatchery fish represent an independent population that is genetically-distinct and potentially domesticated. The exact extent and duration of reproductive isolation that is required for a population to have substantially independent population dynamics is not certain, however, available information indicates that substantial independence will occur when the proportion of a population that consists of migrants is less than 10% (Hastings 1993; McElhany et al. 2000; Mobrand et al. 2005). A hatchery program, for example, would be expected to diverge and become independent from a local natural population when the hatchery broodstock is comprised of less than 10% NOF from the local population.

Figure 2. A comparison of benefits and risks between the Isolated Hatchery Strategy and the Integrated Hatchery Strategy. The level of isolation and the potential to benefit fisheries increases from right to left and the level of integration and the potential to benefit salmon and steelhead conservation increases from left to right.



“Isolated” hatchery programs provide fish for harvest purposes. In general, they are not a tool to promote conservation and can pose significant genetic risks to natural populations. The Hatchery Scientific Review Group (HSRG) has recommended for example that “hatchery-origin spawners from genetically segregated programs represent <5% of the natural spawners as an upper-limit guideline” (Mobrand et al. 2005). Fish from isolated hatchery programs are not the best source for starting a supplementation program. When NOF and fish from an integrated hatchery program do not exist, however, fish from isolated hatchery programs may be used to start an integrated supplementation program. Isolated programs should not be used to supplement natural populations, and natural spawning between fish from isolated hatchery programs and fish from populations important to salmon and steelhead recovery should be strictly limited.

Conversely, under the “integrated” strategy, the natural-to-hatchery gene flow rate must exceed the reverse (hatchery-to-natural) gene flow rate, both for hatchery and natural-origin fish, in order for natural selection effects of the natural environment to exceed hatchery domestication effects (Ford 2002). When a population targeted for supplementation is at very low abundance, it may be impossible, at least immediately, to achieve the desired level of integration. As population abundance increases (abundance is defined here as NOF), it is paramount that the natural-to-hatchery gene flow rate increase because the lesser a hatchery program is integrated with a population targeted for supplementation, the lesser the potential benefit of the program to support recovery. For populations important to ESU or steelhead DPS recovery, the natural population should become capable of sustaining itself without hatchery supplementation, and eventually, the influence of hatchery-origin fish should be strictly limited. “The risks associated with continuing artificial propagation for conservation, harvest supplementation, or both can be reduced, but not entirely eliminated by improving culture practices” (ICTRT 2007). Risks from continued hatchery supplementation should be weighed against the risk of extinction in the absence of hatchery supplementation. Table 2 illustrates hatchery practices under the "Integrated" strategy that will be implemented in the Imnaha River of Northeast Oregon to support the recovery of spring/summer Chinook salmon. The HSRG recommends that for spawning aggregates and populations that are of “moderate or high biological significance or if the goal is to maintain or improve the natural groups viability”, the Proportion of Natural Influence (PNI) should meet or exceed 0.7.

Table 2. One example of an adult management sliding scale using the current production program (360,000 smolts and 242 adults for broodstock) for the Imnaha River in Northeast Oregon above the hatchery weir.

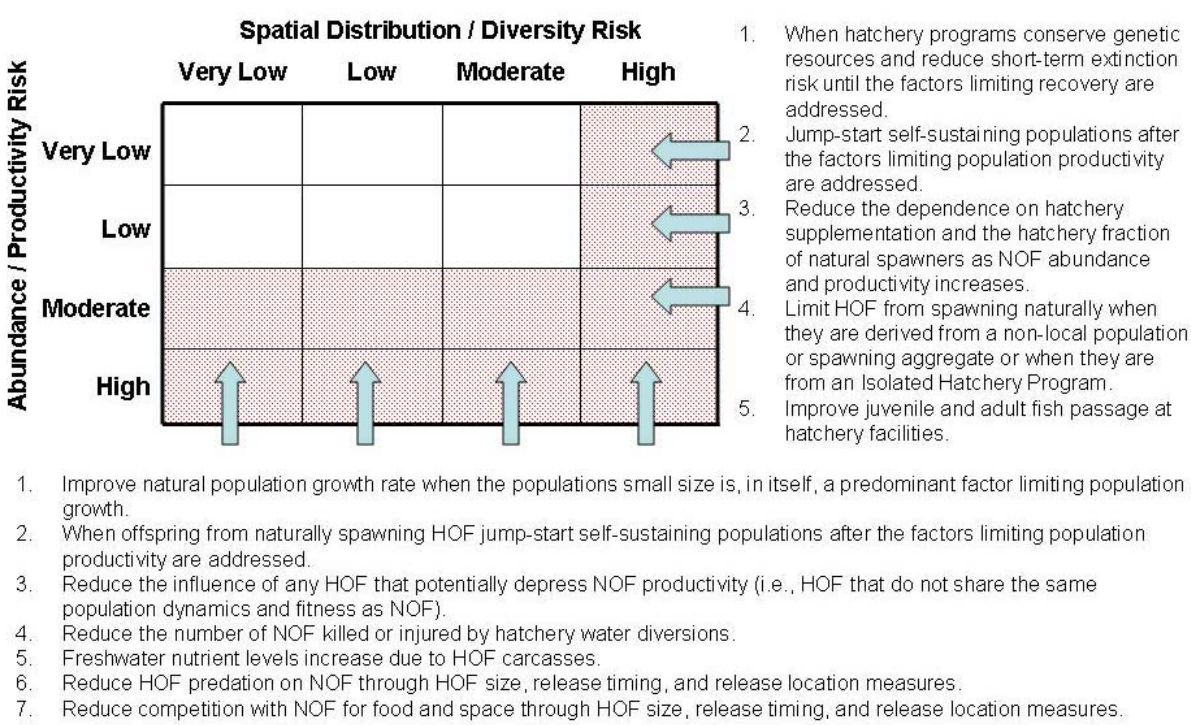
Estimated NOF (ADULTS) to the mouth of the Imnaha River as a Proportion of the Minimum Abundance Threshold (MAT) recommended by the Interior Columbia Technical Recovery Team	Number of ADULT NOF to River Mouth	Expected Handle Rate at Weir of ADULT NOF (50%)	Max % NOF for Broodstock	Number of ADULT NOF Retained for Broodstock (Proportion of Natural Brood)	Proportion of Natural Influence (PNI) Based on Number of NOF Retained for Broodstock	Hatchery Fraction of Natural Spawners
<.05 of Critical	> 15	> 8	0	0		NA
.05 - .5 of Critical	15 - 149	8 - 74	50%	04 - 37 (0.2 - 0.15)		NA
.5 Critical - Critical	150 -299	75 -149	40%	30 - 60 (0.12 - 0.15)	0.15 - 0.26	70%
Critical - .5 of MAT	300 - 499	150 -249	40%	60 - 100 (0.25 - 0.41)	0.29 - 0.41	60%
.5 MAT - MAT	500 - 999	250 - 499	30% **35%**	75 - 150 (0.31 - 0.62) **87 - 175** **(0.36 - 0.72)**	0.38 - 0.55 **0.42 - 0.59**	50%
MAT - 1.5 MAT	1000 - 1499	500 - 749	30% **35%**	150 - 225 (0.62 - 0.93) **175 - 242** **(0.72 - 1.0)**	0.61 - 0.7 **0.67 - 0.73**	40% **35%**
1.5 - 2 MAT	1500 - 1999	750 - 999	25%	188 - 250	0.76 - 0.8	25%
> 2 Times MAT	> 2000	> 1000	25%	> 250	>0.91	<10%

BOLD values would be used after 3 consecutive years greater than minimum abundance threshold (MAT) is achieved.
MAT = Minimum Abundance Threshold

The more closely a hatchery supplementation program meets or exceeds these guidelines for the integrated strategy, the greater the potential benefit of the program from a conservation perspective. In general, and particularly in the case of spawning aggregates or populations that are important for recovery, supplementation hatchery programs are justified only when the demographic risks to a natural population or spawning aggregate exceed the genetic risk from supplementation itself. An analysis of benefits and risks should be a prerequisite to the continued operation of existing hatchery programs and to the implementation of new programs directed at any population determined to be important to the conservation of an ESU or steelhead DPS. Three cases for considering hatchery supplementation include: (1) A natural population is at very low levels of abundance relative to historical levels but the factors limiting viability have been rectified, thus providing the potential or capability of self-sustainability in nature; (2) the natural population is on an extinction trajectory and hatchery intervention is necessary to conserve genetic resources, slow that trajectory and preserve the population until the factors limiting viability are rectified, and (3) reestablishing natural populations throughout all or some portion of their natural or former range.

Under Case 1, supplementation would be used to quickly increase the number of natural spawners and ultimately, the number of natural-origin recruits (the so-called jump-start approach, see Figure 3). The goal for the hatchery program (i.e., the number of years or fish generations in operation and or some minimum threshold of natural-origin recruits) should be predetermined to establish when supplementation has served its purpose and should be terminated. In this case, artificial propagation and supplementation can improve population viability and biological status and benefit salmon and steelhead recovery. A hatchery program under this scenario may be redirected to serve strictly harvest, research or educational purposes, but only if it did not appreciably reduced progress towards ESU or steelhead DPS recovery.

Figure 3. Hatchery actions that can reduce risk and benefit population abundance and productivity (the vertical axis) and risk to spatial distribution and genetic diversity (the horizontal axis). (HOF is hatchery origin fish and NOF is natural-origin fish.)



Under Case 2, the natural population is not-viable under current conditions and hatchery intervention is necessary to prevent extinction. In this case, artificial propagation conserves genetic resources, serves as a "life-support" system, and supplementation is the primary mechanism for preserving at least naturally-spawning fish and natural-origin recruits for a hatchery-maintained population. Supplementation provides a mechanism to produce natural-origin recruits for inclusion into the hatchery broodstock each year, but the natural population is not able to sustain itself and depends on artificial propagation. In this case, artificial propagation and supplementation *cannot* increase viability to meet criteria for ESA recovery until the factors limiting natural population viability are rectified. Artificial propagation in this case can "buy time" until those factors are addressed. Because in this case artificial propagation conserves genetic resources, it can also help to speed recovery as the factors and threats limiting viability are addressed.

The removal of adults from a naturally-spawning population has the potential to reduce the size of the natural population (sometimes called "mining"), cause selection effects, and remove nutrients from upstream reaches (Spence et al. 1996; NRC 1996; Kapuscinski 1997). In cases where a natural population is below its critical threshold for abundance and not replacing itself, a hatchery supplementation program can slow trends toward extinction and buy time until the factors limiting population viability are corrected. Risks to the natural population, including numerical reduction and selection effects, are in some cases subordinate to the need to expeditiously implement the hatchery program and reduce the likelihood of extinction in the short term (e.g., Redfish Lake sockeye).

Under Case 3, hatchery supplementation can improve population viability and biological status and benefit recovery by increasing abundance, spatial structure and, inevitably, diversity following establishment of a self-sustaining natural population (or spawning aggregation).

5. Progress in Hatchery Reform

The process of learning and adjusting and improving hatchery practices has been underway from the fish hatchery programs. Advances in nutrition, disease treatment and prevention, genetics and marking technologies for example, have been profound and have been implemented at hatchery programs to great affect. Examples in hatchery reform are summarized in Table 3**.**

Table 3. A summary of progress in hatchery reform effecting seven distinct groups of Interior Columbia Basin salmon and steelhead.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Progress in Hatchery Reform
Snake River fall Chinook	The Snake River fall Chinook programs have increased ESU genetic resources and spatial structure. Hatchery programs have helped jumpstart the ESU, and natural-origin fall Chinook returns have increased from <100 in 1990 to between 2,000 and 5,000 from 2001 through 2004. Spatial distribution has expanded into the Clearwater and lower Grande Ronde River sub-basins. Changes at the Umatilla program have reduced straying into the Snake River and reduced threats to genetic diversity. Monitoring of hatchery supplementation effectiveness and effects on productivity is scheduled to begin in 2008.
Snake River spring/summer Chinook	Grande Ronde Basin hatchery programs are using local fish for broodstock after terminating the use of Rapid River Chinook in the mid-1990s. Locally derived broodstock is being used in the Tucannon, Imnaha, S. Fork Salmon, Pahsimeroi, and upper Salmon Rivers. Rescue/safety net hatchery programs are conserving genetic resources and reducing short-term extinction risk for populations in Catherine Creek, the upper Grande Ronde, the Tucannon, and the Lostine. A new program, starting in 2001 is reintroducing Chinook into Lookingglass Creek. A new sliding-scale for collecting hatchery broodstock and for controlling the proportion of natural spawners comprised of hatchery-origin fish will help put populations in the Imnaha and Grande Ronde on a trend towards recovery.
Upper Columbia spring Chinook	A rescue program is reducing short-term risk of extinction for White River Chinook. Termination of the Entiat program in 2007 will eliminate a key factor limiting spring Chinook viability. The Winthrop National Fish Hatchery continues a transition (which began in 2001) to a locally derived broodstock and has phased-out the use of Carson lineage stock.
Upper Columbia Steelhead	The use of broodstock derived from lower Columbia Skamania stock steelhead was terminated in the mid 1990s. A local broodstock was developed to replace Wells stock in the Wenatchee. The use of early spawned hatchery fish has been minimized, to promote more natural spawn timing of hatchery fish. Steelhead releases were terminated in the Entiat beginning in 1997. Wells Hatchery has increased the proportion of natural-origin steelhead in the annual broodstock, and has taken steps to synchronize the maturation of hatchery-origin steelhead with natural-origin steelhead in order to increase the reproductive success of hatchery fish spawning in the wild. Monitoring of hatchery supplementation effectiveness and effects on productivity is scheduled to begin in 2008.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Progress in Hatchery Reform
Middle Columbia Steelhead	The Umatilla program terminated the use of broodstock derived from lower Columbia Skamania stock steelhead beginning in 1981. The Walla Walla and Touchet programs have reduced the size of their juvenile releases by more than 25% to reduce straying. A local broodstock is being tested to replace Lyons Ferry stock in the Touchet River.
Snake River Steelhead	Hatchery releases in the lower Salmon River basin have been restricted to the Little Salmon River. Locally derived broodstock is being developed and tested for use in the Tucannon River and in the East Fork Salmon River. Use of hatchery-origin steelhead in tributary habitat has been reduced.

6. Technical Recovery Team Criteria

The ICTRT has included HOF considerations in their work and it is important to understand the relevance of ICTRT developments to hatchery effects assessments which are the subject of this report.

There are multiple considerations in assessing hatchery effects on population risk. The ICRTRT flow-chart approach or graphical representation of risk criteria associated with natural spawner composition (ICTRT 2007), is only one consideration in assessing hatchery effects and genetic risks to population structure and the ICTRT itself makes the point that "we do encourage case-by-case treatment of conditions that may affect the risk experienced by the population" (ICTRT 2005). Flagg et al. 2004 also advises against any single approach to assessing hatchery effects and states that "Genetic risks from any particular strategy must be estimated on a case-by-case basis."

Case-by-case analysis or treatment of hatchery effects is particularly important when a hatchery program is part of a recovery action. ICTRT criteria provide a sound general approach for "assigning risk" based on the source, level, and duration of exogenous fish spawning naturally. Exogenous fish are defined as all fish of hatchery-origin AND all natural-origin fish that are present due to unnatural, anthropogenically-induced conditions, and case-by-case considerations are particularly important when "exogenous" fish are from hatchery programs implemented to promote or aid in recovery.

Hatchery programs can be called upon and used as a tool to aid or promote recovery and reduce population risk (Hard et al. 1992, Flagg et al. 2004). For example, forgoing the possibility of rebuilding a population in the shortest time using artificial propagation potentially increases population risk. Under conditions when the size of a population is very low, then regardless of the amount of genetic variability present, the population may become extinct for demographic reasons (Leigh 1981, Goodman 1987, Lande 1988) and in this case, the risks posed by artificial propagation may be outweighed by its potential to rapidly increase the number of natural spawners and avoid extinction (Hard et al. 1992). Under conditions like these, violating spawner composition criteria (e.g., the percentage of exogenous HOF spawning naturally) may be necessary, and even considered a credit to a hatchery program if NOF adult returns fall to critically low levels and/or the natural population is on an extinction trajectory under current conditions. Clearly then, assessments of hatchery effects and population risk should depend on case-by-case conditions in combination with spawner composition risk criteria developed by the ICTRT.

ICTRT criteria alone do not constitute “best management practices” for operating hatchery programs and for determining hatchery effects. There is no “one-size-fits-all” set of prescriptive “best management practices (see section 4.3.3, Hatchery Practices) and the ICTRT states that “we do not specify specific management practices” but “rather we suggest that hatchery programs that conform to the principles described in recent publications (Flagg et al. 2004, Olson et al. 2004, Mobrand et al. 2005) could be considered to have “best management practices” (ICTRT 2007).

7. Hatchery Overviews

An overview of 45 hatchery programs in the upper Columbia River and Snake River Basin found that 23 programs conserved salmon and steelhead genetic resources and reduced short-term extinction risk while nine programs were determined to be a limiting factor or a threat to viability. To a certain extent, then, the reasons the latter programs represent threats largely indicate the course for correction. Our assessment also concluded that a large number of improvements and new programs have been implemented in recent years and that it is too early to assess their effects.

NMFS (2004a) provides an overview at two levels: at the population level and at the ESU or DPS level. For programs in the Interior Columbia (upstream from Bonneville Dam), Hatchery Effects Appendix (NMFS 2006a) developed with input provided by members of the Hatchery and Harvest Workgroup of the FCRPS collaboration, (1) summarized the major factors limiting salmon and steelhead recovery at the population scale, (2) provided an inventory of existing hatchery programs including their funding source(s) and the status of their regulatory compliance under the ESA and under the National Environmental Policy Act (NEPA), (3) summarized the effects on salmon and steelhead viability from current hatchery operations, and (4) identified new opportunities or changes in hatchery programs likely to benefit population viability. As a follow-up to the Hatchery Effects Report, NMFS developed recommendations for assessing hatchery effects, including an overview of Interior Columbia Basin hatchery program effects, and presented this paper and results to the Hatchery and Harvest Workgroup and to the Policy Workgroup in August of 2006 (NMFS 2006b). NMFS received comments and made edits to this paper (NMFS 2007).

An overview of effects for selected hatchery programs is provided in Table 4. The four categories of effects are; (1) A key factor limiting viability, (2) genetic resources are conserved, (3) viability improves, and (4) provides fishery mitigation. Effects assessments for the category "A key factor limiting viability" are based on available limiting factors and threats analysis (see footnote 1).

For the category "genetic resources are conserved", gamete preservation, juvenile and adult hatchery production, and naturally spawning hatchery fish (i.e., only hatchery fish included in an ESU or steelhead DPS) can; (1) reduce the immediate risk of extinction when NOF abundance is low and declining, or (2) potentially help to accelerate the rate of recovery as limiting factors and threats are addressed. A key feature of the ESU concept is the recognition of genetic resources that represent the ecological and genetic diversity of the species. These genetic resources can reside in a fish spawned in a hatchery as well as in a fish spawned in the wild. Genetic resources are defined as all fish included in an ESU or steelhead DPS. NMFS listing determinations describe which NOF and HOF are included in each ESU or steelhead DPS (70 FR 37160; June 28, 2005).

NOF effects qualify under the category "viability improves". The previous category "genetic resources are conserved", represented the effect of conserving all the resources included in an ESU or steelhead DPS (i.e., NOF and HOF combined) in the absence of any associated improvement in NOF abundance, productivity, diversity, and spatial distribution. Under this category, improvements in NOF viability must be measurable or determined reasonably certain to occur as a result of hatchery actions. Reductions in limiting factors or threats (e.g., reduced HOF naturally spawning that potentially depresses NOF productivity), improved environmental conditions including improved stream flows, spawning gravel composition and nutrient levels, and increases in NOF abundance, productivity, diversity or spatial distribution are considered beneficial or creditable because they reduce the extinction risk of an ESU or steelhead DPS in the foreseeable future (i.e., long-term extinction risk is reduced). The status or viability of an ESU generally depends on four key attributes: abundance; productivity; genetic diversity; and spatial distribution. "The effects of HOF on the status of an ESU will depend on how the HOF within the ESU affect each of the attributes" (70 FR 37160; June 28, 2005). Only HOF included in an ESU or steelhead DPS will be included in assessing an ESU or DPS's status in the context of their contributions to conserving natural self-sustaining populations. "A population that depends upon naturally spawning HOF for its survival is not viable" (McElhany et al 2000).

Another important question is the level or extent of effect (positive or negative) resulting from hatchery actions in each of these categories. For example, a "yes" under the category 'genetic resources are conserved", would constitute a high positive value and benefit if the population affected was determined to be important to recovery and at high risk.

The category "provides fishery mitigation" summarizes which fisheries are served by individual hatchery programs. For example, Columbia River Indian Treaty, recreational, and commercial fisheries under US v. Oregon jurisdiction are supported by production from the Leavenworth hatchery program. Snake River fall Chinook hatchery programs help support ocean fisheries from California to Alaska, and tribal, commercial and public fishing in the Columbia River.

Table 4. An overview of selected hatchery programs.

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Leavenworth NFH	Federal mitigation for Grande Coulee Dam	Wenatchee R. spring Chinook	No	No	No	No	USvOR
Entiat fishery mitigation		Entiat R. spring Chinook	No	Yes Program terminated in 2007 last returns in 2010	No	No	USvOR
Winthrop supplementation & fishery mitigation		Methow R. spring Chinook	Yes	No	Yes	No	USvOR
Winthrop fishery mitigation		Okanogan R. spring Chinook	No	No	No	No	USvOR and Colville fisheries
Chiwawa supplementation & fishery mitigation	PUD mitigation for Rock Is. Dam	Wenatchee R. spring Chinook	Yes	No	Yes	No	USvOR
White River supplementation		Wenatchee R. spring Chinook	Yes	No	Yes	New program	None

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Methow supplementation & fishery mitigation	PUD mitigation for Wells Dam	Methow R. spring Chinook	Yes	No	Yes	No	USvOR
Twisp supplementation & fishery mitigation		Methow R. spring Chinook	Yes	No	Yes	Unknown	USvOR
Wenatchee supplementation	PUD mitigation for Rock Is. Dam	Wenatchee R. steelhead	Yes	No	Yes	Unknown	USvOR
Wells Dam supplementation & fishery mitigation	PUD mitigation for Wells Dam	Methow R. steelhead	Yes	Yes	Yes	No	USvOR
		Okanogan R. steelhead	Yes	Yes	No	New program	USvOR and Colville Tribal

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Winthrop NFH supplementation & fishery mitigation	Federal mitigation for Grand Coulee Dam	Methow R. steelhead	Yes	Yes	No	No	USvOR
Winthrop NFH supplementation & fishery mitigation		Okanogan R. steelhead	Yes	Yes	Yes	No	USvOR and Colville Tribe
Tucannon supplementation & fishery mitigation	Federal mitigation for Lower Snake Dams	Tucannon R. spr/sum Chinook	Yes	No	Yes	New program unknown	USvOR
Lostine supplementation mitigation (captive brood phase)		Lostine R. spr/sum Chinook	Yes	No	Yes	New program unknown	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Catherine Crk supplementation mitigation (captive brood phase)	Federal mitigation for Lower Snake Dams (cont.)	Catherine Crk spr/sum Chinook	Yes	No	Yes	New program unknown	USvOR
Upper Grande Ronde supplementation mitigation (captive brood phase)		Upper Grande Ronde spr/sum Chinook	Yes	No	Yes	New program unknown	USvOR
Imnaha supplementation & fishery mitigation		Imnaha R. spr/sum Chinook	Yes	No	Yes	No	USvOR
Imnaha supplementation & fishery mitigation		Big Sheep & Lick Crks. spr/sum Chinook	Yes	No	Yes	Unknown	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Lookingglass supplementation & fishery mitigation	Federal mitigation for Lower Snake Dams	Lookingglass Crk. spr/sum Chinook	Yes	No	Yes	Unknown	USvOR
McCall fishery mitigation	Federal mitigation for Lwr Snake Dams (cont.)	SF Salmon spr/sum Chinook	Yes	No	Yes	No	USvOR
Sawtooth fishery mitigation		Upper Salmon spr/sum Chinook	Yes	No	No	No	USvOR
Tucannon supplementation mitigation (captive brood phase)	Northwest Power Act	Tucannon R. spr/sum Chinook	Yes	No	Yes	Unknown	USvOR
Johnson Cr supplementation mitigation		SF Salmon spr/sum Chinook	Yes	No	Yes	Unknown	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Rapid River fishery mitigation	Idaho Power Company mitigation for Snake R Dams	Little Salmon spr/sum Chinook	No	No	For spring Chinook originating above Hells Canyon	No	USvOR
Pahsimeroi, fishery mitigation		Pahsimeroi R. spr/sum Chinook	Yes	No	No	No	USvOR
Tucannon, fishery mitigation	Federal mitigation for Lower Snake River Dams	Tucannon R. steelhead	No	No	No	No	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Tucannon, supplementation & fishery mitigation	Federal mitigation for Lower Snake River Dams (cont.)	Tucannon R. steelhead	Yes	No	Yes	Unknown	USvOR
Clearwater supplementation & fishery mitigation		SF Clearwater B-steelhead	Yes	No	Unknown	Unknown	USvOR
Dworshak Lolo Crk supplementation & fishery mitigation		Lolo Crk B-steelhead	Yes	No	Unknown	Unknown	USvOR
Little Salmon fishery mitigation		Little Salmon & Rapid R steelhead	No	No	No	No	USvOR
East Fork Salmon supplementation mitigation		East Fork Salmon R B-steelhead	Yes	No	Yes	Pending	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
East Fork Salmon fishery mitigation	Federal mitigation for Lower Snake River Dams (cont.)	East Fork Salmon R B-steelhead	No	No	No	No	USvOR
Sawtooth fishery mitigation		Upper Salmon R Steelhead	No	Threat	No	No	USvOR
Wallowa fishery mitigation		Wallowa, Minam, Lostine, Deschutes & John Day Steelhead	No	Threat	No	No	USvOR
Cottonwood Pond fishery mitigation		Lwr Grande Ronde steelhead	No	Threat	No	No	USvOR
Little Sheep supplementa tion & fishery mitigation		Imnaha steelhead	Yes	Threat	Yes	No	USvOR

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Dworshak supplementation & fishery mitigation	Federal mitigation for Dworshak Dam	SF Clearwater B-steelhead	Yes	Unknown	Yes	No	USvOR
Dworshak fishery mitigation		NF Clearwater B-steelhead	Yes	No	Yes	Unknown	USvOr
Pahsimeroi fishery mitigation	Idaho Pwr Company mitigation for Snake R Dams	Pahsimeroi R steelhead	No	No	No	No	USvOR
Oxbow fishery mitigation		Hells Canyon tributaries steelhead	No	Threat	No	No	USvOR
Lyons Ferry supplementation & fishery mitigation (includes Pittsburg Landing, Cpt John Rapids and Big Canyon acclimation sites)	Federal mitigation for Lower Snake R. Dams	Lwr Mainstem Snake fall Chinook	Yes	No	Yes	Yes	USvOR , PFMC, US/Canada

Hatchery Program	Authority for the Hatchery Program	Affected Fish	Hatchery fish are included in an ESU or steelhead DPS[1]	Hatchery Program Overviews[5]			
				A major factor limiting viability[2]	Genetic resources are conserved[3]	Viability improves[4]	Provides fishery mitigation
Nez Perce Tribal supplementation & fishery mitigation	Northwest Power Act	Clearwater fall Chinook	Yes	No	Yes	New program	USvOR, PFMC, US/Canada
Oxbow fishery mitigation	Idaho Pwr Company mitigation for Snake R Dams	Mainstem Snake fall Chinook	Yes	No	Yes	Unknown	USvOR, PFMC, US/Canada
Stanley Basin supplementation mitigation	Northwest Power Act	Redfish, Alturas & Petit Lakes Sockeye	Yes	No	Yes	No	No

[1] Hatchery fish included in an ESU or steelhead DPS are identified in NMFS 2003 and in 2004a. Hatchery fish not included in an ESU or steelhead DPS cannot conserve ESU or DPS genetic resources or improve their viability.
[2] Limiting factors are identified on a population scale by final and draft ESA Recovery Plans, recovery planning expert panels, NMFS 2004b and PCSRF 2005, 2006, and 2007.
[3] When abundance is low and declining, hatchery programs, following best management practices, can buy time and reduce short-term extinction risk by preserving genetic resources. Hatchery fish and recruits from naturally spawning hatchery fish increase ESU or DPS resources and reduce short-term extinction risk.
[4] Increases in NOF viability (i.e., effects across the four viability parameters is a net positive) can be attributed to a hatchery program. Can reduce long-term risk of extinction and counts toward achieving criteria for ESA recovery and reducing survival gaps.
[5] See Salmonid Hatchery Inventory and Effects Evaluation Report: An evaluation of the effects of artificial propagation on the status and likelihood of extinction of West Coast salmon and steelhead under the Federal Endangered Species Act (NMFS 2004a).

8. References

For a complete list of literature cited, see Supplementary Comprehensive Analysis, Chapter 12

Hatchery Effects Appendix

May 5, 2008

Hatchery Effects Report for Protected Salmon & Steelhead of the Interior Columbia Basin

July 21, 2006

Working Paper of the FCRPS Remand Hatcheries & Harvest Working Group

Table of Contents

1. Introduction

Securing the future of salmon and steelhead continues to be a substantial challenge. For the Interior Columbia Basin, including the Columbia River Gorge, seven of nine distinct groups of salmon and steelhead and parts of four more (i.e., Lower Columbia Chinook, coho salmon, steelhead, Columbia River chum salmon) are at risk of extinction and protected under the Federal Endangered Species Act (NMFS 2005a, and NMFS 2006a). Interests from all over Idaho, Oregon, and Washington are collaborating to reach a shared vision for salmon and steelhead recovery and to develop widespread support for addressing the factors limiting their survival. This report is intended to inform and support these collaborative efforts.

In the Interior Columbia, hatcheries are used as mitigation or compensation for factors limiting salmon and steelhead viability. Over many years, authorization to build and operate water development projects has included obligations to also fund hatchery mitigation or compensation. More than 95 percent of the hatchery programs from Bonneville Dam upriver are funded annually by Federal, Public Utility, and Private Utility dollars. In general, these programs have been called on to either (1) compensate for areas taken out of salmon and steelhead production altogether (e.g., the Leavenworth, Entiat, and Winthrop National Fish Hatcheries are compensation for Grande Coulee Dam blocking fish passage to at least half of the area producing upper Columbia spring Chinook salmon and steelhead), (2) compensate for losses because of reduced salmon and steelhead productivity from the continuing operation of dams, (3) preserve genetic resources until productivity improves and salmon and steelhead can become self-sustaining, or (4) help re-colonize areas or jumpstart production when productivity improves sufficiently and salmon and steelhead can become self-sustaining. Hatchery programs alone cannot mitigate by promoting salmon and steelhead recovery in lieu of addressing the factors limiting salmon and steelhead productivity.

Incidental to fulfilling their mitigation obligations, hatchery programs can benefit or harm the viability of salmon and steelhead. The presence of hatchery fish potentially can benefit the overall status of salmon and steelhead by contributing to increasing the number of natural spawners and spatial distribution, by serving as a source population for repopulating unoccupied habitat and by conserving genetic resources (NMFS 2005a). Conversely, hatchery-induced genetic change can reduce the fitness of both hatchery and natural-origin fish in the wild (Ford et al. 2002) and hatchery induced ecological effects (e.g., competition for food and space) can reduce salmon and steelhead productivity and abundance. Salmon and steelhead that are partially or wholly dependent on hatchery propagation for their continued existence are not viable (McElhany et al. 2000).

More than one hundred hatchery programs operate in the Columbia Basin above Bonneville Dam; this report: (1) summarizes the major factors limiting salmon and steelhead recovery at the population scale, (2) provides an inventory of existing hatchery programs including their funding source and the status of their regulatory compliance under the Endangered Species Act (ESA) and under the National Environmental Policy Act (NEPA), (3) describes the effects on salmon and steelhead viability (positive, negative, no effect or unknown) from current hatchery operations, including programs not in the same vicinity, and (4) identifies new opportunities or changes in hatchery programs likely to benefit viability. The report focuses on hatchery programs that are associated with salmon and steelhead protected under the ESA (e.g., all spring Chinook salmon hatchery programs located within the geographical boundaries of the Upper Columbia spring Chinook Evolutionarily Significant Unit).

The primary criteria for determining the viability of salmon and steelhead populations are described in McElhany et al. (2000). These criteria are the abundance, productivity, spatial distribution and diversity of natural-origin fish. Hatchery programs can benefit or harm salmon and steelhead viability. In determining the effects (positive or negative) of hatchery programs on salmon and steelhead viability, it is necessary then to determine their influence on these criteria. It is also is important to recognize that a single hatchery effect can and often does influence multiple viability criteria. For example, increases in natural-origin fish (NOF) attributable to a hatchery program can benefit both abundance and spatial structure while, on the other hand, the removal of NOF for hatchery broodstock reduces abundance and can reduce productivity also. Ultimately, the number, nature, and scale of hatchery programs must be consistent with the maintenance of a naturally self-sustaining ESU or steelhead DPS.

The following guidance is intended to help determine the influence of hatchery programs on each of the different viability criteria.

Abundance is the number of fish produced by natural processes that have spent their entire life cycle in nature (i.e., natural-origin fish). This is often referred to as gravel-to-gravel survival or fish originating from naturally spawning parents that hatch in a stream's gravel and that survive to spawn naturally themselves years later. The effect of a hatchery program on salmon and steelhead abundance should be determined by:

1. The proportion of natural-origin fish (NOF) removed from any population or spawning aggregate to provide hatchery broodstock (i.e., NOF that are taken into a hatchery instead of left to spawn naturally). This is often referred to a "mining" a group of fish for broodstock.
2. The proportion of NOF killed or injured by hatchery facilities (e.g., hatchery water intakes).
3. Reduced or lost natural production caused by hatchery facilities that block, delay, or impede adult fish from returning to spawning areas (e.g., weirs, ladders, or traps).
4. Increases in NOF attributable to hatchery supplementation. Eggs and juveniles planted into streams and adult returns from these plants, serve to seed freshwater spawning and rearing areas. Only the progeny of naturally spawning fish (natural-origin and hatchery-origin) count in determining abundance for viability purposes.
5. Injury or mortality of adult NOF at hatchery facilities (i.e., physical injury, handling effects etc.).

Productivity is the survival rate of natural-origin fish as related to parent run size. It is a measure that directly relates to the potential ability for a population or spawning aggregate to be self-sustaining. For example, the productivity measure used by the Interior Columbia Technical Recovery Team is expressed in terms of recruits per spawner or the degree to which natural spawning adults in one generation are replaced by natural-origin natural spawning adults in the next generation. This measure of life-cycle productivity is affected by mortality and survival at all life stages taken together. In general, if productivity is limited by the number of natural spawners (e.g., fish have difficulty finding mates or habitat is being re-colonized), then naturally spawning hatchery fish potentially can increase natural productivity. The effect of a hatchery program on salmon and steelhead productivity should be determined by:

1. The productivity of fish derived from hatchery-origin fish (i.e., the life-cycle survival or replacement rate of progeny of naturally spawning hatchery-origin fish).
2. The productivity of the progeny of naturally spawning hatchery-origin fish (HOF) relative to naturally spawning NOF.
3. The life history characteristics of naturally spawning HOF compared to naturally spawned NOF (e.g., age-of-return, size-at-return, spawn timing, fecundity, etc.).
4. Competition for food or habitat between NOF and planted HOF.
5. Maintenance of within population substructure (e.g., multiple spawning aggregates).
6. Whether hatchery facilities (e.g., weirs, ladders, diversions) affect escapement back to the area of origin, rates of natural straying, or dispersement of fish (adults and juveniles) into under-used habitats, especially when adult returns are large.
7. Competition for prime spawning areas and redd superimposition.
8. Predation on juvenile NOF by planted HOF.
9. Spawning between HOF and NOF that reduces productivity.
10. HOF nutrient contribution to freshwater rearing areas.

Spatial structure is the range or distribution of NOF. Any viability evaluation must consider spatial structure within a population (or group of populations) because spatial structure affects extinction risk (McElhany et al. 2000). The effect of hatchery programs on salmon and steelhead spatial structure should be determined by:

1. Whether hatchery facilities (i.e., weirs, ladders, diversions, etc.) affect escapement back to the area of origin, rates of natural straying, or dispersal of fish (adults and juveniles) into under-used habitats, especially when adult returns are large.
2. Competition for prime spawning areas and redd superimposition.
3. Competition between planted HOF juveniles and NOF for rearing areas.
4. Predation on juvenile NOF by planted HOF.
5. Spawning between HOF and NOF that reduces productivity and affects spatial distribution.

Diversity refers to the distribution of traits within and among populations of salmon and steelhead. These traits include anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, physiology and molecular genetic characteristics. A combination of genetic and environmental factors largely causes phenotypic diversity. Variation or diversity in these and other traits is important to viability because a) it allows fish to take advantage of a wider array of environments; b) it spreads the risk (e.g., different ocean distribution patterns mean not all fish are at risk from local or regional varying ocean conditions); and c) genetic diversity allows fish to adapt to changing environmental conditions. Habitat, harvest, and hatchery factors can all affect diversity. In the case of hatchery programs, gene flow strongly influences patterns of diversity within and among salmon and steelhead populations. The effect of hatchery programs on salmon and steelhead diversity should be determined by:

1. The similarity of HOF traits relative to NOF traits and the rate of gene flow of HOF into a natural population or spawning aggregate. Natural rates of gene flow have helped salmon and steelhead to persist and adapt to local conditions and the natural or background level between spawning aggregates, between populations, between Distinct Population Segments and between Evolutionarily Significant Units should be maintained.
2. The extent to which a hatchery program preserves or builds salmon or steelhead genetic resources.

2. Effects Assessments

There are three categories of effects included in this report: (1) significant factors limiting population viability, (2) slowing trends toward extinction, and (3) improved viability (this corresponds to reducing the long-term risk of extinction or reducing survival gaps). A summary of effects assessments for Interior Columbia hatchery programs is provided in Table 1. A summary of progress in hatchery reform affecting seven groups of Interior Columbia Basin salmon and steelhead is provided in Table 2.

ESU-scale limiting factors analysis is derived primarily from ESA listing determinations and NOAA's 2005 report to Congress (NMFS 2005a). Limiting factors analysis at the population scale (see Attachment 1) is derived from salmon and steelhead recovery plans authored by state and local interests and by information provided by the ICTRT.

Slowing trends toward extinction includes hatchery supplementation programs that preserve genetic resources and increase the number of natural spawners. These programs buy time until the factors limiting viability are addressed. Actions in this category should be considered interim or short-term and, for this reason, risk associated with the origin and influence of naturally spawning hatchery-origin fish should not apply here.

Reductions in hatchery program impacts and, second, actions that benefit viability criteria fall into category three. For example, limiting exogenous hatchery-origin and natural-origin fish natural spawning and reestablishing self-sustaining populations in their former range using hatchery-origin fish would qualify for credit under category three.

The relative value or level of credit attributable to a hatchery action depends on (1) the hatchery practices, (2) the degree to which the hatchery program limits viability, (3) the population's importance to ESU or DPS viability, and (4) the status of the population. Hatchery programs for example that isolate themselves from natural populations or spawning aggregates have little or no value to the biological status of salmon and steelhead.

Table 1. An assessment of hatchery programs in the Interior Columbia Basin.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Authority for the Hatchery Program	Hatchery Program	Affected Population	Hatchery Program Assessment		
				A Top 5 limiting factor affecting population viability[1]	Slows trends toward extinction[2]	Improves viability and population status[3]
Upper Columbia Spring Chin ESU	Federal mitigation for Grande Coulee Dam	Leavenworth fishery mitigation	Wenatchee R.	No	No	No
		Entiat fishery mitigation	Entiat R.	Yes	No	No
		Winthrop supplementation & fishery mitigation	Methow R.	No	Yes	No
		Winthrop fishery mitigation	Okanogan R.	No	No	No
	PUD mitigation for Rock Island Dam	Chiwawa supplementation & fishery mitigation	Wenatchee R.	No	Yes	Pending progress on limiting factors
		White supplementation	Wenatchee R.	No	Yes	Yes
	PUD mitigation for Wells Dam	Methow supplementation & fishery mitigation	Methow R.	No	Yes	No
		Twisp supplementation & fishery mitigation	Methow R.	No	Yes	Pending progress on limiting factors
Upper Columbia steelhead	PUD mitigation for Rock Island Dam	Wenatchee supplementation mitigation	Wenatchee R.	No	Yes	Pending progress on limiting factors
	PUD mitigation for Wells Dam	Wells Dam supplementation & fishery mitigation	Methow R.	Yes	No	No
		Wells Dam supp. & fishery mitigation	Okanogan R.	Yes	No	No

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Authority for the Hatchery Program	Hatchery Program	Affected Population	Hatchery Program Assessment		
				A Top 5 limiting factor affecting population viability[1]	Slows trends toward extinction[2]	Improves viability and population status[3]
Upper Columbia steelhead	Federal mitigation for Grande Coulee Dam	Winthrop NFH supplementation & fishery mitigation	Methow R.	Yes	No	No
		Winthrop NFH supplementation & fishery mitigation	Okanogan R.	No	Yes	Pending progress on limiting factors
Snake R. spring/summer Chinook	Federal mitigation for Lwr Snake Dams	Tucannon supplementation & fishery mitigation	Tucannon R.	No	Yes	Pending progress on limiting factors
		Lostine supplementation mitigation (captive brood phase)	Lostine R.	No	Yes	Pending progress on limiting factors
		Catherine Crk supplementation mitigation (captive brood phase)	Catherine Crk	No	Yes	Yes
		Upper Grande Ronde supplementation mitigation (captive brood phase)	Upper Grande Ronde	No	Yes	Yes
		Imnaha supplementation & fishery mitigation	Imnaha R.	No	Yes	No
		Imnaha supplementation & fishery mitigation	Big Sheep & Lick Crks	No	Yes	No
		Lookingglass supplementation & fishery mitigation	Lookingglass Crk	No	Yes	Yes
		McCall fishery mitigation	SF Salmon	No	Yes	No
		Sawtooth fishery	Upper Salmon	No	Yes	No

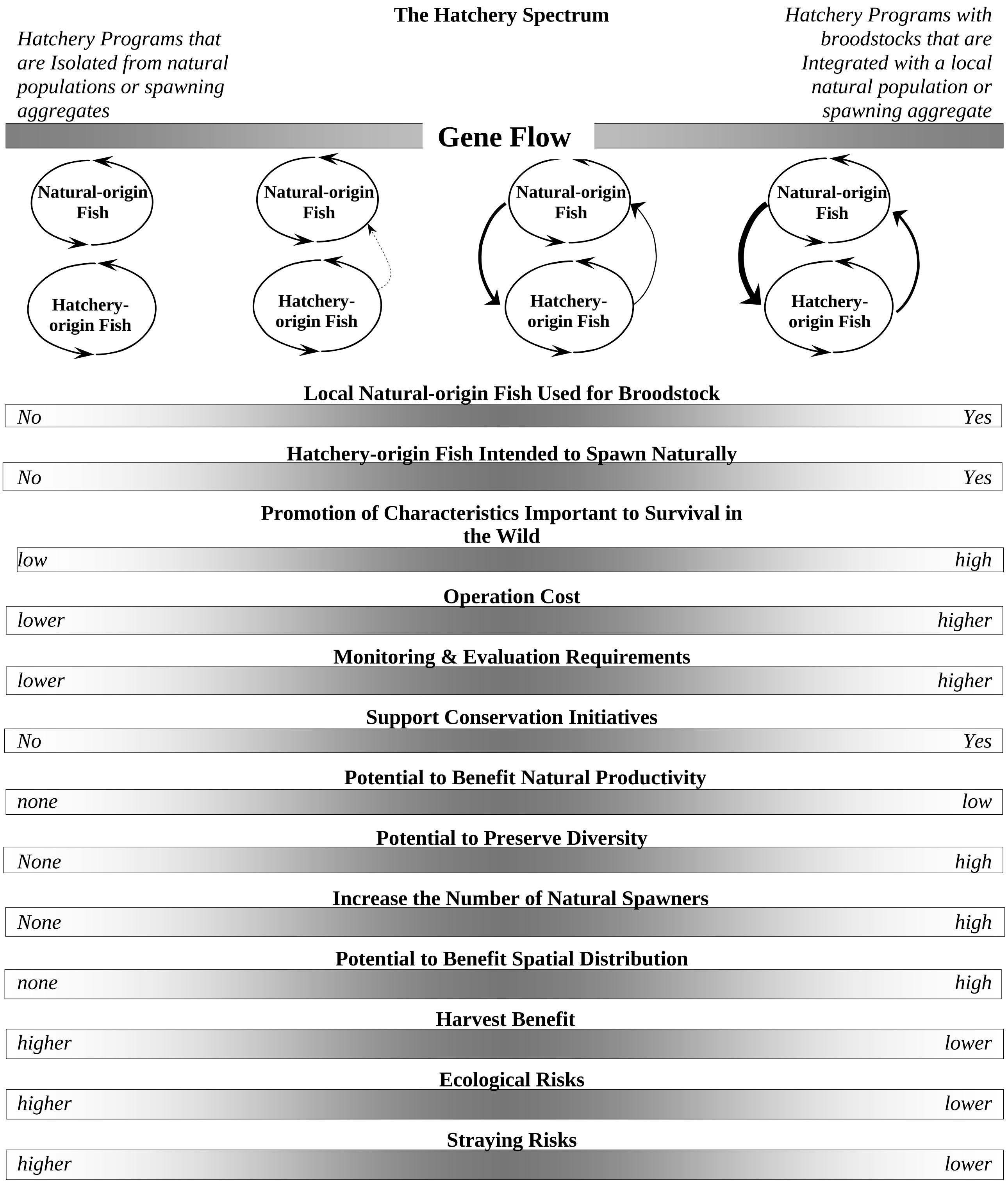
Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Authority for the Hatchery Program	Hatchery Program	Affected Population	Hatchery Program Assessment		
				A Top 5 limiting factor affecting population viability[1]	Slows trends toward extinction[2]	Improves viability and population status[3]
		mitigation				
Snake R spring/summer Chinook	Northwest Power Act	Tucannon supplementation mitigation (captive brood phase)	Tucannon R.	No	Yes	Yes
		Johnson Cr supplementation mitigation	SF Salmon	No	Yes	Pending progress on limiting factors
Snake R spring/summer Chinook (cont.)	Northwest Power Act (cont.)	Lemhi supplementation mitigation (captive brood phase)	Lemhi R.	No	Yes	Yes
		East Fork Salmon supplementation mitigation (captive brood phase)	East Fork Salmon	No	Yes	Yes
		West Fork Yankee Fork supplementation mitigation (captive brood phase)	Yankee Fork	No	Yes	No, program closed
	Idaho Power Company mitigation for Snake R Dams	Rapid River fishery mitigation	Little Salmon	No	No (preserves genetic resources from another ESU)	No
		Pahsimeroi, fishery mitigation	Pahsimeroi R	No	Yes	No
Snake R. steelhead	Federal mitigation for Lower Snake R. Dams	Tucannon, fishery mitigation	Tucannon R.	Yes	No	No
		Tucannon, supplementation & fishery mitigation	Tucannon R.	No	Yes	Pending progress on limiting factors
		Clearwater supplementatio	SF Clearwater	Unknown	Unknown	No

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Authority for the Hatchery Program	Hatchery Program	Affected Population	Hatchery Program Assessment		
				A Top 5 limiting factor affecting population viability[1]	Slows trends toward extinction[2]	Improves viability and population status[3]
		n & fishery mitigation				
		Dworshak Lolo Crk supplementation & fishery mitigation	Lolo Crk	Unknown	Unknown	No
		Little Salmon fishery mitigation	Little Salmon & Rapid R	Unknown	No	No
		East Fork Salmon supplementation mitigation	East Fork Salmon R	No	Yes	Pending progress on limiting factors
		East Fork Salmon fishery mitigation	East Fork Salmon R	No	No	No
Snake R steelhead (cont.)	Federal mitigation for Lower Snake R. Dams (cont.)	Sawtooth fishery mitigation	Upper Salmon R	Unknown	No	No
		Wallowa fishery mitigation	Wallowa, Minam, Lostine, Deschutes & John Day	Yes	No	No
		Cottonwood Pond fishery mitigation	Lwr Grande Ronde	Unknown	No	No
		Little Sheep supplementation & fishery mitigation	Imnaha	No	Yes	Pending progress on limiting factors & improved hatchery practices
	Federal mitigation for Dworshak Dam	Dworshak supplementation & fishery mitigation	SF Clearwater	Unknown	Unknown	No
		Dworshak fishery mitigation	NF Clearwater	No	Yes (only NF Clearwater fish left)	Pending progress on factors limiting NF Clearwater recovery
	Idaho Power Company	Pahsimeroi fishery	Pahsimeroi R	No	No	No

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Authority for the Hatchery Program	Hatchery Program	Affected Population	Hatchery Program Assessment		
				A Top 5 limiting factor affecting population viability[1]	Slows trends toward extinction[2]	Improves viability and population status[3]
	mitigation for Snake R Dams	mitigation				
		Oxbow fishery mitigation	Hells Canyon tributaries	No	Yes (only for fish originating above Hells Canyon Dams	No
Snake R fall Chinook	Federal mitigation for Lower Snake R. Dams	Lyons Ferry supplementation & fishery mitigation (includes Pittsburg Landing, Cpt John Rapids and Big Canyon acclimation sites)	Lower Mainstem Snake	No	Yes	Unknown
	Northwest Power Act	Nez Perce Tribal supplementation & fishery mitigation	Clearwater	No	Yes	Yes
Snake R fall Chinook (cont.)	Idaho Power Company mitigation for Snake R Dams	Oxbow fishery mitigation	Mainstem Snake	No	Yes	Unknown
Snake R sockeye	Northwest Power Act	Stanley Basin supplementation mitigation	Redfish, Alturas & Petit Lakes	No	Yes	Yes

[1] PCSRF 2005, UCSRB 2007
[2] Can slow trends toward extinction or prevent extinction of salmon and steelhead populations in the short-term.
[3] Can improve the viability and status of salmon and steelhead populations.

Figure 1. General hatchery program performance associated with gene-flow between natural-origin and hatchery-origin fish.



This report describes how hatchery programs can affect the abundance, productivity, spatial structure and diversity of natural-origin fish and summarizes the effects of individual interior Columbia hatchery programs on salmon and steelhead viability. Effects are reported as a benefit (+), threat (-), unknown, or no effect; and are based, first, on available information from research, monitoring, and evaluation at the hatchery program (e.g., estimates of hatchery and natural fish productivity and comparisons of hatchery-origin and natural-origin fish population dynamics); and second, on a comparison of hatchery practices at the program relative to guidelines described in Figures 2, 3, and 4. Differences between effects (e.g., weighing the effects of domestication against straying) and different levels of effect within and between categories are not quantified in this report.

Salmon and steelhead viability is the focus of this report and it is accepted here that hatchery programs can benefit or harm viability. Hatchery programs are designated as a benefit or + when:

a. Available information indicates that salmon or steelhead are at greater risk without artificial propagation intervening and that a specific hatchery program has been called upon to promote salmon or steelhead conservation. In general, when natural productivity is low and fish are not sustaining themselves (i.e., average natural-origin fish replacement rates are less than one), hatchery programs potentially can reduce short-term risk of extinction (i.e., buy time until natural productivity is sufficiently improved). When natural productivity is limited by the number of natural spawners, hatchery programs can supplement or reintroduce natural spawning to help a population or spawning aggregate become self-sustaining. These programs strictly follow practices designed to preserve or benefit viability (see Table 2). If the risk to a population or spawning aggregate dictates, hatchery practices may change accordingly. For example, temporarily increasing the proportion of hatchery-origin fish in the hatchery broodstock and the proportion of natural spawners comprised of hatchery-origin fish may be appropriate under particular circumstances to reduce risk. Hatchery practices, including contingencies dictated by different circumstances, must be documented in a Hatchery Genetic Management Plan for the program. A framework for identifying beneficial hatchery actions that potentially reduce spatial structure and genetic diversity risk and abundance and productivity risk is described in Figure 5.

b. A hatchery program serves a research function and does not jeopardize any natural population or major spawning aggregate of salmon or steelhead.

c. There are indications that natural-origin fish abundance, productivity, spatial distribution or genetic diversity has benefited from a hatchery program.

Hatchery programs are designated as a – or threat to population or spawning aggregate viability when:

a. Natural spawners are comprised, on average, of more than 5% hatchery-origin fish from an Isolated Hatchery Program. Isolated Hatchery Programs generally cannot have a + or beneficial effect on population viability because of the hatchery practices they follow (i.e., unless they are the only remaining genetic resources of an otherwise extirpated distinct group of fish).

b. The longer that the hatchery environment drives adaptation of hatchery-origin fish intended to spawn naturally. The proportion of natural-origin fish in the hatchery broodstock must exceed the proportion of hatchery-origin fish on the spawning grounds for the natural environment to drive adaptation. This proportion should exceed 0.7 for populations or spawning aggregates of moderate or high biological significance or if the goal is to maintain or improve their viability (HSRG 2004),

c. Hatchery-origin fish are intended to spawn naturally and when natural-origin fish annually comprise less than 10% of the hatchery broodstock (McElhany et al. 2000 and HSRG 2004),

d. Hatchery-origin fish intended to spawn naturally have different population dynamics (e.g., age structure) than the natural population or spawning aggregate they are intended to benefit,

e. Hatchery-origin fish prey on or compete with natural-origin fish for food and habitat,

f. Hatchery facilities change adult or juvenile spatial distribution,

g. Hatchery water diversions kill or injure juvenile or adult fish, and

h. There are indications that natural-origin fish abundance, productivity, spatial distribution or diversity has been depressed by a hatchery programs.

3. Reducing Incidental Hatchery Impacts on Salmon and Steelhead Viability

Hatchery programs have incidental or collateral impacts on salmon and steelhead in the course of performing their job and there are several key considerations in determining the significance of impacts and the appropriate level of response.

Human caused impacts to freshwater habitat mean river systems can produce fewer fish. When this happens and the productive potential of a river system is reduced or eliminated, hatchery propagation has frequently been called upon to at least preserve treaty and public fishing opportunities. Between 80 and 90 percent of the hatchery programs in the Interior Columbia serve these purposes under public laws (e.g., the Water Resources Development Act of 1986 (P.L. 99-662) authorizing the Lower Snake River Fish and Wildlife Compensation Plan), license agreements and other mitigation commitments. Incidental to fulfilling these obligations, hatchery programs can harm salmon and steelhead viability. Considerations in determining what level of credit is appropriate for actions or reforms that reduce incidental impacts caused by hatchery programs include the following.

1. The biological significance and the management goal for a population or spawning aggregate (e.g., is the condition of a population or spawning aggregate particularly important to the viability of an ESU or DPS)?

2. The biological status of a population or spawning aggregate (e.g., is the group of fish in desperate need of help)?

3. The significance of the incidental impact (i.e., to what extent is the incidental impact a significant factor limiting viability). For example, if stray rates and natural spawning of hatchery fish are relatively low and genetic diversity is not a significant risk factor, then efforts to further reduce straying may not justify substantial credit.

4. A summary of progress in hatchery reform effecting seven distinct groups of Interior Columbia salmon and steelhead

Table 2. A summary of progress in hatchery reform effecting seven distinct groups of Interior Columbia Basin salmon and steelhead.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Progress in Hatchery Reform
Snake River fall Chinook	Good reason to believe that the Snake River fall Chinook programs have increased spatial structure, genetic resources and probably abundance. Hatchery programs have helped jumpstart the ESU, and natural-origin fall Chinook returns have increased from <100 in 1990 to between 2,000 and 5,000 from 2001 through 2004. Spatial distribution has expanded into the Clearwater and lower Grande Ronde River sub-basins and changes at the Umatilla hatchery program has reduced straying from outside the basin and threats to fall Chinook diversity.
Snake River spring/summer Chinook	Grande Ronde Basin hatchery programs are using local fish for broodstock after terminating the use of Rapid River Chinook in the mid-1990s. Locally derived broodstock is being used in the Tucannon, Imnaha, S. Fork Salmon, Pahsimeroi, and upper Salmon Rivers.
Upper Columbia spring Chinook	The Winthrop National Fish Hatchery continues a transition (which began in 2001) to a locally derived broodstock (a combination of Methow River and Chewuch River Chinook) and is phasing out the use of Carson lineage stock.
Upper Columbia Steelhead	The use of broodstock derived from lower Columbia Skamania stock steelhead was terminated in the mid 1990s. A local broodstock was developed to replace Wells stock in the Wenatchee. The use of early spawned hatchery fish has been minimized, to promote more natural

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Progress in Hatchery Reform
	spawn timing of hatchery fish. Steelhead releases were terminated in the Entiat beginning in 1997. Wells Hatchery has increased the proportion of natural-origin steelhead in the annual broodstock, and has taken steps to synchronize the maturation of hatchery-origin steelhead with natural-origin steelhead in order to increase the reproductive success of hatchery fish spawning in the wild. The broodstock used in the propagation program in the Wenatchee basin is using primarily natural-origin fish collected from the Wenatchee River.
Middle Columbia Steelhead	The Umatilla program terminated the use of broodstock derived from lower Columbia Skamania stock steelhead beginning in 1981. The Walla Walla and Touchet programs have reduced the size of their juvenile releases by more than 25% to reduce straying. A local broodstock is being tested to replace Lyons Ferry stock in the Touchet River.
Snake River Steelhead	Hatchery releases in the lower Salmon River basin have been restricted to the Little Salmon River. Locally derived broodstock is being developed and tested for use in the Tucannon River and in the East Fork Salmon River. Use of hatchery-origin steelhead in tributary habitat has been reduced.

5. General guidance to help set expectations for hatchery programs and to understand potential benefits and risks to salmon and steelhead viability

Figure 2. A framework to help establish expectations for different kinds of hatchery programs.

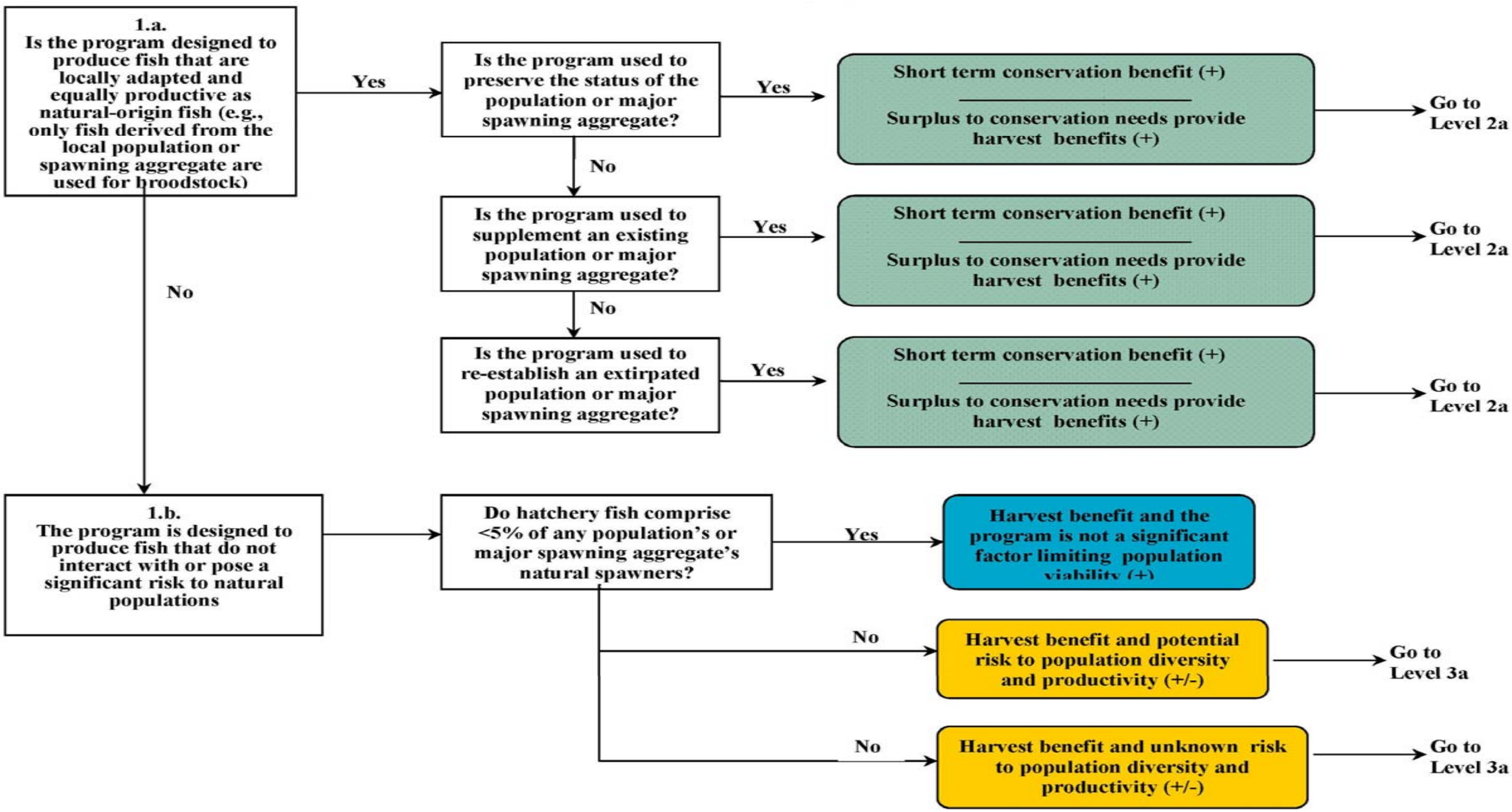
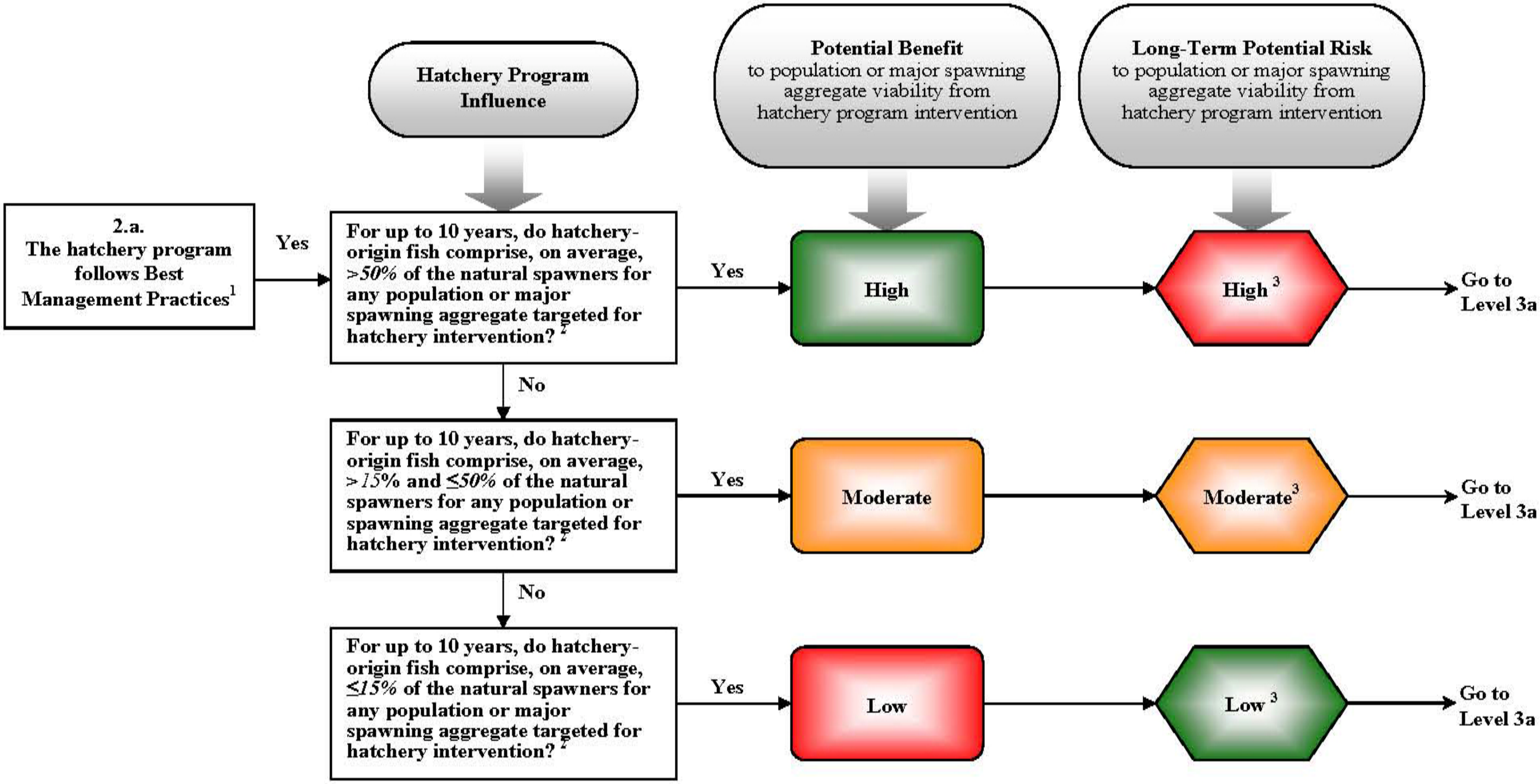


Figure 3. Framework to help evaluate the benefits and risks to salmon and steelhead viability from different levels of hatchery program intervention or influence.

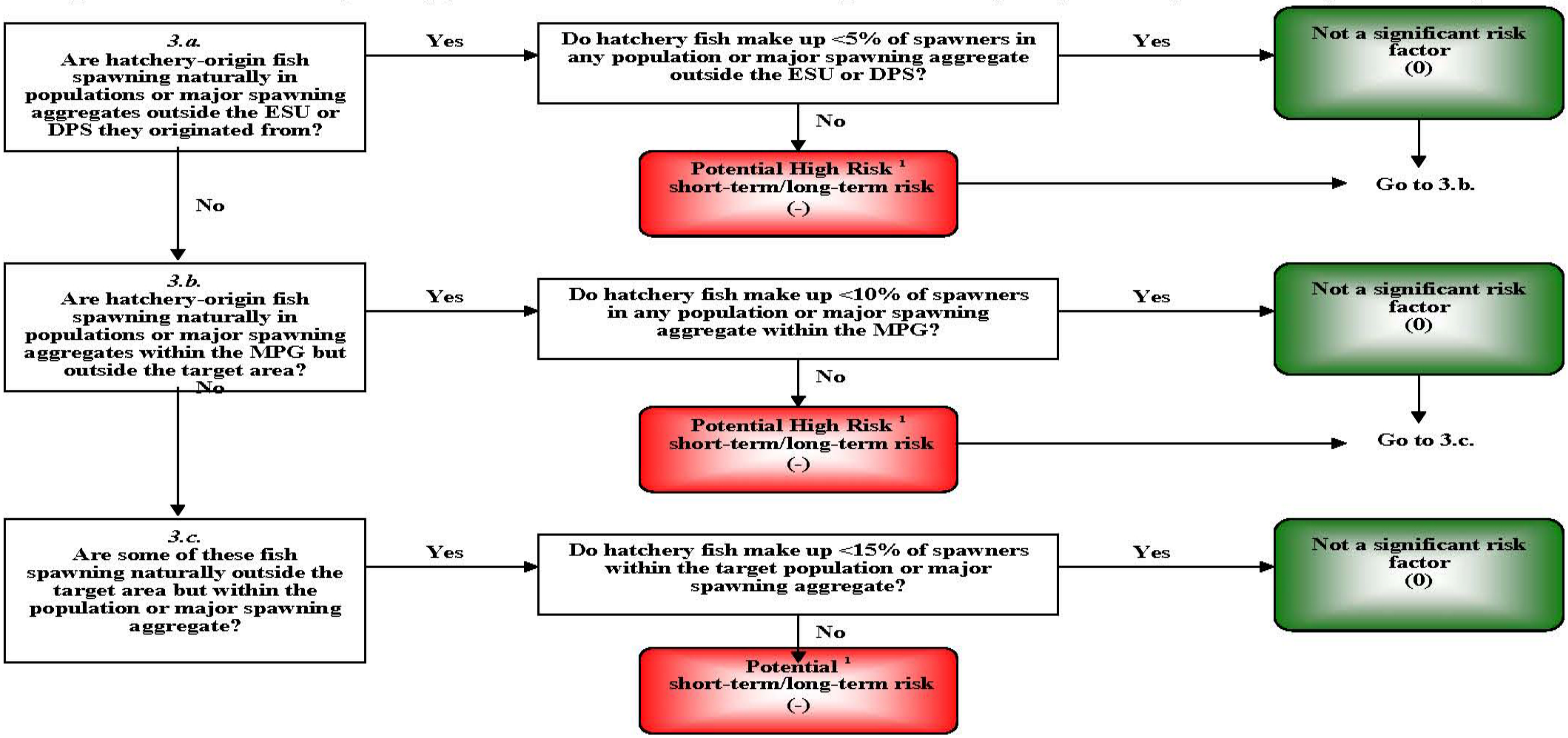


1 Hatchery programs that conform to the principles described in Flagg et al. (2004), Olson et al. (2004), and Mobrand et al. (2005) could be considered "best management practices" (see ICTRT 2007a).

2 Note that hatchery fish fitness or productivity in nature, and risk criteria associated with the hatchery-origin fish composition of natural spawners, should be revisited as new information becomes available.

3 Risk criteria associated with spawner composition (ICTRT 2005).

Figure 4. Framework to help identify potential risk to salmon and steelhead genetic diversity and productivity from hatchery fish that stray and spawn naturally.

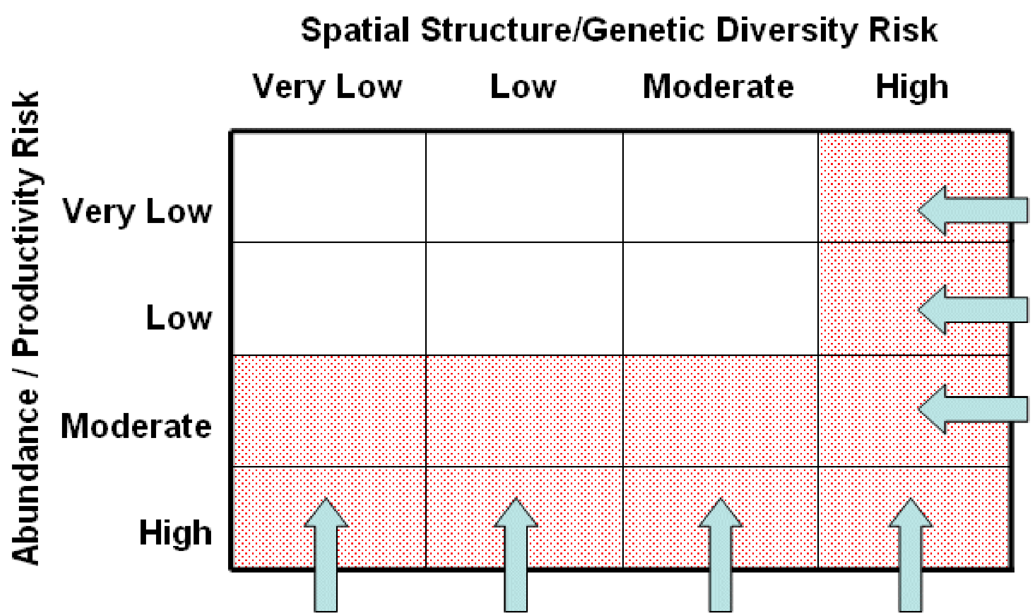


1 Hatchery programs that conform to the principles described in Flagg et al. (2004), Olson et al. (2004), and Mobrand et al. (2005) could be considered "best management practices" (see ICTRT 2007a).

2 Note that hatchery fish fitness or productivity in nature, and risk criteria associated with the hatchery-origin fish composition of natural spawners, should be revisited as new information becomes available.

3 Risk criteria associated with spawner composition (ICTRT 2005).

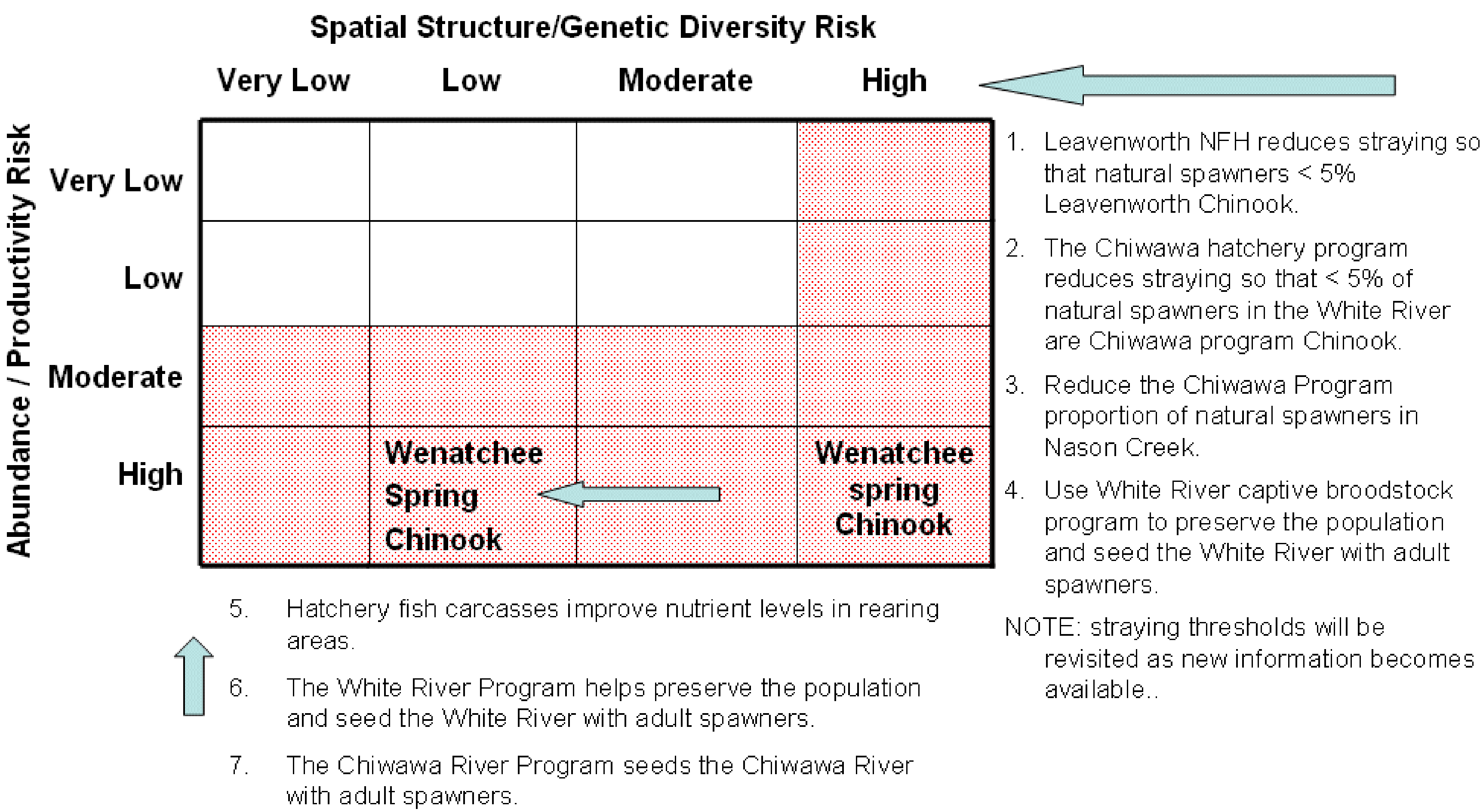
Figure 5. Hatchery actions that potentially can reduce salmon and steelhead population spatial structure and diversity risk and abundance and productivity risk.



1. When hatchery programs preserve a population until the factors limiting recovery are addressed.
2. Jump-start self-sustaining populations after the factors limiting population productivity are addressed.
3. Reduce the hatchery-origin fish (HOF) proportion of natural spawners as natural-origin fish (NOF) abundance and productivity increases.
4. Reduce the influence of any HOF that potentially depress NOF productivity (i.e., HOF that do not share the same population dynamics and fitness as NOF).
5. Improve juvenile and adult fish passage at hatchery facilities.

1. When hatchery programs preserve a population until the factors limiting recovery are addressed.
2. When offspring from naturally spawning HOF jump-start self-sustaining populations after the factors limiting population productivity are addressed.
3. Reduce the influence of any HOF that potentially depress NOF productivity (i.e., HOF that do not share the same population dynamics and fitness as NOF).
4. Reduce the number of NOF killed or injured by hatchery water diversions.
5. Freshwater nutrient levels increase due to HOF carcasses.
6. Reduce HOF predation on NOF through HOF size, release timing and release location measures.
7. Reduce competition with NOF for food and space through HOF size, release timing and release location measures.

Figure 6. **Hatchery actions (numbers 1-4) that potentially can reduce Wenatchee spring Chinook salmon *spatial structure and diversity* risk from high to low when the level of genetic differentiation and variation between spawning aggregations increases (see Interior Columbia Technical Recovery Team risk rating system for spatial structure and genetic diversity). When factors limiting population productivity are addressed, hatchery action 5, 6, and 7 potentially can jumpstart naturally self-sustaining populations in the Chiwawa and White Rivers and reduce *abundance and productivity* risk.**



Appendix D
Hatchery Effects Report

Attachment 1

An Inventory of Current Hatchery Programs in the Interior Columbia Basin and Their Effects on Salmon and Steelhead Viability

In the following table, Major Population Group and Population designations are based on information from the Lower Columbia/Willamette Technical Recovery Team (LCWTRT) and the Interior Columbia Technical Recovery Team (ICTRT). "Major Factors Currently Limiting Population Recovery" are derived from Recovery Plans submitted to NOAA Fisheries (*www.nwr.noaa.gov/salmon-recovery-planning/esa-recovery-plans/draft-plans.cfm*) and the NOAA Fisheries 2005 Report to Congress, Pacific Coastal Salmon Recovery Fund. An online version of this report is available at *www.nwr.noaa.gov/pcsrf/2005_PCSRF_Report.htm.* Individual hatchery program information and hatchery effects information are derived from Hatchery Genetic Management Plans (available from Federal, state and tribal hatchery program operators), from NOAA Fisheries Biological Opinions and from LCWTRT and ICTRT reports.

Also in the following table, Hatchery Effects on Population Viability uses the following Hatchery Influence Criteria developed by the ICTRT (2003).

Table 3. An Inventory of Current Hatchery Programs in the Interior Columbia Basin and Their Effects on Salmon and Steelhead Viability

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Chinook	Columbia Gorge spring Chinook strata	Big White Salmon R.	Extirpated Condit Dam blocked passage to production areas.	None	NA	**Extirpated Population**	Investigate using Klickitat Spring Chinook for reintroduction. Complete planning for remodel of Big White Salmon Ponds and weir to support reintroduction efforts after Condit removal in 2008. Reconstruction of Lyle Falls in Klickitat Master Plan provides proper collection facility for this activity (Yakama Nation). A weir also would control straying and the level of naturally spawning hatchery fish after a self-sustaining pop is reestablished (USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Chinook (cont.)	Columbia Gorge spring Chinook strata (cont.)	Hood R	Extirpated	Hood R. Spring Chinook Reintroduction Program BPA funded. ESA authorization pending an updated HGMP and NEPA	1992	+ for jump-starting re-colonization of spr Chinook in the Hood R. - because broodstock from a different ESU (the nearby Deschutes) were used and because the majority of hatchery fish returns (between 1997 and 2001) derived from this broodstock were precocious males (60% mini jacks and 14% jacks) and stray rates averaged 18% between 1996-2002.	Full-term rearing capability would potentially increase fish survival and the programs potential contribution to recovery. Developing a broodstock from natural-origin fish returning to the Hood River is more likely to achieve successful reintroduction and benefit LCR Chinook ESU viability.
		Lwr Gorge fall Chinook (from upstream of the Washougal R. to Bonneville Dam)		Bonneville Upriver Bright Fall Chinook Program Isolated Fishery Program Corps of Engineers John Day Mitigation ESA authorization pending updated HGMP and NEPA	1977	- naturally spawning fish from Bonneville Hatchery (imports from outside the area) pose a risk to population diversity and productivity.	Consider terminating the release of Upriver Bright Chinook below Bonneville to reduce straying risks to endemic Chinook diversity and productivity. Consider the Spring Crk Hatchery reprogramming proposal as a means to accomplish this and other objectives (USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Chinook (cont.)	Columbia Gorge fall Chinook strata (cont.)	Upper Gorge fall Chinook (from Bonneville Dam to the Big White Salmon River)		Spring Crk National Fish Hatchery Isolated Fishery Program Mitchell Act and Corps of Engineers funded. ESA Section 7 consultation pending and NOAA EIS underway	1973	+ because these fish are the most representative of the historical Columbia Gorge tule population. Preserving genetic resources until inundated habitats are restored. - naturally spawning fish from Bonneville Hatchery, Little White Salmon National Fish Hatchery, and Klickitat Hatchery (all are imports) pose a risk to population diversity and productivity.	Should incorporate natural origin fish into the hatchery broodstock as they become available. The proposed Wahkiacus acclimation facility on the Klickitat will allow for the collection of returning fall Chinook and potentially reduce the impact of these fish on Gorge fall Chinook diversity and productivity (Yakama Nation).
				Little White Salmon National Fish Hatchery Upriver Bright Isolated Fishery Program Mitchell Act Funded ESA Section 7 consultation pending and NOAA EIS underway	1983	- because naturally spawning fish from the Little White Salmon program are imports and pose a risk to population diversity and productivity.	Change the operation of the hatchery ladder (i.e., keep it open longer) and conduct terminal fisheries to put these fish to their intended use and reduce the number that spawn naturally (USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Chinook (cont.)	Columbia Gorge fall Chinook strata (cont.)	Big White Salmon R.		Spring Crk National Fish Hatchery Isolated Fishery Program Mitchell Act and Corps of Engineers funded. ESA Section 7 consultation pending and NOAA EIS underway.	1973	+ because these fish are representative of the historical Columbia Gorge tule population, and for preserving genetic resources until inundated habitats are restored. - because naturally spawning fish from Little White Salmon National Fish Hatchery and Klickitat Hatchery (both are imports) pose a risk to population diversity and productivity.	Should incorporate natural origin fish into the hatchery broodstock as they become available. Complete planning for remodel of Big White Salmon Ponds and weir to support reintroduction efforts after Condit removal in 2008. The proposed Wahkiacus acclimation facility on the Klickitat will allow for the collection of returning fall Chinook and potentially reduce the impact of these fish on Gorge fall Chinook diversity and productivity (Yakama Nation). A weir also would control straying and the level of naturally spawning hatchery fish after a self-sustaining pop is reestablished (USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Steelhead	Columbia Gorge Winter Steelhead Strata	Lower Columbia Gorge Tributaries (from upstream of the Washougal R to Bonneville Dam)		None	NA	**Unknown**	
		Upper Columbia Gorge Tributaries (from Bonneville Dam upstream to below the Big White Salmon R.)		None	NA	**Unknown**	
		Hood R. winter steelhead		Hood R winter steelhead Program BPA funded ESA authorization pending an updated HGMP and NEPA	1991	+ for increasing the number of natural spawners and preserving genetic resources. Research here is providing important hatchery steelhead productivity information.	
		Wind R. summer steelhead		None	NA	**Unknown**	

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Steelhead (cont.)	Columbia Gorge Summer Steelhead Strata	Hood R. summer steelhead		Hood R. summer steelhead Program BPA funded. ESA authorization pending an updated HGMP and NEPA	1998	+ for increasing the number of natural spawners and preserving genetic resources. Research here is providing important hatchery steelhead productivity information.	
		Hood R. summer steelhead (cont.)		Hood R summer steelhead Isolated Fishery Program Oregon Dept of Fish and Wildlife funded. ESA Section 10 permit pending an updated HGMP and NEPA	1987	**No Effect** Hatchery returns are prevented from escaping into Hood R summer and winter steelhead spawning areas. This program uses imported Skamania steelhead and will terminate prior to the removal of Powerdale Dam. Are concerns over straying and potential effects on diversity.	

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Coho	Columbia Gorge strata	Lower Gorge (upstream of the Washougal R to Bonneville Dam)		Bonneville Isolated Fishery Program Mitchell Act and Corps of Engineers funded. ESA authorization pending an updated HGMP and NOAA EIS that is underway	1938	- because these hatchery fish are highly domesticated. High stray rates (hatchery fish comprise 70-80% of the natural spawners) pose a risk to population productivity and diversity.	
		Hood R. (includes all OR tributaries upstream from Bonneville Dam to the Hood R.)		None	NA	- because hatchery strays from Bonneville and Klickitat hatchery programs comprise a high proportion of natural spawners and pose a risk to population productivity and diversity. Annual plants of coho from the Little White Salmon program were terminated in 2004.	The proposed Wahkiacus acclimation facility on the Klickitat will improve homing fidelity to the Klickitat River (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Lower Columbia River Coho (cont.)	Columbia Gorge strata (cont.)	Big White Salmon (includes all WA tributaries upstream from Bonneville Dam to Big White Salmon)		None (Program at Little White Salmon/Willard NFH was discontinued in 2004)	NA	- because hatchery strays from Bonneville and Klickitat hatchery programs comprise a high proportion of natural spawners and pose a risk to population productivity and diversity.	Complete planning for remodel of Big White Salmon Ponds and weir to support reintroduction efforts after Condit removal in 2008. The proposed Wahkiacus acclimation facility on the Klickitat will improve homing fidelity to the Klickitat River (Yakama Nation). A weir also would control straying and the level of naturally spawning hatchery fish after a self-sustaining pop is reestablished (USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Columbia River Chum	Gorge strata (upstream of the Washougal R. to include tributaries to the Bonneville Pool)	Lower Columbia Gorge tributaries (from upstream of the Washougal R to Bonneville Dam)		Duncan Crk/Ives Isl. Program	2001	+ for reintroducing chum salmon into Duncan Crk and for preserving genetic resources.	
		Upper Columbia Gorge tributaries (tributaries upstream from Bonneville dam)		None	NA	**No Effect**	

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Middle Columbia River Steelhead	Cascades Eastern Slope	Fifteen Mile Winter run steelhead	Passage through the mainstem Columbia Hydro system and instream cover, stream temperature, stream flow and sedimentation conditions that limit spawning and rearing success.	None	NA	**No Effect**	
		East side Deschutes tributaries A run steelhead (from the confluence with the Columbia to Trout Crk)	Passage through the Federal Columbia River Power System and high stray rates from Snake River hatchery programs, and instream cover, stream temperature, stream flow, sedimentation and fish passage conditions that limit spawning and rearing success.	None	NA	**-** because high stray rates from Snake River hatchery programs potentially disrupt natural selection processes and pose a risk to population diversity and productivity. Warm Springs National Fish Hatchery removes some stray steelhead.	Research is needed here to better determine the extent to which stray hatchery fish actually spawn in the Deschutes. Operate weirs at the mouths of Bake Oven, Trout and Buck Hollow Creeks to remove stray hatchery steelhead. Sorting facilities at the Sherars Fall ladder to remove stray hatchery steelhead (ODFW, USFWS).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Middle Columbia River Steelhead (cont.)	Cascade Eastern Slope (cont.)	Klickitat A-run steelhead	Passage through the Federal Columbia River Power System and instream cover, channel complexity, passage and sedimentation conditions that limit spawning and rearing success.	Klickitat summer steelhead Isolated Fishery Program Mitchell Act funded. ESA authorization pending an updated HGMP and NOAA EIS that is underway	1983	**-** because transplanted steelhead pose a threat to population diversity and productivity. The Klickitat program uses transplanted highly domesticated Skamania steelhead. From Narum et al. 2006, less than 4% of natural-origin fish had their most likely assignment to naturally spawning hatchery fish. Klickitat steelhead genetic integrity has been maintained despite repeated hatchery introductions (Yakama Nation).	Klickitat Master Plan calls for phasing out the use of out-of- basin Skamania broodstock and converting to an endemic broodstock. The Klickitat program is to function to conduct one year versus two year smolt study.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Middle Columbia River Steelhead (cont.)	Cascade Eastern Slope (cont.)	West-side Deschutes tributaries A-run steelhead (Trout Crk upstream to Pelton Dam)	Passage through the Federal Columbia River Power System passage, high stray rates from Snake River hatchery programs and instream cover, stream temperature, stream flow and channel complexity conditions that limit spawning and rearing success.	Round Butte summer steelhead Isolated fishery program Portland General Electric funded.	1974	**No Effect** Hatchery fish are uniquely marked and surveys indicate <5% spawn naturally. Natural fish excluded from broodstock since 1998. - for high stray rates from Snake River steelhead hatchery programs	Research is needed here to better determine the extent to which stray hatchery fish from Snake River programs are actually spawning in the Deschutes. Use genetic stock identification methods to collect wild Deschutes River steelhead for broodstock. Operate weir at mouth of Shitike Creek to remove stray hatchery steelhead. Sorting facilities at the Sherars Fall ladder to remove stray hatchery steelhead.
		Rock Creek A run steelhead	Channel morph, stream flow, habitat complexity, water quality, sedimentation and fish passage conditions that limit spawning and rearing success.	None	NA	**Unknown,** but straying, especially by non-indigenous hatchery steelhead is a concern	

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Middle Columbia River Steelhead (cont.)	Cascade Eastern Slope (cont.)	Big White Salmon summer/winter steelhead	Extirpated Condit Dam blocked access to production areas	White Salmon winter and summer steelhead Isolated Fishery Programs Mitchell Act funded ESA authorization pending an updated HGMP and NOAA EIS that is underway.	1986	**Extirpated Population** Steelhead pop was extirpated due to Condit Dam. Program uses non ESU Skamania steelhead. No information available regarding stray rates.	Based on biological considerations, identify a donor population to use for reintroduction purposes. Complete planning for remodel of Big White Salmon Ponds and weir to support reintroduction efforts after Condit Dam removal in 2008. A weir also would control straying and the level of naturally spawning hatchery fish after a self-sustaining pop is reestablished (USFWS).
	John Day	North Fork A run steelhead	Passage through the Federal Columbia River Power System, out-of-basin hatchery strays and stream temperature, stream flow, sedimentation and channel complexity conditions that limit spawning and rearing success.	None	NA	**-** for limited strays from outside the ESU and for an avg 6.7% stray rate (based on information from the mainstem John Day), primarily from Snake River hatchery programs poses a potential risk to pop diversity and productivity	Research is needed here to better determine the extent to which stray hatchery fish from outside programs are actually spawning in the John Day.,

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Middle Columbia River Steelhead (cont.)	John Day (cont.)	Middle Fork A run steelhead	Passage through the Federal Columbia River Power System, out-of-basin hatchery strays and stream temperature, stream flow and sedimentation conditions that limit spawning and rearing success.	None	NA	**-** for limited strays from outside the ESU and for an avg 6.7% stray rate (based on information from the mainstem John Day), primarily from Snake R hatchery programs poses a potential risk to pop diversity and productivity	Research is needed here to better determine the extent to which stray hatchery fish from outside programs are actually spawning in the John Day.
		Upper Mainstem A run steelhead	Passage through the Federal Columbia River Power System, out-of-basin hatchery strays, and stream temperature, stream flow, sedimentation, and channel complexity conditions that limit spawning and rearing success.	None	NA	**-** for limited strays from outside the ESU and for an avg 6.7% stray rate (based on information from the mainstem John Day), primarily from Snake R hatchery programs poses a potential risk to pop diversity and productivity	Research is needed here to better determine the extent to which stray hatchery fish from outside programs are actually spawning in the John Day.

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Middle Columbia River Steelhead (cont.)	John Day (cont.)	South Fork A run steelhead	Passage through the Federal Columbia River Power System, out-of-basin hatchery strays and instream cover, stream temperature, stream flow and sedimentation conditions that limit spawning and rearing success.	None	NA	**-** for limited strays from outside the ESU and for an avg 6.7% stray rate (based on information from the mainstem John Day), primarily from Snake R hatchery programs poses a potential risk to pop diversity and productivity	Research is needed here to better determine the extent to which stray hatchery fish from outside programs are actually spawning in the John Day.
		Lower Mainstem A-run steelhead	Passage through the Federal Columbia River Power System and out-of-basin hatchery strays and stream flow, stream temperature, sedimentation and instream cover conditions that limit spawning and rearing success.	None	NA	**-** for limited strays from outside the ESU and for an avg 6.7% stray rate (based on information from the mainstem John Day), primarily from Snake R hatchery programs poses a potential risk to pop diversity and productivity	Research is needed here to better determine the extent to which stray hatchery fish from outside programs are actually spawning in the John Day.

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Middle Columbia River Steelhead (cont.)	Umatilla / Walla Walla Rivers	Umatilla R. A-run steelhead	Passage through the Federal Columbia River Power System and stream flow, channel complexity, sedimentation and stream temperature conditions that limit spawning and rearing success.	Umatilla summer steelhead Program BPA/NWPPC funded. ESA pending an updated HGMP and NEPA	1981	+ Recovery program for preserving genetic resources and temporarily boosting the number of natural spawners. Natural origin fish abundance averaged more than 2,000 from 1999 thru 2004. Tech Recovery Team abundance threshold is 2250. - because out of basin hatchery strays (stray rates (avg. of 5.4% between1992-2003) pose a potential risk to pop diversity and productivity. Note that fish from this program stray into other basins and pose a threat to pop diversity and productivity.	An expanded monitoring program would better determine the extent of natural production and the extent to which stray hatchery fish from outside programs are actually spawning in the Umatilla River.

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Middle Columbia River Steelhead (cont.)	Umatilla / Walla Walla Rivers (cont.)	Walla Walla R. A run steelhead	Passage through the Federal Columbia River Power System and local sedimentation, stream flow, channel complexity and instream cover conditions, seasonal water temperatures and passage that limit spawning and rearing success.	Walla Walla summer steelhead Isolated Fishery program BPA/LSRCP funded ESA Section 7 consultation pending an updated HGMP	1983	**No Effect** Well isolated <5% of hatchery fish spawn naturally. Program uses steelhead from outside the ESU (partially derived from upper Columbia steelhead). Hatchery fish are planted low in the basin away from primary steelhead production areas. Hatchery program size (i.e., smolt releases) has been cut by >40%.	1. Construct acclimation pond and adult trapping facility in lwr Walla Walla (terminate direct stream releases). 2. Fund on station trapping and acclimation if the program is converted to an integrated program. 3. Fund continued M&E for hatchery effects on natural populations. 4. Fund PIT-tagging to M&E hatchery returns.
		Touchet A-run steelhead	Passage through the Federal Columbia River Power System, naturally spawning non-indigenous hatchery fish and channel complexity, sedimentation and stream flow conditions and seasonal water temperatures that limit spawning and rearing success.	Touchet summer steelhead Isolated Fishery Program BPA/LSRCP funded ESA Section 7 consultation pending an updated HGMP	1983	**-** because non-indigenous naturally spawning hatchery fish potentially pose a risk to population diversity and productivity. The program is not well isolated. Facilities are inadequate to manage hatchery fish escapement. Smolt releases reduced by 32% since 2001 to reduce impacts. Plans are to phase this program out if the integrated broodstock Touchet program is successful.	Adult trapping facilities being upgraded. Need to improve curtain over diversion dam to limit jumping, and to install resistance counter in new ladder. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Middle Columbia River Steelhead (cont.)	Umatilla / Walla Walla Rivers (cont.)	Touchet A run steelhead	Same	Touchet summer steelhead Integrated Broodstock Fishery Program BPA/LSRCP funded. ESA section 10 permit pending an updated HGMP and NEPA	2000	**-** because naturally spawning hatchery fish pose a potential risk to pop diversity and productivity.	Existing facilities are being upgraded which will reduce risk to pop productivity and diversity. Need to improve curtain over diversion dam to limit jumping, and to install resistance counter in new ladder. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.
		Willow Creek A run steelhead	Extirpated	None	NA	**Extirpated Population**	
	Yakima	Naches R. A run steelhead	Passage through the Federal Columbia River Power System and fish passage, stream flow, channel complexity and water quality conditions that limit spawning and rearing success.	None	NA	**No Effect** No hatchery releases into the Yakima Basin since 1992	Continue to support Kelt Reconditioning program

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Middle Columbia River Steelhead (cont.)	Yakima (cont.)	Satus Crk A-run steelhead	Passage through the Federal Columbia River Power System and instream cover, channel complexity and stream temperature conditions that limit spawning and rearing success.	None	NA	**No Effect** No hatchery releases into the Yakima Basin since 1992	Continue to support Kelt Reconditioning program
		Toppenish A-run steelhead	Passage through the Federal Columbia River Power System and channel complexity, stream flow, instream cover and water quality conditions that limit spawning and rearing success.	None	NA	**No Effect** No hatchery releases into the Yakima Basin since 1992	Continue to support Kelt Reconditioning program
		Upper Yakima A-run steelhead	Passage through the Federal Columbia River Power System and fish passage, instream cover, stream flow, channel complexity and water quality conditions that limit spawning and rearing success.	None	NA	**No Effect** No hatchery releases into the Yakima Basin since 1992	Continue to support Kelt Reconditioning program

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Middle Columbia River Steelhead (cont.)	Yakima (cont.)		Same as above	Kelt (i.e., surviving spawners) reconditioning program BPA funded ESA Section 10 permit pending an updated HGMP and NEPA	2000	+ Recovery program potentially can increase pop abundance and productivity. Post spawning natural fish are collected in lower Yakima basin, reconditioned, and released to return to their area of origin and spawn a second time.	Continue to support Kelt Reconditioning program

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Snake R. Spr/ Summer Chinook	Lower Snake	Tucannon R.		Tucannon Captive Broodstock program Funded by BPA ESA Section 10 permit pending an updated HGMP and NEPA	1997	+ for preserving and building genetic resources after severe population declines during the mid 1990s. 2006 is the last year that captive broodstock adults will be used for hatchery broodstock. Note: The Umatilla and Walla Walla Chinook programs are not included in this ESU and are not included in this table. Strays from the Umatilla program can exceed 5% of the natural spawners in the Tucannon and pose a risk to productivity and genetic diversity. There is a question about but no data to determine Walla Walla program Chinook natural spawning in the Tucannon.	Apply unique external mark on Umatilla Hatchery spring Chinook to facilitate their removal from the Tucannon and protect diversity. Reduce Umatilla Hatchery spring Chinook program to reduce straying. About 70% of the fish make it to the existing weir on the Tucannon. Provide a new adult weir lower in the Tucannon River to remove strays. WDFW opposes a new weir based on concerns over the potential to disrupt spatial distribution in the Tucannon. Fund genetic analysis of existing samples. Increase mark rate for the Walla Walla spring Chinook program or cap the program at 250k (WDFW). Little Opportunity here to significantly benefit Tucannon Chinook viability.

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Snake R. Spr/ Summer Chinook (cont.)	Lower Snake (cont.)	Tucannon R.		Tucannon Program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	1985	+ Recovery program uses Tucannon broodstock to supplement or boost the number of natural spawners until factors limiting survival are addressed. - for the Umatilla Chinook program because strays can approximate 5% of the natural spawners in the Tucannon.	See above. 1. natural spawner genetic assessment, 2. PIT-tag and M&E hatchery fish returns and distribution, and 3. construct new trap in the lower Tucannon to remove stray hatchery fish (USFWS).
		Asotin Crk.		None	NA	**No Effect**	Re-introduction using Tucannon stock is possible in the future if mainstem survival improves, in-basin habitat is restored and surplus Tucannon fish are available to use as donors. Asotin Creek has limited Chinook production potential but is very important for steelhead.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha	Wenaha R.	Passage through the Federal Columbia River Power System. Spawning and rearing areas are in Wilderness system but water temperatures are a factor limiting fish passage and rearing in the Lower Grande Ronde.	None	NA	**No Effect** Straying from Lookingglass Hatchery Rapid River stock has been eliminated and no longer poses a threat to this population. Approximately 5% of the naturally spawning fish are strays from the Lostine, Catherine Crk and Upper Grande Ronde programs (ODFW).	Continue monitoring spawning escapement. Didson Acoustic Imaging wier recommended by NEOH M&E plan.
		Lostine/Wallowa Rivers		Lostine Captive Broodstock Program BPA funded. ESA Section 10 permit pending an updated HGMP and NEPA	1997 First adult returns in 2002	+ because this temporary captive broodstock program is preserving and building genetic resources. Straying from Lookingglass Hatchery Rapid River stock has been eliminated and no longer poses a threat to this population. The program is shifting to conventional smolt program.	Outplant into vacant habitats including Bear Crk. Preserve stock structure and do not outplant into Hurricane and Wallowa crks (ODFW).

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Lostine/Wallowa Rivers (cont.)		Lostine Program BPA funds captive broodstock BPA/LSRCP funds conventional program ESA Section 10 permit pending an updated HGMP and NEPA	1999 First adult returns in 2001	+ Recovery Program preserves genetic resources and boosts the number of natural spawners until factors limiting survival are addressed.	Complete NEOH to improve current supplementation program. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.
		Minam River	Passage through the Federal Columbia River Power System. Spawning and rearing areas are in productive Wilderness system.	None	NA	**No Effect** Straying from Lookingglass Hatchery Rapid River stock has been eliminated and no longer poses a threat to this population. Approximately 5% of the naturally spawning fish are strays from the Lostine, Catherine Crk and Upper Grande Ronde programs (ODFW).	Continue monitoring spawning escapement.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Catherine Crk		Catherine Crk Captive Broodstock Program BPA/LSRCP funded. ESA Section 10 permit pending an updated HGMP and NEPA	1996	+ because this temporary captive broodstock program is preserving and building genetic resources.	None. Continue as planned. Use surplus eggs from this program as the preferred source for introduction into Lookingglass Creek.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Catherine Crk		Catherine Crk Program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	2001	+ Recovery supplementation program following practices that promote viability in the wild.	Complete NEOH to improve existing supplementation program. Assure that adult weir and trap operates as designed. Manage adult returns based on sliding scale. Consideration should be given to eliminating this program to better balance hatchery/natural production Grande Ronde Basin wide (ODFW). Limit release of surplus hatchery adults to vacant or nearly vacant habitat adjacent to the Catherine Creek. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Grande Ronde Upper mainstem		Upper Grande Ronde Captive Broodstock Program BPA/LSRCP funded. ESA Section 10 permit pending an updated HGMP and NEPA	1996	+ Rescue program Temporary captive broodstock program to preserve and build genetic resources.	None. Continue as currently operated.
		Grande Ronde Upper mainstem (cont.)		Upper Grande Ronde Program BPA/LSRCP funded. ESA Section 10 permit pending an updated HGMP and NEPA	2001	+ Recovery supplementation program following practices that promote viability in the wild.	Complete NEOH to improve existing supplementation progam. Assure that adult weir and trap operates as designed. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Imnaha R.		Imnaha program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	1995	**+** for successfully boosting the number of natural spawners. **-** for continued high hatchery influence that potentially disrupts natural selection. Since the program has successfully jumpstarted natural production, reducing the number of naturally spawning hatchery fish would reduce risk to pop diversity and productivity. Pop abundance at or above recovery threshold in 2001, 02 and 03. The proportion of naturally spawning HOF> proportion of NOF in the hatchery broodstock for 11 of 15 years between 1988 and 2003.	Complete NEOH (modify weir and acclimation ponds) to improve existing supplementation program. Modify weir to improve collection efficiency and manage the escapement and natural spawning of hatchery fish. Do not release hatchery adults above the weir after natural escapement exceeds recovery thresholds for one generation. Increase the proportion of natural fish in the hatchery broodstock so that it meets or exceeds the proportion of hatchery fish spawning naturally. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Big Sheep and Lick Crks		Associated with the Imnaha program described above	1995	+ for boosting the number of natural spawners. Surplus adults from the Imnaha program are planted into Big Sheep and Lick Crks. - the longer the program uses Imnaha broodstock that is thought to have different life-history characteristics than Big Sheep Chinook and limit population diversity.	In near term, continue release of surplus Imnaha Hatchery adults for reintroduction into Lick Creek. Cease the use of Imnaha fish for broodstock (ODFW). Longer term: once natural population established terminate releases of hatchery adults. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	Grande Ronde/Imnaha (cont.)	Lookingglass Crk	Previous hatchery practices that were a limiting factor have been discontinued.	Lookingglass Reintroduction Program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	2001	+ for re-introduction following extirpation. Historic hatchery practices blocked access and extirpated local population. Current reintroduction program is using nearest suitable stock (Catherine Creek).	Complete NEOH to improve the existing program. Continue reintroduction using surplus Catherine Crk captive broodstock. Phase out the use of Catherine Crk Chinook and use natural-origin Chinook returning to Lookingglass Crk for hatchery broodstock. Once in place, increase number of adults released above the hatchery for natural production (the hatchery rears several listed populations used for supplementation). Modify the hatchery intake and fish ladder to allow/reestablish fish passage and improve spatial distribution. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	SF Salmon (cont.)	Little Salmon R.	Limited Chinook salmon production potential.	Rapid River Isolated Fishery Program Idaho Power Company funded. ESA Section 10 permit pending an updated HGMP and NEPA	1964	- Hatchery fish are 100% marked and a hatchery weir prevents their escapement into Rapid River spawning areas. Escapement into the upper Little Salmon River drainage is not controlled. The Rapid River program preserves genetic resources indigenous to areas taken out of salmon and steelhead production by the Hells Canyon Dams. Surplus hatchery fish provide fishing opportunity.	Continue to manage Rapid River for natural production. Little Salmon River has limited natural production potential and is managed as state and tribal terminal fishing area. Conduct spawning ground surveys to determine Little Salmon Chinook production. Develop supplementation program for Rapid River summer Chinook

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Snake R. Spr/ Summer Chinook (cont.)	SF Salmon (cont.)	SF Salmon R.		McCall Isolated fishery program. 3rd phase of Idaho Supplementation Studies BPA/LSRCP funded ESA Section 7 consultation pending an updated HGMP	2004	**Unknown** Too early to determine if Recovery Supplementation has been successful or to determine effects of recent transition to an Isolated program. One way gene flow from hatchery to natural fish is likely until Idaho supplementation study is completed. McCall influence/straying in the Secesh is medium (10-25%) and is highest in large run-size years. Part of the Idaho Supplementation Study to be completed in 2012.	Conduct surveys to determine if hatchery fish spawning is limited to the area immediately below weir. Replace existing adult weir to manage the escapement of hatchery fish. Develop new broodstock management agreement, phase-out ISS Phase III and reinitiate supplementation (Nez Perce). Assess options for providing acclimation facilities as control measure for straying into Secesh River and East Fork South Fork. 1. natural spawner genetic assessment and 2. PIT-tag and M&E hatchery fish returns and distribution.

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Snake R. Spr/ Summer Chinook (cont.)	SF Salmon (cont.)	SF Salmon R.		Johnson Crk Integrated program BPA/LSRCP funded ESA 4(d) limit and NEPA in place	2000	+ because this program is designed to preserve summer Chinook salmon genetic resources until factors limiting recovery are addressed. Important supplementation experiment based on all-natural-origin local broodstock. Longer-term effects on productivity and diversity being evaluated.	None. Continue using temporary facilities until sufficient evaluation information becomes available to help inform proper management. Replace the existing weir to improve its effectiveness. Fund the genetic analysis of existing samples. Potential to increase production to 300K smolts Nez Perce).
		Secesh R.		None	NA	- from McCall Hatchery program influence/strays that pose a potential risk to Secesh population productivity and diversity.	See South Fork above. Continue to monitor spawning escapement.
		East Fork		McCall	2000	**Unknown** Opportunistic reintroduction effort using adult outplants.	None. Continue to monitor spawning escapement.

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Snake R. Spr/ Summer Chinook (cont.)	MF Salmon	Chamberlain Crk	Passage through the Federal Columbia River Power System. Spawning and rearing areas in productive Wilderness system.	None	NA	**No Effect** Important population in wilderness area. No hatchery influence	None. Continue to monitor spawning escapement.
		Lower MF Salmon R.	Same as above	None	NA	**No Effect**	None. Continue to monitor spawning escapement.
		Big Crk	Passage through the Federal Columbia River Power System. Small legacy mining impacts, otherwise spawning and rearing areas in wilderness system.	None	NA	**No Effect** Important population with a unique life history in this MPG (Summer Run). Wilderness area with no hatchery influence.	None. Continue to monitor spawning escapement.
		Camas Crk	Same as above	None	NA	**No Effect**	None. Continue to monitor spawning escapement. As a group, these are important populations for diversity and distribution of natural, upriver Chinook in wilderness streams
		Loon Crk		None	NA	**No Effect**	
		Upper Middle Fork Salmon R.		None	NA	**No Effect**	
		Sulphur Crk		None	NA	**No Effect**	None. Continue to monitor spawning escapement.

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Snake R. Spr/ Summer Chinook (cont.)	MF Salmon (cont.)	Bear Valley Crk	Same as above	None	NA	**No Effect** Important large, productive population that seeded extensive rearing areas downstream in main Middle Fork. Wilderness area with no hatchery influence	None. Continue to monitor spawning escapement.
		Marsh Crk	Same as above	None	NA	**No Effect**	None. Continue to monitor spawning escapement.
	Upper Salmon R.	North Fork Salmon R.		None	NA	**No Effect**	None. Continue to monitor spawning escapement.
		Lower Mainstem		None	NA	**Unknown** No associated hatchery program. This is a unique life history of summer Chinook, mainstem spawners and downstream from the spring Chinook program at Sawtooth Hatchery	None. Continue to monitor spawning escapement.

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Snake R. Spr/ Summer Chinook (cont.)	Upper Salmon R. (cont.)	Pahsimeroi R.		Pahsimeroi Isloated Fishery Program. 3rd phase of Idaho Supplementation Studies Idaho Power Company funded. ESA Section 10 permit pending an updated HGMP and NEPA	2004	**Unknown** Too early to determine effect of Recovery Supplementation or of recent transition to an Isolated program.	Continue to monitor spawning escapement. Develop broodstock management plan, discontinue ISS Phase III and reinitiate supplementation (Nez Perce).
		East Fork	Passage through the Federal Columbia River Power System. Headwaters are in protected wilderness.	East Fork Captive Rearing Experiment BPA funded. ESA Section 10 permit pending an updated HGMP and NEPA	1995	+ for investigating and improving knowledge of captive broodstock techniques. New genetic analysis is necessary to better establish population status.	Phase out as scheduled.

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Snake R. Spr/ Summer Chinook (cont.)	Upper Salmon R. (cont.)	Yankee Fork	Passage through the Federal Columbia River Power System and channel complexity and instream cover conditions limit spawning and rearing success.	West Fork Yankee Fork Captive Rearing Experiment BPA/LSRCP funded.	1997 In final evaluation stage. No longer releasing any fish.	+ for investigating captive rearing techniques	Phase out captive rearing as scheduled. Develop a new HGMP. Initiate a new supplementation program for the upper Yankee Fork upstream of the West Fork Yankee Fork. Initially use Sawtooth Hatchery Chinook for broodstock but in the longer term, develop in basin adult collection and juvenile acclimation facilities and transition to locally derived broodstock for supplementation program. Assess need to provide additional rearing facilities.
		Valley Crk		None	NA	**No Effect**	None. Continue to monitor spawning escapement.

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Snake R. Spr/ Summer Chinook (cont.)	Upper Salmon R. (cont.)	Upper Salmon R.		Sawtooth Isolated Fishery Hatchery Program. 3rd phase of Idaho Supplementation Studies BPA/LSRCP funded. ESA Section 7 consultation pending an updated HGMP	2004	**Unknown** Too early to determine if Recovery Supplementation Program was successful or the effects of the recent transition to an Isolated Program. Primary/best production areas are above Sawtooth Hatchery. Part of Idaho Supplementation study to be completed in 2012.	Monitor to determine if hatchery adults are only spawning naturally immediately below weir. Increase well water supply (pathogen free source) to fulfill production targets and to reduce disease problems. Improve spawner surveys below the hatchery weir. Develop broodstock management plan, discontinue ISS Phase III and reinitiate supplementation (Nez Perce).
		Panther Crk	Passage through the Federal Columbia River Power System and water quality and channel complexity conditions that limit spawning and rearing success.	None	NA	**No Effect**	Potential for future Chinook reintroduction if mining cleanup is successful and mainstem survival is improved.

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Snake R Steelhead	Lower Snake	Tucannon R. A-run steelhead		Tucannon Isolated Fishery Program BPA/LSRCP funded ESA Section 7 consultation pending an updated HGMP	1983	**-** because non DPS broodstock are isolated from most but not all Tucannon steelhead spawning areas. The existing hatchery weir is 70% effective and the most important habitat is upstream.	Phase out use of non Distinct Population Segment (DPS) broodstock and develop a locally derived broodstock, possibly using captive broodstock technology. Relocate the weir to increase its effectiveness (Nez Perce & WDFW).
				Tucannon Supplementation Program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	2001	**+** because the supplementation program is intended to preserve and build genetic resources and boost the number of natural spawners. To early for any significant results.	Improve weir to benefit broodstock collection, eliminate out-of-DPS strays, and improve management of spawning escapement.
		Asotin Crk A-run steelhead		None	NA	**Unknown** 2005 survey revealed large numbers of unmarked steelhead in Asotin Crk. The origin of these fish needs to be determined.	Continue to fund operation of the existing weir and spawning escapement. Fund genetic analysis of existing samples (WDFW).

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Snake R Steelhead (cont.)	Clearwater	L Clearwater A-run steelhead (unique for the Clearwater)		None	NA	**No Effect** No straying based on limited surveys	None. Improve monitoring of spawning escapement. Develop adult collection and juvenile acclimation facilities for supplementing NPT reservation tributaries. Place a weir in the Potlatch River (FWP proposal).
		SF Clearwater B run steelhead.		Dworshak and Clearwater Fishery and Supplementation Program Dworshak funded by COE, Clearwater program funded by BPA/LSRCP. ESA Section 7 consultation pending an updated HGMP	1992	**Unknown** Inadequate evaluation of these programs. 200k Dworshak Hatchery smolts planted for supplementation. About 1 million smolts are released annually without adequate evaluation of their naturally spawning and potential impacts. Straying is low (<10 fish over the last 5 years) based on weir operation in the Crooked and Red rivers.	Improve monitoring of spawning escapement. Continue recently initiated evaluation (USFWS). More evaluation is necessary before assessing options for donor stock originating within the South Fork Clearwater River. Identify new facilities needed to develop local stock.

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Snake R Steelhead (cont.)	Clearwater (cont.)	NF Clearwater B run steelhead	Extirpated The Federal Dworshak Dam has taken this area out of steelhead production.	Dworshak Fishery Program COE funded. ESA consultation pending an updated HGMP	1969	+ because whatever NF Clearwater genetic resources that remain exist in this program.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
		Lolo Creek B run steelhead.		Dworshak BPA/LSRCP funded. ESA Section 7 consultation pending an updated HGMP	1999	**Unknown** Releases 50,000 smolts annually with inadequate evaluation.	Improve monitoring of spawning escapement. Assess options for developing locally derived broodstock.
		Selway River B run steelhead	Passage through the Federal Columbia River Power System. Spawning and rearing areas are in Wilderness system.	None	NA	**Unknown**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
Snake R Steelhead (cont.)	Clearwater (cont.)	Lochsa River B run steelhead	Passage through the Federal Columbia River Power System. Spawning and rearing areas are largely in wilderness & roadless systems.	None	NA	**Unknown** Only 1-3% stray rate from Dworshak program (Fish Crk weir in lower Lochsa).	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.

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	Salmon River	Little Salmon & Rapid A run steelhead		Little Salmon Fishery Program Idaho Power Company and BPA/LSRCP funded. ESA Section 7 consultation pending an updated HGMP	1980s	**Unknown or No Effect** in Rapid River. **–** because naturally spawning hatchery fish (derived from outside the DPS) poses a potential risk to Little Salmon R. pop diversity and productivity. Inadequate evaluation of escapement and natural spawning of hatchery fish.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Terminate release of unmarked hatchery fish. Collect samples and conduct genetic analysis for fish from the Little Salmon (IDFG). Terminate release of Dworshak B steelhead.
		SF Salmon R. B run steelhead		None	NA	**No Effect**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
Snake R Steelhead (cont.)	Salmon River (cont.)	Secesh River B run steelhead		None	NA	**No Effect**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.

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		Big, Camas, Loon Creeks B run steelhead	Passage through the Federal Columbia River Power System. Spawning and rearing areas are in wilderness system.	None	NA	**No Effect**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
		UMF Salmon R. B run steelhead	Same as above	None	NA	**No Effect**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
		Chamberlain Crk A-run steelhead	Same as above	None	NA	**No Effect**	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.
Snake R Steelhead (cont.)	Salmon River (cont.)	Panther Crk A-run steelhead	Extirpated due to mining effects.	Panther Crk egg box releases	1997	**Unknown** Experimental reintroductions with egg boxes using Pahsimeroi fish	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.

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		NF Salmon R. A-run steelhead				-because naturally spawning hatchery fish derived from areas outside the DPS pose a potential risk to pop diversity and productivity.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Eliminate main-stem Salmon River releases in this reach (Nez Perce). Provide acclimation and adult collection facilities to reduce potential risk to diversity. Terminate direct stream releases of out of DPS hatchery fish.
Snake R Steelhead (cont.)	Salmon River (cont.)	Lemhi R. A-run steelhead				- because naturally spawning hatchery fish derived from areas outside the DPS pose a potential risk to pop diversity and productivity.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Terminate release of Pahsimeroi hatchery fish. Terminate mainstem Salmon River releases in this reach (Nez Perce).

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		Pahsimeroi R A-run steelhead		Pahsimeroi Isolated Fishery Program Idaho Power Company funded ESA Section 10 permit pending an updated HGMP and NEPA	1969	**No Effect** on the ESA protected DPS. Strictly harvest mitigation for 3 private Hells Canyon Dams. A weir near the confluence with the Salmon River allows only natural fish to escape into spawning areas. + because genetic resources for areas taken out of production by the Hells Canyon Dams are contained in this program.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Develop a local broodstock.
Snake R Steelhead (cont.)	Salmon River (cont.)	EF Salmon R. A-run steelhead		East Fork Program BPA/LSRCP funded ESA Section 10 permit pending an updated HGMP and NEPA	2003	+ Recovery Program temporarily boosts the number of natural spawners until factors limiting survival are addressed. The population is at about 10% of its abundance goal.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams.

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		EF Salmon R. A-run steelhead (cont.)		East Fork Fishery Program/Squaw Crk Pond	1982	**Unknown** because naturally spawning hatchery fish (in the lower 6 miles of the East Fork) derived from areas outside the basin (NF Clearwater/Dworshak) pose a potential risk to pop diversity and productivity.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Terminate Dworshak B releases and replace with locally derived source.
Snake R Steelhead (cont.)	Salmon River (cont.)	Upper Salmon R. A-run steelhead		Sawtooth Isolated Fishery Program (includes Yankee Fork and mainstem Upper Salmon R. releases) BPA/LSRCP funded. ESA Section 7 consultation pending an updated HGMP	1983	**-** because naturally spawning hatchery fish are derived from outside the DPS and pose a potential risk to pop diversity and productivity.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Terminate release of out of DPS hatchery fish into Valley Creek and Yankee Fork. Develop local upper Salmon River stock. Develop locally derived stock from Yankee Fork for supplementation into that tributary.

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Snake R Steelhead (cont.)	Grande Ronde	Wallowa R., (includes the Minam and Lostine rivers), A-run steelhead	Passage through the Federal Columbia River Power System. Spawning and rearing areas are in a wilderness system.	Wallowa Isolated Fishery Program at Wallowa Hatchery and at Big Canyon Pond. BPA/LSRCP funded ESA Section 7 consultation pending an updated HGMP	1982	**-** because hatchery fish are derived from areas outside the DPS and naturally spawning hatchery fish pose risk to pop diversity and productivity. **-** because Wallowa steelhead strays pose risk to Deschutes and John Day steelhead populations. Planted steelhead reduced from 1.3 million to 870,000. The Minam R. is managed for wild production only	Improve monitoring of spawning escapement to determine if hatchery adults stray into nearby streams or into other populations and DPSs. Reduce number of juveniles produced.
		Joseph Crk A-run steelhead		None	NA	**No Effect** No straying based on surveys.	Improve escapement and natural productivity monitoring.
		Up Gr Ronde R. A-run steelhead		None	NA	**No Effect** Hatchery releases suspended in 1997. Less than 1% straying from other areas.	Continue monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. CTUIR operates weirs on Catherine Crk and on the upper Grande Ronde.

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Snake R Steelhead (cont.)	Grande Ronde (cont.)	Lwr Gr Ronde R.,		Cottonwood Pond Isolated Fishery Program BPA/LSRCP funded. ESA Section 7 consultation pending an updated HGMP	1982	**-** because hatchery fish are derived from areas outside the DPS and naturally spawning hatchery fish pose a potential risk to pop diversity and productivity in Cottonwood, Rattlesnake and Menatchee creeks.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Transition to locally derived broodstock.
		Wenaha River A-run steelhead	Wenaha in wilderness.	None	NA		
	Imnaha	Imnaha River A-run steelhead		Little Sheep Fishery/ Recovery Program BPA/LSRCP funded. ESA Section 10 permit pending an updated HGMP and NEPA	1999	**Unknown,** but Broodstock comprised of >10% natural origin fish in only 6 of last 14 years and natural origin fish comprised >50% of the natural spawners in only 2 of last 14 years (high hatchery influence). Surveys indicate little or no straying by Little Sheep program fish.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Incorporate natural adults from Big Sheep Creek and increase the proportion of natural-origin fish in the hatchery broodstock. Develop guidelines for reducing the proportion natural spawners comprised of hatchery fish (ODFW).

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Snake R Steelhead (cont.)	Hells Canyon	Hells Canyon Tribs A run steelhead		Oxbow/Niagara Springs Isolated Fishery Program Idaho Power funded. ESA Section 10 permit pending an updated HGMP and NEPA	1984	**-** because straying by these fish poses potential risk to population productivity. The Oxbow program operates strictly to provide fishing opportunity as mitigation for the 3 private Hells Canyon Dams. Inadequate evaluation of this program to determine effects on steelhead viability. + because genetic resources for areas taken out of production by the Hells Canyon Dams are contained in the program.	Improve monitoring of spawning escapement to determine if hatchery adults stray to nearby natural production streams. Consider a program to reintroduce steelhead into Pine Crk (ODFW).
		Powder River	Extirpated Taken out of production by the 3 private Hells Canyon Dams	None	NA	**Extirpated Population**	None
		Burnt River	Extirpated Taken out of production by the 3 private Hells Canyon Dams	None	NA	**Extirpated Population**	None
		Weiser River	Extirpated Taken out of production by the 3 private Hells Canyon Dams	None	NA	**Extirpated Population**	None

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Snake R. Fall Chinook	Snake Mainstem	Lower Mainstem Snake R	More than 80% of the populations spawning area is blocked by Private Utility Dams and passage through the Federal Columbia R. Power System. Since proposed for ESA protection in 1990, the population has grown from <100 annual returns to between 2100 and 5100. Available habitat may now be the primary limiting factor. Hatchery strays from outside the basin pose a risk (approx 1100 in 2003). Reduced harvest has contributed to increased natural spawners. Fishing impacts from all fisheries (ocean and in-river) were 66% between 1980-1995 and 45% between 1996 and 2003 (NMFS 05 Biological Opinion). Total in-river harvest rates averaged 55% between 1986 and 1991 and 26% between 1992 and 2003 (CRIFC personal comm).	Lyons Ferry program Fall Chinook Acclimation Project (FCAP) at Pittsburg Landin, Capt. John Rapids and Big Canyon. BPA/LSRCP. ESA Section 10 permit pending an updated HGMP and NEPA	1985	+ because it has successfully jumpstarted natural production and improved spatial distribution. Also because the program includes genetic resources from areas taken out of production by the Hells Canyon Dams (i.e., the Marsing and Salmon Falls reaches). Since proposed for ESA protection in 1990, the population has grown from <100 annual returns to between 2100 and 5100. Hatchery intervention has accomplished its mission and successfully jumpstarted fall Chinook production. Acclimation facilities located in natural spawning areas. Pop abundance has been at or above the ESA recovery threshold in 2001and 03 (the ICTRT abundance threshold is 3,000 natural-origin spawners). Productivity of natural origin fish has been >1:1. Continued high hatchery influence poses potential risks to the population. productiity and diversity. The proportion of naturally spawning HOF> proportion of NOF in the hatchery broodstock since 1992	Improve M&E of natural spawners and reproductive success of hatchery and natural adults. Increase proportion of natural fish into the hatchery broodstock. Promote population diversity by expanding adult collection capabilities in the Clearwater River and Hells Canyon. Develop long-term plan for reducing hatchery fish influence in some areas (i.e., proportion of hatchery fish spawning naturally) and eliminate hatchery fish juvenile releases in other areas to reduce risks to pop productivity and diversity. Control out of basin hatchery strays, primarily from the Umatilla River. Options include; increase removal of strays at Lower Granite Dam and improve the homing fidelity of Umatilla program. Increase Lwr Granite PIT tag sampling capabilities to M&E hatchery program performance.

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Snake R. Fall Chinook (cont.)	Snake Mainstem (cont.)	Clearwater R.	Passage through the Federal Columbia River Power System. See lower Mainstem above for fishing impacts.	Nez Perce Recovery and Fishery Program BPA funded. ESA Section 10 permit pending an updated HGMP and NEPA	1999	+ because the program has jump-started production by boosting the number of natural spawners and increasing spatial distribution. All releases are subyearling and all are marked. 400,00 of the intended 1.4 million releases designed to restore extinct early spawning life history form.	Increase proportion of natural fish in the hatchery broodstock. Reduce reliance on collecting broodstock at Lyons Ferry Hatchery and Lower Granite Dam for Clearwater River supplementation program. Promote population diversity by relying on adults returning to the Clearwater River. Develop an early spawning broodstock for introduction into the middle Fork Clearwater River. Collectively these actions should promote diversity by allowing local adaption to occur over time.

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Snake R. Fall Chinook (cont.)	Snake Mainstem (cont.)	Snake R Mainstem	See Lower Mainstem	Oxbow Isolated Fishery Program Idaho Power funded. ESA Section 10 permit pending an updated HGMP and NEPA	2001	- now because hatchery broodstock practices are isolated and because the high influence of hatchery origin fish (proportion of hatchery origin natural spawners > proportion of natural origin natural spawners) increases risk to population productivity and diversity. Managing Snake River fall Chinook as a single aggregate impedes the development of population diversity and potentially reduces productivity.	Monitor to determine if Hells Canyon Dam releases are isolated. Develop adult collection facilities at Hells Canyon Dam. Reduce reliance on collecting broodstock at Lyons Ferry Hatchery if the program is intended to produce fish that spawn naturally. Reduce proportion of hatchery fish in natural production areas. Reprogram hatchery releases out of a natural production area once natural returns exceed recovery objectives for one generation (to help determine if natural fish are self sufficient). Control out of basin hatchery strays, primarily from the Umatilla River. Options include; increase removal of strays at Lower Granite Dam and improving Umatilla program Chinook homing fidelity.

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Snake R. Fall Chinook (cont.)	Snake Mainstem (cont.)	Marsing Reach	Extirpated Taken out of production by 3 private Hells Canyon Dams	None	NA	**Extirpated Population**	
		Salmon Falls	Extirpated Taken out of production by 3 private Hells Canyon Dams	None	NA	**Extirpated Population**	
Snake R. Sockeye		Redfish Lake		Stanley Basin Captive Broodstock Program BPA funded. ESA Section 10 permit is pending,	1991	+ for preserving and building sockeye genetic resources until the factors limiting survival are addressed.	Expanded facilities are needed to increase production of hatchery smolts to put available genetic resources to use and jumpstart or boost the number of natural spawners.
		Alturas Lake		Reintroductions form the Stanley Basin Recovery Program	1990s	+ for reintroducing sockeye into this system.	Same as above
		Pettit Lake		Reintroductions from the Stanley Basin Recovery Program	1990s	+ for reintroducing sockeye into this system.	Same as above
		Yellowbelly Lake		None	NA	None	
		Stanley Lake		None	NA	None	

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Upper Columbia Spring Chinook	Wenatchee/ Methow	Wenatchee R.	Passage through the Federal Columbia River Power System and through three mainstem Columbia River Public Utility Dams, Leavenworth National Fish Hatchery strays and fish passage, stream flow, stream temperature, sedimentation and channel complexity conditions that limit spawning and rearing success. In Icicle Crk, fish passage, inadequate hatchery water diversion screening and late summer water quality and quantity limit productivity. Total mainstem treaty and non-treaty harvest rates averaged 27% between 1960 and 1991 and 8% between 1992 and 2005 (CRIFC personal comm). Nearly zero ocean fishing impacts	Leavenworth National Fish Hatchery Isolated Hatchery Program operated to mitigate for areas taken out of spring chinook production by Federal Dam (Grande Coulee) construction and is designed to provide fish for treaty and public fishing. 92% BPA and 8% BOR funded. ESA Section 7 consultation is in place.	1940	- because straying from the program poses a potential risk to population diversity and productivity. Hatchery stock is not indigenous to the Wenatchee Basin, not included in the Upper Columbia Spring Chinook ESU, and they may comprise >5% of the natural spawners in areas important to spring Chinook recovery.	Identify actions that would reduce straying by better isolating the program or that would reduce the impacts of limited straying by integrating the program. Consider transitioning to Chinook derived from Wenatchee Basin MSAs (e.g., surplus Chiwawa program fish collected at Tumwater Dam). Consider trapping Leavenworth hatchery strays at Tumwater Dam as a means to reduce impacts to primary production areas upstream (USFWS). For Chinook viability in Icicle Crk, develop Icicle Crk broodstock, improved adult passage and a redesigned screen over the hatchery water intake is needed.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Wenatchee R. (cont.)	Same as above.	Chiwawa Program. Integrated Hatchery Program designed to help Chiwawa Chinook become self-sustaining. Returning hatchery fish surplus to recovery needs can serve other purposes. Funded by Chelan County PUD for construction and continued operation of Rock Island Dam. ESA Section 10 permit #1196 is in place.	1989	+ because the program has successfully jumpstarted Chinook production in the Chiwawa River and because it sustains spatial structure and the number of natural spawners until the factors limiting natural productivity are addressed. - because naturally spawning hatchery fish pose a potential risk to pop productivity and diversity in the Chiwawa and White rivers. The number of juveniles planted into the Chiwawa sometimes results in larger adult returns than are needed to support recovery in the Chiwawa. Stray rates are high (>25%).	Smolt releases in the Chiwawa should match the capacity of existing habitat in the Chiwawa. Changes smolt release sites to reduce straying. Establish protocols for reducing hatchery influence (PNI) phasing out the program as Chiwawa River Chinook become self-sustaining (NOAA). Develop additional acclimation/release sites to distribute returning adults throughout the watershed i.e., Nason Crk. Move broodstock collection to Tumwater Dam to incorporate genetic material from all spawning aggregates in the Wenatchee (Yakama Nation). In short-term, protocols should focus on increasing HOR & NOR natural spawners in spawning aggregates that have small numbers (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Wenatchee R. (cont.)	Passage through the Federal Columbia River Power System and through three mainstem Columbia River Public Utility Dams, Chiwawa hatchery program strays. See Wenatchee for fishing impacts.	White River Program. Captive Broodstock Program designed to help White River Chinook become self-sustaining. Funded by Grant County PUD to mitigate for fish losses fom construction and operation of Priest Rapids Dam. ESA Section 10 permit is pending the development of an HGMP.	1999	+ Recovery Program that is preserving and building genetic resources until limiting factors are addressed.	Provide rearing and acclimation facilities, provide facilities to collect and monitor adult returns to the White River and establish protocols for phasing out the program as White River chinook become self-sustaining. Close the existing program and reallocate funds to address in-basin limiting factors (Yakama Nation). Expand natural acclimation facilities in the Little Wenatchee River with broodstock collection at Tumwater Dam (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Entiat River	Passage through the Federal Columbia River Power System and four mainstem Columbia River Public Utility Dams, naturally spawning hatchery origin fish from Entiat National Fish Hatchery and fish passage, channel complexity and water quality conditions that limit spawning and rearing success. See Wenatchee for fishing impacts.	Entiat National Fish Hatchery Isolated Hatchery Program operated to mitigate for areas taken out of spring Chinook production by Federal Dam Construction and designed to provide fish for treaty and public fishing. 92% BPA and 8% BOR funded to replace fish losses from Grande Coulee Dam construction. ESA Section 7 consultation in place but new information is expected to trigger reinitiation of consultation	1974	**-** because the program is not well isolated and naturally spawning hatchery fish pose substantial risk to population diversity and productivity. Entiat Hatchery Chinook are not indigenous to the Entiat and not included in the UCR spring Chinook ESU	1. Discontinue the Isolated Hatchery Program, 2. determine whether hatchery intervention to support Chinook recovery is appropriate, and 3. if hatchery intervention is determined appropriate, develop a new Hatchery and Genetic Management Plan for the Entiat. Develop a local broodstock from the natural spawning population and implement acclimated smolt releases at suitable sites in the upper Entiat Basin (Yakama Nation). Reprogram the hatchery to propagate summer Chinook which will decrease impacts on spring Chinook (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Methow R.	Passage through the Federal Columbia River Power System and through five mainstem Columbia River Public Utility Dams and stream flow, channel complexity, sedimentation and passage conditions that limit spawning and rearing success. See Wenatchee for fishing impacts	Winthrop National Fish Hatchery Phasing into an Integrated Program to boost the number of natural spawners and help spring Chinook become self-sustaining. Returning hatchery fish surplus to recovery needs can be used for other purposes. 92% BPA and 8% BOR funded to replace fish losses from the construction of Grande Coulee Dam. ESA Section 10 permit # 1300 is in place.	2001	+ for preserving genetic resources when Chinook returns dropped to unprecedented low numbers and for sustaining naturally spawning and the spatial structure of Chinook until factors limiting Chinook productivity are addressed. - because very few natural origin fish are incorporated into the broodstock program and because combining Methow R and Chewuch R fish for hatchery broodstock reduces pop diversity.	Develop individual properly Integrated Hatchery Programs (including supporting broodstock collection facilities and RM&E) for the Chewuch River and the mainstem Methow River that include the ability to collect natural-origin fish for broodstock, rear progeny separately and manage the proportion of natural spawners comprised of returning hatchery fish. Reduce hatchery influence on natural-origin fish as natural-origin Chinook viability improves. Ensure that program smolt release goals are met, improve juvenile acclimation sites (distributed at suitable locations in the watershed), enhance hatchery water supply and improve Bacterial Kidney Disease management options (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Methow R. (cont.)	Same as above	Methow Program Developing an Integrated Program to boost the number of natural spawners and help spring Chinook become self-sustaining. Returning hatchery fish surplus to recovery needs can be used for other purposes. Douglas County PUD funded to mitigate for fish losses from construction and operation of Wells Dam. ESA Section 10 permit #1196 is in place.	1998	+for preserving genetic resources when Chinook returns dropped to unprecedented low numbers and for sustaining the natural spawning and spatial structure of Chinook until the factors limiting Chinook productivity are addressed. - because very few natural origin fish are incorporated into the broodstock program and because combining Methow R and Chewuch R fish for hatchery broodstock reduces pop diversity. Hatchery fish comprised 97% of the broodstock in 2001, 02 and 03. For this same period, 96% of the naturally spawning fish in the Methow R have been hatchery origin (high hatchery influence).	Develop individual properly Integrated Hatchery Programs for the Chewuch River and the mainstem Methow River that include the ability to collect natural-origin fish for broodstock, rear progeny separately manage the proportion of natural spawners comprised of returning hatchery fish and conduct RM&E to determine performance and facilitate adaptive management. Reduce hatchery influence on natural-origin fish as natural-origin Chinook viability improves. Ensure that program smolt goal is met, improve and expand juvenile acclimation/release sites in the watershed, enhance hatchery water supply and improve Bacterial Kidney Disease management options (Yakama Nation).

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Methow R.	Same as above	Twisp Program Integrated Program designed to boost the number of natural spawners and help Twisp Chinook become self sustaining. Funded by Douglas County PUD to mitigate for fish losses from the construction and operation of Wells Dam. ESA Section 10 permit #1196 is in place	1992	+ for preserving genetic resources and temporarily boosting the number of natural spawners. Broodstock comprised of 57% hatchery origin fish between 2001 and 2003. Natural spawners comprised of 47% hatchery origin fish between 1998 and 2003 (high hatchery influence).	Modify the Twisp trap to allow the collection of broodstock and to avoid impacts to spring Chinook spatial distribution. Reduce hatchery influence on natural-origin fish as natural-origin Chinook viability improves.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia Spring Chinook (cont.)	Wenatchee/ Methow (cont.)	Okanogan R.	Extirpated	Okanogan Fishery Program 92% BPA and 8% BOR funded. ESA Section 10 permit #1300 is in place.	Sporadically since 2001	**No Effect** Surplus non ESU out of basin fish from Winthrop NFH are released into vacant habitat	Implement Okanogan reintroduction HGMP & Master Plan using Methow donor fish (Colville Tribe). Test live-capture selective gear to collect hatchery broodstock & remove hatchery returns surplus to recovery needs while reducing harvest impacts on the population (Colville Tribe).
	Kettle/Colville	Sanpoil R.	Extirpated Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Kootenay R	Extirpated Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Kettle/Colville	Extirpated Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
	Spokane	Spokane R	Extirpated Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Hangman Crk	Extirpated Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia R Steelhead	Entiat	Entiat R.	Passage through the Federal Columbia River Power System and through four mainstem Columbia River Public Utility Dams, and fish passage, channel complexity and water quality conditions that limit spawning and rearing success. For fishing impacts, see Wenatchee (below).	None	NA	**Unknown.** Straying from hatcheries outside the Entiat poses a potential risk to population productivity and diversity. Hatchery releases were discontinued in 1997. The Entiat Basin is now managed for natural production only.	Rare opportunity here to conduct scientific research and compare the progress and pace of recovery with and without hatchery intervention.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia R Steelhead (cont.)	Wenatchee	Wenatchee R.	Passage through the Federal Columbia River Power System and through three mainstem Columbia River Public Utility Dams, and fish passage, stream flow, stream temperature, sedimentation and channel complexity conditions limit spawning and rearing success. Fishing impacts averaged 13% in the mainstem Columbia and 2.5% in the Wenatchee between 1985 and 1997 and 5% in the mainstem and zero in the Wenatchee after 1997.	Wenatchee Program Chelan County Public Utility District funded. ESA Section 10 permit #1395 is in place.	1996	+ for preserving and developing steelhead genetic resources and for boosting the number of natural spawners. This program reformed its broodstock collection practices phasing out Wells stock beginning in 1996. Now only uses known local Wenatchee fish and natural-origin fish have comprised 55% of the broodstock since 1998. Spawn timing the same for hatchery and natural-origin fish. Approx 50% of the hatchery fish are AD clipped and the rest are elastomer tagged. - because high stray rates (20-40% measured upriver at Wells Dam) pose potential risks to Entiat, Methow and Okanogan steelhead diversity and productivity. The program intentionally mixes Chiwawa and Nason steelhead.	1. Radio tracking would determine where hatchery fish are actually spawning and the threat to steelhead diversity and productivity. 2. Develop facilities that mimic natural water conditions for acclimating smolts and maturing adults. 3. Accelerate the start of fitness studies to determine hatchery fish productivity in the wild. 4. Develop program(s) that preserve and develop Chiwawa River and Nason Creek steelhead stock structure including RM&E to determine performance and facilitate adaptive management. Reduce hatchery influence on natural-origin fish as natural-origin steelhead viability improves.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia R Steelhead (cont.)	Methow	Methow R. There are 4 major spawning aggregates (MSA) of steelhead in the Methow system. All MSAs are at low risk for spatial distribution and high risk for genetic diversity.	Passage through the Federal Columbia River Power System and through five mainstem Columbia River Public Utility Dams, and channel complexity, stream flow, fish passage and sedimentation conditions that limit spawning and rearing success. See Wenatchee for fishing impacts.	Wells Program The program is poorly Integrated (mixes MSAs and uses few natural-origin fish) and intends to boost the number of natural spawners. Douglas County PUD funded. ESA Section 10 permit #1395 is in place	1982	+ for stepping in to preserve genetic resources and boosting the number of naturally spawning fish when natural origin steelhead returns were < 200 fish for 5 of 6 years between 1993 and 1998. - for risks to pop diversity and productivity by collecting broodstock at Wells Dam and then introducing these fish in different areas throughout the Methow Basin. Hatchery origin fish comprise >90% of all natural spawners which also poses risks to pop diversity and productivity.	Develop facilities to promote stock structure and reduce risks to pop diversity and productivity. 1. Develop, fund and follow new Hatchery and Genetic Management Plan(s) for individual MSA or MSAs that includes RM&E and protocols for phasing out hatchery influence as steelhead viability improves.
			Same as above	Winthrop National Fish Hatchery 92% BPA and 8% BOR funded. ESA Section 10 permit #1396 is in place	1951	Same as above	Same as above

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia steelhead (cont.)	Okanogan	Okanogan R.	Passage through the Federal Columbia River Power System, five mainstem Columbia River Public Utility Dams, and stream temperature, sedimentation, fish passage, water quality and stream flow conditions that limit spawning and rearing success. Hatchery practices at the Wells program may be depressing natural productivity. See Wenatchee for fishing impacts.	Wells Program The program is poorly Integrated (mixes MSAs and uses few natural-origin fish) and intends to boost the number of natural spawners. Douglas County PUD funded. ESA Section 10 permit #1395 is in place	1982	+ for stepping in to preserve genetic resources and boosting the number of naturally spawning fish when natural origin steelhead returns were < 200 fish for 5 of 6 years between 1993 and 1998. - for risks to pop diversity and productivity by collecting broodstock at Wells Dam and then introducing these fish in different areas throughout the Okanogan Basin. Hatchery origin fish comprise >90% of all natural spawners (high hatchery influence) which also poses a potential risk to pop diversity and productivity.	Same as above Upgrade & expand broodstock collection and rearing capability at Cassimer Bar and use strictly Okanogan fish to increase the number of natural spawners (Colville Tribe). Test live-capture selective gear to collect hatchery broodstock & remove hatchery returns surplus to recovery needs while reducing harvest impacts on the population (Colville Tribe).
			Same as above	Omak Crk Program BPA funded. ESA Section 10 permit #1412 is in place.	2003	+ for preserving and building genetic resources and boosting the number of natural spawners	
			Same as above	Salmon Crk Program	2007	+ for preserving and building genetic resources and boosting the number of natural spawners	This program will coincide with improved flows in Salmon Crk provided by the Okanogan Irrigation District.

Evolutionarily Significant Unit or Steelhead Distinct Population Segment	Major Population Group or Strata	Population	Major Factor(s) Currently Limiting Population Recovery	Hatchery Program	Year the Current Hatchery Program was Initiated	Hatchery Effects on Population Viability + Denotes a Beneficial Effect and – Denotes a Risk or Threat to Viability	New Hatchery Actions that Potentially Could Contribute to Recovery
Upper Columbia steelhead (cont.)	Kettle/Colville	Sanpoil R.	Grande Coulee Dam Blocked all passage	None	NA	**Extirpated Population**	
		Kettle/Colville	Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Pend Oreille R	Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Kootenay R	Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
	Spokane	Spokane R	Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	
		Hangman Crk	Grande Coulee Dam blocked all passage	None	NA	**Extirpated Population**	

For a complete list of literature cited, see the Supplemental Comprehensive Analysis, Chapter 12

Hydro Modeling Appendix

May 5, 2008

Snake River Spring Chinook Salmon

Relative Improvements from "Base" to "Current" to "Prospective" Hydro Survival Improvements for NMFS Draft BiOp

NOTE: When Hydro and other Prospective Actions are added to a life-cycle model, the populations may grow to a point where density dependent effects occur; which would be equivalent to reducing the survival improvements.

Population	Avg System Survival Estimates [1]			Avg Smolt to Adult Survival Estimates (Scheurell-Zabel Hypothesis) [2]			Source
	Base	Current	Prospective	Base	Current	Prospective	
Populations Upstream of LGR	0.722			0.00725			Rich Zabel: pers. comm. Mar 26, 2007 e-mail providing TRT "Base" parameters used for life-cycle modeling.
		0.852	0.868		0.00869	0.00914	March 28, 2008 COMPASS model estimates: inriver survival and LGR to LGR SARs
	0.722	**0.852**	**0.868**	**0.00725**	**0.00869**	**0.00914**	**Best Estimate (LGR to BON inriver survival & LGR to LGR SARs)**
		1.181	**1.018**		**1.199**	**1.052**	**Relative Adjustment**

1) Average "Base" (1980 to 2001 migration years) system survival (i.e., estimated number of fish surviving via inriver or transport to below BON) was estimated assuming: Inriver survival = 0.334; Proportion transported = 0.600; and % transport survival = 0.98; average "Current" and "Prospective" system survival was estimated using COMPASS.

2) The average "Base" (1980 to 2001 migration years) LGR to LGR SAR is estimated by applying the Current average inriver ((0.01347) and transport ((0.00927)) SAR estimates generated by the COMPASS model to the Base inriver and transport system survival estimates: 0.00725 = (0.6*0.98*0.00927)+((1-0.6)*0.334*0.01347). NOTE: this equates to a "D" estimate of 0.688.

Snake River Steelhead

Relative Improvements from "Base" to "Current" to "Prospective" Hydro Survival Improvements for NMFS Draft BiOp

NOTE: When Hydro and other Prospective Actions are added to a life-cycle model, the populations may grow to a point where density dependent effects occur; which would be equivalent to reducing the survival improvements.

Population	Avg System Survival Estimates [1]			Avg Smolt to Adult Survival Estimates (Scheurell-Zabel Hypothesis)			Source
	Base	Current	Prospective	Base	Current	Prospective	
Populations Upstream of LGR	0.899						Rich Zabel: pers. comm. Mar 20, 2007 e-mail providing TRT "Base" parameters used for life-cycle modeling.
		0.869	0.857		0.01799	0.01801	March 28, 2008 COMPASS model estimates: inriver survival and LGR to LGR SARs
	0.899	**0.869**	**0.857**		**0.01799**	**0.01801**	**Best Estimate (LGR to BON inriver survival & LGR to LGR SARs)**
		0.966	**0.986**			**1.001**	**Relative Adjustment**

1) Average "Base" (1980 to 2001 migration years) system survival (i.e., estimated number of fish surviving via inriver or transport to below BON) was estimated assuming: Inriver survival = 0.265; Proportion transported = 0.887; and % transport survival = 0.98; average "Current" and "Prospective" system survival was estimated using COMPASS.

Upper Columbia River Spring Chinook Salmon

Relative Improvements from "Base" to "Current" to "Prospective" Hydro Survival Improvements for NMFS Draft BiOp

NOTE: When Hydro and other Prospective Actions are added to a life-cycle model, the populations may grow to a point where density dependent effects occur; which would be equivalent to reducing the survival improvements.

Population	Avg System Survival Estimates [1]			Avg Smolt to Adult Survival Estimates (Scheurell-Zabel Hypothesis) [2]			Source
	Base	Current	Prospective	Base	Current	Prospective	
Wenatchee River (7 dams)	**0.441**						**Rich Zabel: pers. comm. Mar 26, 2007 e-mail providing TRT "Base" parameters (RIS to BON) used for life-cycle modeling.**
		0.667	0.726	0.01056	0.01056	0.01052	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.662	0.823	0.823				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module.[3]
	0.441	**0.549**	**0.597**	**0.00466**	**0.00580**	**0.00629**	**Best Estimate (RIS to BON inriver survival & RIS to RIS SARs)**
		1.245	**1.088**		**1.245**	**1.085**	**Relative Adjustment**
Entiat River (8 dams)	**0.666**						**Estimated MCN to BON survival of 66.6% (RIS to BON = 0.441 / RIS to MCN = 0.662)**
		0.667	0.726	0.01056	0.01056	0.01052	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.573	0.757	0.765				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module.3
	0.382	**0.505**	**0.555**	**0.00403**	**0.00533**	**0.00584**	**Best Estimate (RRE to BON inriver survival & RRE to RIS SARs)**
		1.323	**1.100**		**1.323**	**1.096**	**Relative Adjustment**
Methow and Okanogan Rivers (9 dams)	**0.666**						**Estimated MCN to BON survival of 66.6% (RIS to BON = 0.441 / RIS to MCN = 0.662)**
		0.667	0.726	0.01056	0.01056	0.01052	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.511	0.728	0.736				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module.3
	0.340	**0.486**	**0.534**	**0.00359**	**0.00513**	**0.00562**	**Best Estimate (WEL to BON inriver survival & WEL to RIS SARs)**
		1.427	**1.100**		**1.427**	**1.097**	**Relative Adjustment**

1) Average "Base" (1980 to 2001 migration years) system survival was estimated as 0.441 from Rock Island to Bonneville Dams (7 dams).

2) Average "Base" (1980 to 2001 migration years) system survival was estimated assuming average system survival parameters; estimated SARs from COMPASS: average BON to RIS SAR of 0.01056 for Base and Current and 0.01052 for Prospective.

3) Final Draft QAR Report (Sept 2002): Avg survival estimates (1982-1996) through Mid-Columbia River Dams (Table 18); NMFS Hydro Module - Mid-Columbia River Projects (2004-2009) - Table 4.1a; and (2010-2013) Table 4.1.b.

Upper Columbia River Steelhead

Relative Improvements from "Base" to "Current" to "Prospective" Hydro Survival Improvements for NMFS Draft BiOp

NOTE: When Hydro and other Prospective Actions are added to a life-cycle model, the populations may grow to a point where density dependent effects occur; which would be equivalent to reducing the survival improvements.

Population	Avg System Survival Estimates [1]			Avg Smolt to Adult Survival Estimates (Scheurell-Zabel Hypothesis) [2]			Source
	Base	Current	Prospective	Base	Current	Prospective	
Wenatchee River (7 dams)	**0.468**						Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (7 dams) (.827 per project survival)^4.
		0.479	0.528	0.01369	0.01369	0.01364	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.690	0.727	0.814				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module. [3]
	0.323	**0.349**	**0.430**	**0.00442**	**0.00477**	**0.00586**	**Best Estimate (RIS to BON inriver survival & RIS to RIS SARs)**
		1.080	**1.234**		**1.080**	**1.229**	**Relative Adjustment**
Entiat River (8 dams)	**0.468**						Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (7 dams) (.827 per project survival)^4.
		0.479	0.528	0.01369	0.01369	0.01364	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.633	0.696	0.780				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module. [3]
	0.296	**0.334**	**0.412**	**0.00405**	**0.00457**	**0.00562**	**Best Estimate (RRE to BON inriver survival & RRE to RIS SARs)**
		1.127	**1.235**		**1.127**	**1.231**	**Relative Adjustment**
Methow and Okanogan Rivers (9 dams)	**0.468**						Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (7 dams) (.827 per project survival)^4.
		0.479	0.528	0.01369	0.01369	0.01364	March 28, 2008 COMPASS model estimates: BON to RIS SAR estimates
	0.549	0.670	0.750				Survival Estimates through Mid-Columbia River projects from 2002 Final Draft QAR Report and NMFS' Hydro Module. [3]
	0.257	**0.321**	**0.396**	**0.00351**	**0.00440**	**0.00540**	**Best Estimate (WEL to BON inriver survival & WEL to RIS SARs)**
		1.251	**1.234**		**1.251**	**1.229**	**Relative Adjustment**

1) Average "Base" (1980 to 2001 migration years) Snake River steelhead inriver survival estimate (0.265) through 7 dams system equals an average pre project survival of 0.827. 0.827^4 = 0.468 (and estimate of the average survival through the 4 lower Columbia River projects. NOTE: an estimate of 0.827 per project likely overestimates the actual Base survival levels through the mainstem Columbia River projects.

2) Average "Base" (1980 to 2001 migration years) system survival was estimated assuming average system survival parameters; estimated SARs from COMPASS: average BON to RIS SAR of 0.01354 for Base and Current and 0.01353 for Prospective.

3) Final Draft QAR Report (Sept 2002): Avg survival estimates (1982-1996) through Mid-Columbia River Dams (Table 18); NMFS Hydro Module - Mid-Columbia River Projects (2004-2009) - Table 4.1a; and (2010-2013) Table 4.1.b.

Middle Columbia River Steelhead

Relative Improvements from "Base" to "Current" to "Prospective" Hydro Survival Improvements for NMFS Draft BiOp

NOTE: When Hydro and other Prospective Actions are added to a life-cycle model, the populations may grow to a point where density dependent effects occur; which would be equivalent to reducing the survival improvements.

Population	Avg System Survival Estimates [1]			Source
	Base	Current	Prospective	
Bonneville Pool Tributaries (1 dam)	0.901			Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (7 dams) (.827 per project survival^1) corrected with relative "Current" survival estimates through the lower Columbia River.
		0.900	0.903	March 28, 2008 COMPASS model estimates: inriver survival.
	0.901	**0.900**	**0.903**	**Best Estimate**
		0.999	**1.003**	**Relative Adjustment**
Deschutes River (2 dams)	0.732			Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (.827 per project survival^2) weighted by relative "Current" survival estimates through the lower Columbia River.
		0.730	0.768	March 28, 2008 COMPASS model estimates: inriver survival.
	0.732	**0.730**	**0.768**	**Best Estimate**
		0.998	**1.051**	**Relative Adjustment**
Umatilla and John Day Rivers (3 dams)	0.533			Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (.827 per project survival^3) weighted by relative "Current" survival estimates through the lower Columbia River.
		0.536	0.579	March 28, 2008 COMPASS model estimates: inriver survival.
	0.533	**0.536**	**0.579**	**Best Estimate**
		1.005	**1.082**	**Relative Adjustment**
Yakima and Walla Walla Rivers (4 dams)	0.468			Estimated as TRT "Base" inriver survival estimate (0.265) from LGR to BON (.827 per project survival^4) weighted by relative "Current" survival estimates through the lower Columbia River.
		0.476	0.524	March 28, 2008 COMPASS model estimates: inriver survival.
	0.468	**0.476**	**0.524**	**Best Estimate**
		1.018	**1.102**	**Relative Adjustment**

1) Average "Base" (1980 to 2001 migration years) Snake River steelhead inriver survival estimate (0.265) through 7 dams system equals an average pre project survival of 0.827. 0.827^(# of dams) = the estimated average survival through the corresponding number of lower Columbia River projects. NOTE: an estimate of 0.827 per project likely overestimates the actual Base survival levels through the mainstem Columbia River projects.

NOTE: For MCR steelhead, no assumption is made regarding changes in SARs between the Base, Current, and Prospective periods. It seems likely that improving passage conditions (Current and Prospective model output compared to estimated Base conditions) has reduced sub-lethal effects to some extent, which would, in turn, be likely to increase, by some unquantifiable amount, the average SAR's of these fish compared to SARs during the average Base period. This analysis is therefore conservative in that it only estimates direct survival improvements and does not presume any positive adjustment related to likely increased SARs (reduced latent mortality) for populations in this DPS.

Mid Columbia Steelhead COMPASS modeling results (average project survival estimates)
Average estimates for analysis parameters
(Note: spill survivals adjustments for steelhead at BON are included in these numbers.)

		Project Survival					Stock survivals			
		Bonneville	The Dalles	John Day	McNary		Yakima Walla Walla	Umatilla, John Day	Deschutes	Bonneville Pool
Current condition	70 year	0.900	0.811	0.728	0.876		0.476	0.536	0.730	0.900
Final RPA	Average	0.903	0.850	0.748	0.892		0.524	0.579	0.768	0.903
absolute change		0.002	0.041	0.038	0.018		0.071	0.064	0.040	0.002
Relative Change		0.24%	4.80%	4.73%	1.99%		12.21%	10.03%	5.05%	0.24%

	Est. Current Proj Survival (from COMPASS)	**Deviation from current average per project survival (0.826)**	**Average Base project survival (.827 per project)**	**Base project survival - corrected with current deviation estimates**
BON	0.900	**1.089**	0.827	**0.901**
TDA	0.811	**0.982**	0.827	**0.812**
JDA	0.728	**0.881**	0.827	**0.729**
MCN	0.876	**1.061**	0.827	**0.877**
avg per proj.	**0.826**		0.468	**0.468**
	0.465			

	Cumulative Survival Current		Cum. Survival using average base	**Cum. Survival using weighted base**		Relative Adjustment using average base	**Relative Adjustment using weighted base**	
BON	0.900	1 project	0.827	**0.901**	1 project	1.088	**0.999**	1 project
TDA	0.730	2 project	0.684	**0.732**	2 project	1.068	**0.998**	2 project
JDA	0.536	3 project	0.566	**0.533**	3 project	0.947	**1.005**	3 project
MCN	0.476	4 project	0.468	**0.468**	4 project	1.018	**1.018**	4 project

Snake River Spring/Summer Chinook

Average estimates for analysis parameters

				Median day of arrival		Proportion of population		FCRPS Survival			Composite BON-LGR SAR		
		In River Survival	"destined" for transport	In River Migrants	Transported	In River Migrants	Transported	Survival without "D"	"D" estimate	Survival with "D"	In River Migrants	Transported	Whole population LGR-LGR SAR
Prospective Action	70 year Average	0.608	0.684	140.6	129.0	0.238	0.762	0.868	0.709	0.668	0.01289	0.00914	0.00914
Current		0.528	0.693	139.9	128.4	0.217	0.783	0.852	0.688	0.630	0.01347	0.00927	0.00869
Absolute Change		0.080	-0.010	0.741	0.588	0.022	-0.022	0.016	0.021	0.038	-0.001	0.000	0.000
Relative change		15.1%	-1.4%	0.5%	0.5%	10.0%	-2.8%	1.8%	3.1%	6.0%	-4.3%	-1.4%	5.2%
Prospective Action	<65 KCFS	0.519	0.887	169.0	131.3	0.068	0.932	0.929	2.402	2.147	0.00391	0.00940	0.00836
Current	n=	0.373	0.945	155.2	132.2	0.032	0.968	0.951	1.154	1.089	0.00800	0.00923	0.00855
Absolute Change	13	0.146	-0.058	13.722	-0.890	0.036	-0.036	-0.022	1.249	1.058	-0.004	0.000	0.000
Relative change		39.0%	-6.1%	8.8%	-0.7%	112.1%	-3.7%	-2.3%	108.2%	97.2%	-51.1%	1.8%	-2.2%
Prospective Action	65-80 KCFS	0.604	0.725	142.6	131.3	0.196	0.804	0.877	0.828	0.754	0.01168	0.00968	0.00882
Current	n=	0.539	0.672	145.1	131.2	0.227	0.773	0.838	0.785	0.694	0.01202	0.00943	0.00834
Absolute Change	13	0.065	0.052	-2.491	0.196	-0.031	0.031	0.039	0.043	0.061	0.000	0.000	0.000
Relative change		12.1%	7.8%	-1.7%	0.1%	-13.8%	4.1%	4.7%	5.5%	8.8%	-2.8%	2.6%	5.8%
Prospective Action	80-130 KCFS	0.631	0.635	132.7	128.4	0.278	0.722	0.853	0.605	0.607	0.01564	0.00945	0.00937
Current	n=	0.567	0.646	135.2	127.2	0.248	0.752	0.834	0.610	0.587	0.01521	0.00928	0.00876
Absolute Change	36	0.064	-0.011	-2.469	1.243	0.030	-0.030	0.019	-0.005	0.020	0.000	0.000	0.001
Relative change		11.3%	-1.7%	-1.8%	1.0%	12.0%	-3.9%	2.3%	-0.9%	3.3%	2.8%	1.9%	7.0%
Prospective Action	>130 KCFS	0.652	0.505	126.9	123.9	0.406	0.594	0.819	0.537	0.589	0.01705	0.00916	0.00993
Current	n=	0.586	0.531	127.5	123.2	0.358	0.642	0.796	0.537	0.554	0.01689	0.00906	0.00922
Absolute Change	8	0.067	-0.026	-0.660	0.684	0.048	-0.048	0.023	0.001	0.035	0.000	0.000	0.001
Relative change		11.4%	-4.8%	-0.5%	0.6%	13.3%	-7.4%	2.9%	0.1%	6.3%	1.0%	1.1%	7.7%
Prospective Action	>65 KCFS	0.628	0.637	134.161	128.469	0.277	0.723	0.853	0.709	0.668	0.01493	0.00946	0.00932
Current	n=	0.563	0.636	136.4	127.5	0.259	0.741	0.829	0.631	0.598	0.01472	0.00928	0.00873
Absolute Change	58	0.065	0.002	-2.220	0.925	0.018	-0.018	0.024	0.079	0.069	0.000	0.000	0.001
Relative change		11.5%	0.2%	-1.6%	0.7%	7.1%	-2.5%	2.9%	12.5%	11.6%	1.5%	1.9%	6.8%

Snake River Steelhead

Average estimates for analysis parameters

				Median day of arrival		Proportion of population		FCRPS Survival			Composite BON-LGR SAR		
		In River Survival	"destined" for transport	In River Migrants	Transported	In River Migrants	Transported	Survival without "D"	"D" estimate	Survival with "D"	In River Migrants	Transported	Whole population LGR-LGR SAR
Prospective Action	70 year Average	0.385	0.771	138.1	133.4	0.125	0.875	0.857	1.608	1.303	0.01420	0.02283	0.01801
Current		0.331	0.817	137.8	133.5	0.086	0.914	0.869	1.525	1.282	0.01477	0.02253	0.01799
Absolute Change		0.055	-0.046	0.328	-0.125	0.039	-0.039	-0.012	0.082	0.021	-0.001	0.000	0.000
Relative change		16.6%	-5.7%	0.2%	-0.1%	45.2%	-4.2%	-1.4%	5.4%	1.6%	-3.8%	1.3%	0.1%
Prospective Action	<65 KCFS	0.091	0.890	168.5	136.0	0.013	0.987	0.882	3.645	3.190	0.00604	0.02201	0.01810
Current	n=	0.075	0.936	159.3	136.8	0.007	0.993	0.921	2.051	1.886	0.01045	0.02143	0.01840
Absolute Change	13	0.016	-0.046	9.131	-0.796	0.006	-0.006	-0.039	1.595	1.304	-0.004	0.001	0.000
Relative change		21.6%	-4.9%	5.7%	-0.6%	90.6%	-0.6%	-4.3%	77.8%	69.2%	-42.2%	2.7%	-1.6%
Prospective Action	65-80 KCFS	0.289	0.793	141.1	135.0	0.077	0.923	0.836	1.565	1.276	0.01438	0.02250	0.01737
Current	n=	0.245	0.788	144.3	135.6	0.074	0.926	0.823	1.499	1.209	0.01468	0.02200	0.01644
Absolute Change	13	0.044	0.005	-3.220	-0.625	0.002	-0.002	0.013	0.066	0.067	0.000	0.001	0.001
Relative change		17.8%	0.6%	-2.2%	-0.5%	3.3%	-0.3%	1.6%	4.4%	5.5%	-2.0%	2.3%	5.6%
Prospective Action	80-130 KCFS	0.475	0.751	129.6	132.7	0.147	0.853	0.857	1.383	1.136	0.01664	0.02301	0.01822
Current	n=	0.407	0.806	131.4	132.6	0.096	0.904	0.869	1.409	1.192	0.01620	0.02283	0.01829
Absolute Change	36	0.069	-0.055	-1.865	0.158	0.051	-0.051	-0.012	-0.027	-0.056	0.000	0.000	0.000
Relative change		16.9%	-6.8%	-1.4%	0.1%	53.4%	-5.7%	-1.3%	-1.9%	-4.7%	2.7%	0.8%	-0.4%
Prospective Action	>130 KCFS	0.617	0.628	122.1	129.5	0.281	0.719	0.846	1.474	1.136	0.01619	0.02386	0.01795
Current	n=	0.542	0.718	120.4	129.0	0.187	0.813	0.858	1.536	1.234	0.01552	0.02383	0.01851
Absolute Change	8	0.075	-0.090	1.659	0.505	0.095	-0.095	-0.012	-0.062	-0.097	0.001	0.000	-0.001
Relative change		13.8%	-12.6%	1.4%	0.4%	50.7%	-11.6%	-1.4%	-4.0%	-7.9%	4.3%	0.1%	-3.0%
Prospective Action	>65 KCFS	0.453	0.743	131.157	132.793	0.150	0.850	0.851	1.608	1.303	0.01606	0.02302	0.01799
Current	n=	0.389	0.790	132.8	132.8	0.104	0.896	0.857	1.446	0.786	0.01576	0.02278	0.01790
Absolute Change	58	0.064	-0.046	-1.679	0.028	0.046	-0.046	-0.006	0.162	0.517	0.000	0.000	0.000
Relative change		16.4%	-5.9%	-1.3%	0.0%	44.5%	-5.2%	-0.7%	11.2%	65.8%	2.0%	1.0%	0.5%

UC Chinook

Average estimates for analysis parameters

		In River Survival	Median day of arrival		Est. SAR BON-RIS	Est. RIS to RIS SAR
Prospective Action	70 year Average	0.726	149.1		0.01052	0.00767
Current		0.667	149.0		0.01056	0.00707
Absolute Change		0.059	0.100		0.000	0.001
Relative change		8.82%	0.07%		-0.33%	8.50%
Prospective Action	<200,000 n= 17	0.683	151.0		0.00976	0.00689
Current		0.629	150.9		0.00981	0.00636
Absolute Change		0.054	0.133		0.000	0.001
Relative change		8.64%	0.09%		-0.59%	7.64%
Prospective Action	00,000-325,00 n= 46	0.736	148.4		0.01081	0.00796
Current		0.674	148.4		0.01082	0.00732
Absolute Change		0.061	0.038		0.000	0.001
Relative change		9.07%	0.03%		-0.10%	8.75%
Prospective Action	>325,000 n= 7	0.766	149.2		0.01051	0.00766
Current		0.711	148.8		0.01064	0.00714
Absolute Change		0.055	0.429		0.000	0.001
Relative change		7.70%	0.29%		-1.26%	7.25%
Prospective Action	>200,000 n= 53	0.740	148.5		0.01077	0.00792
Current		0.679	148.4		0.01080	0.00729
Absolute Change		0.060	0.089		0.000	0.001
Relative change		8.88%	0.06%		-0.25%	8.56%

UC Steelhead

Average estimates for analysis parameters

		In River Survival	Median day of arrival		Est. SAR BON-RIS	Est. RIS to RIS SAR
Prospective Action	70 Average	0.528	150.3		0.01364	0.00715
Current		0.479	150.2		0.01369	0.00650
Absolute Change		0.0489	0.1214		0.0000	0.0007
Relative change		10.19%	0.08%		-0.35%	10.09%
Prospective Action	<200,000 n= 17	0.306	150.0		0.01385	0.00569
Current		0.279	149.9		0.01389	0.00515
Absolute Change		0.0269	0.1300		0.0000	0.0005
Relative change		9.64%	0.09%		-0.35%	10.42%
Prospective Action	00,000-325,00 n= 46	0.581	150.5		0.01353	0.00773
Current		0.526	150.4		0.01354	0.00699
Absolute Change		0.0548	0.0252		0.0000	0.0007
Relative change		10.41%	0.02%		-0.03%	10.53%
Prospective Action	>325,000 n= 7	0.721	149.9		0.01382	0.00690
Current		0.658	149.2		0.01416	0.00649
Absolute Change		0.0632	0.7329		-0.0003	0.0004
Relative change		9.62%	0.49%		-2.39%	6.32%
Prospective Action	>325,000 n= 53	0.599	150.4		0.01357	0.00762
Current		0.544	150.3		0.01362	0.00693
Absolute Change		0.0559	0.1187		0.0000	0.0007
Relative change		10.29%	0.08%		-0.35%	10.01%

Mid Columbia Steelhead

Average estimates for analysis parameters

		Project Survival					Stock survivals			
		Bonneville	The Dalles	John Day	McNary		Yakima Walla Walla	Umatilla, John Day	Deschutes	Bonneville Pool
Prospective Action	70	0.903	0.850	0.748	0.892		0.524	0.579	0.768	0.903
Current	Average	0.900	0.811	0.728	0.876		0.476	0.536	0.730	0.900
Absolute Change		0.003	0.039	0.021	0.016		0.048	0.044	0.038	0.003
Relative change		0.31%	4.82%	2.85%	1.86%		10.16%	8.16%	5.15%	0.31%
Prospective Action	<200,000	0.879	0.813	0.525	0.813		0.312	0.378	0.714	0.879
Current	n=	0.875	0.776	0.513	0.798		0.284	0.351	0.680	0.875
Absolute Change	17	0.003	0.036	0.012	0.015		0.028	0.027	0.034	0.003
Relative change		0.36%	4.69%	2.35%	1.92%		9.70%	7.55%	5.07%	0.36%
Prospective Action	00,000-325,00	0.912	0.860	0.802	0.914		0.577	0.630	0.784	0.912
Current	n=	0.909	0.820	0.778	0.897		0.522	0.581	0.746	0.909
Absolute Change	46	0.003	0.039	0.024	0.017		0.054	0.049	0.039	0.003
Relative change		0.35%	4.80%	3.04%	1.91%		10.41%	8.36%	5.17%	0.35%
Prospective Action	>325,000	0.897	0.880	0.936	0.941		0.696	0.739	0.790	0.897
Current	n=	0.897	0.837	0.913	0.928		0.637	0.686	0.751	0.897
Absolute Change	7	0.000	0.044	0.023	0.013		0.059	0.053	0.039	0.000
Relative change		-0.04%	5.23%	2.47%	1.41%		9.31%	7.80%	5.20%	-0.04%
Prospective Action	>325,000	0.910	0.862	0.820	0.918		0.593	0.644	0.785	0.910
Current	n=	0.908	0.823	0.796	0.901		0.538	0.595	0.747	0.908
Absolute Change	53	0.003	0.040	0.024	0.017		0.055	0.049	0.039	0.003
Relative change		0.30%	4.86%	2.95%	1.85%		10.24%	8.27%	5.17%	0.30%

Summary of Dam Passage Survival Estimates Generated by COMPASS Model - March 28, 2008 runs

Current Dam Passage Survival Estimates

Yearling Chinook	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON
Average	**0.964**	**0.960**	**0.938**	**0.966**	**0.942**	**0.918**	**0.914**	**0.971**
Max value	0.969	0.970	0.956	0.967	0.950	0.943	0.919	0.971
75%	0.967	0.968	0.950	0.967	0.944	0.929	0.914	0.971
50%	**0.966**	**0.966**	**0.948**	**0.966**	**0.941**	**0.919**	**0.914**	**0.971**
25%	0.963	0.965	0.947	0.966	0.940	0.911	0.913	0.971
Min value	0.949	0.923	0.882	0.966	0.935	0.893	0.912	0.970

Steelhead	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON
Average	**0.963**	**0.957**	**0.933**	**0.988**	**0.954**	**0.929**	**0.923**	**0.972**
Max value	0.970	0.970	0.952	0.989	0.956	0.954	0.924	0.972
75%	0.968	0.968	0.947	0.988	0.955	0.934	0.923	0.972
50%	**0.966**	**0.966**	**0.944**	**0.988**	**0.954**	**0.928**	**0.923**	**0.972**
25%	0.964	0.964	0.938	0.988	0.953	0.923	0.923	0.971
Min value	0.945	0.945	0.881	0.987	0.952	0.917	0.923	0.970

Proposed Action Dam Passage Survival Estimates

Yearling Chinook	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON
Average	**0.969**	**0.972**	**0.961**	**0.973**	**0.961**	**0.932**	**0.955**	**0.975**
Max value	0.973	0.975	0.966	0.977	0.964	0.960	0.969	0.976
75%	0.970	0.975	0.965	0.974	0.962	0.944	0.956	0.975
50%	**0.969**	**0.974**	**0.962**	**0.973**	**0.962**	**0.934**	**0.956**	**0.975**
25%	0.967	0.973	0.960	0.971	0.961	0.925	0.953	0.974
Min value	0.962	0.959	0.947	0.969	0.959	0.901	0.948	0.973

Steelhead	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON
Average	**0.969**	**0.969**	**0.971**	**0.962**	**0.973**	**0.955**	**0.967**	**0.975**
Max	0.974	0.974	0.975	0.969	0.974	0.975	0.977	0.976
75%	0.971	0.971	0.974	0.968	0.973	0.961	0.967	0.975
50%	**0.969**	**0.969**	**0.973**	**0.965**	**0.973**	**0.955**	**0.967**	**0.975**
25%	0.967	0.967	0.971	0.961	0.972	0.950	0.966	0.974
Min	0.964	0.964	0.959	0.937	0.970	0.943	0.963	0.973

Snake River Spring/Summer Chinook

Average estimates for analysis parameters

		In River Survival	"destined" for transport	Median day of arrival: In River Migrants	Median day of arrival: Transported	Proportion of population: In River Migrants	Proportion of population: Transported	FCRPS Survival: Survival without "D"	FCRPS Survival: "D" estimate	FCRPS Survival: Survival with "D"		Composite Bon-LGR SAR: In River Migrants	Composite Bon-LGR SAR: Transported	Whole population LGR-LGR SAR
PA	70 year Average	0.608	0.684	140.6	129.0	0.238	0.762	0.868	0.709	0.668		0.01289	0.00914	0.00914
NO USBR		0.611	0.659	139.0	127.9	0.262	0.738	0.860	0.698	0.659		0.01344	0.00938	0.00926
absolute change		-0.003	0.025	1.590	1.057	-0.024	0.024	0.008	0.012	0.009		-0.001	0.000	0.000
Relative change from NO USBR		-0.5%	3.8%	1.1%	0.8%	-9.2%	3.3%	0.9%	1.7%	1.3%		-4.1%	-2.5%	-1.3%
PA	<65 KCFS n= 13	0.519	0.887	169.0	131.3	0.068	0.932	0.929	2.402	2.147		0.00391	0.00940	0.00836
NO USBR		0.523	0.892	168.6	131.0	0.065	0.935	0.932	2.385	2.141		0.00393	0.00937	0.00839
absolute change		-0.005	-0.005	0.374	0.285	0.003	-0.003	-0.003	0.018	0.006		0.000	0.000	0.000
Relative change from NO USBR		-0.9%	-0.5%	0.2%	0.2%	4.4%	-0.3%	-0.3%	0.7%	0.3%		-0.5%	0.3%	-0.4%
PA	65-80 KCFS n= 13	0.604	0.725	142.6	131.3	0.196	0.804	0.877	0.828	0.754		0.01168	0.00968	0.00882
NO USBR		0.607	0.713	138.8	130.8	0.205	0.795	0.873	0.747	0.696		0.01290	0.00963	0.00895
absolute change		-0.004	0.012	3.789	0.498	-0.009	0.009	0.004	0.082	0.059		-0.001	0.000	0.000
Relative change from NO USBR		-0.6%	1.6%	2.7%	0.4%	-4.6%	1.2%	0.4%	10.9%	8.4%		-9.4%	0.5%	-1.4%
PA	80-130 KCFS n= 36	0.631	0.635	132.7	128.4	0.278	0.722	0.853	0.605	0.607		0.01564	0.00945	0.00937
NO USBR		0.634	0.604	131.3	127.0	0.307	0.693	0.843	0.578	0.593		0.01621	0.00936	0.00950
absolute change		-0.003	0.031	1.424	1.458	-0.029	0.029	0.010	0.027	0.014		-0.001	0.000	0.000
Relative change from NO USBR		-0.4%	5.2%	1.1%	1.1%	-9.6%	4.2%	1.2%	4.7%	2.3%		-3.5%	1.0%	-1.4%
PA	>130 KCFS n= 8	0.652	0.505	126.9	123.9	0.406	0.594	0.819	0.537	0.589		0.01705	0.00916	0.00993
NO USBR		0.654	0.438	126.1	122.5	0.473	0.527	0.797	0.524	0.592		0.01728	0.00905	0.01012
absolute change		-0.001	0.067	0.737	1.416	-0.067	0.067	0.021	0.014	-0.003		0.000	0.000	0.000
Relative change from NO USBR		-0.2%	15.3%	0.6%	1.2%	-14.2%	12.8%	2.7%	2.6%	-0.6%		-1.3%	1.3%	-1.9%
PA	>65 KCFS n= 58	0.628	0.637	134.161	128.469	0.277	0.723	0.853	0.634	0.623		0.01493	0.00946	0.00932
NO USBR		0.631	0.605	132.3	127.2	0.307	0.693	0.844	0.601	0.605		0.01561	0.00938	0.00946
absolute change		-0.003	0.032	1.867	1.233	-0.030	0.030	0.010	0.033	0.018		-0.001	0.000	0.000
Relative change from NO USBR		-0.4%	5.3%	1.4%	1.0%	-9.8%	4.4%	1.2%	5.4%	3.0%		-4.3%	0.9%	-1.5%

Snake River Steelhead

Average estimates for analysis parameters

		In River Survival	"destined" for transport	Median day of arrival: In River Migrants	Median day of arrival: Transported	Proportion of population: In River Migrants	Proportion of population: Transported	FCRPS Survival: Survival without "D"	FCRPS Survival: "D" estimate	FCRPS Survival: Survival with "D"	Composite Bon-LGR SAR: In River Migrants	Composite Bon-LGR SAR: Transported	Whole population LGR-LGR SAR
PA	70 year	0.608	0.684	140.6	129.0	0.238	0.762	0.868	0.709	0.668	0.01289	0.00914	0.00914
NO USBR	Average	0.611	0.659	139.0	127.9	0.262	0.738	0.860	0.698	0.659	0.01344	0.00938	0.00926
absolute change		-0.003	0.025	1.590	1.057	-0.024	0.024	0.008	0.012	0.009	-0.001	0.000	0.000
Relative change from NO USBR		-0.5%	3.8%	1.1%	0.8%	-9.2%	3.3%	0.9%	1.7%	1.3%	-4.1%	-2.5%	-1.3%
PA	<65 KCFS	0.519	0.887	169.0	131.3	0.068	0.932	0.929	2.402	2.147	0.00391	0.00940	0.00836
NO USBR	n=	0.523	0.892	168.6	131.0	0.065	0.935	0.932	2.385	2.141	0.00393	0.00937	0.00839
absolute change	13	-0.005	-0.005	0.374	0.285	0.003	-0.003	-0.003	0.018	0.006	0.000	0.000	0.000
Relative change from NO USBR		-0.9%	-0.5%	0.2%	0.2%	4.4%	-0.3%	-0.3%	0.7%	0.3%	-0.5%	0.3%	-0.4%
PA	65-80 KCFS	0.604	0.725	142.6	131.3	0.196	0.804	0.877	0.828	0.754	0.01168	0.00968	0.00882
NO USBR	n=	0.607	0.713	138.8	130.8	0.205	0.795	0.873	0.747	0.696	0.01290	0.00963	0.00895
absolute change	13	-0.004	0.012	3.789	0.498	-0.009	0.009	0.004	0.082	0.059	-0.001	0.000	0.000
Relative change from NO USBR		-0.6%	1.6%	2.7%	0.4%	-4.6%	1.2%	0.4%	10.9%	8.4%	-9.4%	0.5%	-1.4%
PA	80-130 KCFS	0.631	0.635	132.7	128.4	0.278	0.722	0.853	0.605	0.607	0.01564	0.00945	0.00937
NO USBR	n=	0.634	0.604	131.3	127.0	0.307	0.693	0.843	0.578	0.593	0.01621	0.00936	0.00950
absolute change	36	-0.003	0.031	1.424	1.458	-0.029	0.029	0.010	0.027	0.014	-0.001	0.000	0.000
Relative change from NO USBR		-0.4%	5.2%	1.1%	1.1%	-9.6%	4.2%	1.2%	4.7%	2.3%	-3.5%	1.0%	-1.4%
PA	>130 KCFS	0.652	0.505	126.9	123.9	0.406	0.594	0.819	0.537	0.589	0.01705	0.00916	0.00993
NO USBR	n=	0.654	0.438	126.1	122.5	0.473	0.527	0.797	0.524	0.592	0.01728	0.00905	0.01012
absolute change	8	-0.001	0.067	0.737	1.416	-0.067	0.067	0.021	0.014	-0.003	0.000	0.000	0.000
Relative change from NO USBR		-0.2%	15.3%	0.6%	1.2%	-14.2%	12.8%	2.7%	2.6%	-0.6%	-1.3%	1.3%	-1.9%
PA	>65 KCFS	0.628	0.637	134.161	128.469	0.277	0.723	0.853	0.634	0.623	0.01493	0.00946	0.00932
NO USBR	n=	0.631	0.605	132.3	127.2	0.307	0.693	0.844	0.601	0.605	0.01561	0.00938	0.00946
absolute change	58	-0.003	0.032	1.867	1.233	-0.030	0.030	0.010	0.033	0.018	-0.001	0.000	0.000
Relative change from NO USBR		-0.4%	5.3%	1.4%	1.0%	-9.8%	4.4%	1.2%	5.4%	3.0%	-4.3%	0.9%	-1.5%

UC Chinook

Average estimates for analysis parameters

		In River Survival	Median day of arrival	Est. SAR BON-RIS	Est. RIS to RIS SAR
PA	70 year	0.726	149.1	0.01052	0.00767
No USBR	Average	0.730	148.9	0.01061	0.00777
absolute change		-0.004	0.208	0.000	0.000
Relative change from NO USBR		-0.53%	0.14%	-0.80%	-1.31%
PA	<200,000	0.683	151.0	0.00976	0.00689
No USBR	n=	0.686	152.1	0.00932	0.00641
absolute change	17	-0.003	-1.059	0.000	0.000
Relative change from NO USBR		-0.43%	-0.70%	4.69%	6.96%
PA	00,000-325,00	0.736	148.4	0.01081	0.00796
No USBR	n=	0.739	148.3	0.01090	0.00806
absolute change	46	-0.003	0.170	0.000	0.000
Relative change from NO USBR		-0.41%	0.11%	-0.85%	-1.26%
PA	>325,000	0.766	149.2	0.01051	0.00766
No USBR	n=	0.777	145.7	0.01181	0.00918
absolute change	7	-0.011	3.536	-0.001	-0.002
Relative change from NO USBR		-1.42%	2.43%	-11.00%	-16.57%
PA	>200,000	0.740	148.5	0.01077	0.00792
No USBR	n=	0.744	147.9	0.01102	0.00821
absolute change	53	-0.004	0.614	0.000	0.000
Relative change from NO USBR		-0.55%	0.42%	-2.29%	-3.52%

UC Steelhead

Average estimates for analysis parameters

		In River Survival	Median day of arrival	Est. SAR BON-RIS	Est. RIS to RIS SAR
PA	70	0.528	150.3	0.01364	0.00715
No USBR	Average	0.545	150.0	0.01377	0.00746
absolute change		-0.0170	0.3264	-0.0001	-0.0003
Relative change from NO USBR		-3.12%	0.22%	-0.97%	-4.08%
PA	<200,000	0.306	150.0	0.01385	0.00569
No USBR	n=	0.324	149.0	0.01423	0.00472
absolute change	17	-0.0176	1.0088	-0.0004	0.0010
Relative change from NO USBR		-5.43%	0.68%	-2.69%	20.58%
PA	00,000-325,00	0.581	150.5	0.01353	0.00773
No USBR	n=	0.600	149.6	0.01394	0.00832
absolute change	46	-0.0187	0.8287	-0.0004	-0.0006
Relative change from NO USBR		-3.11%	0.55%	-2.88%	-7.14%
PA	>325,000	0.721	149.9	0.01382	0.00690
No USBR	n=	0.725	154.5	0.01159	0.00840
absolute change	7	-0.0045	-4.6314	0.0022	-0.0015
Relative change from NO USBR		-0.62%	-3.00%	19.21%	-17.80%
PA	>325,000	0.599	150.4	0.01357	0.00762
No USBR	n=	0.616	150.3	0.01363	0.00833
absolute change	53	-0.0168	0.1075	-0.0001	-0.0007
Relative change from NO USBR		-2.73%	0.07%	-0.40%	-8.56%

Mid Columbia Steelhead

Average estimates for analysis parameters

		Project Survival					Stock survivals			
		Bonneville	The Dalles	John Day	McNary		Yakima Walla Walla	Umatilla, John Day	Deschutes	Bonneville Pool
PA	70	0.903	0.850	0.748	0.892		0.524	0.579	0.768	0.903
No USBR	Average	0.905	0.853	0.765	0.897		0.545	0.599	0.773	0.905
absolute change		-0.003	-0.003	-0.017	-0.005		-0.021	-0.020	-0.005	-0.003
Relative change from No USBR		-0.31%	-0.31%	-2.17%	-0.55%		-3.82%	-3.28%	-0.69%	-0.31%
PA	<200,000	0.879	0.813	0.525	0.813		0.312	0.378	0.714	0.879
No USBR	n=	0.858	0.816	0.544	0.822		0.324	0.387	0.701	0.858
absolute change	17	0.021	-0.004	-0.019	-0.008		-0.012	-0.010	0.013	0.021
Relative change from No USBR		2.44%	-0.45%	-3.49%	-1.02%		-3.68%	-2.47%	1.88%	2.44%
PA	00,000-325,00	0.912	0.860	0.802	0.914		0.577	0.630	0.784	0.912
No USBR	n=	0.920	0.862	0.820	0.919		0.600	0.651	0.793	0.920
absolute change	46	-0.007	-0.003	-0.017	-0.004		-0.023	-0.022	-0.009	-0.007
Relative change from No USBR		-0.77%	-0.29%	-2.12%	-0.49%		-3.80%	-3.31%	-1.08%	-0.77%
PA	>325,000	0.897	0.880	0.936	0.941		0.696	0.739	0.790	0.897
No USBR	n=	0.929	0.881	0.942	0.941		0.725	0.771	0.819	0.929
absolute change	7	-0.032	-0.001	-0.006	0.000		-0.030	-0.032	-0.029	-0.032
Relative change from No USBR		-3.44%	-0.12%	-0.59%	0.05%		-4.07%	-4.12%	-3.56%	-3.44%
PA	>325,000	0.910	0.862	0.820	0.918		0.593	0.644	0.785	0.910
No USBR	n=	0.921	0.865	0.836	0.922		0.616	0.667	0.796	0.921
absolute change	53	-0.010	-0.002	-0.016	-0.004		-0.024	-0.023	-0.011	-0.010
Relative change from No USBR		-1.13%	-0.27%	-1.90%	-0.42%		-3.84%	-3.44%	-1.42%	-1.13%

Inriver Juvenile Survival Appendix

May 5, 2008

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

Memorandum – Final F/NWR5

To: Bruce Suzumoto

From: Ritchie Graves and Gary Fredricks

Date: April 21, 2008

RE: NMFS staff proposal to add an Inriver Survival Performance metric and evaluation process to monitor the expected RPA hydro performance benefits and to provide annual evaluations for consideration in the proposed RPA's adaptive management process.

Introduction:

In addition to the Action Agencies' (AAs') proposed performance evaluation metrics (Juvenile Dam Passage Survival standard, Adult Performance standard, and Juvenile System Survival target - see BA, Section 2.1), NMFS staff recommends the addition of an Inriver Survival Performance Evaluation metric for inclusion in the FCRPS biological opinion. For all intents and purposes, the proposed metric is identical to the Action Agencies proposed Juvenile System Survival targets for UCR spring Chinook salmon and steelhead and MCR steelhead – which migrate inriver (they are not collected and transported) to below Bonneville Dam. The proposed metric would add an analogous performance evaluation metric for inriver migrating SR spring/summer Chinook salmon and steelhead to below Bonneville Dam[1] and an evaluation method for assessing progress towards achieving the Juvenile System Survival targets for the other ESUs.

NMFS staff concurs with the use of the three evaluation metrics proposed by the AAs, but believes the addition of an in-river survival metric for spring migrants is needed because the Juvenile Dam Passage Survival standard 1) is not evaluated each year at each dam and 2) does not include potential juvenile losses in the forebay or reservoir reaches. NMFS staff proposes an Inriver Survival Performance Evaluation metric to better assess inriver survival through the system (Lower Granite to Bonneville for the Snake River ESUs). The following sections describe the proposed metric, how the metric would be used in conjunction with the RPA's adaptive management provisions, and additional considerations that should be considered to ensure the proper use of this metric in future years.

In-River Survival Metric:

The use of an Inriver Survival Performance metric has two distinct advantages compared to specific dam passage performance standards. First, the use of PIT-tag data for in-river system survival metric is transparent and measurable annually. There is no need for interpretation of

[1] A high proportion of SR spring/summer Chinook salmon and steelhead are collected at Lower Granite, Little Goose, and Lower Monumental dams and transported to below Bonneville Dam.

multiple year dam passage studies. Second, it likely captures more direct, indirect, and delayed effects of the hydro system (any effects that occur between the point of release and the Bonneville tailrace) including, but not limited to, avian and piscivorous predation, dam related injuries, and forebay mortalities (which have been shown to be significant sources of mortality at some dams). It also can capture effects potentially unrelated to the hydro system (e.g. fish condition), however, these potentially unrelated effects can be neutralized to some degree through the evaluation study design.

Presently, no acceptable method exists to adequately monitor in-river or system survival of juvenile Fall Chinook Salmon through the FCRPS. This poses a severe limitation for monitoring and evaluating the performance of this ESU as they migrate through the FCRPS. This issue is receiving attention and will continue to be addressed within ongoing RM&E collaboration processes and the COMPASS modeling forum.

Process for Examination of In-river Survival:

A. Stepwise outline for the in-river survival evaluation

Before issuance of the biological opinion.

Step 1. Current reach survival estimates. Determine the current route specific survival and passage parameters for each dam (already in COMPASS for 2006) and calibrate COMPASS to empirically derived in-river survival estimates determined under the current system configuration to assure that the reservoir survival functions reasonably reflect observed in-river survival estimates (already completed). To assess the likely relative effects of RPA hydro actions across a wide range of flow conditions (Comprehensive Analysis and Biological Opinion analysis), the COMPASS model provides biological output based on a 70-year historical record. However, the model is also capable of providing biological output for a single year.

Step 2. Expected benefit estimates. Determine prospective route specific passage and survival improvements that are proposed by the AA's for the life of the BiOp (primarily Phase I actions listed in the BA). Add these to current values determined in Step 1. These new values are currently included in the BA text, but will be specifically listed in the RPA for use in the annual COMPASS runs listed below.

After issuance of the biological opinion.

Step 3. Near the end of each year as data become available, run COMPASS[2] with prospective survival estimates (from Step 2) for the action items that were implemented at the start of the migration season to estimate the expected in-river survival (LGR to BON for SR fish, MCN to BON for UCR fish, etc.[3]) for that year.[4] The current year data will include river conditions (flow, temp, turbidity, etc.,), fish migration patterns, and dam and transport operations. The

[2] NMFS will coordinate and assist the action agencies in collecting the necessary information for COMPASS modeling each year.
[3] SR Chinook salmon and steelhead estimates will be used as surrogates for the other interior basin Chinook salmon and steelhead population until more ESU specific information becomes available.
[4] COMPASS will be used to model the fish distribution, passage route, and operational conditions experienced by the study fish (PIT tagged at present or potentially acoustic tagged in the future).

results of these runs will become the in-river survival comparison metric for the following annual and mid-term checks explained below. [5]

Step 4. Each year, empirically measure in-river survival (LGR to BON and MCN to BON) with the best tagging method available at the time (PIT now, maybe active tag in the future).

These results will be compared to the COMPASS model results for that year (step 3) to provide important information for the annual implementation of the adaptive management process required by the biological opinion.

Step 5. Comprehensive Report. In 2012 and 2015, compare the expected in-river survival benefits (Step 3) from the past years of RPA implementation with empirical in-river survival estimates (Step 4). AAs and NMFS will check to see that the COMPASS point estimate is within the 95 percent confidence interval (for survival of Snake River Sp/Su Chinook and Steelhead from Lower Granite Dam to Bonneville Tailrace) of the empirical estimate. If or when COMPASS incorporates stochastic methods, this will be checked to determine if the 95 percent confidence interval for COMPASS overlaps with the 95 percent confidence interval of the empirical information.

Comparable estimates would indicate that the expected benefits from the RPA actions implemented to date are likely accruing as expected. Non-comparable estimates (especially cases in which the empirically derived in-river survival estimate is lower than that predicted by the COMPASS model) would trigger the adaptive management process to diagnose the cause of the discrepancy (expected benefits of RPA actions not fully achieved, model calibration issues, condition of study fish, other sources of mortality, etc.), and take necessary corrective actions, which could include pursuing alternative survival improvement actions, modifying research priorities, obtaining additional information to better calibrate the COMPASS model, and implementing potential in-river actions (e.g. predator control, etc.) to assure that the expected benefits will be achieved within the span of the BiOp.

Step 6. NMFS Review. In 2017, NMFS will assess, in coordination with regional co-managers, whether or not the 2013 to 2016 empirical in-river survival estimates support a conclusion that the RPA has achieved the expected in-river survival improvements initially estimated by the COMPASS model for the prospective condition.

B. Considerations:

1. Advantages: Use of an inriver system survival metric has two distinct advantages compared to dam specific goals:

- It is transparent and measurable annually; and
- It likely captures more direct, indirect, and delayed effects of the hydro system (any effects that occur between the point of release and the Bonneville tailrace) including, but not limited to, avian and piscivorous predation, dam related injuries, and forebay mortalities – which has been shown to be significant sources of mortality at some dams).

[5] NOTE: This does not limit the future use of the COMPASS model. NMFS or the Action Agencies could also use the model to compare the actual (empirically based route-specific survival and passage rates resulting from new construction or altered operations) to the expected benefits articulated in the RPA, or to the empirically derived inriver survival estimates (step 4) to provide further insights for consideration in the adaptive management process.

2. Disadvantages: Because current methodologies rely upon the single release PIT methodology, there are several weaknesses inherent in an in-river survival metric:

- Estimates are derived from fish that use bypasses and bypass systems have been shown to be selective. Active tag studies may be able to shed some light on this in the near future. Also, if PIT detection is expanded to RSW/TSWs in the future, estimates may be more representative of the entire population.
- The accuracy of PIT in-river survival estimates decline downstream of McNary Dam and are generally least accurate for the John Day to Bonneville reach.
- Fall Chinook in-river survival estimates do not truly represent survival because SR fall Chinook salmon are now known to residualize and over-winter in substantial numbers. Thus, in-river survival estimates actually represent the joint probability of migrating and survival, not just survival. Furthermore, there is no established method for determining mortalities vs. fish that over-winter.

3. Measurement Concerns:

- Currently, only lower Snake River ESUs are empirically evaluated for reach survival. Survival estimates for the other ESU would have to be based on the survival of these Snake River fish in the specific reaches that the other ESUs must pass through.
- At present, single release PIT survival estimates are available from Lower Granite or McNary Dam downstream to Bonneville Dam tailrace for in-river migrating spring/summer Chinook, steelhead, and fall Chinook (the RPA does not rely upon COMPASS modeling or upon hydro survival improvements for fall Chinook. This exercise is to make sure that current survival levels continue or are enhanced). In the future, the use of acoustic tags or PIT tag detectors at non-bypass passage routes are likely, through ongoing RM&E efforts, to provide more accurate survival estimates, especially through the lower Columbia River reaches, that are more representative of the general population (i.e., ESUs or DPSs).

4. Exclusions. The in-river survival requirements will not apply to years of extreme low or high flows as follows:

- Low Flow. Years in which average spring flows trigger "full transport" operations at the Snake projects (≤65 kcfs) will be excluded from consideration for fish originating above the collector projects because juvenile system survival under these extreme conditions will rely almost exclusively on transportation. Also in-river PIT survival estimates would be substantially biased under this operation because they are virtually the only fish left to migrate, the predation rate can be much higher under these conditions than would otherwise be the case. For Columbia River ESU's, the survival requirement exclusion will apply when flows are at or below the lower fifth percentile of the 70 year average spring flow record (~140 kcfs) at McNary Dam.
- High Flow. Years in which the average spring flows exceed the upper 95 percentile of the 70 year average flow record (~350 kcfs at McNary and ~145 kcfs at Lower Granite) will also be excluded from consideration. We recognize that these flow conditions will exceed the hydraulic capacity of the FCRPS projects for significant periods of the passage season and therefore limit the Action Agencies' ability to manage fish passage. We would, however, expect the Agencies to implement appropriate debris management actions to help ensure safe fish passage under extreme high flow conditions.

Marine Mammal Predation Appendix

May 5, 2008

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

Memorandum - Final F/NWR5

To: Bruce Suzumoto

From: Ritchie Graves and Gary Fredricks

Date: April 24, 2008

RE: Estimation of Marine Mammal Predation Rates in the vicinity of Bonneville Dam for Base-to-Current to Prospective Adjustments.

Summary of Recommended Base-to-Current Adjustments

The analysis below supports an initial base-to-current adjustment of 0.915 (using radio telemetry data) to reflect the likely impact to spring Chinook salmon from sea lion predations in the Bonneville Dam tailrace. This impact is comparable to minimum survival estimates (adjusted conversion rates based on PIT tagged fish) of adult Snake River spring Chinook salmon between Bonneville Dam and Lower Granite Dam. A relatively conservative assumption regarding the effectiveness of authorized lethal take of "nuisance" sea lions in this area (estimated as about 30 individuals each year), yields an estimated additional base-to-current to prospective adjustment of 1.060. Thus, the net base-to-current adjustment would be 0.970, an overall continuing impact of about 3.0% resulting from sea lion predation in approximately two-mile reach downstream of Bonneville Dam.

For winter-run steelhead, the initial base-to-current adjustment is estimated at 0.782 (adjusting the 7.8% steelhead consumption estimate based on visual observations by the spring Chinook Radio Telemetry to visual observation ratio of 2.8). Using the same assumption used for spring Chinook salmon regarding the effectiveness of removing "nuisance" sea lions yields an estimated additional base-to-current adjustment of 1.182. The net base-to-current adjustment would be 0.924, an overall continuing impact of about 7.6 percent from sea lion predation in the tailrace of Bonneville Dam.

General Considerations

Predation of adult salmon and steelhead by marine mammals – primarily by California sea lions – in the vicinity of the Bonneville Dam tailrace has increased in recent years. Starting in 2002, the Corps of Engineers began monitoring sea lions and estimating the number (and if possible, the species) of fish killed and consumed. This monitoring has established that early migrating steelhead and spring migrating Chinook salmon are significantly impacted by these predators. The purpose of this memorandum is to describe the methodology used by NOAA Fisheries to estimate the proportion of fish taken by these predators (and assess the potential for measures to reduce these impacts) for use as an adjustment (Base-to-Current and Current-to-Prospective) in the life-cycle analysis of the affected populations.

Estimation of Base Sea Lion Predation Impacts

NOAA Fisheries assumes that sea lion predation during the Base period was extremely low (effectively zero) until recently (since 2001), when sea lions became more commonly viewed in the vicinity of Bonneville dam and observed of salmon and steelhead predation warranted further research.

Estimation of Current Sea Lion Predation Impacts

Spring Migrating Chinook Salmon Based on Visual Observations

Sea lions feed primarily on Chinook salmon once these fish begin to dominate the ladder counts at Bonneville Dam. Estimating the Current rate of sea lion predation for SR spring/summer Chinook, UCR spring Chinook, and LCR spring Chinook salmon populations upstream of Bonneville Dam required a number of steps and calculations [See Attachment].

1) The number of Chinook salmon vulnerable to sea lion predation was estimated using Bonneville dam counts from January 1 to May 31 (1983 to 2007 data was considered). [See Attachment, column 2]

2) The number of Chinook salmon estimated to be killed and eaten by sea lions was estimated using annual consumption rates (of all species) reported in WDFW et al. (2006), updated with 2007 estimates (Stansell 2007a).
[See Attachment, column 4]

These numbers were corrected to apply to Chinook salmon only by removing the number of steelhead estimated to have been killed and eaten by sea lions.
[See Attachment, column 6]

Subtracting the numbers in column 6 from those in column 4 leaves the estimated number of Chinook salmon consumed and eaten by sea lions.
[See Attachment, column 7]

3) NOAA Fisheries next assessed the years that would be most representative of the "Current" condition and determined that the take of Chinook salmon between 2004 and 2007 appears to be relatively stable [see Attachment, column 7]. NOAA Fisheries considers the average take of Chinook salmon during these years to be the best estimate of "Current" sea lion predation levels.

4) The average proportion of Chinook salmon lost to sea lion predation was estimated as the average estimated number of Chinook salmon taken by sea lions (2004 to 2007)

divided by the average number of Chinook salmon taken by sea lions (2004 to 2007) taken plus the average number of Chinook salmon passing Bonneville Dam.
See Attachment, Estimated Base-to-Current Adjustment [2004-2007 average values for column 7 / (column 7 + column 2)]

This method estimates that the average proportion of Chinook salmon killed and eaten by sea lions in the vicinity of Bonneville Dam is approximately 3.0% [3,168 / (3,168 + 101,488)]. This equates to a life cycle model adjustor of 0.97 for the affected populations. Because this number is based on observed predation events, it should be considered a minimum estimate of the proportion of spring Chinook salmon killed by California sea lions.

Winter Migrating Steelhead Based on Visual Observations

Sea lions feed primarily on steelhead (or other species like white sturgeon) until Chinook salmon begin to dominate the ladder counts at Bonneville Dam. Using estimated steelhead numbers and steelhead dam counts at Bonneville between January 1 and March 31, Robert Stansell (Corps of Engineers) estimated that 7.8% of the steelhead migrating during this time (likely to represent primarily winter run Lower Columbia River steelhead populations upstream of Bonneville Dam)[1] are consumed by sea lions (Stansell 2007b). NOAA Fisheries considers this to be the best estimate currently available related to observed fish mortalities from California sea lions.

Spring Migrating Chinook Salmon Based on Adult Radio-Telemetry Studies

Since 1997, researchers have captured and radio tagged adult spring Chinook salmon at Bonneville Dam to assess the survival and migration behavior of these fish through the hydrosystem. As part of the protocols for these studies, fish were often released some distance downstream of Bonneville Dam. Individuals were detected entering the tailrace of Bonneville Dam (in the vicinity of the juvenile bypass outfall, approximately two miles downstream of the dam), as well as in the upper sections of the adult fishways. Because this data includes both recent years during which sea lions have been consuming relatively constant numbers of Chinook salmon, as well as earlier years prior to the occurrence of substantial numbers of sea lions, comparisons of the tailrace survival estimates between these two periods can be used as a surrogate for the relative impact of sea lion predation on adult spring Chinook salmon survival (Table 1).

Formal observation of the numbers of sea lions and their predation activities in the vicinity of Bonneville Dam began in 2002 because of concerns stemming from an apparent increase in the number of sea lions and observed acts of predation. These observations (see Attachment) indicate that the number of Chinook salmon consumed by sea lions has been relatively constant since 2004.

1. Estimate Base Period Passage Success

Prior to 2001, the percentage of tagged (unknown origin) spring migrating Chinook salmon successfully migrating from the Bonneville Dam tailrace to the adult ladder exits

[1] Interior basin steelhead ESUs do not begin migrating until mid-summer after sea lions have left the area for breeding colonies along the Pacific Coast.

(including fish that fall back at the dam and reascend) averages 96.1%, ranging from 94.8% to 96.8% (1997, 1998, and 2000 studies).

Table 1. Passage Success of Spring Chinook Salmon at Bonneville Dam During Sea Lion Predation Season (Late march to End of May) - 1997 to 2007.

Year	# Entering Tailrace	# Passing Dam	# Falling Back	# Re-ascending	% Successful Passage*
1997[1]	625	610	114	109	96.8%
1998[1]	616	597	84	71	94.8%
2000[1]	683	668	116	109	96.8%
2001[2]	511	491	33	29	95.3%
2002[3]	527	515	45	37	96.2%
2003[3]	659	606	41	39	91.7%
2004[3]	297	268	10	7	89.2%
2006[3**]	299	226	43	28	70.6%
2007[3]	228	203	16	9	86.0%
Average of 1997, 1998, and 2000			**96.1%**		
Average of 2004 and 2007			**87.6%**		

*** calculated as: (# passing dam - # falling back + # reascending) / # entering tailrace**
**** 2006 is not used for calculating the estimated % successful passage in recent years (see text below).**
[1] Tagged fish were of unknown origin.
[2] Tagged fish were of both known and unknown origin.
[3] Tagged fish were of known origin (interior Columbia River basin Chinook populations).

2. Estimate Current Passage Success

Since 2004, consumption rates and the number of sea lions in the vicinity of Bonneville Dam have been relatively constant. Radio telemetry studies were conducted in 2004, 2006, and 2007. These studies indicate that passage success has ranged from 70.6% to 89.2% during this period of time.

However, the passage success estimate from the 2006 study likely overestimates the impact of sea lion predation. In this year, the relatively constant number of fish tagged and released below Bonneville (typically 8 to 10 fish daily) comprised a disproportionately high percentage of the number of fish passing Bonneville dam early in the season. Thus, these fish would have been consumed at higher rates (were disproportionally vulnerable to a relatively constant number of predators) than would have been the case if they were released in proportions similar to the observed pattern of migration at Bonneville Dam in 2006. For this reason, 2006 data are removed from the average used to estimate the “Current” level of passage success.

The average of the 2004 and 2006 studies is 87.6% (range of 86.0% to 89.2%).

Estimation of Base-to-Current Adjustment for Sea Lion Predation Impacts

Spring Chinook Salmon

Using only the observed consumption of Chinook salmon by sea lions yields an estimate of 3.0%. This could be used as a base-to-current adjustment, assuming that predation in this area was generally insignificant in the majority of years prior to 2001. However, as previously explained, such an estimate should be viewed as a minimum estimate of the impact sea lions are having on the survival of spring Chinook salmon in the Bonneville Dam tailrace.

Using differences in average passage success estimates based on radio-telemetry studies (see Table 1) yields a base-to-current adjustment of 8.5% ("Base Period' estimate of 96.1% minus the "Current" estimate of 87.6%).[2] This number appears to be a reasonable estimate of the likely total impact of sea lions in the Bonneville tailrace as NOAA Fisheries has estimated between 3.6 and 12.6 percent of the listed spring Chinook salmon are likely being consumed in this area based on the bioenergetic needs of sea lions (NMFS 2008p). Therefore, I recommend the use of 8.5% as the base-to-current adjustment (a multiplier of 0.915) representing the likely impact of sea lions on spring Chinook salmon populations migrating past Bonneville Dam since 2004 relative to the majority of prior years when sea lion predation was likely insignificant in this area.

Winter Steelhead - Corrected for Spring Chinook Radio-Telemetry Findings

As discussed above, based on observations, an estimated 7.8% of the winter-run steelhead migrating between January 1 and March 31 are consumed by sea lions. However, the spring Chinook salmon radio-telemetry data (see analysis above) indicates that 2.8 times as many fish (8.5% / 3.0%) are likely being consumed than estimated using observational data alone. Applying this correction factor to winter steelhead would yield an estimate of 21.8 percent. Based on the relatively low numbers of steelhead passing Bonneville Dam during the winter months (0 to 140 individuals per day – Columbia River DART adult passage data for 2005 to 2008), even a small number of sea lions would be capable of consuming approximately 20% of the migrating fish.

Assessment of Current-to-Prospective Sea Lion Predation Adjustment.

Note: While these effects are referred to as "prospective," they reflect a current action that has been the subject of a completed ESA consultation. Therefore, this action is also a component of "base-to-current" survival adjustments in the SCA.

Spring Chinook Salmon

NOAA Fisheries recently permitted the States of Oregon and Washington to remove (and, if necessary, euthanize) sea lions in the Columbia River downstream of Bonneville Dam (NMFS 2008o). While the lethal take of up to 85 nuisance animals per year is authorized, it is expected that actual number of animals that will be removed each year is

[2] NOTE: in addition to the impacts of sea lions, this approach captures any other differences that may have occurred between the pre- and post-sea lion periods (changes in harvest, dam operations, etc.) However, at this time, NMFS is unaware of any hydro operations or harvest actions that would have decreased survival significantly in the Bonneville tailrace between the two periods.

closer to thirty (NMFS 2008p). While the removal of individuals may not be wholly effective (depending upon the extent to which other individuals move into the area vacated by removals), this action should still substantially reduce the impacts of sea lions on spring migrating adult Chinook salmon.

Removal of 30 sea lions per year would equate to the removal of approximately 35% of the average number of sea lions (86) currently estimated to be utilizing the Bonneville Dam tailrace. Assuming a current impact of 8.50%, an absolute (maximum) reduction of nearly 3.0% (35% of 8.5%) could be attained if no sea lions moved into the Bonneville Dam tailrace to take the place of those removed. A more conservative (and realistic) assumption would be that the removal of "nuisance" animals would result in a reduction of 10% each year, cumulatively. Using this assumption, at the end of 10 years, the average consumption rate of spring-run Chinook salmon should be reduced to 3.0% ($8.5\% * 0.9^{10}$). Based on this analysis I recommend that the current to prospective adjustment for sea lion predation in the Bonneville Dam tailrace should be a reduction in average consumption from 8.5% to 3.0% annually (a multiplier of 1.060 calculated as .970 [future expected impact] / .915 [current estimated impact]).

Winter Steelhead

Using the same assumption for winter steelhead (i.e., that removing "nuisance" animals would result in a reduction of 10% each year, cumulatively), I estimate that the average consumption rate of winter steelhead should be reduced to 7.60% ($21.8\% * 0.9^{10}$). Based on this analysis I recommend that the current to prospective adjustment for sea lion predation in the Bonneville Dam tailrace should be a reduction in average consumption from 21.8% to 7.6% annually (a multiplier of 1.182 calculated as 0.924 [future expected impact] / 0.782 [current estimated impact]).

Qualitative Considerations

Marine mammal predation can also cause indirect loss of adult salmon in the hydrosystem above Bonneville Dam. Not all marine mammal predation attempts are successful. These unsuccessful attempts often leave telltale marks on the intended prey fish. These marks, characteristic descaling and flesh wound patterns, have been monitored on spring Chinook at the Lower Granite Dam adult salmon trap since 1990 (Harmon 2008). Of the marks observed, it is thought that the majority of the descaling is from encounters with harbor seals which are more likely to use clawed flippers to grasp and rake fish. Considering only flesh wounds would more likely weight the analysis towards sea lion predation attempts. Observations from 1990 to 2007 (no trapping in 2004) indicate an average prevalence of flesh wounds on spring Chinook of 7.8% with a range of 4.7% to 14.1%. However, if the data are split between pre and post sea lion build up in the Bonneville Dam tailrace area (i.e., pre vs post 2004) it is apparent that flesh wound prevalence has increased over time. The average prevalence of wounds for the 14 years before 2004 was 6.9% (range 4.7% to 10.2%) compared to an average of 12.3% (range 10.5% to 14.1%) for the three years of data after that year.

An estimate of loss attributable to marine mammal wounds can be made by monitoring the escapement of fish between Bonneville Dam and Lower Granite Dam and beyond. In 2002, the University of Idaho assessed escapement for known origin spring/summer chinook salmon with injuries (Clugston 20008). Fish with minor to moderate injuries survived at rates similar to fish without injuries and fish with severe injuries appeared, as expected, to have a lower escapement rate. However, the numbers of fish in the severe injury category was too low (only 10 fish) to draw firm conclusions.

Taken together, this information suggests that some additional, though unquantifiable, losses of adult spring Chinook salmon are occurring between Bonneville Dam and McNary Dam (for UCR spring Chinook salmon) and Lower Granite Dam (for SR spring-run Chinook salmon) as a result of injuries due to sea lion predation attempts. Thus, measures to reduce direct losses of adult Chinook salmon (through hazing, harassment, or removal activities) should also reduce the proportion of injured fish, and increase adult survival rates accordingly. This benefit would be in addition to those estimated above.

For a complete list of references, see Chapter 12 of the SCA: Literature Cited

Observed California Sea Lion Predation Assessment Spreadsheet
R. Graves (NMFS)

Year	Jan 1 to May 31 Chinook passing BON dam (ladder counts) [1]	Est. # of Chinook and steelhead passing BON dam [2]	Est. # of Salmonids taken during the study period [3]	Est. % of Salmonids taken during the study period. [3]	Est. # (unexpanded) of Steelhead taken between Jan 1 and May 31 [5]	Est. # of Chinook salmon taken between Jan 1 and May 31 [6]	Est. % of Chinook salmon passing BON between Jan 1 and May 31 taken by sea lions [7]
1983	54,898						
1984	46,593						
1985	82,951						
1986	117,535						
1987	97,929						
1988	8,774						
1989	80,887						
1990	93,934						
1991	57,171						
1992	88,115						
1993	110,820						
1994	20,169						
1995	10,194						
1996	51,265						
1997	114,071						
1998	38,342						
1999	38,574						
2000	177,774						
2001	391,842						
2002	269,520	284,733	1010	0.4%	6	1004	0.4%
2003	195,770	217,185	2329	1.1%	10	2319	1.2%
2004	168,794	186,804	3533	1.9%	25	3508	2.0%
2005	74,053	82,006	2920	3.4%	31	2889	3.8%
2006	96,458	105,063	3023	2.8%	297	2726	2.7%
2007	66,646	88,474	3859	4.2%	311	3548	5.1%
1983 to 2003 Average	102,244						
2004 to 2007 Averages	101,488	115,587	3,334		166	3,168	3.0%
		Estimated Base to Current Adjustment [8]					**0.97**

1 Dam Counts from Columbia River DART - 9-18-07

2 Numbers of salmonids (Chinook and steelhead) passing Bonneville Dam during ACOE study periods. Sources: Stansell 2004, ACOE, unpublished data for 2007.

3 Estimated number of salmonids taken by sea lions during the ACOE study period. Sources: Stansell 2004, ACOE, unpublished data for 2007.

4 Estimated percentage of salmonids taken by sea lions during the ACOE study period. Sources: Stansell 2004, ACOE, unpublished data for 2007.

5 Estimated number of steelhead taken between Jan 1 and May 31. Source: ACOE, upublished data - e-mail from Stansell to Graves dated Sept. 17, 2007.

6 Calculated as Est. number of Chinook and steelhead taken by sea lions - estimated number of steelhead taken by sea lions.

7 Estimated percentage of Chinook salmon passing Bonneville Dam taken by sea lions during between Jan 1 and May 31.

8 2004-2007 average estimated percentage of Chinook salmon passing Bonneville Dam taken by sea lions between Jan 1 and May 31. This represents NMFS' best estimate of the Base to Current adjustment stemming from marine mammal predation (primarily sea lions) in the Bonneville Dam tailrace.

Quantitative Analysis of Harvest Actions Appendix

May 5, 2008

Quantitative Analysis of Harvest Actions

Most of the base-to-current survival changes attributable to changes in harvest management that are applied in the SCA are described in the February 8, 2008, memorandum from a *US v Oregon* Work Group to B. Suzumoto, which is included as Attachment 1 to this Appendix. This memorandum estimates base-to-current survival multipliers for SR fall Chinook salmon and A- and B-run steelhead. The steelhead estimates apply to SR steelhead (both A- and B-run), UCR steelhead (A-run), and MCR steelhead (A-run).

The SCA includes estimates of current-to-future survival changes, some of which are not explicitly described in the memorandum for each species. NOAA Fisheries derived these estimates by dividing base-to-future estimates by base-to-current estimates:

SR fall Chinook: 1.16/1.09 = 1.06 for current-to-"expected" future multiplier
B-run steelhead: 1.06/1.04 = 1.02 for current-to-"expected" future multiplier
A-run steelhead: 1.034/1.041 = 0.99 for current-to-future multiplier

Additionally, an estimate of base-to-current survival multipliers for SR spring/summer Chinook salmon was provided by the US v Oregon Work Group in May 2008 and the calculations were included in the Action Agencies' August 2007 Comprehensive Analysis as Table G-1 of Appendix G. That table is reproduced in this appendix as Table 1. The text originally accompanying the calculations states:

> "For spring Chinook we've included two lifecycle adjustments. One is for a base managed under the Columbia River Fish Management Plan (CRFMP) that was in place for many years. The other is for a base managed under an "adjusted CRFMP" for which we've calculated the harvest rates for 2000 through 2003 as a function of the relationship between the CRFMP and 05-07 Bridge for the years 1996-1999. This adjustment is our attempt to recognize that we likely would have managed these fisheries in recent years, despite large returns, so that harvest rates were less than those contemplated under the CRFMP. Our approach of using a CRFMP-derived base and a 05-07 interim-agreement-derived current takes into account the abundance-based management scheme we've employed for these stocks." (Nigro, A. 2007. Harvest lifecycle adjustments. May 16, 2007, e-mail to J. Stier)

NOAA Fisheries used the "adjusted CRFMP" option in the SCA calculations.

Harvest Appendix Table 1. Calculation of base-to-current survival multiplier, based on reductions in harvest during the base period, for SR spring/summer Chinook. This table was previously included as Table G-1 in Appendix G of the August 2007 Comprehensive Analysis.

Spring Chinook	Harvest Rate (%)				
	Under the Columbia River Fish Management Plan (CRFMP)	Under an Adjusted CRFMP (Rates in 2000-2004 equal "05-07 Bridge" Rates for those years multiplied by the the average "CRFMP" rate for 1996-1999 divided by the average "05-07 Bridge" rate for 1996-1999)	05-07 Bridge	**Survivals (Using CRFMP Rates for 2000-2003)**	**Survivals (Using Adjusted CRFMP Rates for 2000-2003)**
1983	12.00%	12.00%	8.50%		
1984	12.00%	12.00%	7.00%		
1985	12.00%	12.00%	9.00%		
1986	12.00%	12.00%	10.00%		
1987	12.00%	12.00%	10.00%		
1988	12.00%	12.00%	9.00%	Base (CRFMP:1983-2003)	Base (Adjusted CRFMP:1983-2003)
1989	12.00%	12.00%	9.00%	0.79	0.87
1990	12.00%	12.00%	9.00%		
1991	12.00%	12.00%	8.50%	Current (05-07 Bridge:1983-2006)	Current (05-07 Bridge:1983-2006)
1992	12.00%	12.00%	9.00%	0.91	0.91
1993	12.00%	12.00%	10.00%		
1994	10.00%	10.00%	5.50%	Lifecycle Adjustment	Lifecycle Adjustment
1995	10.00%	10.00%	5.50%	(Base-to-Current)	(Base-to-Current)
1996	12.00%	12.00%	8.50%	1.15	1.04
1997	12.00%	12.00%	10.00%	Survival improvements are of adult fish returning to the mouth of the Columbia River, not smolts arriving at Bonneville Dam	
1998	10.00%	10.00%	6.00%		
1999	10.00%	10.00%	6.00%		
2000	41.90%	15.87%	11.00%		
2001	81.70%	23.08%	16.00%		
2002	72.20%	20.20%	14.00%		
2003	58.00%	17.31%	12.00%		
2004	53.00%	17.31%	12.00%		
2005	12.00%	12.00%	9.00%		
2006	13.60%	13.60%	10.00%		
Average Harvest Rate (1983-2006)	22.02%	13.14%	9.35%		
Base Period Average Harvest Rate (CRFMP:1983-2003)	21.42%	12.97%			
Current Period Average Harvest Rate (05-07 Bridge:1983-2006)			9.35%		

Attachment 1

Memorandum To:	Bruce Suzumoto
From:	U.S. v Oregon Work Group
Date:	February 8, 2008
Subject:	Estimated Survival Adjustments for Expected Future Steelhead and Snake River fall Chinook Harvest Rates

The *U.S. v. Oregon* Parties have tentatively concluded a new agreement regarding the management of harvest and production activities in a significant portion of the Columbia River Basin. The new agreement (2008 Agreement) would extend for ten years through 2017. Finalizing the 2008 Agreement requires completion of an ESA section 7 consultation by the National Marine Fisheries Service (NOAA Fisheries) on the Agreement, and resolution of associated issues in the Federal Columbia River Power System (FCRPS) remand process. NOAA Fisheries expects to complete biological opinions on the FCRPS and harvest actions described in the 2008 Agreement by mid-March.

Under the 2008 Agreement there will be no change from the 2005-2007 Agreement in harvest management provisions, with respect to overall ESA take limits for winter, spring, and summer season fisheries. However, the 2008 Agreement does include two notable changes regarding management of fall season fisheries. In recent years, fall season fisheries have been subject to fixed harvest rate constraints for both Snake River fall Chinook and B-run steelhead. The 2008 Agreement includes abundance based harvest rate schedules for both stocks that allow fisheries to be more responsive to overall stock status.

Since 1996 fall season fisheries in the Columbia River have been managed subject to a harvest rate limit of 31.29% for Snake River fall Chinook, a 30% reduction from the pre-listing average harvest rate. The new abundance based harvest schedule allows harvest to vary up or down from the current limits depending on the overall abundance of upriver fall Chinook and wild Snake River fall Chinook (Table 1).

Wild summer steelhead and particularly B-run steelhead, are caught incidentally in fall fisheries that target upriver Chinook. Although wild steelhead are not targeted in either Treaty Indian or non-Treaty fisheries, current incidental take limits can constrain access to fall Chinook. Prior to 1998, Columbia River fisheries were limited to a 34% impact limit for B-run steelhead. Since 1998 fall season fisheries in the Columbia River have been managed subject to an overall harvest rate limit for B-run steelhead of 17% with 2% allocated to non-Treaty fisheries and 15% to treaty Indian fisheries. The new abundance based harvest rate schedule allows the tribal harvest rate to vary up or down from the status quo depending on the overall abundance of upriver fall Chinook and B-run steelhead (Table 2).

Under the current agreement, non-Treaty fisheries are subject to a 2% harvest rate limit on A-run steelhead in spring and summer season fisheries and a 2% harvest rate limit in fall fisheries. There are no specific constraints in tribal fisheries. B-run steelhead are used as the constraining indicator stock. Current management provisions for A-run steelhead will not change under the 2008 Agreement, but implementation of abundance based management during fall fisheries may result in increases in impacts to A-run steelhead.

To evaluate the impact of the 2008 Agreement on productivity of A-run and B-run steelhead and SR fall Chinook salmon, we provide information consistent with the analytical approach described in Chapter 7 of the October 30, 2007, draft Supplemental Comprehensive Analysis (SCA) supporting the FCRPS biological opinion. Parts of the SCA analysis rely on information in the August 2007 Comprehensive Analysis (CA) that the FCRPS action agencies submitted in support of their biological assessment. The SCA considers, among other things, changes in survival that have occurred in recent years, and that may occur in the future as a result of various proposed activities. The analysis relies on estimates of the change in survival by comparing "base" and "current" time periods, and subsequently by comparing "current" and "future" periods. The final step is to calculate the "base-to-current" survival adjustment. The initial base-to-current calculations for upriver bright Chinook (including Snake River fall Chinook), and A-run and B-run steelhead are reported in Appendix G of the CA. The B-run steelhead analysis is reported in the Harvest Appendix of the SCA.

The following sections update the initial base-to-current calculations for fall Chinook and B-run steelhead, and provide estimates for the subsequent current-to-future analytical step. The analysis is also extended to provide alternative estimates of the base-to-future survival adjustments that are intended to better represent the range of likely outcomes. In the first case, the harvest rate for the base time period is estimated using observed harvest rates, and for the future time period, maximum allowable rates. This approach tends to underestimate the survival adjustment that may occur as a result of changes in harvest because it assumes that future fisheries will always be managed up to the harvest rate limit. This method therefore provides a lower bound of the survival rate adjustment. In fact, for both steelhead and fall Chinook, actual harvest rates have typically been less than those allowed. In the second case, base harvest rates are again estimated using the observed harvest rates. But future harvest rates are adjusted down to account for the expectation that actual harvest rates will continue to be, on average, less that allowable harvest rates. The adjustment is done by multiplying the maximum allowable rates described above, by the proportion that represents the deviation between observed and allowable harvest rates in recent years. This approach provides an upper bound to the survival rate adjustment.

For steelhead we update the base-to-current calculations in Appendix G to reflect some minor changes in the catch data for both the non-Treaty and treaty Indian fisheries. The subsequent current-to-future calculation accounts for the change in expected harvest rates in future fisheries that may result from implementation of the abundance based harvest rate schedules for fall fisheries.

Survival Adjustments for Snake River Fall Chinook

The first step in the analysis is to estimate the change in survival that has occurred as a result of reductions in harvest in recent years. This is referred to as the base-to-current survival adjustment. The second step is to estimate the change in survival that can be expected as a consequence of implementing future fisheries - referred to as the current-to-future survival adjustment. The respective survival adjustments are then multiplied to calculate an overall base-to-future survival adjustment that represents the change in survival resulting from reductions in what fisheries used to be to what we expect them to be in the future[1].

Data regarding run size and harvest rates for Snake River fall Chinook are available for return years 1983 to 2006. The harvest rate information reported in Table G-4 was used to calculate preliminary estimates of the base-to-current survival adjustment.

The data provided in Table 3 is modified from that in Table G-4 of the CA. Table 3 shows the run sizes of upriver bright Chinook and Snake River fall Chinook since these are the two abundance indicators used in the harvest rate schedule (Table 1). The observed harvest rates are the same as those in Table G-4. The allowable harvest rates are the maximum harvest rates allowed for 1983 to 2006. Note that the observed rates and the maximum allowable rates are identical for 1983 to 1991 return years. Fall season fisheries were first subject to ESA related harvest rate limits in 1992. Future harvest rates are those that would have been allowed in past years if the Table 1 had been applied retrospectively.

The "base" period harvest rates are the harvest rates that were observed from 1983 to 2003, as in Table G-4. The average base period harvest rate was 0.354 with an associated survival of 0.646 (1 – HR = survival rate).

The "current" harvest rate is re-defined to represent the allowable harvest rates from 1994 to 2006. The reason for using the allowable, rather than observed, recent harvest rates is because the *U.S. v. Oregon* parties consider these to be an indicator of the harvest rates that could occur in the future under current management practices (See the SCA Chapter 8.5 for a similar discussion regarding use of maximum allowable to represent "current" steelhead harvest rates.) The average "current" harvest rate is 0.298 with an associated survival of 0.702. Note that, because allowable harvest rates are used to represent "current" survival in this analysis, the base-to-current adjustment will be less than that estimated in the Table G-4.

Future allowable harvest rates are derived by applying the harvest rate schedule in Table 1 to run sizes observed from 1983 to 2006. The future allowable harvest rate was estimated using the 1983 to 2003 average to be consistent with the time frame used to

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[1] The CA uses a two step process to calculate what is in the end, a base-to-future survival adjustment. The base-to-current survival adjustment is calculated as a ratio of average current/base survival rates; the current-to-future adjustment is calculated as a ratio of future/current survival rates. The base-to-future survival adjustment is the product of the two ratios. The base-to-future survival adjustment can therefore be calculated directly as a ratio of future/base survivals. The choice of a value to represent the current average survival rate is therefore of no direct consequence to the end result since the "current" value cancels algebraically through the multiplication of the ratios (C/B * F/C = F/B). Nevertheless, we provide estimates derived through the two step process in the analysis so that it continues to be consistent with the sequential analysis used in the CA.

estimate base period productivity. The associated average harvest rate is 0.298 with an associated survival of 0.702. The respective base-to-current, current-to-future, and base-to-future survival adjustments are 1.09, 1.00, and 1.09.

As discussed above, this approach is conservative and provides a likely lower bound on the survival adjustment that may result from harvest. Since 1996 the fall season harvest has been subject to a 31.3% harvest rate limit. From 1996 to 2006 the observed harvest rate has averaged 26.2% which is 0.837 of the allowable limit (0.262/0.313 = 0.837). This difference between the observed and allowable harvest rates can be used to approximate the survival adjustment that might occur as a result of implementing the harvest rate schedule. The average future harvest rate using the allowable limits was 0.298 (see above). Alternatively, the expected harvest rate under future conditions can be estimated as 0.298 * 0.837 = 0.249, with an associated survival rate of 0.751. The base-to-future survival adjustment is calculated by dividing the alternative estimate of future survival rate by the survival rate observed during the base period – 0.751/0.646 = 1.162. The alternative base-to-future survival adjustments - 1.09 and 1.16 – again provide a reasonable range of likely outcomes.

Survival Adjustments for B-Run Steelhead
Data regarding run size and harvest rates for B-run steelhead are available for return years 1985 to 2006. The Harvest Appendix in the SCA provided preliminary estimates of the base-to-current survival adjustment. Here again we update the data and extend the analysis to include the current-to-future and alternative base-to-future survival adjustments.

The data provided in Table 4 is modified from that provided in the Harvest Appendix. Table 4 shows the run size of upriver bright Chinook and the total river mouth return of B-run steelhead since these are the two abundance indicators used in the steelhead harvest schedule. Estimates of the treaty Indian harvest rate are also updated and modified slightly from those reported in the Appendix. Future harvest rates are those that would have been allowed in past years if the B-run harvest rate schedule is been applied retrospectively.

The base period harvest rate was calculated as an average of the observed harvest rates for 1990 to 2003. The resulting harvest rate is 0.202. The current harvest rate is 0.170, the maximum allowed under existing ESA constraints. The resulting survivals are 0.798 and 0.830. This is consistent with the approached used in the SCA. The future harvest rate was projected based on application of the abundance based harvest rate schedule to all past years 1985 to 2006. The implicit assumption of this retrospective analysis is that past circumstances can be used to describe expectations for the future. The resulting projected average future harvest rate is 0.191 with an associated survival of 0.809. The respective base-to-current, current-to-future, and base-to-future survival adjustments are 1.04, 0.97, and 1.01 (Table 4).

As discussed above, this approach is conservative and provides a likely lower bound on the survival adjustment that may result from harvest. Since 1998 the fall season harvest has been subject to a 17% harvest rate limit. From 1998 to 2006 the observed harvest rate has averaged 13.8% which is 0.812 of the allowable limit (0.138/0.170 = 0.812). This difference between the observed and allowable harvest rates can be used to approximate the survival adjustment that might occur as a result of implementing the harvest rate schedule. The future harvest rate using the allowable limits was 0.191 (see above). Alternatively, the expected harvest rate under future conditions can be estimated as 0.191 * 0.812 = 0.155, with an associated survival rate of 0.845. The base-to-future survival adjustment is calculated by dividing the alternative estimate of future survival rate by the survival rate observed during the base period – 0.845/0.798 = 1.06. The alternative base-to-future survival adjustments - 1.01 and 1.06 - provide a reasonable range of likely outcomes.

Survival Adjustment for A-Run Steelhead

Data regarding run size and harvest rates for A-run steelhead are available for return years 1985 to 2006. Table G-2 in Appendix G of the CA provided preliminary estimates of the base-to-current survival adjustment. The harvest rate information used in Appendix G was updated for this analysis, but the changes were small and did not affect the previously calculated base-to-current survival adjustment of 1.04 (Table 5).

For A-run steelhead it is next necessary to consider whether future harvest rates will increase as a result of implementing the 2008 Agreement. A-run steelhead are caught in spring, summer, and fall season non-Treaty and treaty Indian fisheries. Management provisions for non-Treaty fisheries will not change under the 2008 Agreement. Spring and summer season treaty Indian fisheries will likewise be consistent with those used under the current management framework. As a consequence, we expect that future harvest rates will be unchanged for these components of the fishery.

For treaty Indian fall season fisheries it is necessary to consider whether there will be an increase in the harvest of A-run steelhead associated with the proposed 2008 Agreement. As noted above, B-run steelhead are used as the indicator stock for steelhead to limit fishery impacts in the treaty Indian fall season fisheries. There are no specific harvest rate limits for A-run steelhead. The retrospective analysis discussed in the preceding section suggests that harvest rates on B-run steelhead in the treaty Indian fall season fisheries may be higher than 15% about half the time. The average of the allowable harvest rate limits in the tribal fishery from the retrospective analysis is 17.1% (Table 4, 19.09 – 2.0 = 17.1; the 2% is the allowable harvest rate in non-Treaty fall fisheries). This represents a 14% increase over the current fall season harvest rate limit of 15% (17.1/15.0 = 1.14). It does not necessarily follow that harvest rates on A-run steelhead will also increase, but A-run and B-run harvest rates are loosely correlated. It is therefore reasonable to assume that A-run harvest rates will increase in proportion to B-run harvest rates. If we assume that the tribal *fall* season harvest rates will increase by 14% in proportion to the expected increase for B-run steelhead, the expected future *total* harvest rate would increase by 8.9%. (The calculation accounts for the fact that only the fall component of the tribal fishery is expected to increase.) The expected future harvest rate in the tribal fishery therefore increases from 7.26% to 7.91% (0.0726 * 1.089 = 0.0791) (Table 5). The expected future harvest rate, including non-treaty fisheries is 9.39%. The associated base-to-current and base-to-future survival adjustments are 1.041 and 1.034, respectively (Table 5).

Qualitative Considerations Related to Abundance-Based Management

The structure of the CA is limited in that it allows only for calculation of the average change in survival rate as a consequence of an action. However, abundance based harvest rate schedules are, by definition, variable and thus provide greater protection to the population when run sizes are low and associated protections are most important, while allowing higher harvest rates when abundance is high. For fall Chinook, for example, the abundance based harvest rate schedule is structured such that higher harvest rates are allowed when there is a reasonable likelihood that the recovery abundance objective of 3,000 wild spawners would be achieved. Table 1 includes a column showing expected escapements past fisheries. For example, for a run size of 8,000 Snake River wild fall Chinook, the harvest rate may go up to 45% with an expected post-fisheries escapement of 4,400. Even with significant subsequent upstream passage losses, the expected escapement to Lower Granite Dam would be in excess of 3,000 spawners.

Biological risk assessments confirm that adjustment of impacts downward in years of low abundance provides additional protection during those years when populations are at the highest risk. A management response to low abundance reduces the quasi extinction risk to the populations and also provides a compensatory response to low spawner abundance that could otherwise delay population response to recovery actions. Although we recognize the difficulty in quantifying the survival benefit of abundance-based management at low abundance for fall Chinook and steelhead consistent with the CA analysis, we believe it is appropriate to consider the benefits as a positive contributor when assessing the future survival of Snake River wild fall Chinook and B-run wild steelhead.

Table 1. Proposed Fall Chinook Harvest Rate Schedule

State/Tribal Proposed Snake River Fall Chinook Harvest Rate Schedule

	Expected URB River Mouth Run Size		Expected River Mouth Snake River Wild Run Size [1]	Treaty Total Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate	Expected Escapement of Snake R. Wild Past Fisheries
<	60,000	<	1,000	20%	1.50%	21.50%	784
	60,000		1,000	23%	4%	27.00%	730
	120,000		2,000	23%	8.25%	31.25%	1,375
>	200,000		5,000	25%	8.25%	33.25%	3,338
			6,000	27%	11%	38.00%	3,720
			8,000	30%	15%	45.00%	4,400

Footnotes for Table.

1. If the Snake River natural fall Chinook forecast is less than level corresponding to an aggregate URB run size, the allowable mortality rate will be based on the Snake River natural fall Chinook run size.
2. Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from August 1-December 31.
3. Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the confluence of the Snake River and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from August 1-December 31.
4. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.
5. Fishery impacts in Hanford sport fisheries count in calculations of the percent of harvestable surplus achieved.
6. When expected river-mouth run sizes of naturally produced Snake River Fall Chinook equal or exceed 6,000, the states reserve the option to allocate some proportion of the non-treaty harvest rate to supplement fall Chinook directed fisheries in the Snake River.

Table 2. Proposed Abundance Based Harvest Rate Schedule for Steelhead.

Up-River Summer Steelhead Total B Harvest Rate Schedule

	Forecast Bonneville Total B Steelhead Run Size	River Mouth URB Run Size	Treaty Total B Harvest Rate	Non-Treaty wild B Harvest Rate	Total Harvest Rate
<	20,000	Any	13%	2.0%	15.0%
	20,000	Any	15%	2.0%	17.0%
	35,000	>200,000	20%	2.0%	22.0%

Table 3. Estimated Survival Adjustments for Snake River Fall Chinook

Year	Upriver Bright Run Size	Snake River wild Run Size	Total Observed Harvest Rate (%)	Total Allowable Harvest Rate (%)[1]	Total "Future" Harvest Rate (%)[2]
1983	86,100	1,051	19.72	19.72	27.00
1984	131,400	1,728	42.12	42.12	27.00
1985	196,400	2,015	46.41	46.41	31.25
1986	281,600	3,429	56.78	56.78	31.25
1987	420,700	2,173	57.05	57.05	31.25
1988	339,900	4,643	63.71	63.71	31.25
1989	261,300	2,356	57.14	57.14	31.25
1990	153,600	575	53.09	53.09	21.50
1991	103,300	2,047	40.15	40.15	27.00
1992	81,000	1,338	26.32	28.20	27.00
1993	102,900	1,518	27.77	42.20	27.00
1994	132,800	1,000	18.19	21.00	27.00
1995	106,500	1,328	18.95	22.00	27.00
1996	143,200	1,795	26.37	31.29	27.00
1997	161,700	1,863	32.17	31.29	27.00
1998	142,300	777	26.60	31.29	21.50
1999	166,100	2,495	30.35	31.29	31.25
2000	155,700	2,753	28.79	31.29	31.25
2001	232,600	14,469	21.05	31.29	45.00
2002	276,900	3,760	28.29	31.29	31.25
2003	373,200	8,008	21.54	31.29	45.00
2004	367,858	8,350	20.55	31.29	45.00
2005	268,744	5,525	25.61	31.29	33.25
2006	230,390	6,444	27.08	31.29	38.00
	Average Base Period Harvest Rate (1983-2003)		35.36		
	Average Current Period Harvest Rate (1994-2006)		29.78		
	Average "Future" Harvest Rate (1983-2003)				29.81
	Average Observed Harvest Rate (1996-2006)		26.22		

Survivals using future harvest rate	
Base (1983-2003)	0.65
Current (1994-2006)	0.70
Allowable Future (1983-2003)	0.70
Expected Future	0.75
Lifecycle adjustments	
(Base-to-Current)	1.09
(Current-to-Allowable Future)	1.00
(Base-to Allowable Future)	1.09
(Base-to-Expected Future)	1.16

[1]Observed harvest rates from 1983 to 1991 and maximum allowable harvest rates from 1992 to 2006.
[2]Retrospective analysis of maximum harvest rates allowed under the abundance based harvest rate schedule.

Table 4. Estimated Survival Adjustments for B-Run Snake River Steelhead

Year	Upriver Bright Run Size	Total B-Run Steelhead Run Size	Observed(%) Non-Treaty Harvest Rate	Observed(%) Treaty Indian Harvest Rate	Observed(%) Total Observed Harvest Rate	"Future" Allowable Harvest Rate
1985	196,500	40,870	2.00	31.03	33.03	17.00
1986	281,500	64,016	2.00	26.74	28.74	22.00
1987	420,600	44,959	2.00	37.25	39.25	22.00
1988	340,000	81,643	2.00	23.45	25.45	22.00
1989	261,300	77,604	2.00	35.01	37.01	22.00
1990	153,600	47,174	2.00	21.55	23.55	17.00
1991	103,300	28,265	2.00	29.95	31.95	17.00
1992	81,000	57,438	2.00	26.33	28.33	17.00
1993	102,900	36,169	2.00	19.10	21.10	17.00
1994	132,800	27,463	2.00	18.59	20.59	17.00
1995	106,500	13,221	2.00	18.62	20.62	15.00
1996	143,200	18,693	2.00	34.61	36.61	15.00
1997	161,700	36,663	2.00	14.26	16.26	17.00
1998	142,300	40,241	2.00	15.61	17.61	17.00
1999	166,100	22,137	0.99	12.57	13.56	17.00
2000	155,700	40,909	1.43	14.34	15.77	17.00
2001	232,600	86,426	1.08	11.52	12.60	22.00
2002	276,900	129,882	1.10	3.40	4.50	22.00
2003	373,200	37,229	1.81	14.94	16.76	22.00
2004	367,858	37,398	1.18	11.31	12.49	22.00
2005	268,744	48,967	1.29	12.28	13.57	22.00
2006	230,388	74,127	1.27	16.00	17.27	22.00
Average Harvest Rate (1985-2006)					22.12	
Base Period Average Harvest Rate (1990-2003)					19.99	
Current Maximum Harvest Rate					17.00	
Future Allowable Harvest (1985-2006)						19.09
Average Observed Harvest Rate (1998-2006)					13.79	

Survivals	
Base (1990-2003)	0.80
Current Maximum	0.83
Allowable Future (1985-2006)	0.81
Expected Future	0.84
Lifecycle Adjustment	
(Base-to-Current)	1.04
(Current-to-Allowable Future)	0.97
(Base-to-Allowable Future)	1.01
(Base-to-Expected Future)	1.06

Table 5. Estimates Survival Adjustment for A-run Steelhead

Return Year	Wild A-run steelhead run size	Non-Treaty Harvest Rates (%)/1	Treaty-Indian Harvest Rates (%) /2	Total Harvest Rates (%)
1985	51,922	2.00	19.51	21.51
1986	56,570	2.00	12.70	14.70
1987	106,690	2.00	14.77	16.77
1988	64,331	2.00	16.25	18.25
1989	57,513	2.00	18.94	20.94
1990	27,102	2.00	17.99	19.99
1991	60,264	2.00	16.41	18.41
1992	44,294	2.00	17.62	19.62
1993	28,650	2.00	16.17	18.17
1994	21,212	2.00	10.89	12.89
1995	25,997	2.00	12.19	14.19
1996	25,721	2.00	11.37	13.37
1997	30,852	2.00	12.82	14.82
1998	34,836	2.00	12.35	14.35
1999	56,626	0.93	7.42	8.35
2000	63,628	1.44	5.06	6.50
2001	137,230	0.99	5.97	6.96
2002	87,276	1.32	4.67	5.99
2003	67,049	1.68	5.38	7.06
2004	60,421	1.58	7.01	8.58
2005	58,917	1.49	5.95	7.43
2006	63,734	1.37	6.00	7.37
Average Harvest Rate (1985-2006)		1.76	11.70	13.46
Base Period Harvest Rate (1991-2003)/3		1.72	10.64	12.36
Current Period Harvest Rate (1997-2006)		1.48	7.26	8.74
Expected Future Harvest Rate/4		1.48	7.91	9.39

Survivals	
Base (1991-2003)	0.876
Current (1997-2006)	0.913
Expected Future	0.906

Lifecycle Adjustment	
(Base-to-Current)	1.041
(Base-to-Future)	1.034

/1 Non-Treaty mainstem sport and commercial harvest mortality rate of wild A-run steelhead in mainstem fisheries up to Priest Rapids Dam during all fishing seasons.

/2 Treaty Indian harvest rate of Wild A-run steelhead in all fishing seasons.

/3 Average return age 4-5 years; first harvest impact to brood year 1996 (used in Interior Columbia Technical Recovery Team analysis) would occur in return year 1991.

/4 Assumes an 8.9% increase in impacts in the treaty fishery as a result of increases in fall season fisheries.

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Quantitative Analysis of Hatchery Actions Appendix

May 5, 2008

Quantitative Analysis of Hatchery Actions Appendix

Stier and Hinrichsen (2008), attached to this Appendix, describe methods of calculating changes in productivity resulting from changes in hatchery management actions. These methods were applied to five populations of SR spring/summer Chinook and four populations of UCR steelhead in the SCA. Changes in hatchery management actions, the timing of the changes, the effect of the management changes on the relative reproductive success of hatchery-origin natural spawners (compared to that of natural-origin natural spawners), and the effect of the management changes on the expected fraction of natural-origin natural spawners are described in Sections 8.3 and 8.7 of the SCA.

The following tables display the application of the expected effects of changes in hatchery management practices to the calculation of changes in return-per-spawner (R/S) productivity, using the methods in Stier and Hinrichsen (2008).

The estimated fraction of natural-origin natural spawners (*f*) that has been observed to date is from the ICTRT data base for each population (Cooney 2007, 2008a). The "future *f*" is either considered to be the average of the natural-origin fraction in recent years or it represents a different expectation based on current management practices, as described in SCA Section 8.3.3.1 (SR spring/summer Chinook) and 8.7.3.1 (UCR steelhead).

Estimates of the relative reproductive success of hatchery-origin natural spawners (compared to that of natural-origin natural spawners), *e*, during the historical period and the expectation for "future *e*" are either described in SCA Section 8.3 (SR spring/summer Chinook) and 8.7 (UCR steelhead), or in notes in the tables included in this Appendix. Estimates are based on Araki et al. (2007a).

Yellow highlighting generally indicates values that are different from those originally presented in the Action Agencies' August 2007 Comprehensive Analysis.

References

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Table 1. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Upper Grande Ronde population of Snake River spring/summer Chinook salmon.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio		
1979	1.00	0.2	0		0.45	0.67	-0.200281882	**1.21**		
1980	1.00	0.2	0							
1981	1.00	0.2	0			based on current management goal				
1982	1.00	0.2	0							
1983	1.00	0.2	0							
1984	1.00	0.2	0							
1985	1.00	0.2	0							
1986	0.86	0.2	-0.121360857							
1987	0.18	0.2	-1.075355427							
1988	0.08	0.2	-1.341173926							
1989	0.01	0.2	-1.570217199							
1990	0.50	0.2	-0.510825624							
1991	0.60	0.2	-0.385662481							
1992	0.21	0.2	-1.008664052							
1993	0.23	0.2	-0.960093355							
1994	0.33	0.2	-0.766795808							
1995	1.00	0.2	0							
1996	1.00	0.2	0							
1997	0.90	0.2	-0.083381609							
1998	1.00	0.2	0							
1999	1.00	0.2	0							
2000	1.00	0.2	0							
2001	1.00	0.2	0							
2002	0.95	0.2	-0.039156715							
2003	0.80	0.45	-0.116533816							
2004	0.05	0.45	-0.740343615		use .45 not .50 in CA - upper end of 6-45% range for Category 3 from Araki et al. (2006)					
2005	0.04	0.45	-0.747286627							
average	0.77	0.20	-0.39							

Table 2. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Lostine River population of Snake River spring/summer Chinook salmon.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio		
1979	1.00	0.2	0		0.45	0.67	-0.200281882	**1.03**		
1980	1.00	0.2	0							
1981	1.00	0.2	0			based on current management goal				
1982	1.00	0.2	0							
1983	1.00	0.2	0							
1984	1.00	0.2	0							
1985	1.00	0.2	0							
1986	0.77	0.2	-0.204095356							
1987	0.68	0.2	-0.295714244							
1988	0.55	0.2	-0.451985124							
1989	0.24	0.2	-0.946143695							
1990	0.60	0.2	-0.385662481							
1991	0.65	0.2	-0.328504067							
1992	0.25	0.2	-0.916290732							
1993	0.49	0.2	-0.523983708							
1994	0.75	0.2	-0.223143551							
1995	1.00	0.2	0							
1996	0.88	0.2	-0.100925919							
1997	1.00	0.2	0							
1998	1.00	0.2	0							
1999	0.96	0.2	-0.033901552							
2000	0.75	0.2	-0.21915153							
2001	0.74	0.2	-0.232805462							
2002	0.48	0.2	-0.53680111							
2003	0.59	0.45	-0.252386431							
2004	0.28	0.45	-0.507163574		use .45 not .50 in CA - upper end of 6-45% range for Category 3 from Araki et al. (2006)					
2005	0.28	0.45	-0.506576755							
average	0.70	0.20	-0.23							

Table 3. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Catherine Creek population of Snake River spring/summer Chinook salmon.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio
1979	1	0.2	0		0.45	0.67	-0.200281882	**1.20**
1980	1	0.2	0					
1981	1	0.2	0			based on current management goal		
1982	1	0.2	0					
1983	1	0.2	0					
1984	1	0.2	0					
1985	1	0.2	0					
1986	0.80	0.2	-0.174353387					
1987	0.22	0.2	-0.973449146					
1988	0.24	0.2	-0.942958979					
1989	0.38	0.2	-0.693147181					
1990	0.01	0.2	-1.570217199					
1991	0.13	0.2	-1.181993898					
1992	0.25	0.2	-0.916290732					
1993	0.40	0.2	-0.653926467					
1994	0.50	0.2	-0.510825624					
1995	1	0.2	0					
1996	1	0.2	0					
1997	1	0.2	0					
1998	1	0.2	0					
1999	1	0.2	0					
2000	1	0.2	0					
2001	0.79	0.2	-0.186811622					
2002	0.51	0.2	-0.496265472					
2003	0.45	0.45	-0.357103607					
2004	0.34	0.45	-0.447537885		use .45 not .50 in CA - upper end of 6-45% range for Category 3 from Araki et al. (2006)			
2005	0.35	0.45	-0.438970187					
average	0.75	0.20	-0.38					

Table 4. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Minam River population of Snake River spring/summer Chinook salmon.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	
1979	1.000	0.2	0		0.20	0.96	-0.030469805	**1.22**	
1980	1.000	0.2	0						
1981	1.000	0.2	0						
1982	1.000	0.2	0						
1983	1.000	0.2	0						
1984	1.000	0.2	0						
1985	1.000	0.2	0						
1986	0.500	0.2	-0.510825624						
1987	0.500	0.2	-0.510825624						
1988	0.625	0.2	-0.356674944						
1989	1.000	0.2	0						
1990	0.438	0.2	-0.597837001						
1991	0.615	0.2	-0.36772478						
1992	0.095	0.2	-1.28666452						
1993	0.559	0.2	-0.435318071						
1994	0.556	0.2	-0.43936666						
1995	1.000	0.2	0						
1996	0.952	0.2	-0.039478811						
1997	0.960	0.2	-0.032523192						
1998	1.000	0.2	0						
1999	0.952	0.2	-0.038839833						
2000	0.987	0.2	-0.010178205						
2001	0.865	0.2	-0.113944259						
2002	0.980	0.2	-0.016129382						
2003	0.943	0.2	-0.046792162						
2004	0.985	0.2	-0.011834458						
2005	1.000	0.2	0						
average	0.96	0.20	-0.23						

Table 5. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Wenaha River population of Snake River spring/summer Chinook salmon.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio		
1979	1	0.2	0		0.20	0.95	-0.041776053	**1.39**		
1980	1	0.2	0							
1981	1	0.2	0							
1982	1	0.2	0							
1983	1	0.2	0							
1984	1	0.2	0							
1985	1	0.2	0							
1986	1.00	0.2	0							
1987	0.09	0.2	-1.310944924							
1988	0.28	0.2	-0.867500568							
1989	0.75	0.2	-0.223143551							
1990	0.22	0.2	-0.973449146							
1991	0.33	0.2	-0.762140052							
1992	0.09	0.2	-1.310944924							
1993	0.54	0.2	-0.456758402							
1994	0.20	0.2	-1.021651248							
1995	0.67	0.2	-0.310154928							
1996	0.98	0.2	-0.016807118							
1997	0.97	0.2	-0.027493141							
1998	0.98	0.2	-0.014652277							
1999	0.85	0.2	-0.131336002							
2000	0.97	0.2	-0.02279301							
2001	0.85	0.2	-0.124512948							
2002	0.96	0.2	-0.029522439							
2003	1.00	0.2	0							
2004	0.98	0.2	-0.01342302							
2005	0.94	0.2	-0.046792162							
average	0.95	0.20	-0.37							

Table 6. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Wenatchee River population of Upper Columbia River steelhead.

Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio		
1979	0.33	0.2	-0.771974682		0.45	0.38	-0.417620295	**1.60**		
1980	0.20	0.2	-1.024571235							
1981	0.20	0.2	-1.024968677		current hatchery fraction and current e continue					
1982	0.22	0.2	-0.967828216		no agreements in place for future changes					
1983	0.17	0.2	-1.089624782							
1984	0.08	0.2	-1.344343811							
1985	0.11	0.2	-1.253664192							
1986	0.15	0.2	-1.140373989							
1987	0.17	0.2	-1.084304872							
1988	0.35	0.2	-0.730873829							
1989	0.35	0.2	-0.731943311							
1990	0.39	0.2	-0.67548291							
1991	0.33	0.2	-0.772959725							
1992	0.40	0.2	-0.654033082							
1993	0.16	0.2	-1.112538429							
1994	0.24	0.2	-0.939272714							
1995	0.16	0.2	-1.123894827							
1996	0.28	0.2	-0.852811725							
1997	0.52	0.2	-0.481306798							
1998	0.42	0.45	-0.630363195							
1999	0.70	0.45	-0.178976824							
2000	0.35	0.45	-0.438271266							
2001	0.42	0.45	-0.383656168							
2002	0.39	0.45	-0.409229715		use .45 not .50 in CA - upper end of 6-45% range for Category 3 from Araki et al. (2006)					
2003	0.33	0.45	-0.461908943							
2004	0.22	0.45	-0.558809412							
average	0.38	0.24	-0.89							

Table 7. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Entiat River population of Upper Columbia River steelhead.

Low estimate									
Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	
1979	0.17	0.2	-1.095516979		0.20	0.22	-0.973231916	**0.82**	
1980	0.21	0.2	-1.000737233						
1981	0.25	0.2	-0.90677886		No change in f or e from last 10 years - conservative because data very uncertain				
1982	0.17	0.2	-1.094357065						
1983	0.18	0.2	-1.071913671						
1984	0.38	0.2	-0.691461291						
1985	0.40	0.2	-0.648055546						
1986	0.23	0.2	-0.950114797						
1987	0.40	0.2	-0.655219035						
1988	0.44	0.2	-0.599405864						
1989	0.69	0.2	-0.286439271						
1990	0.38	0.2	-0.688491271						
1991	0.27	0.2	-0.876576449						
1992	0.94	0.2	-0.048819903						
1993	0.76	0.2	-0.214314961						
1994	0.45	0.2	-0.580486872						
1995	0.28	0.2	-0.856021986						
1996	0.31	0.2	-0.805839642						
1997	0.23	0.2	-0.951582432						
1998	0.09	0.2	-1.314378154						
1999	0.13	0.2	-1.189660287						
2000	0.24	0.2	-0.927591549						
2001	0.26	0.2	-0.903313055						
2002	0.33	0.2	-0.764375392						
2003	0.26	0.2	-0.901582193						
2004	0.09	0.2	-1.288587125						
average	0.22	0.20	-0.77						

High estimate									
Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	
1979	0.17	0.2	-1.095516979		0.20	0.50	-0.510825624	**1.30**	
1980	0.21	0.2	-1.000737233						
1981	0.25	0.2	-0.90677886		Reasonable to assume that natural fraction will increase under current management prog				
1982	0.17	0.2	-1.094357065		No change in e expected				
1983	0.18	0.2	-1.071913671						
1984	0.38	0.2	-0.691461291						
1985	0.40	0.2	-0.648055546						
1986	0.23	0.2	-0.950114797						
1987	0.40	0.2	-0.655219035						
1988	0.44	0.2	-0.599405864						
1989	0.69	0.2	-0.286439271						
1990	0.38	0.2	-0.688491271						
1991	0.27	0.2	-0.876576449						
1992	0.94	0.2	-0.048819903						
1993	0.76	0.2	-0.214314961						
1994	0.45	0.2	-0.580486872						
1995	0.28	0.2	-0.856021986						
1996	0.31	0.2	-0.805839642						
1997	0.23	0.2	-0.951582432						
1998	0.09	0.2	-1.314378154						
1999	0.13	0.2	-1.189660287						
2000	0.24	0.2	-0.927591549						
2001	0.26	0.2	-0.903313055						
2002	0.33	0.2	-0.764375392						
2003	0.26	0.2	-0.901582193						
2004	0.09	0.2	-1.288587125						
average	0.22	0.20	-0.77						

Table 8. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Methow River population of Upper Columbia River steelhead.

Low estimate

Year	%Wild (f)	e	log(f+(1-f)*e)	future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	Notes
1979	0.12	0.2	-1.219000759	0.3	0.10	-0.985320544	**1.17**	
1980	0.12	0.2	-1.219000759					
1981	0.12	0.2	-1.219000759					0.3 is lower end of expected e
1982	0.12	0.2	-1.219000759					hatchery fraction expected to be same as since 2002
1983	0.08	0.2	-1.337261834					
1984	0.02	0.2	-1.548080807					
1985	0.03	0.2	-1.494887239					
1986	0.05	0.2	-1.420525503					
1987	0.04	0.2	-1.473610724					
1988	0.26	0.2	-0.894785098					
1989	0.25	0.2	-0.907297881					
1990	0.28	0.2	-0.858468576					
1991	0.32	0.2	-0.788293819					
1992	0.24	0.2	-0.938237685					
1993	0.15	0.2	-1.151179389					Note: includes corrected TRT hatchery fractions from July 2007
1994	0.20	0.2	-1.032228104					
1995	0.16	0.2	-1.117926575					
1996	0.30	0.2	-0.813795831					
1997	0.10	0.2	-1.275430473					
1998	0.03	0.2	-1.484994408					
1999	0.09	0.3	-1.008958895					management changed in 1999 for effectiveness
2000	0.14	0.3	-0.928766971					
2001	0.10	0.3	-0.99444567					
2002	0.06	0.3	-1.079440763					management changed in 2002 for natural fraction
2003	0.11	0.3	-0.974809273					
2004	0.13	0.3	-0.93360819					
2005	0.12	0.3	-0.959470387					
average	0.10	0.21	-1.15					

High estimate

Year	%Wild (f)	e	log(f+(1-f)*e)	future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	Notes
1979	0.12	0.2	-1.219000759	0.45	0.10	-0.678045365	**1.55**	
1980	0.12	0.2	-1.219000759					
1981	0.12	0.2	-1.219000759					.45 is high end of expected e
1982	0.12	0.2	-1.219000759					hatchery fraction expected to be same as since 2002
1983	0.08	0.2	-1.337261834					
1984	0.02	0.2	-1.548080807					
1985	0.03	0.2	-1.494887239					
1986	0.05	0.2	-1.420525503					
1987	0.04	0.2	-1.473610724					
1988	0.26	0.2	-0.894785098					
1989	0.25	0.2	-0.907297881					
1990	0.28	0.2	-0.858468576					Note: includes corrected TRT hatchery fractions from July 2007
1991	0.32	0.2	-0.788293819					
1992	0.24	0.2	-0.938237685					
1993	0.15	0.2	-1.151179389					
1994	0.20	0.2	-1.032228104					
1995	0.16	0.2	-1.117926575					
1996	0.30	0.2	-0.813795831					
1997	0.10	0.2	-1.275430473					
1998	0.03	0.2	-1.484994408					
1999	0.09	0.45	-0.691636602					management changed in 1999 for effectiveness
2000	0.14	0.45	-0.644976859					0.45 is upper end of 6-45% range for Category 3 from Araki et al. (2006)
2001	0.10	0.45	-0.683308178					
2002	0.06	0.45	-0.731347552					management changed in 2002 for natural fraction
2003	0.11	0.45	-0.671957936					
2004	0.13	0.45	-0.647838012					
2005	0.12	0.45	-0.663026404					
average	0.10	0.23	-1.12					

Table 9. Estimation of base-to-current survival multiplier to represent changes in hatchery management practices for the Okanogan River population of Upper Columbia River steelhead.

High Estimate									
Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	
1979	0.07	0.2	-1.373186461		0.45	0.07	-0.720882773	**1.88**	
1980	0.07	0.2	-1.373186461						
1981	0.07	0.2	-1.373186461		high end of expected e from Colville program that started 1 year ago				
1982	0.07	0.2	-1.373186461		no change in hatchery fraction because of continued Wells program				
1983	0.04	0.2	-1.451579223						
1984	0.01	0.2	-1.576427572						
1985	0.02	0.2	-1.546631887						
1986	0.03	0.2	-1.503080163						
1987	0.02	0.2	-1.5344001						
1988	0.12	0.2	-1.227580673						
1989	0.11	0.2	-1.251181481						
1990	0.16	0.2	-1.112195904						
1991	0.13	0.2	-1.202603909						
1992	0.17	0.2	-1.096324193						
1993	0.09	0.2	-1.313018184						
1994	0.09	0.2	-1.298768737						
1995	0.07	0.2	-1.351534082						
1996	0.15	0.2	-1.136834673						
1997	0.06	0.2	-1.385090983						
1998	0.02	0.2	-1.542751876						
1999	0.05	0.2	-1.424459704						
2000	0.08	0.2	-1.342750162						
2001	0.06	0.2	-1.408864458						
2002	0.03	0.2	-1.481313642						
2003	0.06	0.2	-1.391582171						
2004	0.08	0.2	-1.330350825						
2005	0.07	0.2	-1.359401309						
average	0.07	0.20	-1.35						

Low Estimate									
Year	%Wild (f)	e	log(f+(1-f)*e)		future e	future f	future log(f+(1-f)*e)	Integrated productivity increase as a ratio	
1979	0.07	0.2	-1.373186461		0.3	0.07	-1.06065499	**1.34**	
1980	0.07	0.2	-1.373186461						
1981	0.07	0.2	-1.373186461		lower end of expected e from Colville program that started 1 year ago				
1982	0.07	0.2	-1.373186461		no change in hatchery fraction because of continued Wells program				
1983	0.04	0.2	-1.451579223						
1984	0.01	0.2	-1.576427572						
1985	0.02	0.2	-1.546631887						
1986	0.03	0.2	-1.503080163						
1987	0.02	0.2	-1.5344001						
1988	0.12	0.2	-1.227580673						
1989	0.11	0.2	-1.251181481						
1990	0.16	0.2	-1.112195904						
1991	0.13	0.2	-1.202603909						
1992	0.17	0.2	-1.096324193						
1993	0.09	0.2	-1.313018184						
1994	0.09	0.2	-1.298768737						
1995	0.07	0.2	-1.351534082						
1996	0.15	0.2	-1.136834673						
1997	0.06	0.2	-1.385090983						
1998	0.02	0.2	-1.542751876						
1999	0.05	0.2	-1.424459704						
2000	0.08	0.2	-1.342750162						
2001	0.06	0.2	-1.408864458						
2002	0.03	0.2	-1.481313642						
2003	0.06	0.2	-1.391582171						
2004	0.08	0.2	-1.330350825						
2005	0.07	0.2	-1.359401309						
average	0.07	0.20	-1.35						

Attachment 1

A Method for Estimating Population Productivity Changes Resulting from Certain Improvements to Artificial Propagation Programs

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ESTIMATION METHOD[1]

For salmonid populations where relatively accurate spawner counts and run reconstruction information are available, productivity can be measured as the number of adult progeny returning for each adult in the previous generation. Progeny are referred to as recruits; parents as spawners. The relationship is expressed in mathematical terms as recruits-per-spawner (R/S), or often as logarithmically transformed recruits-per-spawner (log(R/S)). A mean log(R/S) value greater than 0.0 (geometric mean R/S>1.0) indicates a growing population over the time period used for the analysis; a value less than 0.0 (geometric mean R/S<1.0) indicates a population declining in size.

In calculating recruit-per-spawner productivity, it is conventional to count both natural-origin and hatchery-origin fish spawning naturally as spawners whenever hatchery-origin fish are present on the spawning grounds. However, only natural-origin fish returning to the spawning grounds are counted as recruits.

Recruit-per-spawner productivity is, therefore, a measure of the productivity of the entire naturally spawning population. However, in the 2000 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp), the National Marine Fisheries Service (NMFS) attempted to tease out the productivity of the natural-origin spawners within the spawning population by estimating lambda assuming two alternative values of the relative reproductive effectiveness of hatchery-origin spawners. The Interior Columbia Basin Technical Recovery Team (ICTRT) has taken a similar approach in its treatment of certain Upper Columbia River steelhead populations (ICTRT 2007). This approach treats hatchery-origin spawners within a naturally-spawning population as unwanted strays and attempts to estimate the productivity of the non-hatchery portion of the spawning population independent of the effect the hatchery-origin spawners have on the population's measured productivity.

As a matter of law and public policy, artificial propagation is widely used to supplement declining populations of salmon and steelhead in an effort to improve their status. The hatchery-origin spawners in these populations are not strays; they have been intentionally produced and allowed to spawn naturally in order to bolster native populations of fish. Therefore we treat these populations as integrated wholes and use the method described in this report to estimate the productivity changes in the entire naturally-spawning population that result from certain improvements in hatchery practices (and thus improvements in the relative reproductive effectiveness of the hatchery-origin spawners within these populations).

The emerging scientific consensus is that hatchery-origin fish are generally not as productive as natural-origin fish and that the difference in productivities is greatest when

[1] This report is intended to provide an update to Appendix E of the "Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions" submitted by the Federal Action Agencies to NOAA Fisheries on August 21, 2007.)

the hatchery broodstock used is derived from non-local, domesticated sources. Research into this issue is limited. Very little is known of the relative reproductive effectiveness of hatchery-origin and natural-origin stream-type chinook salmon, for instance. The relatively few existing studies on the subject are dominated by steelhead, coho salmon and Atlantic salmon.

However, Berejikian and Ford's review of the research literature advises that "to the extent that the general loss of fitness increases with the duration of the lifecycle spent in captivity, we believe that is it reasonable to extrapolate the results from steelhead, coho, and Atlantic salmon to hatchery propagation of other species that have an extensive freshwater life history phase" (Berejikian and Ford 2004). For Pacific salmon in the Pacific Northwest, these species include stream-type Chinook salmon, which spend approximately 1 year in fresh water (Healey 1991), sockeye salmon, and anadromous cutthroat trout.

Fitness in this instance is characterized in terms of relative reproductive success of hatchery-origin spawners compared to natural-origin spawners. A case where hatchery-origin spawners have reproductive success, or productivity, equal to that of natural-origin spawners would be described in mathematical terms as hatchery effectiveness equal to 1.0 ($e=1.0$). Where hatchery-origin spawners are less productive than natural-origin spawners (which is generally believed to be the case), hatchery effectiveness would be estimated to be less than 1.0 ($e<1.0$).

Mean log(R/S) values are estimated for individual populations of listed fish over an historical period. These historical averages do not necessarily represent current productivities, in part because changes may have taken place as a result of hatchery reforms implemented in recent times. Reforms that will likely have the greatest impact on mean log(R/S) include significant improvements in broodstock management protocols and curtailment of significant straying of hatchery-origin fish into native populations being managed as wild-only populations. This method can also be used to estimate prospective changes in cases where significant improvements are made to broodstock protocols or where significant straying can be curtailed.

By estimating the relative reproductive effectiveness of hatchery-origin spawners before and after a hatchery reform action, and making a reasonable forecast of the future percentage of natural- and hatchery-origin fish in the spawning population, it is possible to calculate the improvement in population productivity resulting from a hatchery reform action whose effect would be to increase relative reproductive success of hatchery-origin fish (or curtail straying of less fit hatchery-origin fish).

We do not intend to suggest that the only negative effect that hatchery fish can have on population productivity and/or other viable salmonid population (VSP) parameters results from the lower reproductive effectiveness of hatchery-origin fish. Risks associated with artificial production are significant and have been well-documented (see for instance

Busack et al 2004; Busack and Currens 1995; Waples 1999; Cuenco et al. 1993 quoting Riggs 1990).

The method described in this report estimates only the expected effects on population productivity resulting from improvements to the relative reproductive effectiveness of hatchery-origin spawners within a naturally-spawning population. It is acknowledged that improved hatchery practices could lead to other fitness and survival improvements in the natural-origin component of the population. It is also acknowledged that adverse effects on the fitness of the natural-origin component of the spawning population could complicate the comparison of the relative reproductive effectiveness of hatchery-origin spawners to a hypothesized natural-origin fish (this would more likely be an issue for populations with extremely high historical hatchery influence). However, any reduction in the estimated survival improvements that might result from genetic fitness loss in natural-origin spawners could be negated by a long-term improvement in natural-origin spawner fitness as a result of kinds of the hatchery reforms considered in this analysis.

The following diagram illustrates the concept of improved integrated productivity due to improved hatchery effectiveness (setting aside genetic effects). In the table on the left in Figure 1, R/S productivity of the naturally-spawning population is 0.5; 50 hatchery-origin and 50 natural-origin spawners produced 50 recruits (50/100=0.5). For the purposes of this example, the hatchery-origin fish are assumed to be derived from non-native, domesticated broodstock and have relative reproductive effectiveness of 0.[2] In the table to the right in Figure 1, broodstock management protocols have been significantly improved and the hatchery-origin fish in the spawning population are now thought to have relative reproductive effectiveness of 1.0 (i.e., they are producing an equal number of adult progeny as the natural-origin spawners). All other things being equal, it is expected that the same numbers of hatchery-origin and natural-origin spawners would produce twice as many recruits, an overall productivity improvement of 100 percent (100/100=1.0).

[2] This example is intended to simplify the concept. It is not intended to imply that pre-reform hatchery-origin spawners would be likely to have relative reproductive effectiveness of 0, nor that post-reform hatchery-origin fish would be likely to be as reproductively effective as wild fish.

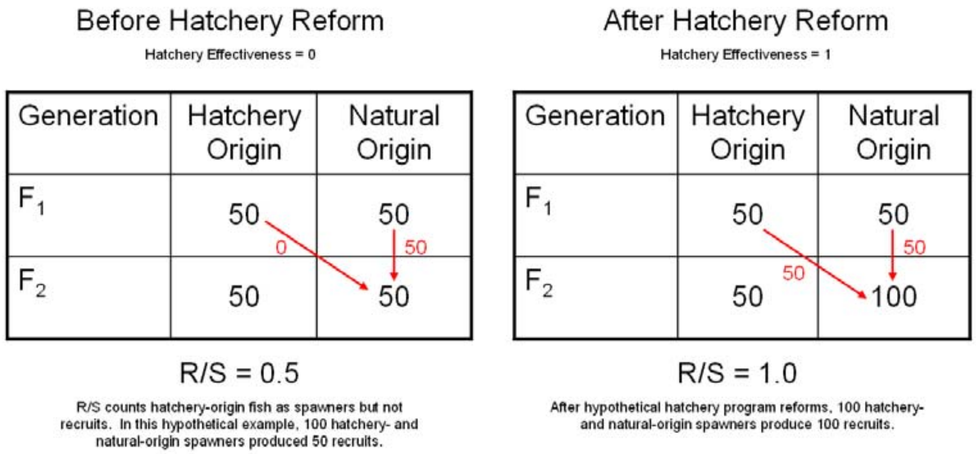

Figure 1. Simplified Illustration of Hatchery Reform Effects on Productivity of the Naturally Spawning Population

This phenomenon is even more clearly illustrated in a case where significant straying of relatively unfit, non-native hatchery fish is curtailed. In the example above, it would be as though the hatchery-origin component of the naturally-spawning population was simply eliminated, again resulting in a productivity improvement of 100 percent, relative to the productivity estimated for the historical period during which straying occurred.

Guidance from NMFS (NMFS 2007) provided the basis for the hatchery effectiveness and future hatchery/wild fraction estimates used in the Comprehensive Analysis (FCRPS Action Agencies 2007). The NMFS guidance based its conclusions on works by Berejikian and Ford (2004) and Araki et al. (2006). Briefly, four categories of hatchery programs were identified, distinguished primarily on the basis of broodstock management protocols.

Category 1, includes non-local domesticated broodstock, hatchery-origin fish (hatchery-origin fish)<30 percent as reproductively effective as natural-origin fish (natural-origin fish);

Category 2, includes local-origin natural-origin fish broodstock (the broodstock consists entirely or primarily of natural-origin fish each generation), hatchery-origin fish are 90 to 100 percent as reproductively effective as natural-origin fish;

Category 3, includes local-origin natural-origin fish and hatchery-origin fish broodstock (includes varying mixtures of hatchery and natural-origin fish in the broodstock each generation), hatchery-origin fish are 6-45 percent as reproductively effective as natural-origin fish (Araki et al. 2006); and

Category 4 includes captive and farmed broodstocks.

In the 2007 Comprehensive Analysis, hatchery programs affecting certain populations in the interior Columbia River Basin were assessed according to these categories, both historically and prospectively. Estimates were made of past, present and likely future hatchery-origin fish/natural-origin fish fractions in the spawning populations. The equations that follow were then used to estimate changes in productivity expected to result from past and prospective hatchery reforms.

EQUATIONS DESCRIBING IMPROVEMENTS IN PRODUCTIVITY

The equations that follow describe a method of estimating the changes in the productivity of the naturally spawning population as hatchery effectiveness improves. Assume that $S_{h,t}$ represents hatchery-origin spawners in the naturally spawning population, $S_{w,t}$ represents the number of natural-origin spawners in that population, and e_t represents the relative reproductive success of hatchery-origin spawners. The goal is to find an expression for the productivity of the natural spawners, regardless of their origin. To do this, assume that the number of recruits from the natural-origin spawners is given by $R_{w,t}$ and that the number of recruits for the hatchery-origin spawners is given by $R_{h,t}$. Further assume that the proportion of natural-origin spawners is f_t and that $P_{w,t}$ represents the productivity of the natural-origin spawners, and $P_{h,t}$ represents the productivity of the hatchery-origin spawners.

The productivity of all natural spawners is equal to:

$$P(e_t) = \frac{R_{w,t} + R_{h,t}}{S_{w,t} + S_{h,t}} = \frac{P_{w,t} S_{w,t} + P_{h,t} S_{h,t}}{S_{w,t} + S_{h,t}} = \frac{P_{w,t} S_{w,t} + e_t P_{w,t} S_{h,t}}{S_{w,t} + S_{h,t}} = P_{w,t}(f_t + (1 - f_t)e_t)$$

Let's assume we are interested in how the geomean of natural spawner productivity changes over time, and we are interested in the change at time t_s and assume the final time in the series is t_f. The change in productivity can then be described by:

$$\delta = \sum_{t=t_s+1}^{t_f} \log\{P_{w,t}(f_t + (1 - f_t)e_t)\} / (t_f - t_s) - \sum_{t=1}^{t_s} \log\{P_{w,t}(f_t + (1 - f_t)e_t)\} / t_s$$

One of the difficulties in applying this equation directly is that $P_{w,t}$ is not known. However, if it is assumed that the average productivity of natural-origin spawners does not change after time t_s then we can write:

$$\delta = \sum_{t=t_s+1}^{t_f} \log\{(f_t + (1 - f_t)e_t)\} / (t_f - t_s) - \sum_{t=1}^{t_s} \log\{(f_t + (1 - f_t)e_t)\} / t_s$$

If it is further assumed that the fraction of natural-origin spawners and relative reproductive success of hatchery-origin spawners do not change after time t_s (assume they are fixed at f^* and e^*, respectively) then we can write:

$$\delta = \log\{(f^* + (1 - f^*)e^*)\} - \sum_{t=1}^{t_s} \log\{(f_t + (1 - f_t)e_t)\} / t_s$$

The fixed fraction of natural-origin spawners, f^*, could be set to the average over a subset of the data (e.g., the last 10 years) or to some assumed value. The current method fixes t_s at the most recently available year of spawner values and f^* and e^* represent assumed future values.

In order to place this result in terms of productivity ratios, the ratio of productivities is given as $\exp(\delta)$.

Acknowledgements

The authors wish to thank Mike Schiewe, Jeff Gislason and Charlie Paulsen for comments on an earlier version of this report.

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Snake River Steelhead Kelt Appendix

May 5, 2008

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

Memorandum – Final F/NWR5

To: Bruce Suzumoto

From: Blane Bellerud, Ritchie Graves, and Gary Fredricks

Date: April 21, 2008

RE: Assessment of the likely survival improvement resulting from enhancement strategies for steelhead kelts (B-run kelts in particular).

Introduction

Since steelhead are capable of surviving to spawn more than once (iteroparity), enhancing this life history has the potential to increase the number of steelhead spawners. In the past kelts have generally been thought to be of little significance to inland populations of steelhead such as those in the Snake and upper Columbia Rivers. However, recent research has indicated that kelts which return to spawn may be significant to many populations (Wertheimer and Evans 2005). In this document, we review potential strategies for improving kelt survival and provide an estimate of the potential increase in Snake River B-run steelhead recruitment that could result if these enhancement strategies were implemented.

Kelt Enhancement Strategies

Reconditioning

Reconditioning strategies are based on capturing downstream migrating kelts and holding them in tanks. During the holding period they are fed and medicated to control disease. The Yakama Nation have employed two different strategies in their reconditioning studies-long-term where the kelts are held until mature and then released directly into their natal streams, and short-term where kelts are reconditioned for 3-5 weeks and then transported and released downstream of Bonneville Dam (Branstetter et al. 2006).

Survival of long-term reconditioned kelts in the Yakama program from 2001-2005 ranged from 19.6% to 61.8% in with an average success rate of 35.7% (Hatch et al. 2006). Success rates declined in recent years possibly due to the poor conditions of available kelts. One potential problem with long-term reconditioning is that the actual success of reconditioned kelts spawning in the wild is unknown. Under hatchery conditions, progeny showed good survival until shortly after hatch when there was a 50-60% increase in mortality (Hatch et al. 2006). Another study (Stephenson et al. 2007) which uses DNA technology to identify the parents of outmigrating steelhead smolts has failed to identify any offspring from reconditioned kelts released into the streams where the study was conducted. It is thought that these problems may be related to maturation or nutrition of the reconditioned kelts and more study is needed.

The average survival rate of short-term reconditioned kelts to release 2002-2005 was 82.5%. Short-term reconditioned kelts (released downstream of Bonneville) returned to Prosser Dam at a rate of approximately 4.8%; approximately twice the rate of fish which were just transported to below Bonneville and released with no reconditioning. To date, no progeny viability studies have been completed with short-term reconditioned kelts. However, short-term reconditioned fish, which finish maturation in the ocean, may not have the same potential problems with the viability of their offspring which currently appear to be affecting long-term reconditioned kelts.

Transportation

Boggs and Peery (2004) transported kelts captured in the juvenile bypass system at Lower granite Dam (LGR) in 2001-2003. Approximately 98% of transported kelts survived to below Bonneville compared with in river kelt survivals of 8.3% in 2001, 13.3% in 2002, and 33% in 2003. Repeat kelt return rates (KRR) to Lower Granite of in-river migrants were approximately 0.5%, KRR of transported Kelts to Lower Granite was 2.3%. Transportation not only resulted in a much higher FCRPS survival but also increased KRR by almost five-fold.

Improved In-River passage

The previous two strategies rely on capturing kelts. Previous work (Dygert 2007) indicated that approximately 7% and 22% of the wild Snake River steelhead run pass back downstream as kelts into the bypass system at Lower Granite Dam with and without spill, respectively, and could be removed from the system for these extractive enhancement efforts. The capture potential in the mid and upper Columbia River is unknown but likely much more limited since adequate capture facilities are limited or lacking at the dams in these river reaches. This indicates that even with these other strategies in place, approximately 80% or more of the outmigrating kelts will pass downstream in-river and that passage improvements would be a benefit to much of the downstream outmigrating kelt population.

Most of the passage and operational improvements currently being implemented for the benefit of outmigrating juvenile salmon and steelhead would also likely improve kelt downstream survival (Wertheimer and Evans 2005). Such is probably particularly relevant for lower Columbia River steelhead stocks. Kelts show a strong preference for surface passage; as indicated by the reduced delay and increased passage efficiency at of kelts at the Bonneville Dam Powerhouse II corner collector (B2CC) in 2004 (Wertheimer 2007). Like the B2CC, in an RSW study (Clabough and Peery 2004) at LGR in 2002, 62% of radio-tagged kelts passed via the RSW, in 2003, 80% of kelts passed via the RSW. In the lower Columbia kelt passage efficiencies ranged from 88-99% for spill rates in excess of 30%. The proposed surface passage routes to be installed in the FCRPS should benefit kelts both by passing more of them through a more benign route of passage and reducing forebay delay, which may result in kelts reaching the ocean more quickly, in slightly better condition, and returning at higher rates.

Benefit Analysis

This analysis is based on an earlier analysis conducted by Peter Dygert of NOAA Fisheries Sustainable Fisheries Division (Dygert 2007). He estimated a potential 3% average increase in the number of B-run spawners for a kelt reconditioning program. We expanded on his analysis for the years 2000-2006 to estimate the potential benefits of kelt reconditioning or transport under the PA spill program, with collection at both LGR and LGS.

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For wild steelhead, Dygert estimated a 7% collection efficiency at LGR during spill, and a 22% collection efficiency during no spill periods (as a percentage of the prior years wild steelhead run at LGR). Since he was unsure of the proportion of the kelts which would pass under each condition he used the average collection rate, 14.6%, for his analysis. We used his estimates of spill and no-spill collection efficiency; however we weighted the analysis based on the proposed spill program which concludes voluntary spill in the lower Snake River on May 15. To accommodate this management scenario we weighted the collection rates by the proportion of the kelts which passed during spill or no spill periods (based on kelt passage data from the Fish Passage Center).

Steelhead kelts collected = (WSKR*Kspill* 0.7) + (WSR*Knospill* 0.22)

where WSKR = wild steelhead kelt run;
Kspill = proportion of kelts passing during spill; and
Knospill = proportion of kelts passing no spill.

Dygert assumed that 11.8% of the wild kelts were B-run Steelhead. However, more detailed analysis based on length criteria yielded an estimate that 18.7% of wild kelts were B-run steelhead (Ellis, 2008).

B-run kelts collected= kelts collected *.187

We also wanted to examine how many kelts could be collected if they were also collected at Little Goose Dam (LGO). This required an estimate of the number of kelts remaining after collection at LGR and the number surviving passage through LGR and through the LGO reservoir. The total number of wild kelts at LGR was estimated by extracting FGE (average for Bonneville Dam and John Day Dam juvenile bypasses reported by Wertheimer and Evans 2005) of 53.3% from the no spill collection efficiency under no spill conditions and then applying it to the prior years wild steelhead run (41.5%). We estimated a 70% dam passage survival for kelts during no spill conditions and a 80% dam passage survival for kelts during spill. LGR to LGO reservoir survival of 96% was derived from the Snake River reach survival of 88.5% reported by Boggs and Peery (2004).

The total number of kelts was calculated as the sum of weighted spill and no spill collections at each dam:

Kelts collected (KC) =

((WSKR* 0.7) + (((WSKR*.415)-(LGR Collection))* LGR survival*LGS res survival))*.7) *Kspill)
+
((WSKR* 0.22) + (((WSKR*.415)-(LGR Collection))* LGR survival*LGS res survival))*0.22) *Knospill)

where WSKR = wild steelhead kelt run;
Kspill = proportion of kelts passing during spill; and
Knospill = proportion of kelts passing no spill.

B-run female kelts collected (BKC) = KC*0.187* 0.8 (proportion of female kelts)

The total number of B-run female kelts collected was multiplied by the success rate of the various kelt enhancement strategies to give the estimated number of kelts provided by each strategy. The average numbers of B-run female kelts contributed by the various strategies was divided by the average number

of female B-run steelhead in the upstream run at LGR (3000) to give an estimate of the expected average increase in the number of female B-run steelhead passing Lower Granite Dam. The results are listed in Tables 1 and 2. The specific equation for each strategy is as follows:
Long term reconditioning (LTR) = BKC* LTR success rate*spawning success rate (assumed to be 1, but may be lower)

Long-term reconditioning with viability loss = LTR * 0.5

Short term reconditioning (STR) = BKC * STR success rate * STR kelt return rate

Transport (TR) = BKC * Transport survival * TR kelt return rate

In –River (IR) = (WSR*.415*.187) * IR survival * IR kelt return rate

Results and Discussion

Table 1. Analysis results for prospective kelt enhancement strategies.

Kelt strategy	Average estimated numbers of B-run female kelts returned for spawning	Percent increase to average B-steelhead female run 2000-2006 (3000 females)
LT reconditioning	267.0	8.90%
LT reconditioning w/50% viability loss	133.5	4.45%
ST reconditioning	24.5	0.82%
Transport	12.5	0.42%

Table 2. Analysis results for current in-river passage conditions.

Kelt strategy	Average estimated numbers of B-run female kelts returned for spawning	Percent increase to average B-steelhead female run 2000-2006 (3000 females)
In-River	2.3	0.08%
In-River after collection	1.1	0.04%

Long term reconditioning

This appears to be the most promising of all of the potential kelt strategies. However, there are two significant problems. The first is the apparent problems with the viability of long-term reconditioned kelt offspring that may result from maturation timing and nutrition problems. Further studies to assess the viability of reconditioned kelt offspring and potential solutions will be required before the potentials of this strategy are realized. The second potential problem is the large amount of materials, facilities and personnel, and the accompanying high costs associated with this strategy.

Short term reconditioning

Though it appears that much lower numbers of kelts are returned to the spawning population, this strategy could approximately doubles the number of kelts that would be returned by transport alone.

Additionally, since these fish complete their maturation in the ocean under natural conditions, offspring viability problems associated with maturation or nutrition seem less likely (though there has been no research to assess offspring viability of short term reconditioned kelts).

Transport

This strategy returns the lowest number of kelts of any of the strategies which capture kelts. However, the numbers still represent a six fold increase in the number of kelts which return under current in-river passage conditions. The logistical requirements of a kelt transport program are already in place for Snake River populations and would require relatively little additional effort in comparison to the reconditioning strategies.

In-River

Boggs and Peery (2004) cite an estimate of a 2% kelt return for the Clearwater river in 1952. Our estimate for the current post hydrosystem passage conditions (0.08%) is much lower than the historic estimate indicating that there is much room for improvement in in-river survival from the ongoing passage improvements for juvenile salmon outmigrants, especially the implementation of additional surface passage routes. The in-river after collection estimate represents the expected number of fish which would return after kelt collection for reconditioning or transport are removed from the population.

Summary

Wertheimer and Evans (2005) suggest enhancing kelt returns by pursuing passage improvements, kelt transportation, and kelt reconditioning The results of this analysis support that suggestion. The primary limiting factor for reconditioning and transport is the number of kelts which can be captured. Since the majority of kelt passage occurs during spill and kelts show a strong preference for surface passage routes, collection rates are likely to be relatively low under the proposed action. Another caveat is that since the number of kelts which are captured is primarily dependent upon the number of kelts returning to LGR (after spending one to two years in the ocean), and in turn the size of the steelhead run, the effectiveness of kelt enhancement actions will be reduced to the extent that other activities (e.g. harvest) reduce the number (proportional survival) of the steelhead run returning to LGR.

Considering the potential gains in B-run spawners listed in Table 1 above and the caveats discussed for each enhancement strategy, we believe an estimate of increased B-run returns could fall somewhere in the 0.4 –9% range depending on the strategies adopted. Assuming a successful long-term recondition program and after adding a likely but unspecified survival increase from in-river survival improvements, we believe it is reasonable that an estimated average increase of 6% in B-run Snake River steelhead returns to Lower Granite Dam is possible.

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West Coast River Survival Appendix

May 5, 2008

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112-2097

October 2, 2007

MEMORANDUM FOR: F/NWR5 - Bruce Suzumoto

FROM: F/NWC3 - John W. Ferguson

SUBJECT: Preliminary survival estimates among large west coast rivers

As part of our NOAA Fisheries FCRPS Biological Opinion Implementation funding, I convened a mini-workshop on 16-18 July 2007 to discuss the current approaches and methods used to assess and estimate juvenile salmonid survival among large, west coast rivers. The workshop was attended by Bruce McFarlane and Steve Lindley (SFWSC, Santa Cruz Laboratory), David Welch and several staff from Kintama Research (Nanaimo, British Columbia), and several NWFSC scientists from the Fish Ecology Division. The goal of the workshop was to share information, develop common approaches, and hopefully reach agreement about how to make comparative assessments of survival among the rivers in the future and report results in peer-reviewed journals. The following preliminary estimates of survival among the rivers were discussed or are otherwise currently available. The acoustic estimates of survival are preliminary and it is not appropriate to imply their meaning regarding policy issues at this time. Further analyses, review, and replication will be needed before the utility of these data becomes clear. However, these are the best estimates currently available, and they are being provided in this context.

- Estimated survival based on PIT tags of yearling Chinook salmon and steelhead from the Snake River trap to the tailrace of Bonneville Dam: Preliminary estimated survival for 2007 and comparisons to final estimates for the 2001-2006 are reported in a Memorandum to you from me dated 31 August 2007. Mean estimated survival was 56.0% for yearling Chinook salmon traveling through the entire hydropower system (all 8 reservoirs and dams) in 2007, which was second only to 2006 in our series. Estimated survival of steelhead traveling through the same reach was 39.2% in 2007.
- At the workshop, David Welch provided powerpoint slides showing estimated survival of yearling Chinook salmon that were acoustically tagged and released from Kooskia National Fish Hatchery in the Snake River in 2006 (n = 396; FL >140 mm). Estimated survival of acoustically-tagged fish and PIT-tagged fish appeared similar from the point-of-release to the extent of our estimates based on PIT tags, or approximately 500 km below the release point in the Columbia River. No statistical analyses were performed,

but the regressions for both sets of data showed similar patterns in survival versus distance through the hydropower system ($S_{PIT} = e^{-0.0015x}$ and $S_{acoustic} = e^{-0.0014x}$).

- At the workshop, David Welch provided estimates on the survival of yearling Chinook salmon that were acoustically tagged and released into the Coldwater, Nicola or Soius Rivers of the Thompson-Fraser watershed in 2006. Survival of these fish was estimated to detection arrays in the lower Fraser River near its mouth; however, the exact distance over which the estimates were made was not provided. David also released acoustically tagged yearling Chinook salmon from Kooskia National Fish Hatchery in the Snake River, and measured survival to the McGowen channel below Bonneville Dam in 2006. He then compared to the survival of yearling Chinook released into the Thompson River tributaries and measured to the 'mouth,' to the survival of fish released into the Snake River to below Bonneville Dam, and reported that the survival of fish in both groups was similar (not significantly different); the 95% CI for Thompson-Fraser salmon appeared to range from approximately 14-34%.
- At the workshop, David also compared the survival of steelhead released into the Snake-Columbia River to steelhead acoustically tagged and released into the Thompson-Fraser system in 2006. I do not know the total sample sizes, fish lengths, source, rearing history, or whether the fish released into the Snake-Columbia River were tagged with PIT or acoustic tags. My notes indicate that the Thompson River steelhead were of wild origin. The survival of fish in both tag groups was similar (not significantly different) when survival through the Thompson-Fraser was compared to the 'impounded' Snake-Columbia; the 95% CI for Thompson-Fraser salmon appeared to range from approximately 21-39%. These estimates are from a verbal presentation of data. We do not have a document on this study at this time.
- Steve Lindley presented results of the studies conducted in the Sacramento River. Late-fall yearling Chinook salmon (mean FL=160 mm) and steelhead (mean FL=180 mm) from the Coleman National Fish Hatchery located on Battle Creek below Shasta Dam were acoustically tagged and released at the beginning of 2007. Estimated survival to the mouth (Golden Gate Bridge) was approximately 5% for steelhead and 2% for the yearling Chinook salmon. It was an extremely low flow year in California in 2007, and they felt the resultant environmental conditions influenced the results. I asked whether warm water temperatures were of concern, and they said no, these fish migrate during February and March on the outflow of the spring snowmelt off the west slope of the northern Sierra Nevada mountains. They have analyzed their data and detections to some degree, and believe at this time that most of the mortality occurred in the freshwater component of the river.
- In 2006, NOAA Fisheries, USGS, and PNNL initiated a study to compare the survival of acoustically- and PIT-tagged fish through the FCRPS. The survivals of hatchery yearling Chinook salmon released at the tailrace of Lower Granite Dam were not statistically different among tag types to downstream sites (Little Goose, Lower Monumental, McNary, John Day, and Bonneville dams) except for the Lower Granite to Little Goose reach, where survival of acoustically tagged fish was higher than that of PIT-tagged fish. Mean estimated survival to Bonneville Dam was 0.48 (SE = 0.03) and 0.54 (SE = 0.09) for acoustically and PIT-tagged fish, respectively (Hockersmith et al. In review).

- Since 2001, we have been working with our partners (PNNL and USACE) to downsize acoustic transmitters for implantation into subyearling Chinook salmon and develop concomitant detection equipment. In 2006, we evaluated survival for acoustically-tagged, run-of-the-river yearling and subyearling Chinook salmon from below Bonneville Dam through the lower Columbia River and estuary and the mouth of the river (235 river kilometers) using the Cormack-Jolly-Seber (CJS) single-release survival model (McMichael et al. 2007). Four groups of yearling Chinook salmon were obtained from the daily smolt monitoring sample at the Bonneville Dam Second Powerhouse, tagged, and released into the juvenile bypass system. Preliminary survival estimates for groups of fish released on May 2, 11, 19, and 27 were 0.66 (SE = 0.035), 0.57 (SE = 0.036), 0.84 (SE = 0.038), and 0.62 (SE = 0.040), respectively. Eight groups of subyearling Chinook salmon were tagged and released at 5-d intervals from 17 June through 22 July. Preliminary survival estimates for the first four release groups ranged from 0.84 (SE = 0.038) to 1.01 (SE = 0.046). However, estimated survival for the remaining groups ranged from 0.67 (SE = 0.040) for the fifth group to 0.18 (SE = 0.041) for the final group. Mean estimated survival from Bonneville Dam to the mouth of the Columbia River was 0.68 (SE = 0.038) and 0.66 (SE = 0.036) for spring and summer releases, respectively. Results from studies conducted in 2005 showed similar magnitudes and temporal trends in estimated survival. Mean estimated survival during spring and summer 2005 was 0.69 (SE = 0.061) and 0.50 (SE = 0.037), respectively.

In summary, studies of comparative survival between tag types or among large west coast rivers are just beginning, but we have some estimates of survival through the impounded and regulated Columbia River, the regulated Sacramento, and the unimpounded and unregulated Fraser River. Other than the estimates of survival through the FCRPS based on PIT tags, estimates of survival through these rivers and the Columbia River below Bonneville Dam are preliminary and are still being reviewed, analyzed, and reported. When using the CJS method to estimate survival, the results presented as survival actually include the joint probability of survival and the tendency to migrate to the downstream site. For yearling (stream-type) juvenile Chinook salmon, data and observations over years of study suggest that smolts have a directed migration to the ocean and do not linger or residualize. Thus, the “survival” estimates appear robust. For subyearling (ocean-type) Chinook salmon in the Snake River, recent evidence shows that not all fish have a directed migration (Connor et al. 2005). Thus, estimates of “survival” to downstream detection arrays for this life-history type represent a minimum estimate. Tagged smolts that delay migration for weeks to months, but survive and migrate past downstream detection arrays after batteries in tags have died or the detection arrays have been removed for the winter, are not included in the standard CJS survival estimates provided here.

Each tag type has its strengths and weaknesses; we are most comfortable with PIT-tag based estimates at this time because we have 20 years of experience with this tagging methodology. However, use of PIT tags to estimate survival requires a high level of infrastructure that is typically not available in large river systems. Thus, we are discussing how to use and apply common acoustic-based methods among the studies of survival in large river systems to standardize the methods as much as possible. Results of our discussions at the mini-survival workshop were positive and promising for achieving our goal of standardizing the source fish, and the tagging, release, and analysis protocols. All three research groups are very cognizant of potential tagging and tag effects (Chittenden et al., Submitted; Hockersmith et al. In review; Welch et al. Submitted). Survival studies in all three rivers are scheduled to be replicated through 2009 to incorporate inter-annual variability, and we hope to develop a joint manuscript after the 2008 or 2009 field seasons. David Welch has developed a draft manuscript comparing survival in the Fraser River to the Columbia River, and once the manuscript has been submitted to a journal, we will have a chance to review it and better understand the river reaches studied, source fish, analytical methods used, and the point estimates of survival reported.

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