UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

January 11, 2013

Lorri Lee
Pacific Northwest Regional Director
U.S. Bureau of Reclamation
1160 North Curtis Road, Suite 100
Boise, Idaho 83706-1234

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the U.S. Bureau of Reclamation's Odessa Subarea Modified Partial Groundwater Replacement Project. (NWR-2012-9371)

Dear Ms. Lee:

Enclosed is the Endangered Species Act (ESA) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Essential Fish Habitat (EFH) Consultation prepared by National Marine Fisheries Service (NMFS) regarding the U.S. Bureau of Reclamation's (Reclamation) Odessa Subarea Modified Partial Groundwater Replacement Project on the Columbia River in Adams, Lincoln, Franklin and Grant Counties, Washington.

NMFS received a final biological assessment (BA) from Reclamation on November 6, 2012. Reclamation's BA determined that Columbia River chum salmon were likely to be adversely affected by the proposed action, 12 other species of ESA listed salmon and steelhead would not likely be adversely affected by the proposed action, and that Pacific eulachon, green sturgeon, and southern resident killer whales would not likely be adversely affected by the proposed action.

NMFS disagreed with Reclamation's "Not Likely to Adversely Affect" determinations for 12 species of salmon and steelhead. NMFS's Biological Opinion (Section 2 of the enclosed document) analyzes the effects of the proposed Federal action on all 13 ESA-listed salmon and steelhead species in the Columbia River Basin: Upper Columbia River spring Chinook salmon, Upper Columbia River steelhead, Mid-Columbia River steelhead, Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye, Snake River steelhead, Columbia River chum salmon, Lower Columbia River Chinook salmon, Lower Columbia River steelhead, Lower Columbia River coho salmon, Upper Willamette River Chinook salmon, and Upper Willamette River steelhead in accordance with Section 7 of the Endangered Species Act (ESA) of 1973 as amended (16 USC 1531 *et seq.*). NMFS concludes that the proposed action is not likely to jeopardize the continued existence of these 13 species, or destroy or adversely modify their designated critical habitat.

Section 3 of the enclosed document is a consultation regarding EFH under the MSA, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267). NMFS finds that the proposed action could adversely affect Chinook salmon EFH in the Hanford Reach of the Columbia River and recommends that Reclamation curtail diversions for Odessa project when flows at Priest Rapids Dam fall below 40,000 cfs. Pursuant to MSA (§ 305(b)(4)(B)) and 50 CFR 6000.920(j), Federal agencies are required to provide a written response to NMFS' EFH conservation recommendations within 30 days of receipt of those recommendations.

NMFS would also like to note issues, which were raised through our consultations with several affected tribes. First, there are concerns about the number and magnitude of Columbia River Basin water withdrawal proposals being raised through state processes, and what cumulative effects these withdrawal might have on the survival and behavior of migrating salmon if they are implemented. The tribes have asked for, and NMFS supports, further dialogue with Reclamation, NMFS, and other regional stakeholders regarding this issue.

Second, the tribes, and NMFS, recognize that substantial efforts are underway to better understand how juvenile salmon and steelhead are using habitat within the Columbia River estuary, and how that use and timing relates to survival throughout their life cycle. The new information obtained from these studies should substantially improve our understanding of how a variety of factors affect the conservation value of this habitat and the upstream migratory corridor. NMFS encourages Reclamation to keep abreast of the information coming out of these studies and integrate these findings into their processes for considering long-term water management operations.

Comments or questions regarding this Biological Opinion and MSA consultation should be directed to Rich Domingue at 503.231.6858 or(Richard.Domingue@noaa.gov) or Ritchie Graves, FCRPS Branch Chief, at 503.231.6891 (Ritchie.Graves@noaa.gov).

Sincerely,

For

William W. Stelle, Jr
Regional Administrator

cc: Wendy Christenson (USBR)
Gerald Kelso (USBR)

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) "Not Likely to Adversely Affect" Determination, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Odessa Subarea Partial Groundwater Replacement Project

NMFS Consultation Number: NWR-2012-9371

Action Agency: U. S. Bureau of Reclamation

Affected Species and Determinations:

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

Lower Columbia River coho (*O. kisutch*)	Threatened	Yes	No	No
Columbia River chum (*O. keta*)	Threatened	Yes	No	No
Southern green sturgeon (*Acipense meiorostris*)	Threatened	No		
Eulochon (*Thaleichthys pacificus*)	Threatened	No		
Southern resident killer whale (*Orcinus orca*)	Threatened	No		

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

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

Issued By: For William W. Stelle, Jr.
Regional Administrator

Date: 1/11/13

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TERMS AND ABBREVIATIONS

A/P	Abundance and Productivity
BA	Biological Assessment
BPA	Bonneville Power Administration
BRT	Biological Review Team
CBP	Columbia Basin Project
Chart	Critical Habitat Analytical Review Teams
CO_2	Carbon Dioxide
Corps	US Army Corps of Engineers
CR	Columbia River
DDT	Dichlorodiphenyltrichloroethane
DNA	Deoxyribonucleic acid
DPS	Distinct Population Segment
DQA	Data Quality Act
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FMP	Fisheries Management Plan
GBT	Gas Bubble Trauma
HGMP	Hatchery and Genetic Management Plan
HUC	Hydrologic Unit Code
HUC-5	Hydrologic Unit Code at the fifth field scale
IC	Interior Columbia
ICTRT	Interior Columbia Technical Review Team
ITS	Incidental Take Statement
Kaf	Thousand acre feet
LC	Lower Columbia
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Program
LWD	Large Woody Debris
MAF	Millions of acre feet
MCR	Middle Columbia River
MGD	Million gallons per day
MMPA	Marine Mammal Protection At
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service

NOAA	National Oceanic Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
NPMP	Northern Pikeminnow Management Program
NWFSC	Northwest Fisheries Science Center
OCR	Of the Columbia River
ODFW	Oregon Department Fish and Wildlife
Opinion	Biological Opinion
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyls
PCE	Primary Constituent Element
PFMC	Pacific Fishery Management Council
PIT	Passive Integrated Transponder
PIT-TAGS	Passive Integrated Transponder Tags
PVA	Population Viability Analysis
RECLAMATION	U.S. Bureau of Reclamation
RM	River Mile
RM&E	Research, Monitoring, & Evaluation
RMU inflow	River Mill Unregulated Inflow
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measures
R/S	Average returns per spawner
RSW	Removable Spillway Weir
SAR	Smolt-to-Adult Return Rate
SR	Snake River
SRB	Snake River Basin
SS/D	Spatial structure and diversity
TDG	Total Dissolved Gas
TRT	Technical Recovery Team
UCR	Upper Columbia River
USFWS	U.S. Fish and Wildlife Services
USGS	U.S. Geologic Survey
UWR	Upper Willamette River
VSP	Viable Salmon Population
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
W/LC	Willamette/Lower Columbia
WLCTRT	Willamette/Lower Columbia Technical Recovery Team

1. INTRODUCTION

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

1.1 Background

This is an Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.) biological opinion and Magnuson-Stevens Fishery Conservation and Management Act (MSA) consultation by the National Marine Fisheries Service (NMFS) for the U.S. Bureau of Reclamation's (Reclamation) proposed action titled: Odessa Subarea Modified Partial Groundwater Replacement Project.

NMFS prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with Section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with MSA Section 305(b)(2) of the (16 U.S.C. 1801, et seq.) and implementing regulations at 50 CFR 600.

The opinion, ITS, and EFH conservation recommendations are each in compliance with the Data Quality Act (DQA) (44 U.S.C. 3504(d)(1) et seq.) and they underwent pre-dissemination review.

1.2 Consultation History

This biological opinion and MSA consultation is based on information provided in Reclamation's November 6, 2012 biological assessment (Reclamation 2012) and the August 2012 environmental impact statement (Reclamation and WDOE 2012) and other sources. A complete record of this consultation is on file at NMFS' Portland Regional Office.

Since 2006, Reclamation and its contractors, three Columbia Basin Project irrigation districts, the East Columbia, South Columbia, and Quincy irrigation districts, plus the Washington Department of Ecology's Office of Columbia River, have been working to develop a plan for replacing groundwater-sourced irrigation in the Odessa subarea with surface water from the Columbia River. NMFS worked with the project proponents to identify alternatives designed to avoid or minimize potential adverse effects on ESA-listed salmonids. The proposed action considered in this opinion is the culmination of those efforts. A primary objective for NMFS during this process was avoiding any diminution of Columbia River flow during the juvenile outmigration season (April through August), which corresponds with the irrigation season. Reclamation modified its preferred alternative in the FEIS (Reclamation and WDOE 2012) to avoid withdrawing water during the juvenile migration season (Reclamation 2012). This opinion evaluates the proposed action as presented in Reclamation's biological assessment (Reclamation 2012). While the project proponents include local irrigation districts and agencies of the State of Washington, Reclamation owns and operates Grand Coulee Dam and the Keys Pumping Plant, the water supply for the project, and is the Federal action agency with which NMFS is consulting.

NMFS and Reclamation most recently consulted on the continued operation and maintenance of the Columbia Basin Project (CBP) as part of the 2008/2010 FCRPS consultation (NMFS 2008a, 2010a) and concluded that the CBP, as part of the FCRPS action under that BiOp's Reasonable and Prudent Alternative (RPA), was not likely to jeopardize any affected listed species or adversely modify any designated critical habitat. The CBP annually diverts an average of about 2.7 Maf from the Columbia River at the Keys Pumping Plant, a part of Grand Coulee Dam on Lake Roosevelt. The proposed action for this consultation would increase the total annual diversions of the CBP by 164 kaf. Existing water rights for the CBP would be used to serve new surface water customers in the Odessa subarea whose source is now groundwater. All users that would be served by the proposed action are within the existing CBP boundaries.

In the 2008 FCRPS BiOp we recognized that the state of Washington was interested in increasing diversions at Lake Roosevelt to alleviate groundwater problems and informed Reclamation that such project expansion would require further ESA consultation. (NMFS 2008a). This opinion is the culmination of that consultation.

This is the first opinion considering the Odessa Subarea Partial Groundwater Replacement Project. However, RPA Article 31 of the 2000 FCRPS Biological Opinion (NMFS 2000a), required Reclamation to evaluate drafting Banks Lake an additional 5 feet (about 133,600 acre-feet) in July-and August to benefit outmigrating fall Chinook salmon. Reclamation evaluated the proposal in an Environmental Impact Statement and concluded in a Record of Decision that the estimated 1-2% increase in the frequency NMFS' summer flow objective at McNary Dam would be met and the associated benefits to ESA-listed salmon and steelhead were not sufficient to outweigh the adverse impacts of the drawdown to other resources (Reclamation 2004a, Reclamation 2004b). The subsequent RPAs for the 2008/2010 FCRPS Biological Opinions (NMFS 2008a, 2010a) did not include an action further considering water releases from Banks Lake as originally contemplated in the RPA for the 2000 FCRPS BiOp and evaluated by Reclamation's 2004 Record of Decision (Reclamation 2004b).

Also relevant to this consultation are NMFS's previous biological opinions concerning water withdrawals from the mainstem Columbia River that implement a "zero net impact" approach during the juvenile migration season (April through August). See, for example, the biological opinion for the Inland Lands permit (NMFS 1997a). These opinions differ from this proposed action because they evaluated water withdrawals from the mainstem Columbia River during the juvenile salmon outmigration.

The Bureau provided its Biological Assessment for the Odessa Project on November 6, 2012 (Reclamation 2012). The BA fully described the project, its effects and the Bureau's determination that the project was not likely to adversely affect all species except for Columbia River chum Salmon.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

Reclamation proposes to replace groundwater currently used for irrigating lands within the boundaries of the CBP with surface water from the Columbia River by constructing or modifying distribution systems and appurtenant structures and increasing total water diversions from Lake Roosevelt and thus the Columbia River. The Odessa Subarea Special Study and the associated FEIS evaluated several groundwater replacement alternatives (Reclamation and WDOE 2012). Of those alternatives, the Modified Partial Replacement Alternative, Alternative 4A in the FEIS, was the preferred alternative. As described above, Reclamation modified Alternative 4A in its proposed action to avoid or minimize impacts to ESA-listed species (Reclamation 2012). This proposed action would supply surface water to 70,000 acres of existing farmland currently irrigated with groundwater. Reclamation is not proposing to expand irrigated acreage but may move irrigated acreage closer to new laterals for greater efficiency. Where lands currently irrigated with groundwater would be served by new surface water supplies, the state of Washington would issue superseding water rights for surface water and wells would be placed in standby status. Figure 1 shows the existing facilities of the CBP, proposed new facilities, the locations of existing groundwater irrigated lands, and possible relocation of irrigated lands.

Water levels in the aquifer underlying the Odessa Subarea have declined significantly since substantial pumping began in the 1960s, requiring irrigators to pump from increasing depths (wells up to 2,000 feet deep). In addition, deep-water aquifer pumping has also reduced water quality in the aquifer. The State of Washington identified the declining Odessa Subarea aquifer as one of the highest priority issues in the Columbia River basin. U.S. Geological Survey (USGS) groundwater studies have concluded that the Columbia Plateau Regional Aquifer system is currently being pumped at an unsustainable level. The proposed action is intended to reduce reliance on groundwater and provide greater water security to irrigated lands within the CBP. At full build-out, about 70,000 acres of CBP land currently irrigated with groundwater would be converted to surface water irrigation.

The average additional volume of surface water needed to replace groundwater supplied to 70,000 acres in the Odessa subarea would be 164,000 acre-feet per year; although it would take at least the full 10-year build-out period for the conveyance systems to be in place so that annual quantity to be fully used (Reclamation 2012). Reclamation has designed the proposed action to minimize impacts on its ability to operate Grand Coulee Dam and Lake Roosevelt consistent with RPA in NMFS biological opinion for the operation and maintenance of the FCRPS (NMFS 2008a). Under the proposed action, Banks Lake would refill between October and March, with most pumping occurring in October and limited pumping from November through March.

It is anticipated that the project would be developed in phases and full build-out is unlikely for 10 years or more. However, this opinion makes the conservative assumption that the project would be immediately complete and its effects continuous.

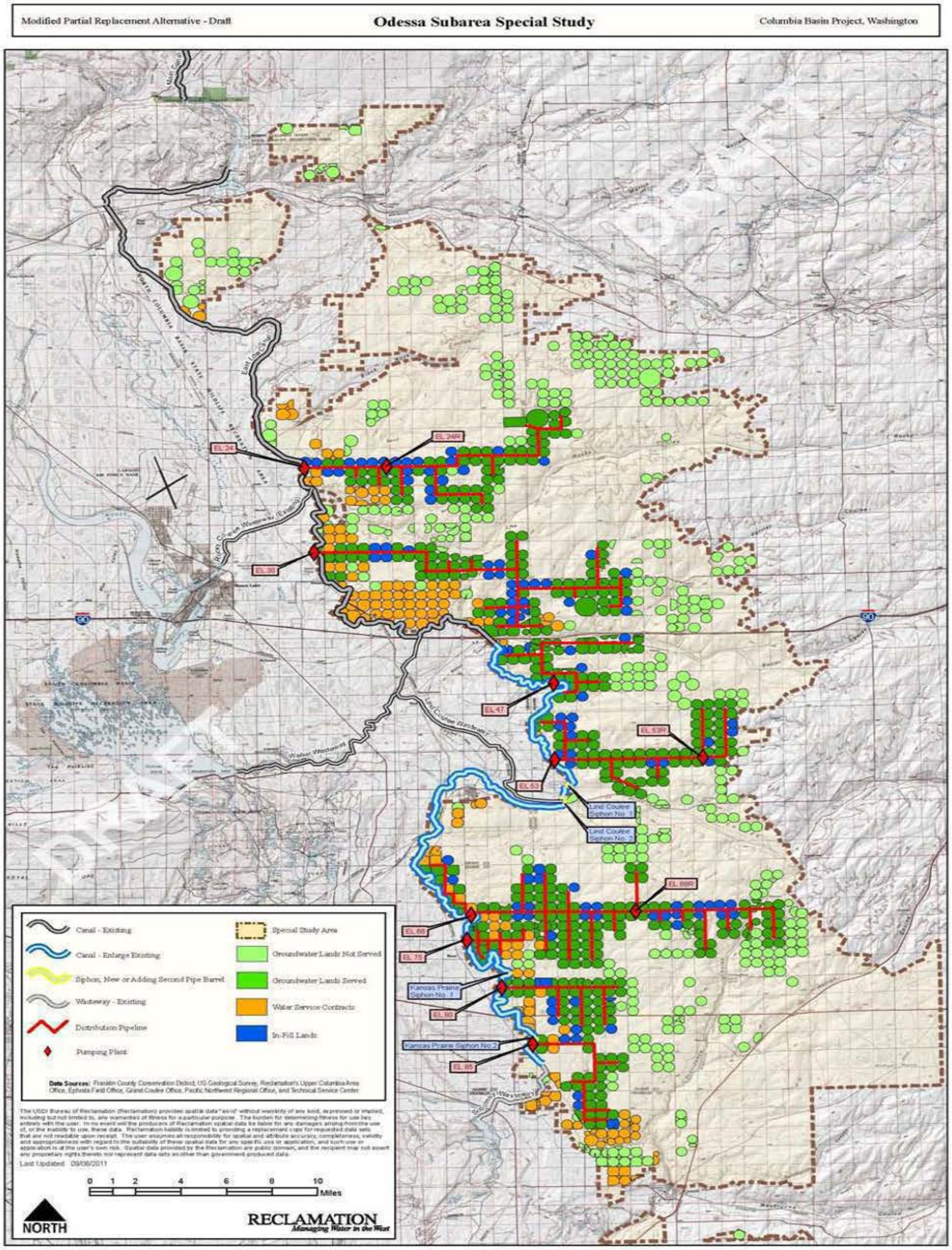


Figure 1. Existing irrigation works of the Columbia Basin Project within the Odessa subarea and proposed changes to the system.
Source: Reclamation 2012a**.**

1.3.1 Diversions from the Columbia River

On average, an additional 164,000 acre-feet of water would be diverted from the Columbia River at Grand Coulee Dam to refill Banks Lake at the end of, and after, the irrigation season. Lake Roosevelt storage would not be used but would be affected for a short time initially when the pumps are turned on and the outflows from Grand Coulee Dam are adjusted for the increased pumping to Banks Lake.

Reclamation would pump additional water from the Columbia River using the existing Keys Pump-Generating Plant. The facility consists of six individual pumps and six pump-generators with a combined capacity of about 22,000 cfs. Keys Pump-Generating Plant pumps water from Lake Roosevelt into the Feeder Canal, which has a capacity of about 16,000 cfs, then into Banks Lake for delivery to the CBP. Pumping to Banks Lake for the CBP under current operations takes place during the irrigation season in March through October. Routine facility maintenance typically occurs at the end of the irrigation season; however, operations for maintenance have occurred concurrently with irrigation operations during some years.

Additional pumping to supply water to the Odessa Subarea would occur primarily in October. Although the pump and canal delivery system has a capacity of about 16,000 cfs (Feeder Canal capacity), immediate impacts to the Columbia River downstream from Grand Coulee Dam depend on dam operations which are independent of Keys Pump-Generating Plant operations.

Additional diversion from Lake Roosevelt to refill Banks Lake would follow a set of operational parameters that would constrain the timing and total volume of water withdrawn from the Columbia River. All parameters are expressed as increases in total monthly acre-feet pumped from the Columbia River under the proposed action. These parameters are as follows:

- **Fall Diversion.** Average additional diversions of 164,000 acre-feet during October. Hydrologic modeling shows that the full diversion could be taken in October in 70 of the 70 years modeled**.** However, the full diversion in October might not occur every year because of mechanical issues or operational limitations or needs.
- **Winter Diversions.** If the full 164,000 acre-foot replacement of storage is not satisfied by November 1, additional diversions of up to 21,000 acre-feet per month (at a monthly average rate of 350 cfs) could occur from November through March if chum salmon flow targets are met below Bonneville Dam. When chum salmon flow targets would not be met, Reclamation would limit additional diversions to 6,000 acre-feet per month during November through March (at a monthly average rate of 100 cfs). When diversions are proposed for the November-through-March period, Reclamation would coordinate any anticipated diversion during this period with NMFS before implementing those operations. Winter diversions are anticipated to occur very infrequently (between 1-2 percent of years) under the Proposed Action, if at all.
- **Spring/Summer.** No additional diversions would occur from April through September

The proposed action primarily relies on October diversions from the Columbia River when the anticipated effects on ESA-listed salmon would be smallest. October is the end of the irrigation season for the CBP and demand decreases. Typically, there would be sufficient pump capacity to pump an additional 164,000 acre-feet of water to Banks Lake. November through March FCRPS management objectives protect chum salmon spawning habitat in the Columbia River, downstream from Bonneville Dam, at river-mile (RM) 143. The operational parameters are intended to minimize the likelihood of dewatering chum salmon spawning and incubation habitat during November through March.

To estimate the likely effects of the proposed action on Columbia River flows, Reclamation used the HYDSIM model (Mellema 2012) over a 70-year period (water years 1929 – 1998) with and without the proposed action. To illustrate those effects, Reclamation selected 4 years from that analysis to represent wet, average, dry and drought years (Table 1). Table 1 summarizes monthly changes in flow conditions for the proposed action relative to current conditions for representative wet (1982), average (1995), dry (1988), and drought (1931) years.

To illustrate the full range of potential additional diversions that could occur, Reclamation also modeled the 70-year maximum change in monthly Columbia River flows from 1929 and 1998 (Table 2).

Table 1 Modeled decrease in average monthly flow from Grand Coulee Dam under the proposed action for wet, average, dry, and drought water years. Source: Reclamation 2012.

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Water Year 1982 (Wet Year)	-2660	0	0	0	0	0	0	0	0	0	0	0
Water Year 1995 (Average Year)	-2662	0	0	0	0	0	0	0	0	0	0	0
Water Year 1988 (Dry Year)	-2666	0	0	0	0	0	0	0	0	0	0	0
Water Year 1931 (Drought	-2620	0	0	0	0	0	0	0	0	0	0	0

Year)												

Table 2 Columbia River flow reductions under Reclamation's proposed action based on an analysis of the maximum monthly diversion changes and their frequency of occurrence resulting from the proposed action modeled over a 70-year period between 1929 and 1998.

Source: Reclamation 2012

	Oct	Nov [1]	Dec [1]	Jan [1]	Feb [1]	Mar [1]	Apr	May	Jun	Jul	Aug	Sep
Max Change in Monthly Average Outflow from Grand Coulee Dam (cfs)	**-2,700**	**-350/-100**	**-350/-100**	**-350/-100**	**-350/-100**	**-350/-100**	**0**	**0**	**0**	**0**	**0**	**0**
Frequency of Occurrence in period of record	**70 of 70 years**	**0 of 70 years**	**0 of 70 years**	**0 of 70 years**	**0 of 70 years**	**0 of 70 years**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

[1] 350 cfs average diversion to meet the 21,000 acre-feet per month diversion amount during Nov.-March in years when Banks Lake cannot be refilled with October diversions alone: (diversions restricted to 100 cfs average, or 6,000 acre-feet per month, when chum salmon elevation target below Bonneville Dam is not being met).

Based on these modeling results, implementing the proposed action would reduce flow in the Columbia River downstream from Grand Coulee Dam each October by an average of about 2,700 cfs. Actual instantaneous pumping rates would vary.

As illustrated in Table 2, throughout the historical record there has never been a year in which sufficient flow was not available to capture an average of 2,700 cfs throughout October. Reclamation determined that when combined with current rates of diversion, ample pump capacity would be available to refill Banks Lake during October each year under the proposed action. The total October pumping demand for existing operations combined with the increased pumping requirements under the proposed action is about 320,000 acre-feet. This value is within the existing range of irrigation season operations for the Keys Pump-Generating Plant (up to 430,000 acre-feet per month). Increased October operations would likely shift some routine maintenance activities from October into November but should not impact long term operational capabilities of the facility.

In rare instances, there may be a need to divert additional water from the Columbia River from November through March in the event that the full 164,000 acre-feet cannot be diverted in October for an unforeseen reason (e.g., multiple pump failures, a condition, which is possible, but not previously observed). In these cases, as long as the FCRPS Opinion operating objectives for chum salmon below Bonneville Dam would be satisfied, Reclamation would divert an additional 21,000 acre feet per month until 164,000 acre-feet, on average, were moved to Banks Lake. November through March monthly average Columbia River flow would be reduced by up to 350 cfs. In the case where operating objectives for chum salmon would not be satisfied, Reclamation would limit the diversions to 6,000 acre-feet per month, an average monthly reduction in Columbia River flow of 100 cfs.

1.3.1.1 Other Water Storage and Conveyance Operations

The proposed action would not alter the operation of any water storage and conveyance routes in the CBP or their effects on water bodies located downstream of the Odessa Subarea, including Moses Lake, Potholes Reservoir, and both upper and lower Crab Creek.

1.3.2 Water Accounting and Monitoring

As a part of its routine operations, Reclamation measures the water delivered for irrigation purposes as required by the existing contracts between the East, South and Quincy–Columbia Basin Irrigation districts. Irrigation water is diverted at mile 0.2 of the main canal and the cost distributed to the appropriate district. Data from the monitoring and accounting protocol is necessary for assessment of repayment obligations for lands served by Reclamation facilities. Water deliveries to additional lands under the proposed action would be monitored and accounted for using the same methods.

1.3.3 Environmental Commitments

Reclamation, Washington Department of Ecology (WDOE), and Washington Department of Fish and Wildlife (WDFW) have entered into a Memorandum of Understanding (WDOE 2004) that will facilitate coordination and communication concerning these mitigation measures and environmental commitments. This agreement is aimed at protecting terrestrial and off-channel aquatic resources. NMFS has reviewed these commitments and concludes that they would not affect any of the species or habitats within NMFS jurisdiction under the ESA. For this reason, these commitments are not considered further in this opinion.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for this consultation is comprised of the Odessa Subarea, depicted on the map on page 7, drainage pathways from irrigated lands, the mainstem Columbia River above Chief Joseph Dam including Lake Roosevelt, as well as the following areas within the range of the listed species: as the mainstem Columbia River from Chief Joseph Dam downstream to its confluence with the Pacific Ocean, including the Columbia River estuary and plume. Within the action area, anadromous salmonid Evolutionarily Significant Unit/Distinct Population Segments (ESU/DPSs) designated within the Upper Columbia, Middle Columbia, and Snake River basins use portions of this action area during one or more life stage. NMFS has also designated critical habitat within the lower Columbia River below Bonneville Dam for several species of Pacific salmonids, the eulachon, and green sturgeon. Although Southern Resident Killer Whales (Southern Residents; Orcinus orca) are not found in the action area, Reclamation has determined that they may be affected if effects within the action area reduced the abundance of Chinook salmon, a preferred prey (Reclamation 2012). The area of analysis addressed in this opinion therefore includes all areas on the mainstem Columbia River that would be hydrologically influenced by the proposed action and are either inhabited by the species considered in this consultation (or produce species relied upon for prey) or have designated critical habitat within that area.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitats upon which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service (USFWS), NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions would affect listed species and their critical habitat. If incidental take is expected, Section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures(RPM) to minimize such impacts.

2.1 Approach to the Analysis

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts on the conservation value of designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02).

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[1]

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action (Section 2.2).
- Describe the environmental baseline in the action area (Section 2.3).
- Analyze the effects of the proposed action on both species and their habitat (Section 2.4).
- Describe any cumulative effects in the action area (Section 2.5).
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat (Section 2.6).
- Reach jeopardy and adverse modification conclusions (Section 2.7).

[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

    - If necessary, define a reasonable and prudent alternative to the proposed action.
- Identify and estimate the range of likely incidental take under the proposed action and identify RPM to further reduce incidental take (Section 2.9).

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be affected by the proposed action. The status is the level of risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

One factor affecting the status of salmonid fishes, and aquatic habitat at large is climate change. We discuss the anticipated effects of climate change in Section 2.3, Environmental Baseline.

2.2.1 Status of Listed Species

NMFS, in consultation with Reclamation, identified 16 species listed under the ESA likely to be affected by the proposed action (Table 3). The following summarizes the status of these species, and their designated critical habitats, that could be affected by the proposed action and are considered in this opinion. More detailed information on the status and trends of these listed resources, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register and NMFS' status reviews.

Table 3 Federal Register notices for final rules that list threatened and endangered species and designated critical habitats for species considered in this consultation.

Species/DPS	Listing Status	Critical Habitat
CHINOOK SALMON (*Oncorhynchus tshawytscha*)		
Upper Columbia River spring run	Endangered; NMFS 2011a	NMFS 2005a
Snake River spring/summer run	Threatened; NMFS 2011a	NMFS 1999a
Snake River fall run	Threatened; NMFS 2011a	NMFS 1993
Lower Columbia River	Threatened; NMFS 2011a	NMFS 2005a
Upper Willamette River	Threatened; NMFS 2011a	NMFS 2005a
COHO SALMON (*O. kisutch*)		
Lower Columbia River	Threatened; NMFS 2011a	Under development

Species/DPS	Listing Status	Critical Habitat
STEELHEAD (*O. mykiss*)		
Upper Columbia River	Threatened; NMFS 2011a	NMFS 2005a
Snake River	Threatened; NMFS 2011a	NMFS 2005a
Middle Columbia River	Threatened; NMFS 2011a	NMFS 2005a
Lower Columbia River	Threatened; NMFS 2011a	NMFS 2005a
Upper Willamette River	Threatened; NMFS 2011a	NMFS 2005a
SOCKEYE SALMON (*O. nerka*)		
Snake River	Endangered; NMFS 2011a	NMFS 1993a
CHUM SALMON (*O. keta*)		
Columbia River	Threatened; NMFS 2011a	NMFS 2005a
GREEN STURGEON (*Acipenser mediorostris*)		
Southern DPS	Threatened; NMFS 2006a	NMFSc2009b
EULACHON (*Thaleichthys pacificus*)		
Eulachon	Threatened; NMFS 2009b	NMFS 2011b
KILLER WHALE (*Orcinus orca*)		
Southern Resident	Endangered; NMFS 2011c	NMFS 2006b

For Pacific salmon and steelhead and eulachon NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany *et al.* 2000). These Viable Salmon Population ("VSP") criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

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

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

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

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

For species with multiple populations, once the biological status of a species’ populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany *et al.* 2000).

The status of species sections below are organized under two recovery domains: the Interior Columbia Recovery Domain and the Willamette/Lower Columbia Recovery Domain (Table 4) to better integrate recovery-planning information that NMFS is developing on the conservation status of the species and designated critical habitats considered in this opinion. Recovery domains are the geographically based areas that NMFS uses to prepare multi-species recovery plans.

For each recovery domain, a technical review team (TRT), appointed by NMFS, has developed, or is developing, criteria necessary to identify independent populations within each species, recommended viability criteria for those species, and descriptions of factors that limit species survival. Viability criteria are prescriptions of the biological conditions for populations, biogeographic strata, and ESUs that, if met, would indicate that the ESU will have a negligible risk of extinction over a 100-year time frame.

Table 4. ESA-listed salmon and steelhead considered in this opinion and their respective recovery planning domains

Recovery Domain	Species
Interior Columbia (IC)	UCR spring Chinook salmon UCR Steelhead SR spring/summer Chinook salmon SR fall Chinook salmon SR sockeye SR Steelhead MCR Steelhead
Willamette/Lower Columbia (LC)	LCR Chinook salmon CR chum salmon LCR coho salmon LCR Steelhead UWR Chinook salmon UWR Steelhead

Although the TRTs operated from the common set of biological principals described in McElhany *et al.* (2000), they worked semi-independently from each other and developed criteria suitable to the species and conditions found in their specific recovery domains. All of the criteria have qualitative as well as quantitative aspects. The diversity of salmonid species and populations makes it impossible to set narrow quantitative guidelines that will fit all populations in all situations. For this and other reasons, viability criteria vary among salmonid species, mainly in the number and type of metrics and the scales at which the metrics apply (*i.e.*, population, major population group (MPG), or ESU) (Busch *et al.* 2008).

Overall viability scores (high to low risk of extinction) are based on combined ratings for the abundance and productivity (A/P) and spatial structure and diversity[2] (SS/D) metrics. The A/P score considers the TRT's estimate of a populations' minimum threshold size, current abundance, proportion of natural-origin spawners, and its productivity. The four metrics (abundance, productivity, spatial structure, and diversity) are not independent of one another and their relationship to sustainability depends on a variety of interdependent ecological processes (Wainwright *et al.* 2008).

The size and distribution of the populations considered in this opinion generally have declined over the last few decades due to natural phenomena and human activity, including climate change (as described in Section 2.3.3), the operation of hydropower systems, over-harvest, effects of hatcheries, and habitat degradation. Enlarged populations of terns, seals, California sea lions, and other aquatic predators in the Pacific Northwest may be limiting the productivity of some Pacific salmon and steelhead populations (Ford *et al.* 2011).

2.2.1.1 Salmonids in the Interior Columbia (IC) Recovery Domain

Species considered in this opinion in the IC Recovery Domain include Upper Columbia River (UCR) spring Chinook salmon, UCR steelhead, Snake River (SR) spring/summer Chinook, SR fall Chinook, SR sockeye salmon, SR steelhead, and Middle Columbia River (MCR) steelhead.

Upper Columbia River spring Chinook salmon
On March 24, 1999, NMFS listed UCR spring-run Chinook salmon as an endangered species (NMFS 1999a) and their endangered status was affirmed on June 28, 2005 (NMFS 2005a). NMFS issued a five-year review on August 15, 2011 (NMFS 2011a), and concluded that this species should remain listed as endangered.

This ESU includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River (Figure 2). The ESU also includes six artificial propagation programs: the Twisp River, Chewuch River, Methow Composite, Winthrop NFH, Chiwawa River, and White River spring-run Chinook salmon hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural populations than what would be expected between closely related natural populations within the ESU (NMFS 2005b). The spring-run Chinook

[2] The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) provided ratings for diversity and spatial structure risks. The Interior Columbia Technical Review Team (IC-TRT) provided spatial structure and diversity ratings combined as an integrated SS/D risk.

salmon hatchery program at the Entiat National Fish Hatchery was determined to be a threat to the ESU and was discontinued in 2007.

For recovery planning and development of recovery criteria, the ICTRT identified independent populations within the UCR spring-run Chinook salmon ESU and grouped them into genetically similar Major Population Groups (MPGs) (ICTRT 2003). Within the UCR spring-run Chinook salmon ESU, there are four independent populations (three extant and one extinct) that all belong to one MPG (Eastern Cascades). A historical population in the Okanogan River has been extirpated (ICTRT 2005).

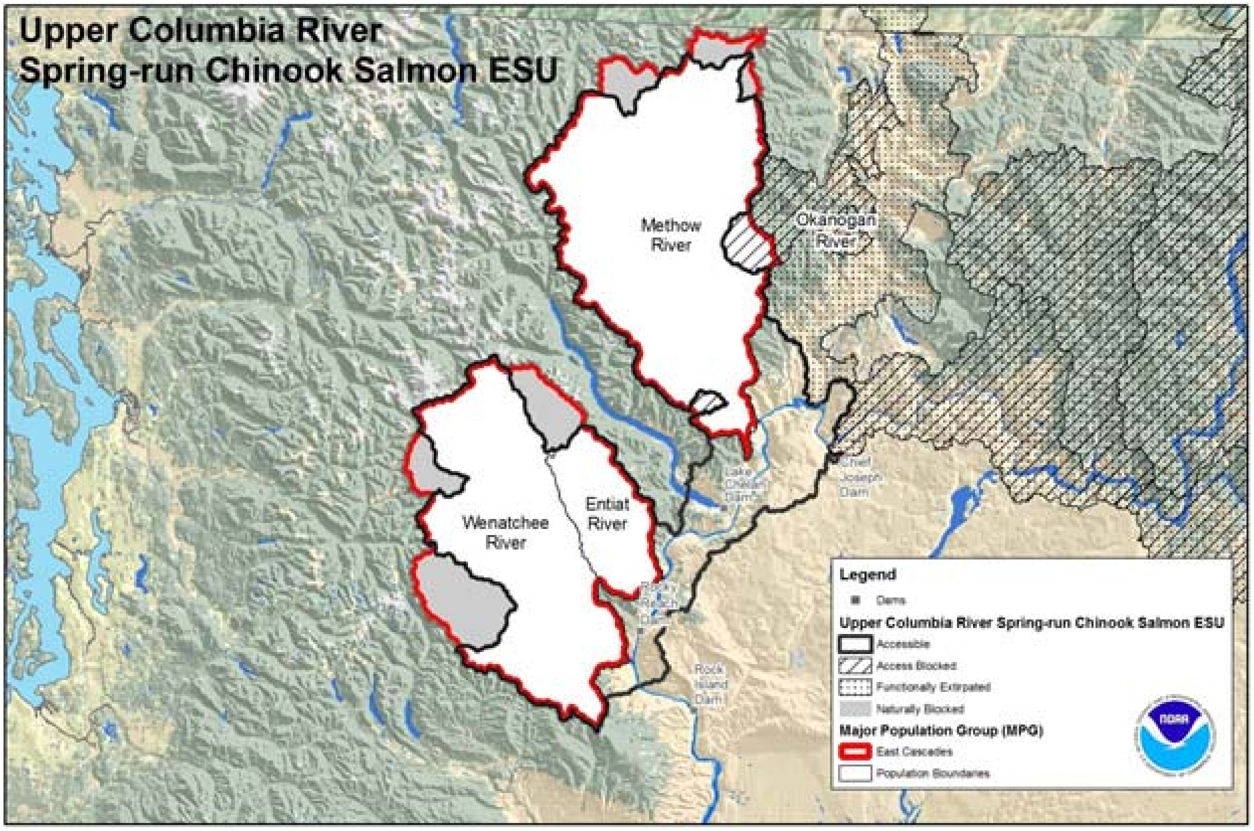


Figure 2 UCR spring-run Chinook salmon ESU population structure.

Life History. Spring-run Chinook salmon in this ESU have a stream-type life history, which means that juveniles enter marine waters during their second year and return to fresh water as preadults, maturing during their upriver spawning run. Three independent populations of spring-run Chinook salmon are identified for the ESU: those that spawn in the Wenatchee, Entiat, and Methow River basins. Most of these fish return to the Columbia River from March through mid-May. Adults returning to the Wenatchee River enter fresh water from late March through early May, those returning to the Entiat and Methow Rivers enter fresh water from late March through June. Their arrival times in the spawning tributaries tend to be earlier in low flow years and later in high flow years. On their way up the tributaries, the fish hold in deeper pools or under cover until the onset of spawning. They may spawn in the areas where they hold, or move further up into smaller streams. Peak spawning for all three populations occurs from August to September, though the timing varies with water temperature. Most adults return after spending two years in the ocean, although 20 to 40 % return after three years at sea.

The egg incubation/alevin stage goes from August into December and emergence dates extend from that point into March. The juveniles typically enter the mainstem Columbia and begin migrating downstream in May and June.

Spatial Structure and Diversity. The ICTRT characterizes the spatial structure risk to UCR spring-run Chinook salmon populations as “low” for the Wenatchee and Methow rivers and “moderate” for the Entiat River.

The ICTRT characterizes the diversity risk to all UCR spring-run Chinook salmon three extant populations as “high.” The high risk is a result of reduced genetic diversity from homogenization of populations that occurred under the Grand Coulee Fish Maintenance Project between 1939 and 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.

Abundance and Productivity. As of NMFS’ most recent biological review (Ford ed. 2011), the 10-year geometric mean (1997 to 2003) spawner abundance was 222 for the Wenatchee population, 59 for the Entiat population, and 180 for the Methow population. These numbers equaled 9 % to 12 % of the minimum abundance thresholds for recovery (2,000 spawners each in the Wenatchee and Methow river basins and 500 in the Entiat River basin. In 2007, NMFS issued a final recovery plan for the UCR spring run Chinook salmon ESU which adopted the ICTRT’s (2007) viability goals as biological delisting criteria (72 FR 57303). These recovery goals represent the numbers that, taken together, may be needed for the population to be self-sustaining, or recovered, in its natural ecosystem.

The short-term indices of population growth rate depict an upward trend in natural-origin returns since 1995 at a higher average rate than during the period leading up to the previous ESA status review (Ford ed. 2011). However, estimated population growth rates, assuming that hatchery-origin spawners and natural-origin spawners are contributing to natural production at the same rate, are below replacement for all three populations in this ESU

Overall, the viability of the Upper Columbia Spring Chinook salmon ESU has likely improved somewhat since the time of the last Biological Review Team (BRT) status review, but the ESU is still clearly at moderate-to-high risk of extinction (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats to the UCR spring-run Chinook salmon ESU include (UCSRB 2007, NMFS 2011a):

- Mainstem Columbia River hydropower–related adverse effects: upstream and downstream fish passage, ecosystem structure and function, flows, and water quality.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
- Degraded estuarine and nearshore marine habitat
- Hatchery related effects: including past introductions and persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species
- Harvest in Columbia River fisheries

Upper Columbia River steelhead

The UCR steelhead DPS was listed as endangered on August 18, 1997 (NMFS 1997b). Its status was upgraded to threatened on January 5, 2006 (NMFS 2006a) and then returned to endangered status per U.S. District Court decision in June 2007. On June 18, 2009, the district court revised its ruling, effectively re-instating UCR steelhead to threatened status under the ESA. NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), and concluded that this species should remain listed as threatened.

This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams in the Columbia River basin upstream from the Yakima River, Washington, to the U.S.Canada border (Figure 3) (NMFS 1997b). Six artificial propagation programs are considered part of the DPS: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop National Fish Hatchery (NFH), Omak Creek, and the Ringold steelhead hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural populations than what would be expected between closely related natural populations within the DPS (NMFS 2006a).

There are four independent populations within this DPS: the Wenatchee River, Entiat River, Methow River, and Okanogan Basin of a single MPG. NMFS determined that the Crab Creek anadromous component is functionally extirpated (ICTRT 2007).

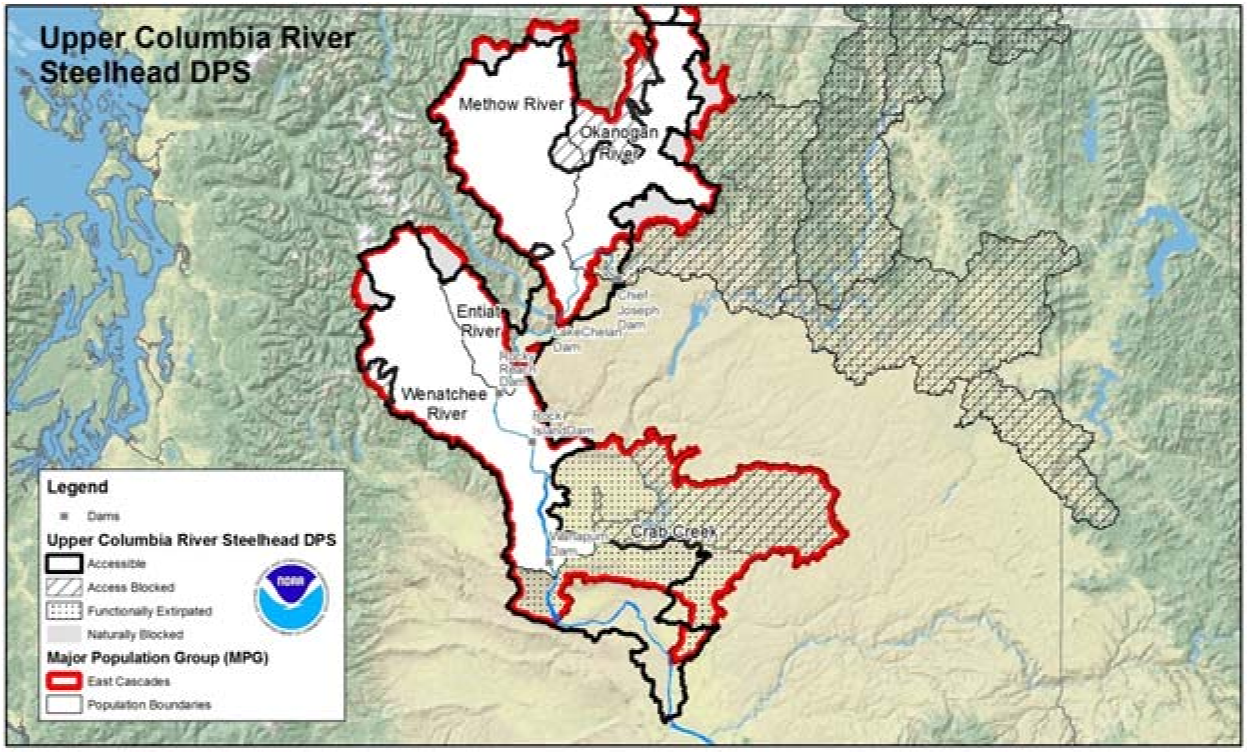


Figure 3. UCR steelhead DPS population structure

Life History. Life history characteristics for UCR steelhead are similar to those of other inland steelhead DPSs. Unlike Pacific salmon, steelhead are capable of spawning more than once. After spawning, spent steelhead, known as kelts, attempt to migrate back to the ocean and those that survive will return to freshwater to spawn again. However, it is rare for steelhead to spawn more than twice and most that do so are females. Steelhead can be divided into two basic run types based on their level of sexual maturity at the time they enter fresh water and the duration of the spawning migration. The stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in fresh water to mature. The ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns relatively shortly after river entry. Fish in the UCR steelhead DPS are made up entirely of summer steelhead.

Upper Columbia River steelhead spawn in cool, clear streams with suitable gravel size, depth, and current velocity. Adults enter fresh water between May and October. They migrate inland toward spawning areas, overwinter in the larger rivers, and resume migrating to natal streams in early spring before spawning. In general, adults in this DPS spawn later than in most downstream (mid- and lower-Columbia River) summer steelhead populations—often remaining in fresh water for a year before spawning. After spawning, some adults may migrate back to the ocean, and return to spawn again. These fish are referred to as kelts.

Depending on water temperature, steelhead eggs may incubate for 1.5 to four months before hatching. Rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Some older juveniles move downstream to rear in larger

tributaries and mainstem rivers. Productive juvenile steelhead habitat is characterized by complexity—primarily in the form of large and small wood.
Most current natural production occurs in the Wenatchee and Methow River systems, with a smaller run returning to the Entiat River. Very limited spawning also occurs in the Okanagan River basin. Most of the fish spawning in natural production areas are of hatchery origin. The limited data available show that most juveniles begin to smolt and emigrate to the ocean after 2 years in freshwater. It also appears that most steelhead from the Wenatchee and Entiat Rivers return to fresh water after one year in salt water, whereas Methow River steelhead primarily return after two years of ocean residence.

Spatial Structure and Diversity. 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. The ICTRT considers the spatial-structure risk to be high for the Okanogan population because only the lower of two major spawning areas in the United States is occupied.

The ICTRT has characterized the diversity risk to all UCR steelhead populations as "high." 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 to 1943, and then again from 1960 to 1981. In addition, the Methow and Okanogan populations have particularly high proportions of hatchery-origin spawners, and recent monitoring confirms that hatchery fish are straying into non-target areas, likely contributing to the continued homogenization of the populations.

*Abundance and Productivity***.** As of NMFS' most recent biological review (Ford ed. 2011), average abundances over the most recent 10-year period were below the thresholds that the ICTRT identified as a minimum for low risk of extinction. Geometric mean 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 % improvement (Fisher and Hinrichsen 2006). The recent geometric mean 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.

On average, 1980-1981 through 1999-2000 brood years (start dates vary by population), including adult returns through 2004-2005, UCR steelhead populations had not replaced themselves when only natural production is considered (i.e., average returns per spawner (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 during more brood years (ICTRT 2007).

Hatchery-origin returns continue to constitute a high fraction of total spawners in natural spawning areas for this DPS. Estimates of natural-origin spawner abundance are higher for the most recent five-year cycle. Current patterns in the proportion of natural-origin spawners among populations are similar to that reported in the previous status review. The proportions of natural-origin spawners are highest in the Wenatchee River, and remain at extremely low levels in the Methow and Okanogan Rivers.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. The limiting factors and threats for this DPS include:

- Mainstem Columbia River Hydropower–related adverse effects.
- *Degraded freshwater habitat*: floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Hatchery-related effects.
- Harvest-related effects.

Middle Columbia River steelhead

The MCR steelhead DPS was listed as threatened on March 25, 1999 (NMFS 1999b) and its threatened status was reaffirmed on January 5, 2006 (NMFS 2006c) and again on August 15, 2011 (NMFS 2011a), during subsequent status reviews.

This DPS includes all naturally spawned populations of steelhead in streams from above the Wind River, Washington, and the Hood River, Oregon, upstream to, and including, the Yakima River, Washington, excluding steelhead from the Snake River basin (Figure 4). Seven artificial propagation programs are considered part of the DPS: The Touchet River Endemic, Yakima River Kelt Reconditioning Program (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River, and the Deschutes River steelhead hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural populations than what would be expected between closely related natural populations within the DPS (NMFS 2006a).

Major watersheds within this DPS include the Klickitat, Fifteenmile, Deschutes, John Day, Umatilla, Yakima, and Walla Walla basins. The ICTRT (2007) identified 20 populations in four major population groups (MPGs) (Eastern Cascades, John Day River, the Umatilla/Walla Walla, and the Yakima River). There are three extinct populations, the White Salmon and Crooked River populations in the Eastern Cascades MPG, and the Willow Creek population in the Umatilla Rivers/Walla Walla MPG.

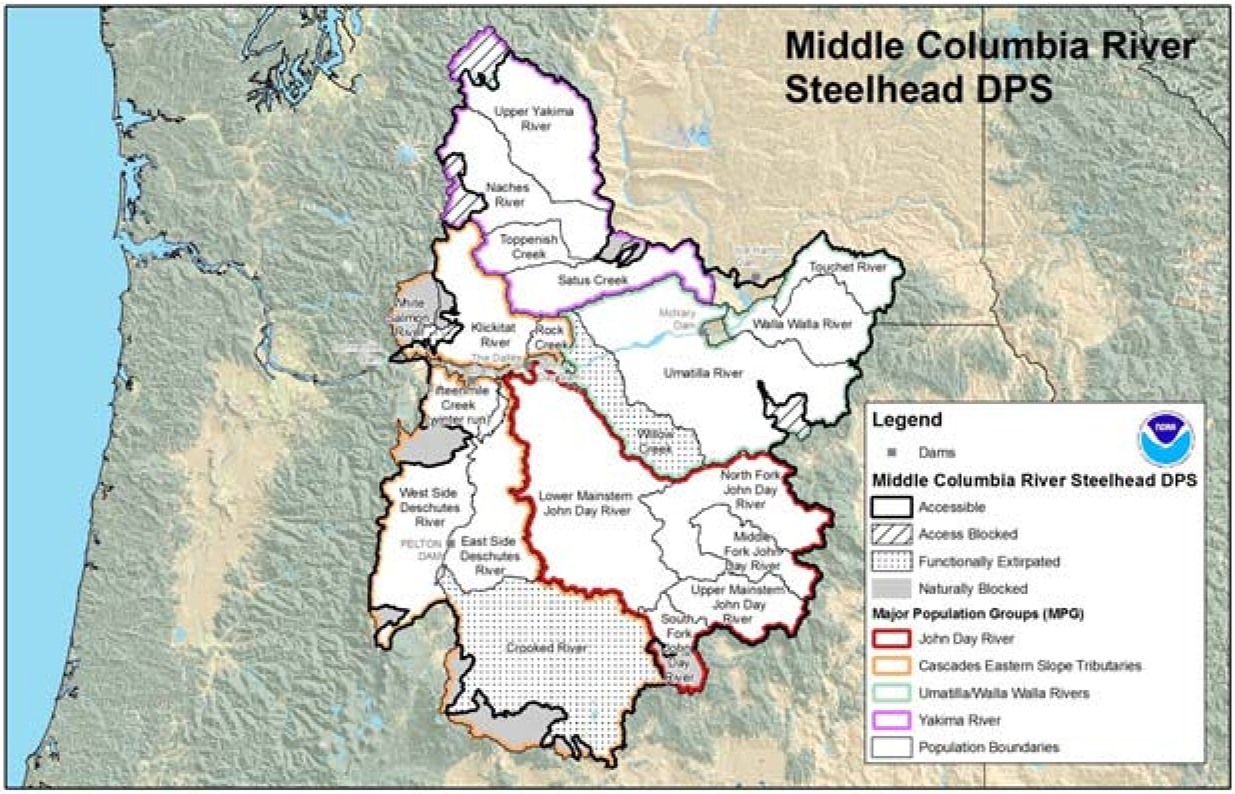


Figure 4. MCR steelhead DPS population structure.

Life History. Life history characteristics for MCR steelhead are similar to those of other inland steelhead DPSs. Fish in the MCR steelhead DPS are predominantly summer steelhead. All steelhead upstream of The Dalles Dam are summer-run (Reisenbichler *et al.* 1992), entering the Columbia River from June to August. However, low numbers of winter-run fish are found in the Klickitat River, Washington, and Fifteenmile Creek, Oregon, populations.

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering fresh water, where they may remain for up to a year before spawning. Age-2-ocean steelhead dominate the summer steelhead run in the Klickitat River, whereas most other rivers with summer steelhead produce about equal numbers of both age-1- and 2-ocean fish. After spawning, some adults may migrate back to the ocean, and return to spawn again. These fish are referred to as kelts.

Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. A nonanadromous form of *O. mykiss* (redband and rainbow trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate. In addition, hatchery steelhead are also distributed within the range of this DPS.

Spatial Structure and Diversity. The ICTRT characterizes the spatial structure risk to MCR steelhead populations as "very low" to "moderate" for all populations except the Upper Yakima. The Upper Yakima population has "high" diversity risk because 7 of 10 historical major spawning areas are not occupied.

The ICTRT characterizes the diversity risk to all but one MCR steelhead population as "low" to "moderate". The Upper Yakima is rated as having "high" diversity risk because of introgression with resident *O. mykiss* and loss of presmolt migration pathways. The ICTRT found moderate risks to the DPS's productivity, spatial structure, and diversity, with the greatest relative risk being attributed to the DPS's abundance.

Abundance and Productivity. NMFS' most recent biological review (Ford ed. 2011) found that the average abundances of three of the 14 populations for which recent abundance has been estimated, are above the abundance thresholds that the ICTRT has identified as a minimum for low risk of extinction. The remaining 11 populations had average abundances below the ICTRT abundance thresholds. Geometric mean abundance since 2001 had substantially increased for the DPS as a whole. Geomean abundance of natural-origin fish from 2001 to 2005 was 17,553 compared to 7,228 for the 1996 to 2000 period, a 143 % improvement (Fisher and Hinrichsen 2006).

Considering only natural production over 20 full brood years, most MCR steelhead populations for which estimates are available had replaced themselves, but a few had not. The ICTRT characterized the 100-year extinction risk as "moderate" for most MCR steelhead populations. One population (North Fork John Day) had a "very low" risk and four populations (Rock Creek, Touchet, Toppenish, and Upper Yakima) had a "high" risk of extinction (Ford ed. 2011).

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

*Limiting Factors and Threats***.** Limiting factors and threats to the Snake River basin steelhead DPS include the following:

- Mainstem Columbia River Hydropower–related adverse effects.
- *Degraded freshwater habitat*: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Impaired water quality and increased water temperature.
- Related harvest effects, particularly for B-run steelhead.
- Predation.
- Genetic diversity effects from out-of-population hatchery releases.

Snake River spring/summer Chinook salmon

NMFS listed Snake River (SR) spring/summer Chinook salmon as threatened, and protective regulations were issued under Section 4(d) of the ESA, on April 22, 1992 (NMFS 1992). Their threatened status was reaffirmed on June 28, 2005 (NMFS 2005a). NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), and concluded that this species should remain listed as threatened.

The ESU includes all naturally spawned populations of SR spring/summer Chinook salmon in the mainstem Snake River, Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins (Figure 5) (NMFS 1992). Fifteen artificial propagation programs are also considered to be part of the ESU, including: the Tucannon River Conventional Hatchery, Tucannon River Captive Broodstock Program, Lostine River, Catherine Creek, Lookingglass Hatchery Reintroduction Program, Upper Grande Ronde, Imnaha River, Big Sheep Creek, McCall Hatchery, Johnson Creek Artificial Propagation Enhancement, Lemhi River Captive Rearing Experiment, Pahsimeroi Hatchery, East Fork Captive Rearing Experiment, West Fork Yankee Fork Captive Rearing Experiment, and the Sawtooth Hatchery spring/summer-run Chinook hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural populations than what would be expected between closely related natural populations within the ESU (NMFS 2005b).

For the purposes of recovery planning and development of recovery criteria, the ICTRT identified independent populations for each SR ESA-listed species, and grouped them together into MPGs (ICTRT 2003). The SR spring/summer Chinook salmon ESU is comprised of 28 extant populations in five MPGs: Lower Snake River, Grande Ronde/Imnaha, South Fork Salmon River, Middle Fork Salmon River, and the Upper Salmon River (Figure 5). Historical populations upstream of Hells Canyon Dam are extinct (ICTRT 2005).

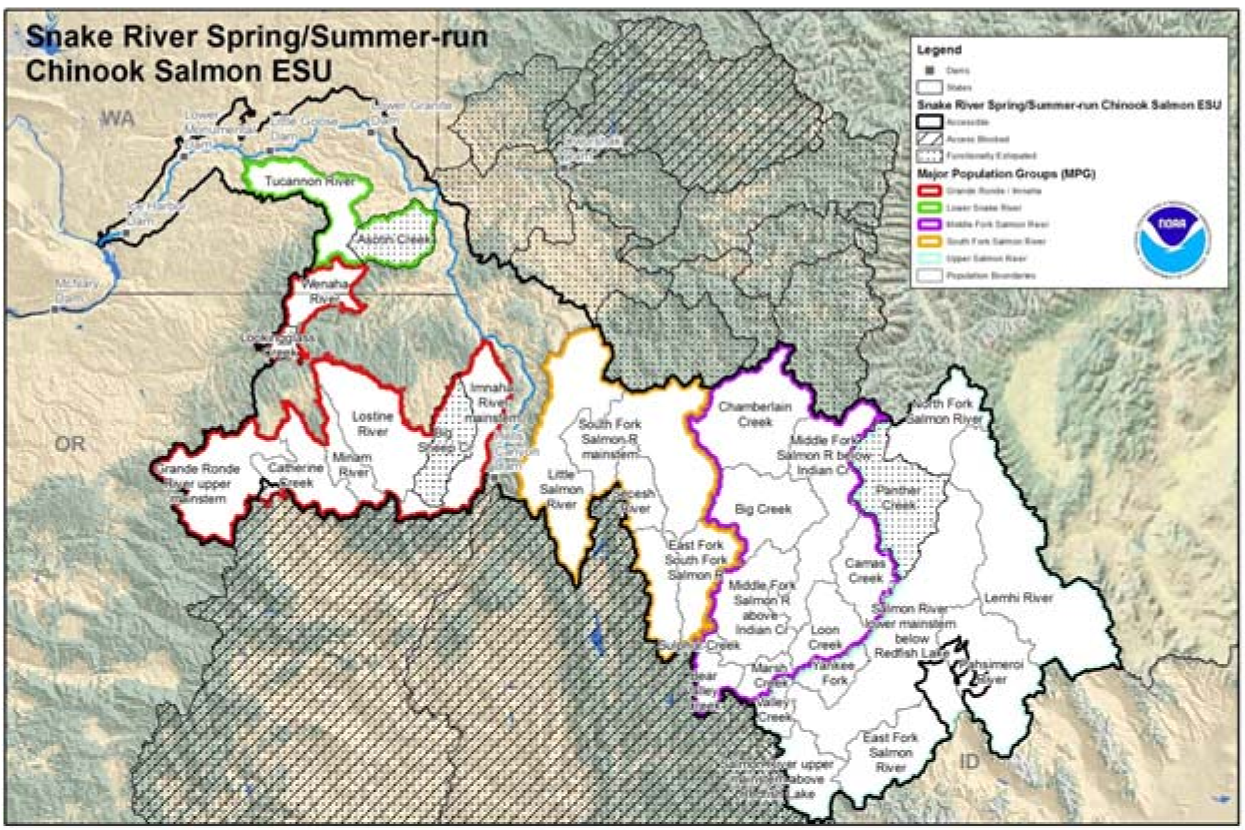


Figure 5. Snake River spring/summer-run Chinook salmon ESU major population groups.

At the time of NMFS' most recent biological review (Ford ed. 2011), population level status ratings remained at high risk across the ESU, although recent estimates of natural-origin spawners had increased. Spawning escapements in the most recent years were generally above the extreme low levels in the mid-1990s, but below peak returns. Low natural productivity remained a major concern across the ESU so that the ability of SR spring/summer Chinook salmon populations to be self-sustaining through periods of low ocean productivity remained uncertain.

Life History. Snake River spring/summer-run Chinook salmon exhibit the same stream-type life history as presented for UCR spring Chinook above.

Spatial Structure and Diversity. The ICTRT characterizes the spatial structure risk to nearly all SR spring/summer Chinook salmon populations as "low" or "moderate". "High" risk exceptions are the Upper Grande Ronde and Lemhi populations, which have accessible but currently unoccupied spawning areas that were historically significant.

The ICTRT characterized the diversity risk to nearly all SR spring/summer Chinook salmon populations as "low" or "moderate." "High" risk exceptions were found in the Upper Salmon MPG including the Lemhi, which has lost the summer-run life history characteristic. Ten of the fourteen hatchery programs were using fish included in the ESU and were 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.

Abundance and Productivity. Ford (ed. 2011) found that the average abundance of all populations over the most recent 10-year period was below the average abundance thresholds that the ICTRT identified as minimum for low risk of extinction. Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels near the recovery abundance thresholds during a few years in the early 2000s, and is now at levels intermediate to those of the mid 1990s and early 2000s.

Ford (ed. 2011) found that the abundance of natural-origin and total spawners had been stable or increasing for most SR spring/summer Chinook salmon populations over the last 20 full brood years, based on lambda and BRT trend estimates generally >1.0. For many populations, this stability or increase had been at least partially dependent on production from naturally spawning hatchery fish, the progeny of which were considered natural-origin fish in these calculations. For most populations, natural survival rates had not been sufficient for spawners to replace themselves, as indicated by average R/S and lambda estimates <1.0.

When considering only natural production, over the 1980-1999 brood years, including adult returns through 2006, about two-thirds of SR spring/summer Chinook salmon populations had not replaced themselves (Ford ed. 2011). 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. While natural productivity for most populations was low during this period, the BRT trend in abundance of natural fish was stable or increasing for nearly all populations.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats to the SR spring/summer Chinook salmon ESU include:

- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, elevated water temperature, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Mainstem Columbia River and Snake River hydropower impacts.
- Harvest-related effects.
- Predation.

Snake River fall Chinook salmon

NMFS listed SR fall-run Chinook salmon as threatened on April 22, 1992 (NMFS 1992) and their threatened status was reaffirmed on June 28, 2005 (NMFS 2005b). NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), concluding that this species should remain listed as threatened.

The ESU includes all naturally spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. Four artificial propagation programs are considered to be part of the ESU: the Lyons Ferry Hatchery, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery, and Oxbow Hatchery fall-run Chinook hatchery programs (NMFS 2005b).

The SR fall-run Chinook salmon ESU consists of one MPG, with three historical populations (only one of which is extant). The two upstream populations (above the Hells Canyon hydropower complex), Marsing Reach and Salmon Falls, are extirpated. The remaining SR fall-run Chinook salmon population occupies the Snake River from its confluence with the Columbia River to the Hells Canyon Dam tailrace, and the lower reaches of the Clearwater, Imnaha, Grande Ronde, Salmon, and Tucannon Rivers (Figure 6), about 20 % of the ESU's historical range (Ford ed. 2011).

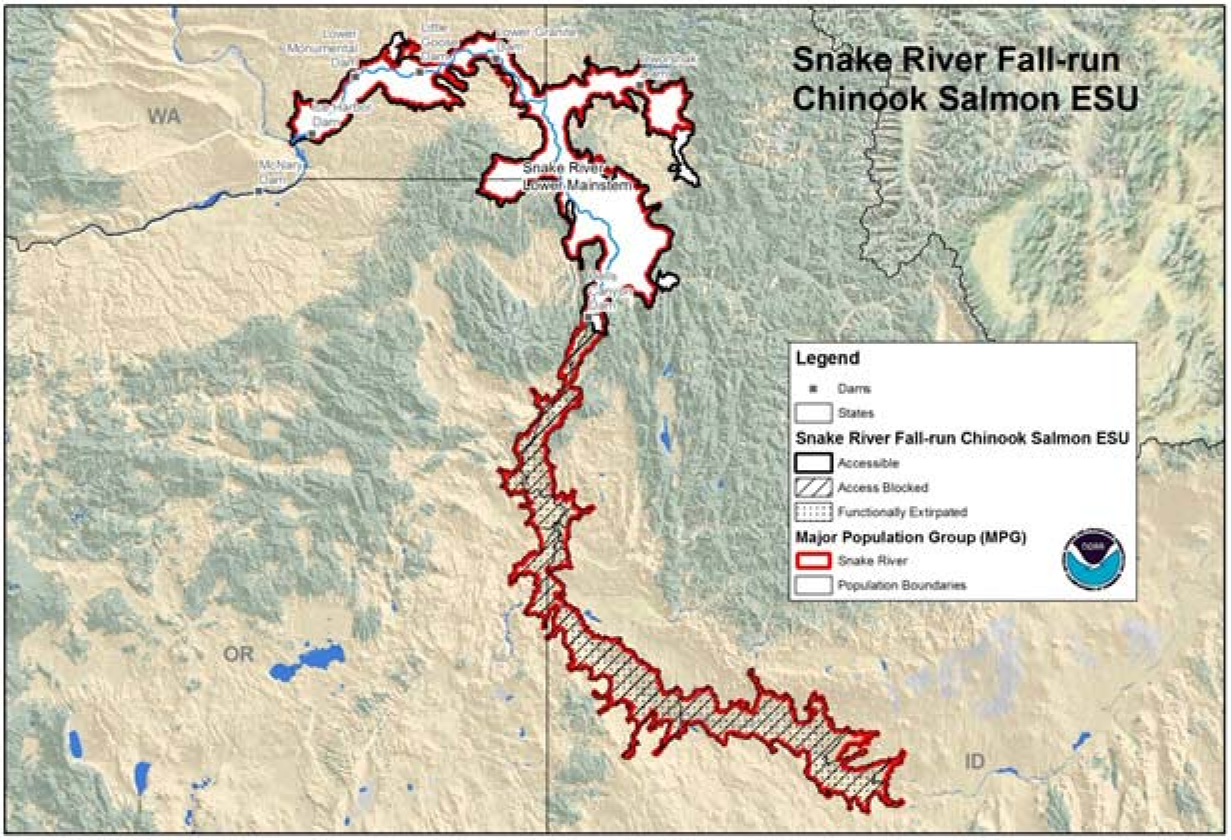


Figure 6. Snake River Fall-run Chinook Salmon ESU population structure.

As of NMFS' most recent biological review (Ford ed. 2011), the Lower Mainstem population (below the Hells Canyon hydropower complex) was rated at moderate risk relative to ICTRT criteria. The ICTRT concluded that the single MPG must be at low risk (highly viable) for the ESU to be considered viable (ICTRT 2007). This would require the re-establishment of at least one other population to meet the minimum viability criteria established by the ICTRT for ESUs with a single MPG. The ICTRT recognized the difficulty of re-establishing fall-run Chinook salmon populations and suggested initial recovery efforts emphasize improving the viability of the extant population, while creating the potential for re-establishment of an additional population (ICTRT 2007).

The ICTRT criteria for low viability risk stipulate that the 10-year geometric mean natural origin escapement should exceed 3,000, with a minimum of 2,500 natural origin spawners in the mainstem Snake River major spawning areas. Achieving a very low risk rating for abundance and productivity requires exceeding the same natural-origin abundance threshold combined with a productivity estimate of 1.5 or higher. The ICTRT described five major spawning areas within the Lower Mainstem population – three mainstem reaches (Salmon River confluence to Hells Canyon Dam site, Lower Granite Dam to the Salmon river confluence, and the mainstem off of and including the lower Tucannon River), and two tributary mainstems (lower Grande Ronde River and the Clearwater River). In addition, the ICTRT defined smaller spawning reaches in the Imnaha River and the Salmon River as minor spawning areas.

Life History. Fall-run Chinook salmon in this ESU are ocean-type. Adults return to the Snake River at ages 2 through 5, with age 4 most common at spawning (Waples *et al.* 1991). Spawning, which takes place in October through November, occurs in the mainstem Snake River and in the lower parts of major tributaries. Juveniles emerge from the gravels in March and April of the following year, moving downstream from natal spawning and early rearing areas from June through early fall. Juvenile SR fall Chinook salmon move seaward slowly as subyearlings, typically within several weeks of emergence (Waples *et al.* 1991). Scale samples from natural origin SR fall Chinook salmon taken at Lower Granite Dam continue to indicate that about half of the returns overwintered in fresh water. The majority of these fish are likely from the Clearwater River (Ford ed. 2011).

Spatial Structure and Diversity. Spatial structure and diversity pose moderate risks to SR fall Chinook salmon. About 80 % of historical habitat is inaccessible and the distribution of the extant population makes it relatively vulnerable to variable environmental conditions and large disturbances. The large fraction of hatchery-origin fish in the spawning population (~ 70%) poses risks to diversity (ICTRT 2007).

Abundance and Productivity. Ford (ed. 2011) reported that the average abundance (1,273) of SR fall-run Chinook salmon over a recent 10-year period was below the 3,000 natural spawner average abundance thresholds that the ICTRT identified as a minimum for low risk of extinction. The 1999-2008 10-year geometric mean of natural origin Snake River Fall Chinook spawning abundance was just over 2,200. The ICTRT recommended that no fewer than 2,500 of the 3,000 natural-origin fish be mainstem SR spawners. Total returns of SR fall Chinook salmon over Lower Granite Dam increased steadily from the mid-1990s with natural-origin fish returning at roughly the same rate as hatchery origin returns through run year 2000. However, since then hatchery returns had increased disproportionately such that Cooney and Ford (2007) reported that the median proportion of natural-origin was only 32 % over the past two brood cycles.

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 pattern, the supplementation program or other factors. At this time, there is insufficient information to estimate the relative contributions of these factors.

On average over 23 recent full brood year returns (1977-1999 brood years, including adult returns through 2004), when only natural production is considered, SR fall Chinook salmon populations did not replaced themselves. Returns per spawner 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.

Ford (ed. 2011) reported an updated estimate of productivity of 1.28 based on a data series beginning in 1990. The estimate for the longer series (1983-2003) brood years was 1.07. When a natural spawning escapement estimate of 2,200 was combined with either of the productivity estimates, the result was a “moderate” risk of extinction for the ESU with respect to both abundance and productivity. However, there was considerable uncertainty in both the abundance and productivity estimates for the natural-origin component due to the inability to discriminate between hatchery and naturally produced fish.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats to the Snake River Fall-Run Chinook ESU include the following:

- Degraded freshwater habitat: Floodplain connectivity and function, and channel structure and complexity have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Harvest-related effects.
- Mainstem Columbia River hydropower impacts.
- Hatchery-related effects.
- Degraded estuarine and nearshore habitat.

Snake River sockeye salmon

NMFS listed SR sockeye salmon as an endangered species on November 20, 1991 (NMFS 1991) and their endangered status was reaffirmed on June 28, 2005 (NMFS 2005b). NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), concluding that this species should remain listed as endangered.

The ESU includes all anadromous and resident sockeye salmon from the Snake River basin (SRB), Idaho (extant populations occur only in the Sawtooth Valley), as well as residual sockeye salmon in Redfish Lake, Idaho, and one captive propagation hatchery program. Artificially propagated sockeye salmon from the Redfish Lake captive propagation program are considered part of the ESU. In 1993 NMFS determined that the residual population of SR sockeye that exists in Redfish Lake is substantially reproductively isolated from kokanee (i.e., non-anadromous populations of *O. nerka* that become resident in lake environments over long periods of time), represents an important component in the evolutionary legacy of the biological species, and thus was included in the SR sockeye ESU (NMFS 2005b). The SR sockeye salmon hatchery program has not changed substantially from the previous ESA status review. Jones *et al.* (2011) did not recommend further review of this program.

Of five historical populations in this ESU, four are extirpated (Alturas Lake, Pettit Lake, Yellowbelly Lake and Stanley Lake) (Figure 7). The single extant population of anadromous SR sockeye salmon is currently restricted to the Sawtooth Valley. At the time of listing in 1991, the only confirmed fish that belonged to this ESU were from a beach-spawning population of sockeye from Redfish Lake. Historical records indicate that sockeye once occurred in several other lakes in the Stanley Basin but no adults were observed in these lakes for many decades and when residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure et al. 2005). Since listing, progeny of Redfish Lake sockeye have been outplanted to Pettit and Alturas lakes, which are also within the Sawtooth Valley.

Sawtooth Valley lakes are relatively small compared to other lake systems that historically supported sockeye production in the Columbia basin. Stanley, Pettit, and Yellowbelly lakes are assigned to the smallest size category. Redfish Lake and Alturas Lake fall into the next size category – intermediate. The average abundance targets recommended by the Snake River Recovery Team (Bevan et al. 1994) were incorporated as minimum abundance thresholds into a sockeye viability curve. It was generated using historical age structure estimates from Redfish Lake sampling in the 1950s-1960s, and year-to-year variations in brood-year replacement rates generated from abundance series for Lake Wenatchee sockeye. The minimum spawning abundance threshold is set at 1,000 for the Redfish and Alturas Lake populations (intermediate category), and at 500 for populations in the smallest historical size category (e.g., Alturas and Pettit Lakes). The ICTRT recommended that long-term recovery objectives should include restoring at least three of the lake populations in the ESU to viable or highly viable status.

.

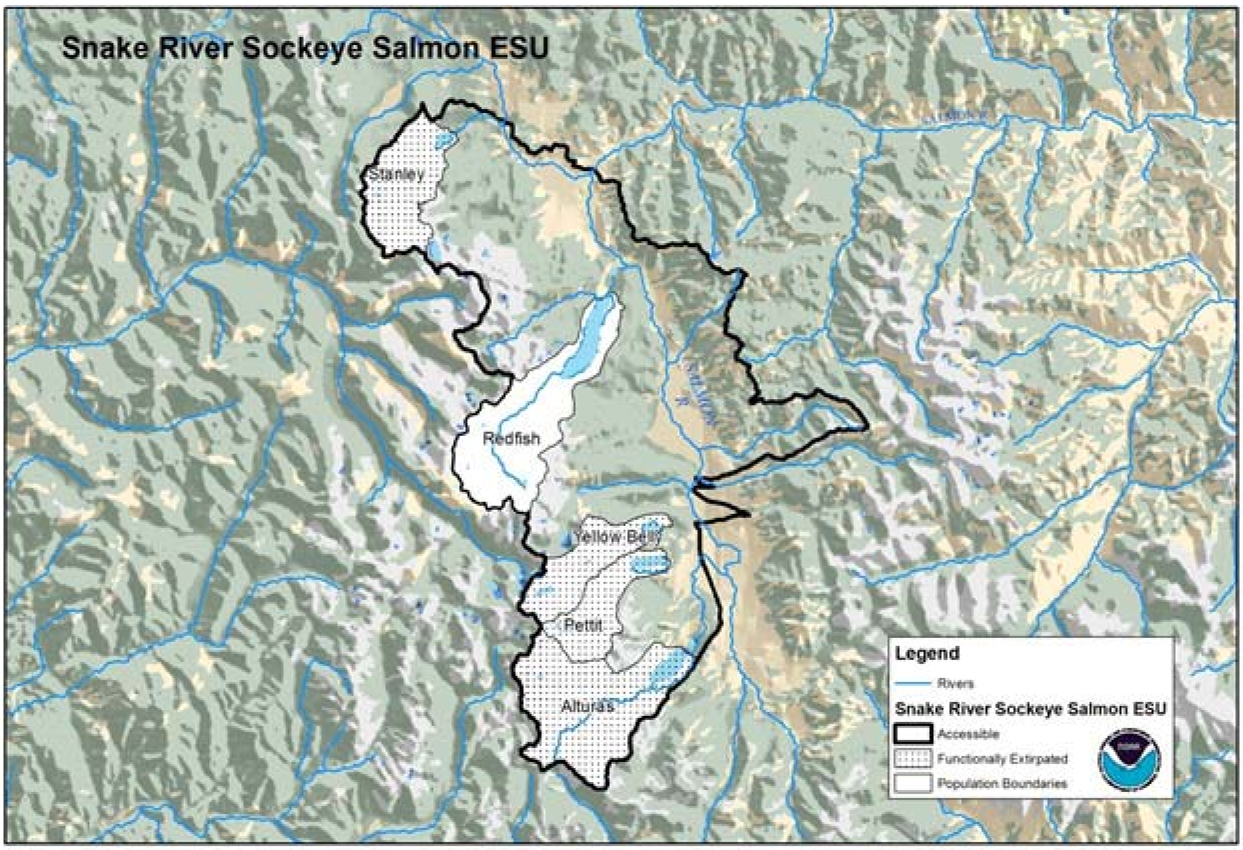


Figure 7. Snake River Sockeye Salmon ESU population structure.

Life History. Snake River sockeye salmon adults enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of SR sockeye salmon, usually occurs in August, and spawning occurs primarily in October (Bjornn *et al.* 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for 3 to 5 weeks, emerge in April through May, and move immediately into the lake. Once there, juveniles feed on plankton for 1 to 3 years before they migrate to the ocean. Migrants leave Redfish Lake from late April through May (Bjornn *et al.* 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. SR sockeye salmon usually spend 2 to 3 years in the Pacific Ocean and return in their fourth or fifth year of life.

Spatial Structure and Diversity. Ford (ed. 2011) did not provide any updated information on the spatial structure/diversity metric for Snake River sockeye. It is unlikely that these metrics have changed since the last status review.

Abundance and Productivity. The 2005 BRT review included a summary of adult returns through the 2002-run year. Estimates of annual returns are now available through 2009. Adult returns in 2008 and 2009 were the highest since the current captive brood-based program began with a total of 650 and 809 adults counted back to the Stanley Basin (Ford ed. 2011). About two thirds of the adults captured in each year were taken at the Redfish Lake Creek weir; the remaining adults were captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. Returns for 2003-2007 were relatively low, similar to the range observed between 1987 and 1999. In many years, more than 50% of the adult sockeye passing Lower Granite Dam do not survive to the Sawtooth Valley. The cause of this high level of adult loss has not been identified.

Increased returns in recent years have supported substantial increases in the number of adults released above the Redfish Lake Creek weir. Annual adult releases since 2003 have ranged from 173 to 969 compared to the range for the five year period ending in 2002 (0 to 190 sockeye). The large increase in returning adults, in recent years, reflect improved downstream and ocean survivals as well as increases in juvenile production since the early 1990s. Unmarked juvenile migrants emigrating from the three lake systems have also dramatically increased in recent years – annual estimates have ranged from 16,000 to 61,000 over the 2005 through 2009 outmigrations. Estimates of the total annual outmigration across all of these components have ranged from 143,500 to 210,300 during the most recent five year period (2005-2008) compared to a range of 19,600-146,300 for (1998-2002), the period corresponding to the 2005 BRT review.

As a result, overall, although the risk status of the Snake River Sockeye Salmon ESU appears to be on an improving trend, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. The key factors limiting recovery for this ESU are the legacy effects of the demographic bottleneck the anadromous component experienced in the early 1990s and currently, survival outside of the Stanley Basin:

- Portions of the migration corridor in the Salmon River are impaired by water quality and temperature. Increased temperatures may reduce the survival of adult sockeye returning to the Stanley Basin.
- …The natural hydrological regime in the upper mainstem Salmon River basin has been altered by water withdrawals.
- …In the Columbia and lower Snake River migration corridor, predation rates on juvenile sockeye salmon are unknown, but terns and cormorants consume 12 % of all salmon smolts reaching the estuary, and piscivorous fish consume an estimated 8 % of migrating juvenile salmon.

***Snake River steelhead*.**

NMFS listed SR steelhead as a threatened species on August 18, 1997 (NMFS 1997b) and protective regulations were issued under Section 4(d) of the ESA on July 10, 2000 (NMFS 2000c). Their threatened status was reaffirmed on June 28, 2005 (NMFS 2005a). NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), and concluded that this species should remain listed as threatened.

The DPS includes all naturally spawned steelhead populations below natural and manmade impassable barriers in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. Six artificial propagation programs are considered part of the DPS: the Tucannon River, Dworshak NFH, Lolo Creek, North Fork Clearwater, East Fork Salmon River, and the Little Sheep Creek/Imnaha River Hatchery steelhead hatchery programs (NMFS 2006c). The ICTRT (2007) identified 26 populations in the following six MPGs for this species: Clearwater River, Grande Ronde River, Hells Canyon, Imnaha River, Lower SR, and Salmon River. The North Fork population in the Clearwater River is extirpated. The ICTRT noted that SRB steelhead remain spatially well distributed in each of the six major geographic areas in the SRB (Good *et al.* 2005). Environmental conditions are generally drier and warmer in these areas than in areas occupied by other steelhead species in the Pacific Northwest. Snake River basin steelhead were blocked from portions of the upper SR beginning in the late 1800s and culminating with the construction of Hells Canyon Dam in the 1960s.

The SR steelhead DPS is comprised of five extant MPGs with 24 extant populations: Clearwater River, Grande Ronde River, Imnaha River, Lower Snake River, and the Salmon River.(Figure 8) The SR basin steelhead DPS also includes the Hells Canyon Tributaries MPG but does not contain an extant population and therefore is not expected to contribute to recovery of the DPS. This DPS consists of A-run steelhead, which primarily return to spawning areas beginning in the summer, and the larger sized B-run steelhead, which begin the migration in the fall.

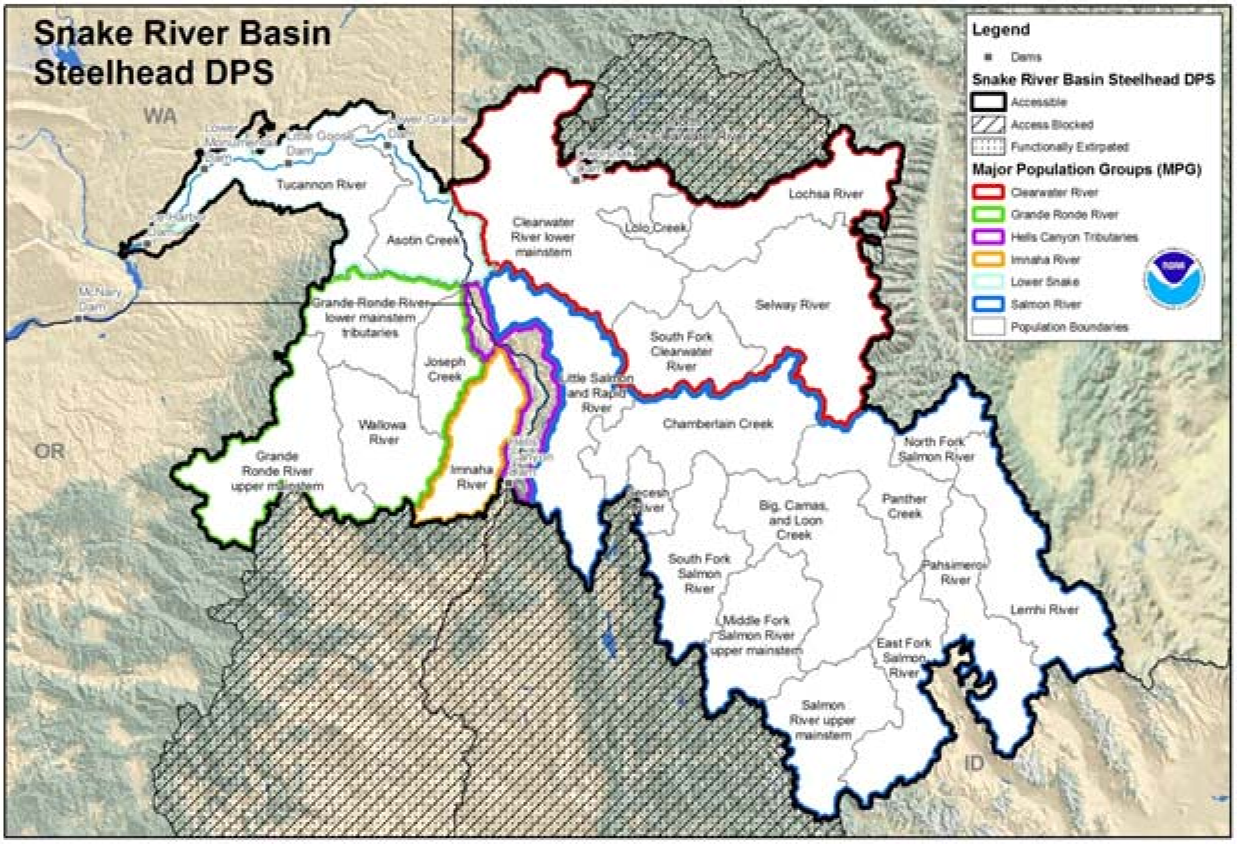


Figure 8. Snake River steelhead DPS population structure.

Life History. The Snake River steelhead ESU is distributed throughout the Snake River drainage system, including tributaries in southeast Washington, eastern Oregon and north/central Idaho. Snake River steelhead migrate a substantial distance from the ocean (up to 930 mi) and use high elevation tributaries (typically 3,300-6,600 ft above sea level) for spawning and juvenile rearing. Snake River steelhead occupy habitat that is considerably warmer and drier (on an annual basis) than other steelhead ESUs.

Snake River basin steelhead are summer run. Summer steelhead enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn during the following spring (March to May). Managers classify up-river summer steelhead runs into two groups based primarily on ocean age and adult size upon return to the Columbia River. Those classified as A-run steelhead are predominately age-1 ocean fish while B-run steelhead are larger, predominately age-2 ocean fish. After spawning, some adults may migrate back to the ocean, and return to spawn again. These fish are referred to as kelts.

After hatching, juvenile SR steelhead typically spend two to three years in fresh water before they smolt and migrate to the ocean, primarily between April and June.

Spatial Structure and Diversity. The ICTRT characterizes the spatial structure risk of nearly all SR steelhead populations as "very low" or "low".

The ICTRT characterizes the diversity risk of all SR steelhead populations as “low” or “moderate”.

Abundance and Productivity. As of NMFS’ most recent biological review (Ford ed. 2011), abundance had 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 was the Upper Grande Ronde population under one assumption for lambda. For B-run SR steelhead populations, natural survival rates were not sufficient for spawners to replace themselves each generation, as indicated by average R/S estimates less than 1.0.

Population-specific adult 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 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.

Ford (ed. 2011) found that the recent five-year geometric mean total run (wild plus hatchery origin) to Lower Granite Dam was up substantially from the corresponding estimates for the prior BRT review and the time period leading up to listing. Natural origin and hatchery origin returns each showed increases, although hatchery fish increased at a higher rate. Both the aggregate A and B run estimates have increased relative to the levels associated with prior assessments.

Overall, therefore, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats to the Snake River basin steelhead DPS include the following:

- Mainstem Columbia River Hydropower–related adverse effects.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Impaired water quality and increased water temperature.
- Related harvest effects, particularly for B-run steelhead.
- Predation.
- Genetic diversity effects from out-of-population hatchery releases.

2.2.1.2 Salmonids in the Willamette/Lower Columbia Recovery (WLC) Domain

Species considered in this opinion in the W/LC Recovery Domain include: lower Columbia River Chinook, lower Columbia River steelhead, Columbia River chum, upper Willamette River Chinook, upper Willamette River steelhead, and lower Columbia River coho.

Columbia River chum salmon
NMFS listed Columbia River chum salmon - both natural and some artificially propagated fish—as a threatened species on March 25, 1999 (NMFS 1999c). Their threatened status was reaffirmed on June 28, 2005 and protective regulations were issued under Section 4(d) of the ESA (NMFS 2005b). NMFS issued results of a five-year review on Aug. 15, 2011 (NMFS 2011a), concluding that this species should remain listed as threatened.

The ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon (Figure 8). Three artificial propagation programs are part of the ESU: the Chinook River (Sea Resources Hatchery), Grays River, and Washougal River/Duncan Creek chum Hatchery Programs. A new chum hatchery program was initiated in 2010 at Big Creek Hatchery in Oregon to develop chum salmon for reintroduction into Lower Columbia River tributaries.

Description and Geographic Range. The Columbia River chum salmon ESU consists of 17 historical populations in three strata: Coastal, Cascade, and Gorge (Figure 9). The Upper Gorge population includes the White Salmon subbasin (Myers *et al.* 2006; McElhany *et al.* 2003).

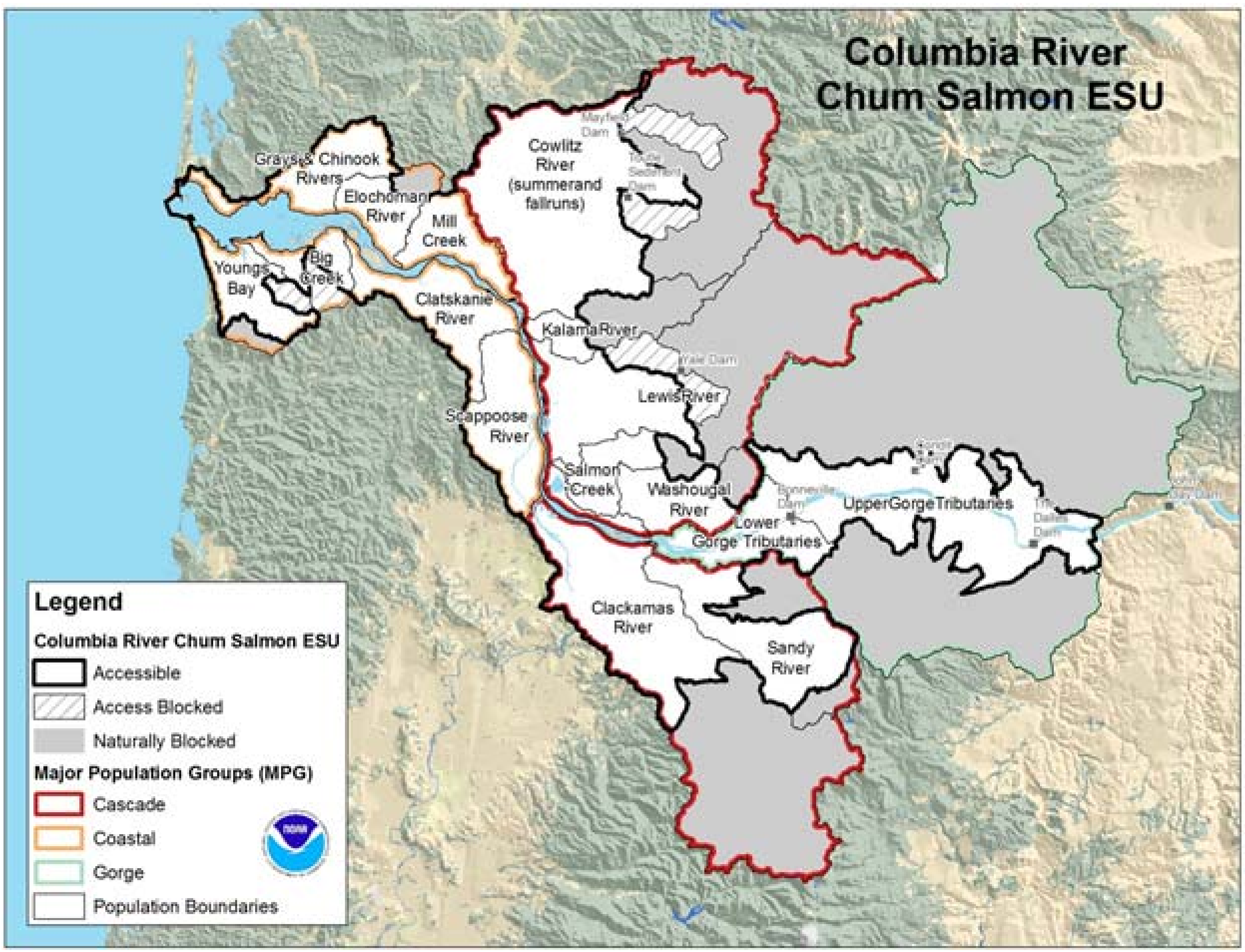


Figure 9. Columbia River Chum Salmon ESU population structure.

Life History. The following brief description is based largely on life history information and excerpts from the report of the Lower Columbia Fish Recovery Board (LCFRB 2004) and the (McElhany *et al.)* recent review of historical population structure for this ESU (Myers *et al.* 2003).

Intensive monitoring of chum spawning escapement is conducted in three Washington tributaries in the lower Columbia basin. Currently, spawning populations of Columbia River (CR) chum salmon are limited to tributaries below Bonneville Dam, with most spawning occurring in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton Creeks, about three miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in the Bonneville pool. Chum salmon populations exist in other river systems of the lower Columbia, but are not consistently monitored and are assumed extremely low in abundance.

Chum salmon returning to the Columbia River are considered a fall run. Adult fall run chum salmon return to the Columbia River from mid-October through November, but apparently do not reach the Grays River until late October-early December. Spawning occurs in the Grays River from early November to late December. Fish returning to Hamilton and Hardy Creeks begin to appear in the tributaries in early November and their spawn timing is more protracted (mid-November-mid-January). Adults typically mature as 4-year-olds, although age-3 and age-5 fish are also common (Fulton 1970).

Chum salmon seldom show persistence in surmounting river blockages and falls, which may be why they usually spawn in lower river reaches. Chum salmon typically dig their redds in the mainstem or in side channels of rivers from just above tidal influence to nearly 60 miles (100 km) from the sea. They spawn in shallower, slower-running streams and side channels more frequently than do other salmonids. In some locations, subgravel flow (upwelled groundwater from seeps and springs) may be important in the choice of redd sites by chum salmon. Many CR chum have been found to select spawning sites in areas of upwelling groundwater. New spawning grounds for chum were recently discovered along the northern Columbia River shoreline near the I-205 Glen Jackson Bridge where groundwater upwelling occurs. A significant number of chum returning to Hamilton Creek spawn in a spring-fed channel, and portions of the Grays River and Hardy Creek populations spawn in the area of springs. Hundreds of chum salmon once returned to spawn within spring-fed areas along Duncan Creek; efforts have been completed to restore passage to these productive areas and protect the springs that feed them.

Chum do not have a clearly defined smolt stage, but are nonetheless capable of adapting to seawater soon after emerging from gravel. Downstream migration may take only a few hours or days in rivers where spawning sites are close to the mouth of the river. Historical information concerning the timing of chum salmon emigration in the lower CR is limited. Recent seining projects conducted in the Grays River and at Ives Island indicate outmigration occurs from March through May and peaks from mid-April to early May (Table 5).

Chum salmon juveniles, like other anadromous salmonids, use estuaries to feed before beginning long-distance oceanic migrations. However, chum and ocean-type Chinook salmon usually have longer residence times in estuaries than do other anadromous salmonids. The period of estuarine residence appears to be the most critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult run back to fresh water. Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Juveniles feed primarily on plankton and epibenthic organisms, while subadults feed on similar items as well as larger prey (including fishes and squid). Most adults mature and spawn as 3-year old fish.

Table 5. Lower Columbia River chum salmon life-history stages.

Life Stage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult upstream migration												
Spawning												
Egg incubation												
Fry emergence												
Fry migration												

Spatial Structure and Diversity. The WLC-TRT partitioned CR chum salmon into three strata based on ecological zones. Ecological zones range from areas at the mouth of the Columbia River that are influenced by the ocean to the Columbia River gorge above Bonneville Dam. The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in each stratum.

Assessments conducted as part of recovery planning since the last status review indicate that spatial structure within most Washington chum salmon populations is moderate to good (Ford ed. 2011). However, methods for evaluating spatial structure of chum salmon populations may incompletely consider their microhabitat requirements, making the assessments imprecise. Assessments also show that most Washington chum salmon populations are at high risk for diversity. Diversity and spatial structure of Oregon chum salmon populations has not been assessed since the last status review.

Substantial spawning occurs in only two of the 17 historical populations, meaning 88% of the historical populations are extirpated, or nearly so. The two extant populations, Grays River and the lower gorge population, appear to contain only a fraction of the wild historic abundance. Both populations have benefited from artificial spawning channels constructed to provide habitat that is lacking in the Columbia River.

A large portion of the upper gorge chum population is believed to have been inundated by Bonneville Dam. The WDFW and Oregon Deparment of Fish and Wildlife (ODFW) conducted surveys to determine the distribution and abundance of chum salmon in the lower Columbia.

Very small numbers were observed in several locations in Washington; one chum salmon was observed in Oregon out of 30 sites surveyed (Good *et al.* 2005).

The leading factor affecting CR chum salmon diversity is the extirpation (or nearly so) of 14 of the 16 historical populations. The remaining populations are at low abundance, although increases in the early 2000s are encouraging. Chum run-timing is rather fixed, compared to other salmon and steelhead, and thus may not help improve the overall diversity of the ESU. Hatchery programs are established for CR chum, in the Chinook, Grays, and Washougal Rivers, but it is unknown how they have affected natural CR chum salmon. Chum are released at a small size thus are not externally marked before release, though many are otolith marked. Columbia River chum salmon diversity may not be adversely affected by hatchery releases because the releases have been relatively small and intermittent compared to other stocks in the Columbia River (McElhany *et al.* 2004).

Abundance and Productivity. Historically, CR chum salmon supported a large commercial fishery that landed more than 500,000 fish per year, and chum salmon were reported in almost every river in the lower Columbia River basin. However, most runs had disappeared by the 1950s. There are now no recreational or directed commercial fisheries for chum salmon in the Columbia River, although chum salmon are taken incidentally in the gill-net fisheries for coho and Chinook salmon, and some tributaries support a minor recreational harvest. The estimated minimum run size for the Columbia River has been relatively stable, although at a very low level, since the run collapsed during the mid-1950s. Current abundance is probably less than 1% of historical levels, and the species has undoubtedly lost some (perhaps most) of its original genetic diversity.

Currently, the WDFW regularly monitors only a few natural “index” populations in the basin, one in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to those two streams. Average annual natural escapement to the index spawning areas was about 1,300 fish from 1990 through 1998. The WDFW surveyed other (nonindex) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner Creeks and in the North Fork Lewis and the Washougal Rivers. The state of Oregon does not conduct targeted surveys, so the current extent of chum salmon spawning on the Oregon side of the river is unknown. Recent estimates for the lower Columbia Gorge and Grays River chum salmon populations range from 3,000 to 18,500 adults (WDFW 2010a). The average spawner abundance based solely on these two populations is about 6,000 naturally produced adult CR chum salmon. The number of hatchery spawners is unknown.

WDFW (2010a) developed planning ranges for abundance of viable CR chum salmon populations. ODFW (2010) has not set abundance goals for historical populations in Oregon. Of the 17 historical populations in the CR chum ESU, all of the populations that occurred in Oregon are considered extirpated or nearly so (McElhany *et al.* 2007). The range of abundance goals for existing populations is from 900 to 2,000 fish (in the Lower Gorge population). Except for the Grays River, all of the populations are well below abundance targets. In 2008, the number of naturally produced chum salmon spawning in the Grays River was well above the abundance goal.

Trends and growth rate for CR chum salmon are difficult to determine because 14 of the 16 historical populations are extirpated, or nearly so. The two extant populations are at Grays River and the lower Columbia Gorge. The majority of chum salmon spawning in the Grays River currently occurs in less than 1.1 km of the river. Data from a WDFW analysis conducted in 2000 shows a small upward trend from 1967 to 1998, and a low probability that the population is declining. However, a longer data set indicates that both long- and short-term trends are negative over the period 1950–2000, with a high probability that the trend and growth rate are less than one.

Data from the Gorge populations showed a downward trend since the 1950s and a relatively low abundance up to 2000. However, preliminary data indicate that the 2002 abundance showed a substantial increase, estimated to be more than 2,000 chum salmon in Hamilton and Hardy Creeks, plus another 8,000 or more in the mainstem. Overall, due to a limited number of populations and low abundance, CR chum salmon productivity is low (Good *et al.* 2005).

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Threats and impacts to the Columbia River chum ESU include the following:

- Degraded estuarine and nearshore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system.
- Degraded freshwater habitat, in particular of floodplain connectivity and function, channel structure and complexity, stream substrate, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development.
- Degraded stream flow as a result of hydropower and water supply operations.
- Loss of access and loss of some habitat types as a result of passage barriers such as roads and railroads.
- Current or potential predation from hatchery-origin salmonids, including coho.

Lower Columbia River Chinook salmon

On June 28, 2005, NMFS listed Lower Columbia River(LCR) Chinook salmon—both natural and some artificially propagated fish—as a threatened species (NMFS 2005b). NMFS issued results of a five-year review on August 15, 2011 (NMFS 2011a), and concluded that this species should remain listed as threatened.

The ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries originating from its mouth upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River (NMFS 1999a). Seventeen artificial propagation programs are considered to be part of the ESU: The Sea Resources Tule Chinook Program, Big Creek Tule Chinook Program, Astoria High School (STEP) Tule Chinook Program, Warrenton High School (STEP) Tule Chinook Program, Elochoman River Tule Chinook Program, Cowlitz Tule Chinook Program, North Fork Toutle Tule Chinook Program, Kalama Tule Chinook Program, Washougal

River Tule Chinook Program, Spring Creek NFH Tule Chinook Program, Cowlitz spring Chinook Program in the Upper Cowlitz River and the Cispus River, Friends of the Cowlitz Spring Chinook Program, Kalama River Spring Chinook Program, Lewis River Spring Chinook Program, Fish First Spring Chinook Program, and the Sandy River Hatchery (ODFW stock #11) Chinook Salmon Hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (NMFS 2005b).

The LCR Chinook salmon ESU consists of 32 historical populations in six strata: Coastal fall-run, Cascade spring-run; Cascade fall-run; Cascade late fall-run; Gorge fall-run; and Gorge spring-run (Figure 10).

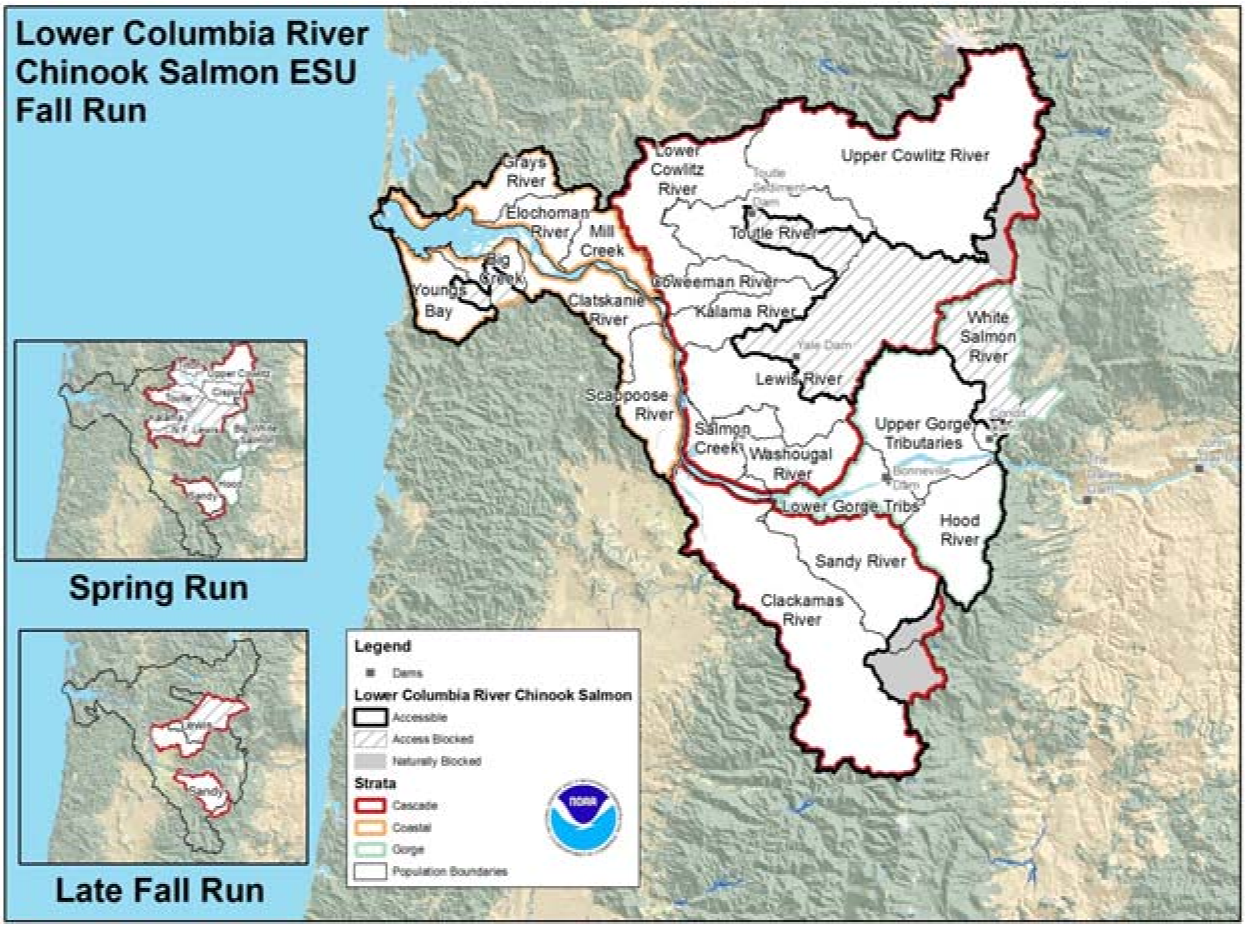


Figure 10. Lower Columbia River Chinook Salmon ESU population structure.

Life History. Of the Pacific salmon, Chinook salmon exhibit the most diverse and complex life history strategies. Chinook salmon follow one of two general freshwater cycles: stream or ocean type. After emerging from the gravel, stream-type Chinook salmon reside in fresh water for a year or more before migrating to the ocean as yearling fish. Ocean-type Chinook salmon migrate to the ocean within their first year as subyearlings. These two types of Chinook salmon have different life history traits, geographic distribution, and genetic characteristics. Chinook in the lower Columbia River generally follow an ocean-type life history cycle.

Runs are designated on the basis of when adults enter freshwater; however, distinct runs may also differ in the degree of maturation at river entry and time of spawning. Early, spring-run (stream-maturing) Chinook salmon tend to enter freshwater as immature or bright fish, migrate upriver (holding in suitable thermal refuges for several months), and finally spawn in late summer and early autumn. Late, fall-run (ocean maturing) Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the main stem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry. Fall Chinook dominate Chinook salmon runs in this ESU. Today, the once abundant natural runs of fall and spring Chinook have been largely replaced by hatchery production. Large Chinook runs continue to return to many of their natal streams, but there are few sustained native, naturally reproducing populations.

Fall Chinook return to the Columbia River at 3 to 4 years of age, although 5-year olds are common in some populations. They enter fresh water from August to September and spawning generally occurs from late September to November, with peak spawning activity in mid-October. Bright fall Chinook adults enter the Columbia River August to October; dominant age class varies by population and brood year, but is typically age 4. Spawning occurs in November to January, with peak spawning in mid-November. Chinook salmon eggs incubate throughout the autumn and winter months. In the LCR, spring Chinook fry emerge from the gravel from November through March; peak emergence time is likely December and January. Fall Chinook fry generally emerge from the gravel in April, depending on the time of egg deposition and incubation water temperature. The emerging fry quickly migrate to quiet waters and off-stream areas where they can find food and protection from predators.

Spatial structure and diversity. . Myers *et al.* (2006) identified 32 historical demographically independent populations in three geographic/ecological subregions for the LCR Chinook salmon ESU. The subregions range from basins with strong coastal influences to ecological zones in the Columbia River gorge above Bonneville Dam. The distribution of populations with distinct run times varied among the three ecological subregions. Fall Chinook salmon historically were found throughout the LCR Chinook Salmon ESU, 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).

The WLC-TRT estimated that 8-10 historic populations have been extirpated, most of them spring-run populations (NMFS 2005a). The near loss of that important life history type remains an important concern. In addition, some of the populations have been blocked for many years by dams on the Cowlitz and Lewis rivers. Trap and haul operations on the Cowlitz have recently re-introduced Chinook salmon to many miles of suitable spawning and rearing habitat. Thus, the LCR Chinook salmon current spatial structure is less diverse than its historical structure, but management actions are underway to improve the situation.

One of the leading factors affecting the diversity of LCR Chinook is the loss of habitat due to impassable barriers such as dams. As described above, several major river systems in the lower

Columbia are blocked. Trap and haul operations and artificial propagation have mitigated some of the effects, but many negative effects continue.

Assessments conducted as part of recovery planning since that status review indicate that most LCR tule fall Chinook salmon populations are at high to moderate risk for issues related to diversity and at relatively low risk for issues related to spatial structure (Ford ed. 2011). These assessments also indicate that the two LCR late fall Chinook salmon populations are at moderate to low risk for issues related to diversity and spatial structure. LCR spring Chinook salmon populations range from very high to moderate risk because of diversity, and most are at very high risk due to spatial structure concerns (Ford ed. 2011).

Artificial propagation has also been identified as a major factor affecting diversity among LCR Chinook salmon. It is unknown how many populations in this ESU are being sustained, at least in part, by artificial propagation. Some of the populations contain substantial numbers of hatchery-origin spawners (first generation hatchery fish). The development and implementation of stock transfer policies in Oregon and Washington has reduced, but not eliminated, artificial production's effects on natural fish.

Abundance and Productivity. Historical records of Chinook salmon abundance are sparse, but cannery records suggest a peak run of 4.6 million fish in 1883. Although fall-run Chinook salmon are still present throughout much of their historical range, most of the fish spawning today are first-generation hatchery strays. Furthermore, spring-run populations have been severely depleted throughout the species' range and extirpated from several rivers. NMFS calculated adult abundance using the geometric mean of natural-origin spawners in the five years before 2003. In 2005, NMFS estimated the LCR Chinook salmon abundance at about 14,130 fish (Good *et al.* 2005). The Oregon and Washington LCR draft recovery plans (WDFW 2010a, ODFW 2010) recommend targets for abundance of natural origin spawners in LCR Chinook salmon populations. The range of abundance recommended for recovery is from 500 (Kalama and Big White Salmon) to 7,300 (North Fork Lewis). Current abundance estimates from WDFW, ODFW, and Streamnet suggest that only five of the 32 LCR Chinook salmon populations are at or have exceeded abundance goals.

Summary statistics on population trends and growth rate are available in the status review update completed in 2005 (Good *et al.* 2005) with further updates in 2010 (Ford ed. 2011). Growth rate estimates were calculated in two ways, one assuming that hatchery-origin spawners would have zero reproductive success; the other assuming that hatchery-origin spawners would have a reproductive success equal to that of natural-origin spawners. Because growth rate was only calculated for time series for which the fraction of hatchery-origin spawners was known, most of the long-term trend estimates used data dating from 1980, even though the abundance time series of total spawners may have extended earlier than 1980. Using both calculations, the majority of populations have a long-term trend of less than 1, indicating the population is in decline.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats include (LCFRB 2010, NMFS 2011a):

- The FCRPS has altered the flow regime and temperatures in the estuary; cumulative impacts of land use and flow management have degraded shallow estuarine habitat.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Reduced access to spawning and rearing habitat mainly as a result of tributary hydropower projects.
- Hatchery-related effects.
- Harvest-related effects on fall Chinook salmon.
- Reduced access to off-channel rearing habitat in the lower Columbia River.
- Reduced productivity resulting from sediment and nutrient-related changes in the estuary.
- Juvenile fish strandings that result from ship wakes.
- Contaminants affecting fish health and reproduction.

In summary, the LCR Chinook Salmon ESU is at high risk of extinction due to the high number of extirpated populations. The main causes for the decline of this ESU include degradation of freshwater habitats and freshwater hydropower related adverse effects.

Lower Columbia River coho salmon

On June 28, 2005, NMFS listed LCR coho salmon—both natural and some artificially propagated fish—as a threatened species (NMFS 2005b). Originally part of a proposed species with a larger geographic range (Lower Columbia River/Southwest Washington), LCR coho salmon were identified as a separate threatened species on June 28, 2005 (NMFS 2005b). NMFS issued results of a five-year review on Aug. 15, 2011 (NMFS 2011a*)*, and concluded that this species should remain listed as threatened.

The listing includes all naturally spawned populations of coho salmon in streams and their tributaries to the Columbia River in Washington and Oregon, from the mouth of the Columbia River at the Pacific Ocean up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River to Willamette Falls, Oregon. Twenty-five artificial propagation programs are part of the ESU and are also listed as follows: the 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, Washougal Hatchery Type-N Coho Program, Lewis River Type-N Coho Program, Lewis River Type-S Coho Program, Fish First Wild Coho Program, Fish First Type-N Coho Program, Syverson Project Type-N Coho Program, Eagle Creek National Fish Hatchery, Sandy Hatchery, and the Bonneville/Cascade/Oxbow Complex Coho Hatchery Programs.

Description and Geographic Range. The LCR coho salmon ESU consists of 24 historical populations in three strata: Coastal, Cascade, and Gorge (Figure 11).

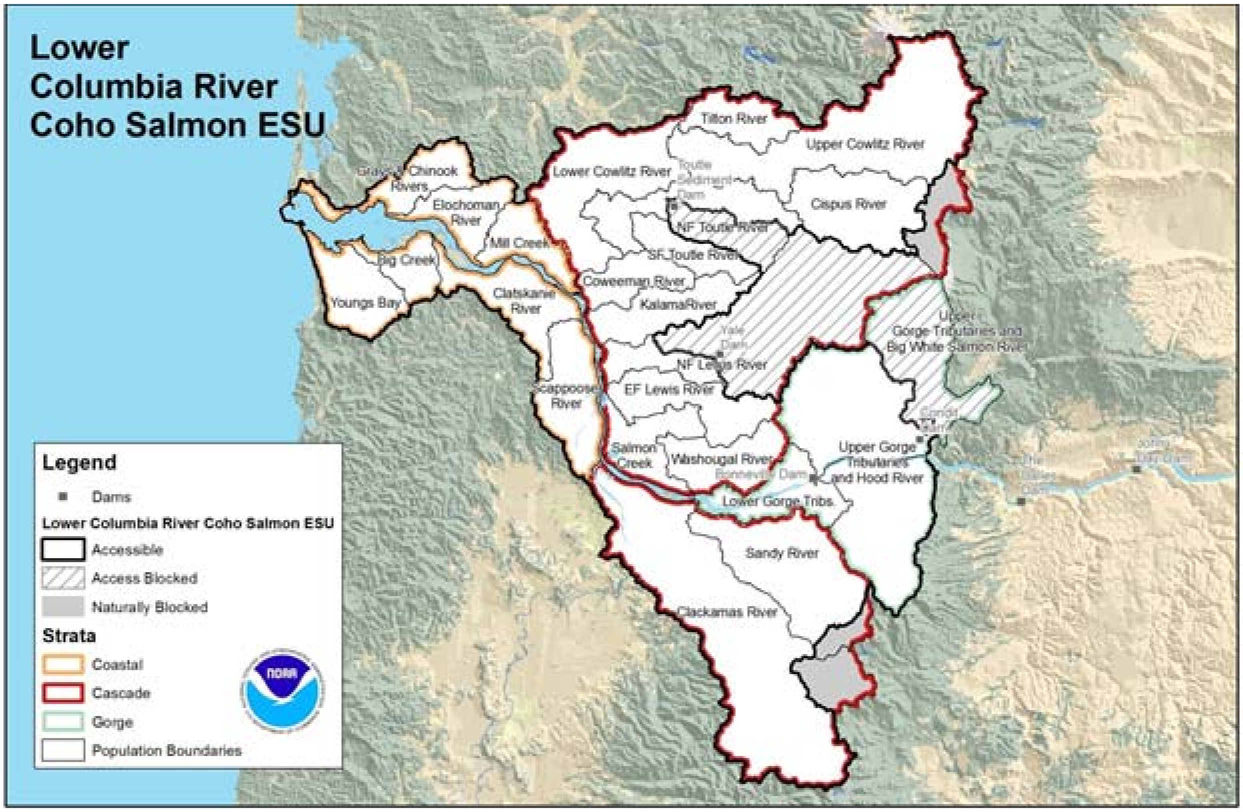


Figure 11. Lower Columbia River Coho Salmon ESU population structure

Life History. The vast majority of coho salmon adults are 3-year-olds, having spent about 18 months in fresh water and 18 months in salt water. Coho salmon smolts typically leave freshwater in the spring (April to June) and re-enter freshwater when sexually mature from September to November, and spawn from November to December and occasionally into January. Stocks from British Columbia, Washington, and the Columbia River often have very early (entering rivers in July or August) or late (spawning into March) runs in addition to "normally" timed runs.

Spatial Structure and Diversity. The LCR coho salmon ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (McElhany *et al.* 2007). Historically, coho were present in all LCR tributaries. Because Willamette Falls was a natural barrier to fall migrating salmonids, LCR coho were not historically found above the falls. In 2005, the WLC-TRT stated that very few wild coho salmon were spawning in LCR subbasins and a number of local populations have become extinct. The WLC-TRT described 18 populations as extant, all heavily influenced by extensive hatchery releases (NMFS 2005a). The majority of extinct populations (or those at very high risk) are in Washington and range from the Grays River population near the mouth of the Columbia River to the Big White Salmon population in the upper gorge.

One of the leading factors affecting the diversity of the ESU is loss of natural spawners. No natural spawners were observed in lower Columbia River tributaries during the 1980s and 1990s.

The 1995 Status Review (Weitkamp *et al.* 1995) determined that the extant natural populations could not be identified, except possibly in the Clackamas River. A lack of natural spawners adversely affects the genetic diversity of this ESU.

Assessments conducted as part of recovery planning since the last status review indicate that Oregon and Washington LCR coho salmon populations are at moderate to low risk as a result of spatial structure and at high to moderate risk from issues related to diversity (Ford ed. 2011). Overall hatchery production remains relatively high, and most populations in the ESU likely contain a substantial fraction of hatchery-origin spawners (although data are limited, particularly for Washington populations). Artificial propagation has been identified as another major factor affecting diversity of LCR coho salmon.

Abundance and Productivity. The majority of the natural production of LCR coho comes from the Clackamas and Sandy River populations. Although adult returns in 2000 and 2001 for the Clackamas and Sandy River populations exhibited moderate increases when compared with returns from the late 1990s, the 5- year mean of natural-origin spawners for both populations (reported in 2004) was less than 1,500 adults. During the 1980s and 1990s, natural spawners were not observed at all in the lower Columbia River tributaries. Coincident with the 2000–2001 abundance increases in the Sandy and Clackamas populations, a small number of coho salmon spawners of unknown origin were surveyed in some lower tributaries. In any case, short- and long-term trends in productivity are below replacement. Based on the best available data and using a three-year geometric mean, the estimated run size of LCR coho salmon for 2010 is 20,765 naturally produced fish and 394,540 hatchery fish.

Long- and short-term trends and growth rate are not available for the majority of populations of LCR coho salmon. The Clackamas River population above North Fork Dam and the Sandy River population above Marmot Dam are the only two populations in the ESU for which natural production trends can be estimated. The long-term trends and growth rate estimates over the time series 1957 to 2002 for the total count at North Fork Dam and the early run portion have been slightly positive and short-term trends and growth rate have been slightly negative. There is very limited information on the other populations in the ESU; most are considered extirpated, or nearly so (Good *et al.* 2005).

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Limiting factors and threats to LCR coho salmon include (LCFRB 2010, NMFS 2011a):

- The FCRPS has altered the flow regime and temperatures in the estuary; cumulative impacts of land use and flow management have degraded shallow estuarine habitat.
- Fish passage barriers that limit access to spawning and rearing habitats.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Hatchery-related effects.

- Harvest-related effects.
- Reduced access to off-channel rearing habitat in the LCR.
- Reduced productivity resulting from sediment and nutrient-related changes in the estuary.
- Juvenile fish strandings that result from ship wakes.
- Contaminants affecting fish health and reproduction.

In summary, the LCR coho salmon ESU is at high risk of extinction due to the degradation of freshwater habitats and hatchery related adverse effects.

Lower Columbia River steelhead

On January 5, 2006, NMFS listed LCR steelhead—both natural and some artificially propagated fish—as a threatened species (NMFS 2006a). NMFS issued results of a five-year review on Aug. 15, 2011(NMFS 2011a), and concluded that this species should remain listed as threatened.

The listing included all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive) and the Willamette and Hood Rivers, Oregon (inclusive). Steelhead in the upper Willamette River basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers in Washington are excluded. Ten artificial propagation programs are part of the listed species and are listed. Hatchery programs included in the DPS are: the 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. Excluded are O. mykiss populations in the upper Willamette River basin above Willamette Falls, Oregon, and from the Little and Big White Salmon Rivers, Washington.

Description and Geographic Range. The Lower Columbia River steelhead DPS consists of 23 historical populations in four strata: Cascade winter-run, Cascade summer-run, Gorge winter-run, and Gorge summer-run (Figure 12).

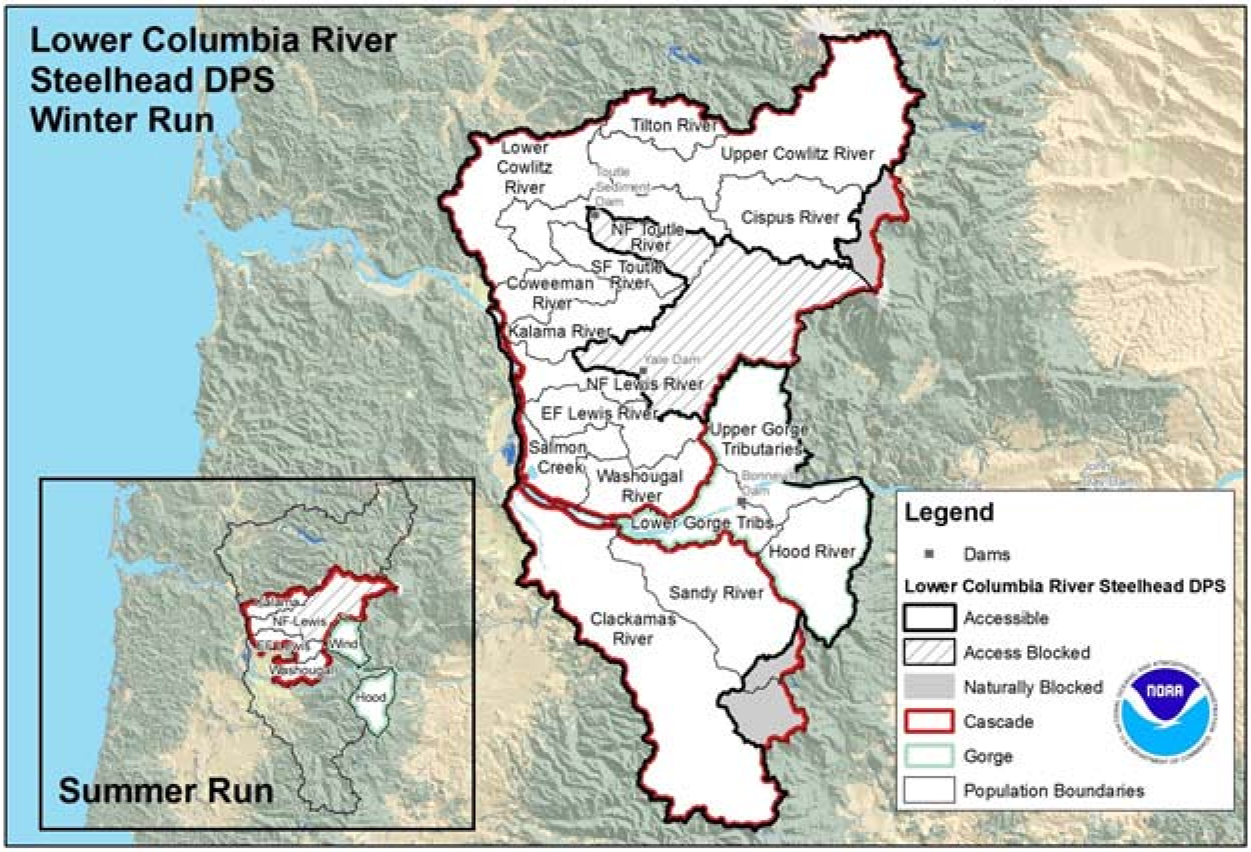


Figure 12. Lower Columbia River Steelhead population structure

Life History. In the lower Columbia basin, migrating adult steelhead can occur in the Columbia River year-round, but peaks in migratory activity and differences in reproductive ecotype lend themselves to classifying steelhead into two races: summer and winter steelhead. Summer steelhead return to fresh water from May to October, and enter the Columbia in a sexually immature condition, requiring several months in fresh water to reach sexual maturity and spawn. Winter steelhead enter fresh water from November to April, and return as sexually mature individuals that spawn shortly thereafter. After spawning, some adults may migrate back to the ocean, and return to spawn again. These fish are referred to as kelts.

Some rivers have both summer and winter steelhead, while others have only one race. LCR steelhead have both winter and summer runs, and several river basins have both (e.g., Kalama River, Sandy River, Clackamas River, and Hood River). Where both runs occur in the same stream, summer steelhead tend to spawn higher in the watershed than do winter forms, perhaps suggesting that summer steelhead tend to exist where winter runs do not fully use available habitat. In rivers where both winter and summer forms occur, a seasonal hydrologic barrier, such as a waterfall, often separates them.

Historically, Celilo Falls may have excluded winter steelhead from interior Columbia River subbasins. A nonanadromous form of *O. mykiss* (redband or rainbow trout) co-occurs with the anadromous form and juvenile life stages of the two forms can be very difficult to differentiate.

Spatial Structure and Diversity. The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) identified 23 historical populations in this DPS. The 23 populations fall into four strata (Myers *et al.*2006). In 2003, a TRT analysis suggested that a viable DPS would need (in addition to other factors) multiple viable populations in each stratum.

One of the leading factors affecting the spatial structure of this DPS is the loss of habitat associated with construction of dams. Although most of the species' historical range remained available, the Bull Run dams (1929) in the Sandy River basin, Merwin Dam (1931) in the Lewis River basin, and Mayfield Dam (1963) in the Cowlitz basin inundated or blocked historical habitat, although winter-run steelhead are now trapped and hauled above Mayfield dam, and passage will soon be restored at Merwin.

Artificial propagation has been identified as another major factor affecting diversity of LCR steelhead. Total releases of hatchery steelhead in the LCR steelhead DPS have increased since the 2005 status review, from about 2 million to around 3 million fish per year. Some populations (e.g., the Hood River and the Kalama) have relatively high fractions of hatchery-origin spawners, whereas others (e.g., the Wind) have relatively few hatchery-origin spawners (Ford ed. 2011). Assessments since the last status review indicate that Oregon and Washington LCR steelhead populations are generally at moderate risk because of diversity issues and low risk because of spatial structure (Ford ed. 2011).

Abundance and Productivity. The Lower Columbia Fish Recovery Board (LCFRB 2004) developed planning ranges for abundance of viable LCR steelhead populations. Some abundance goals were not set; the range of abundance is from 61 in the North Fork Lewis to 1,895 fish in the Kalama. The LCFRB identified most of the populations as currently at high risk of extinction. The Wind River summer steelhead and the Kalama River, South Toutle River, and Lower Gorge tributaries' winter steelhead populations are at moderate risk. The North Fork Lewis River summer run and Tilton River winter run were described as either extinct or at very high risk. Some of the populations are approaching the abundance targets, and one (the E.F. Lewis) exceeded it. As of 2009 the total estimated hatchery-origin spawners in the DPS was 17,377 while the estimated natural-origin spawners totaled 11,483 fish (ODFW and WDFW 2009a, WDFW 2010).

Recent abundance data show that most LCR steelhead populations grew from 1998 through 2004 when they peaked and then declined to be near the long term mean by 2008 (Ford ed. 2011). The North Fork Toutle population is still recovering from the 1980 eruption of Mount St. Helens and average abundance is still low but increasing. Potential reasons for overall declines in growth rate for the entire DPS are habitat degradation, deleterious hatchery practices, and climate-driven reductions in marine survival.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats. Threats and impacts to the Lower Columbia River steelhead DPS include the following:

- Degraded estuarine and nearshore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system.
- *Degraded freshwater habitat*: floodplain connectivity and function, channel structure and complexity, riparian areas and recruitment of large wood, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Reduced access to spawning and rearing habitat as a result of tributary hydropower projects and
- lowland development
- Avian and marine mammal predation in the lower mainstem Columbia River and estuary.
- Hatchery-related effects.

Upper Willamette River Chinook salmon.

NMFS listed the Upper Willamette River (UWR) Chinook salmon ESU as threatened on March 24, 1999(NMFS 1999a). On June 28, 2005, NMFS reaffirmed the UWR Chinook salmon as a threatened species (NMFS 2005a). NMFS issued results of a five-year review on Aug. 15, 2011(NMFS 2011a), concluding that this species should remain listed as threatened.

This ESU includes all naturally spawned spring-run Chinook salmon populations in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon (NMFS 1999a). Seven artificial propagation programs are considered to be part of the ESU: The McKenzie River Hatchery (ODFW stock #241), Marion Forks/North Fork Santiam River (ODFW stock #21), South Santiam Hatchery (ODFW stock #23) in the South Fork Santiam River, South Santiam Hatchery (ODFW stock #23) in the Calapooia River, South Santiam Hatchery (ODFW stock #23) in the Mollala River, Willamette Hatchery (ODFW #22), and Clackamas Hatchery (ODFW #19) spring-run Chinook salmon hatchery programs. NMFS has determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (NMFS 2005a).

Description and Geographic Range. Based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, environmental and habitat characteristics, and with guidance found in McElhany *et al.* 2000, the WLC-TRT identified seven demographically independent populations within the ESU (Figure 13). These include: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette (Myers *et al.* 2006).

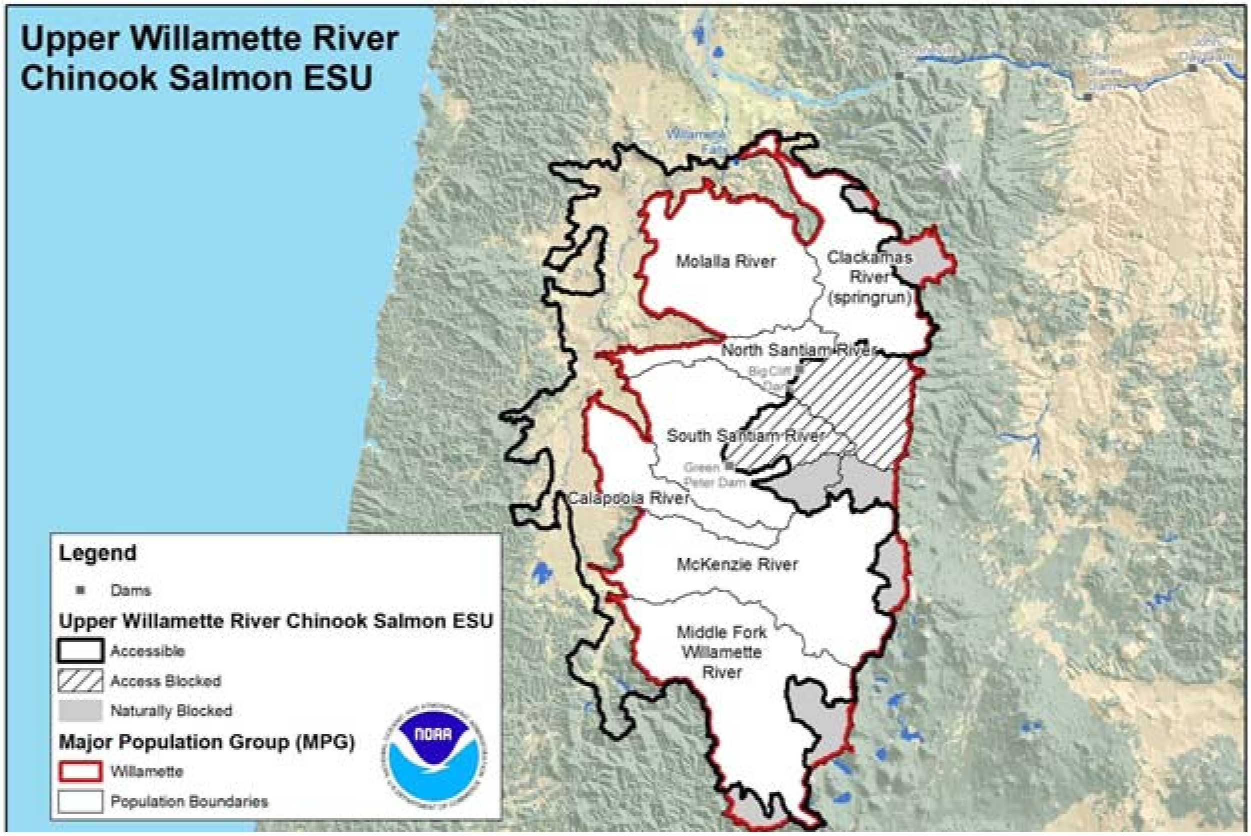


Figure 13. UWR Chinook Salmon ESU population structure.

Life History. Spring-run Chinook salmon generally enter the Upper Willamette River from March through mid-August and spawn primarily from September through November. Most juveniles exhibit a yearling strategy, rearing in natal streams for a full year before migrating downstream to estuarine habitats (WRI 2004). Although some fish may move throughout the year, juvenile Chinook salmon in the Willamette River exhibit a peak in their downstream migration in the fall with the onset of the fall rains in October and November and again in the late winter and spring with freshets.

Spatial Structure and Diversity. The WLC-TRT identified seven historical populations. All seven populations are in one stratum, the Cascade spring run stratum (NMFS 2005a). The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in this stratum. The North Fork Dam on the Clackamas River, Big Cliff and Detroit dams on the North Santiam River, Foster and Green Peter dams on the South Santiam River, Blue River and Cougar dams on the McKenzie River, Fall Creek and Dexter dams on the Middle Fork Willamette, and numerous blockages on smaller tributaries of the Molalla and Calapooia rivers either eliminate historical habitat or impede upstream passage or juvenile outmigration. Good *et al.* (2005) estimated that perhaps a third of the historical habitat used by fish in this ESU is currently inaccessible behind dams.

The lack of access to historical habitat above dams continues to be a key limiting factor for the spatial structure metric. The Clackamas population is at very low risk of extinction for spatial structure, the Molalla and McKenzie populations are at low to moderate risk, while the remaining four populations are at very high risk. Spawning ground surveys in upper Willamette tributaries indicate that the vast majority of fish in the Molalla, North and South Santaim, Calapooia, and Middle Fork Willamette populations are of hatchery origin and are at moderate to high risk for diversity. Most of the natural origin spawners in the ESU are in the McKenzie population above Leaburg Dam. Although both the Clackamas and McKenzie rivers have substantial natural production, both are at moderate risk of extinction for the diversity metric.

Abundance and Productivity. Based on records of egg collections at salmon hatcheries, the estimated spring Chinook salmon run in the 1920s may have been 275,000 fish. The geometric mean of the estimated run size from 1946 through 1950 was 43,300 fish, compared to an estimate of 25,500 for 1994 through 1998. In 1994, only 3,900 natural spawners were estimated to reach the Upper Willamette basin; about 1,300 of these were naturally produced. The number of naturally spawning fish has increased gradually in recent years, but many are considered first-generation hatchery fish.

Previous status reviews described the long-term trends in UWR Chinook escapement as mixed—ranging from slightly upward to moderately downward. Good *et al.* (2005) did not address UWR Chinook salmon productivity trends specifically, but did indicate that most natural-origin spring-run Chinook populations are likely extirpated, or nearly so. The only population considered potentially self-sustaining is the McKenzie River population. However, its abundance has been relatively low (low thousands), with a substantial number of these fish being of hatchery origin.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

Limiting Factors and Threats: Limiting factors and threats to UWR Chinook salmon include (ODFW and NMFS 2011, NMFS 2011a):

- Significantly reduced access to spawning and rearing habitat because of tributary dams.
- Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development.
- Degraded water quality and altered temperature as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development.
- Hatchery-related effects.
- Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon.
- Historical ocean harvest rates of about 30 %, which in recent years have decreased to around 11 %.

Upper Willamette River steelhead
NMFS listed the UWR steelhead ESU as threatened on March 25, 1999, and reaffirmed this listing on January 5, 2006 (NMFS 2006a). NMFS issued results of a five-year review on Aug. 15, 2011(NMFS 2011a), and concluded that this species should remain listed as threatened.

The listing included all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive (NMFS 1999b). This DPS does not include any artificially propagated steelhead stocks that reside within the historical geographic range of the DPS. Hatchery summer-run steelhead occur in the Willamette Basin but are an out-of-basin stock that is not included as part of the DPS (NMFS 2006a).

Description and Geographic Range. Major river basins containing spawning and rearing habitat for this ESU comprise about 4,872 square miles in the Willamette River basin. For recovery planning and development of recovery criteria, the WLC-TRT identified four historical demographically independent populations for UWR winter steelhead. These include: the Molalla, North Santiam, South Santiam and Calapooia (Figure 14) (Myers *et al.* 2006). There is intermittent spawning and rearing in westside Willamette River tributaries but these areas do not constitute an independent population (Ford ed. 2011).

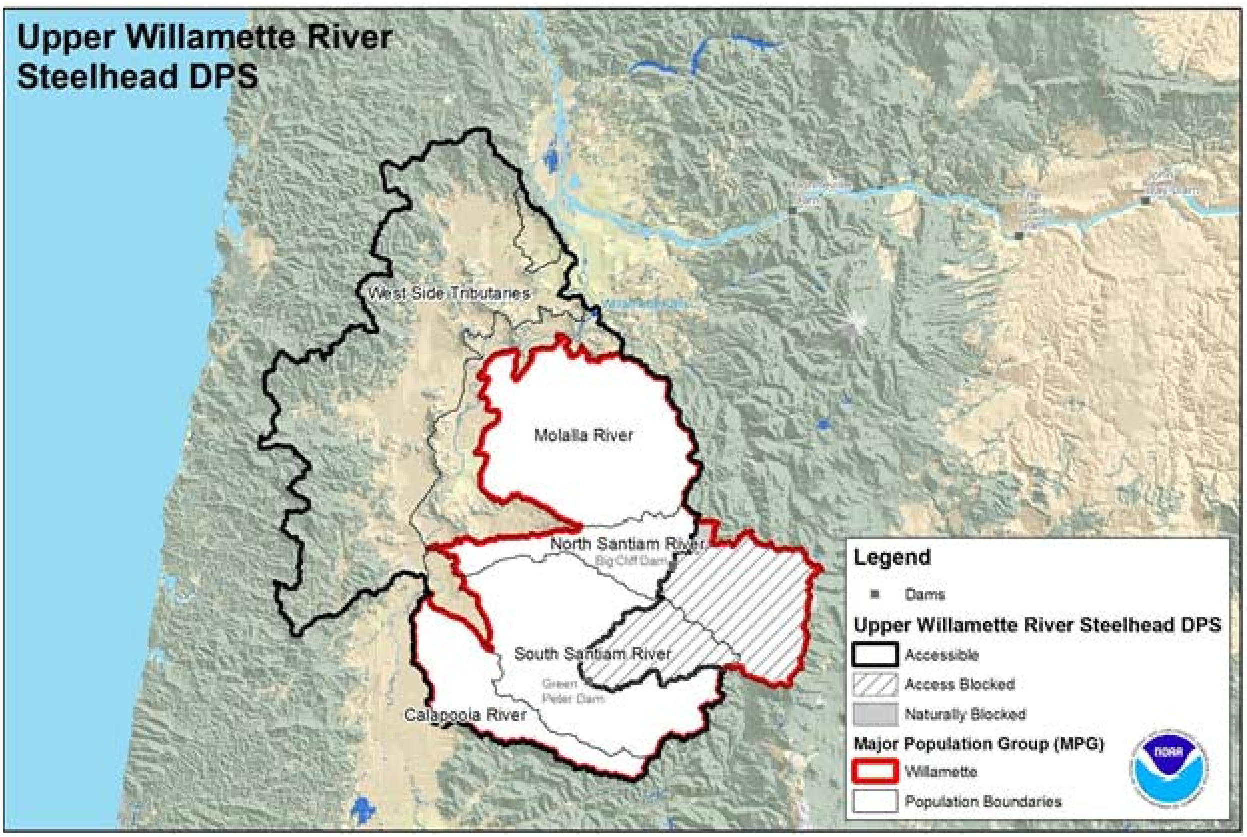


Figure 14. UWR steelhead population structure

Life history. Listed UWR steelhead are late-migrating winter steelhead, entering fresh water primarily in March and April. This atypical run timing appears to be an adaptation for ascending Willamette Falls, which functioned as an isolating mechanism for the Upper Willamette basin before the falls were laddered. Reproductive isolation resulting from passing above the falls may explain the genetic distinction between steelhead from the UWR and those in the lower river. After spawning, some adults may migrate back to the ocean, and return to spawn again. These fish are referred to as kelts.

Spatial Structure and Diversity. The WLC-TRT identified four historical populations (Molalla, North Santiam, South Santiam, and Calapooia) and one "population sink" area (the west side tributaries) for this DPS. All of the populations and the sink are in one stratum. The WLC-TRT determined that the west side tributaries were unlikely, individually or collectively, to have constituted a demographically independent population. The WLC-TRT included the west side tributaries as a population sink to recognize that although some winter steelhead may intermittently use these tributaries for spawning or rearing, this does not increase the productivity of the populations. None of the four historical populations are extinct, thus the species' current spatial structure appears to be relatively intact. However, access to entire basins has been affected by habitat changes—especially passage barriers at dams on the North and South Santiam. Historically, the areas above these dams were primary production areas for UWR steelhead. Good *et al*. (2005) considered the loss of access to historical spawning grounds because of the Corps Willamette Valley flood control dams to be a major risk factor to spatial structure.

Ford (ed. 2011) considered the Molalla population to be in the low risk category and the other three populations to be in the moderate to high-risk categories for spatial structure, because dams block access to the upper watersheds in the North and South Santiam watersheds, and, other water quality problems exist in the Calapooia River. South Santiam steelhead access to the upper watershed is dependent upon trap and haul of fish at Foster Dam.

Winter steelhead hatchery releases in the UWR ceased in 1999. However, there is still a substantial hatchery program for non-native summer steelhead. In recent years, returning non-native summer steelhead outnumber the native winter-run steelhead, which raises genetic (diversity) and ecological concerns. All four UWR populations are considered to be in the moderate risk category for diversity.

Steelhead from the UWR are genetically distinct from those below Willamette Falls (Busby et al. 1996). Reproductive isolation from lower river populations may have been facilitated by the existence of the falls, which is known to be a migration barrier to some anadromous salmonids. For example, winter steelhead and spring Chinook salmon occurred historically above the falls, but summer steelhead, fall Chinook salmon, and coho salmon did not (PGE 1997).

Abundance and Productivity. Overall, numbers of native winter steelhead in the Upper Willamette basin declined in the early 1970s, exhibited large fluctuations in abundance from the late 1970s through late 1980s, declined to very low numbers in the 1990s, and rebounded to moderate levels in the early 2000s. Good *et al.* (2005), using data from the early 2000s, estimated the mean abundance of the entire listed species at less than 6,000 fish. (No artificially propagated steelhead stocks are considered part of the listed species.)

All four UWR steelhead populations are at relatively low abundance. Although hatchery production has been reduced or eliminated, hatchery progeny continue to have a large effect natural spawning. No single population has been identified as naturally self-sustaining.

Good *et al.* (2005) described the populations of UWR steelhead as in decline, with no single self-sustaining natural population. All populations are relatively small, and are affected to an unknown degree by hatchery production. Ford ed. (2011) considers all four populations to be in the moderate risk of extinction category for abundance and productivity.

Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford ed. 2011).

*Limiting Factors and Threats***:** Threats and impacts to the Lower Columbia River steelhead DPS include the following:

- Degraded estuarine and nearshore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system.
- Degraded freshwater habitat: floodplain connectivity and function, channel structure and complexity,
- riparian areas and recruitment of large wood, stream substrate, stream flow, and water quality have
- been degraded as a result of cumulative impacts of agriculture, forestry, and development.
- Reduced access to spawning and rearing habitat as a result of tributary hydropower projects and
- lowland development.
- Avian and marine mammal predation in the lower mainstem Columbia River and estuary.
- Hatchery-related effects.

2.2.1.3 Non-Salmonids

Non-salmonid species considered in this opinion include: southern DPS Pacific eulachon, southern resident DPS killer whale, and southern DPS green sturgeon.

Southern DPS Pacific Eulachon

Pacific eulachon, or smelt, are a small, anadromous forage fish inhabiting the northeastern Pacific Ocean, ranging from northern California northward to south-central Alaska and into the southeastern Bering Sea. Upon completion of a status review, NMFS determined that populations of Pacific eulachon spawning from the Skeena River in British Columbia, Canada south to the Mad River in northern California comprised a southern DPS and was evaluated for listing under the ESA (NMFS 2009a). The southern DPS of Pacific eulachon was listed as threatened under the ESA by NMFS on March 18, 2010 (NMFS 2010b). Information from these sources is summarized below.

Description and Geographic Range. Eulachon are endemic to the northeastern Pacific Ocean, ranging from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. In the portion of the species' range that lies south of the U.S. – Canada border, most eulachon production originates in the Columbia River Basin. Within the Columbia River Basin the major and most consistent spawning runs return to the mainstem of the Columbia River and the Cowlitz River. Periodic spawning also occurs in the Grays, Elochoman, Kalama, Lewis, and Sandy Rivers. Adult eulachon have been recorded at several locations on the Washington and Oregon coasts, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams, although these tend to be erratic, appearing in some years but not others, and appearing only rarely in some river systems (Hay and McCarter 2000; Willson *et al.* 2006; NMFS 2010b). Adult eulachon are known to migrate up coastal rivers, including the Columbia River, spawning in the mainstem and select tributaries (Figure 15), with larval forms outmigrating through the estuary and with juvenile forms rearing in marine waters extending out along the continental shelf (NMFS 2008d).

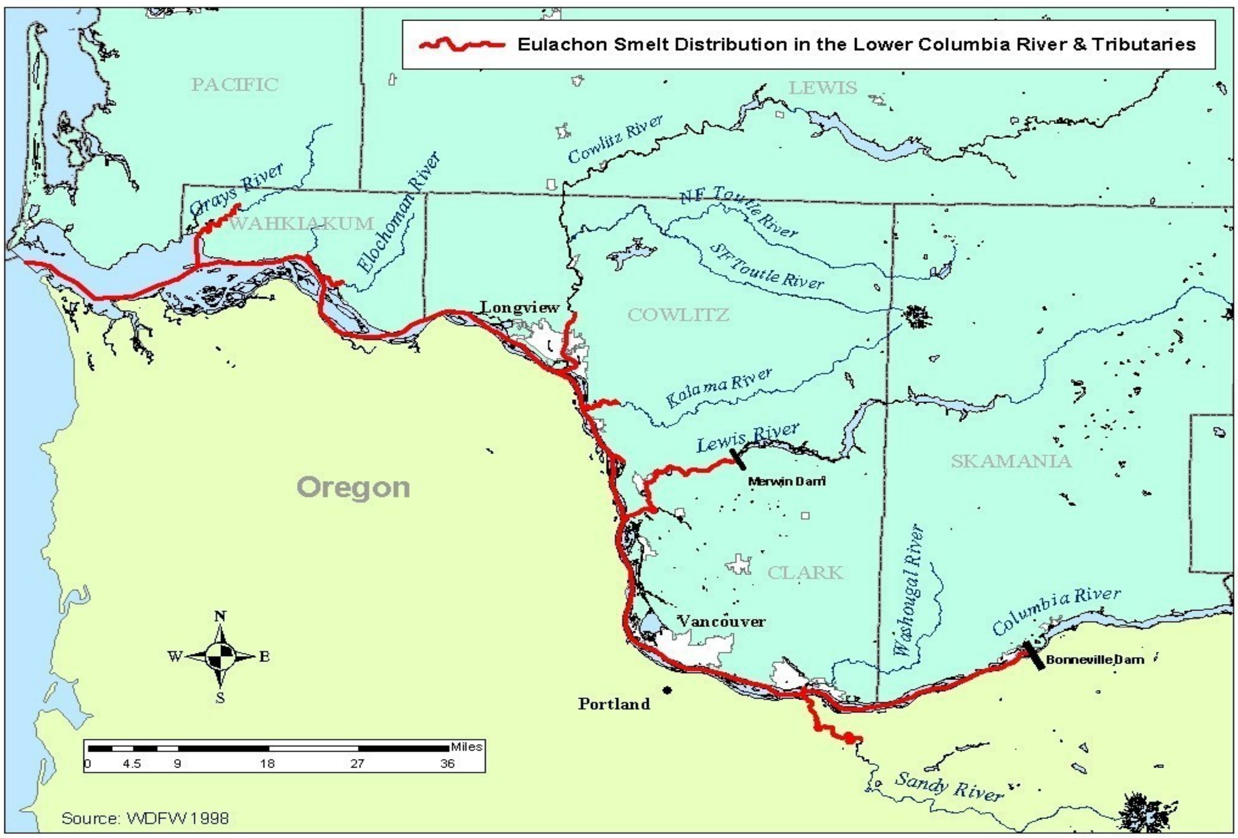


Figure 15. Distribution of eulachon in the lower Columbia River and tributaries.

Biological Requirements. The biological requirements of southern DPS eulachon are not completely understood, but we know that eulachon require adequate spatial structure and diversity, habitat, abundance, and productivity to ensure their survival and recovery in the wild (NMFS 2010b).

Rivers within the range of the southern DPS of eulachon are influenced by medium to high rainfall and generally drain mountainous terrain with steep canyons. Between the ocean and the mountains lies a narrow coastal plain composed of sand, silt, and gravel. Average annual river flows for most rivers in this region are among the highest found on the West Coast when adjusted for watershed area. Peak flows occur during winter rainstorms common in December and January. Snowmelt adds to the surface runoff in the spring, providing a second flow peak (spring freshet), and there are long periods when the river flows are maintained at a level of at least 50% of peak flow.

Life History. Eulachon generally spawn in rivers fed by either glaciers or snowpack and that experience spring freshets. It has been suggested that because these freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000).

Adult eulachon return to fresh water to spawn at 2 to 5 years of age. Eulachon typically enter the Columbia River system from December to May with peak entry and spawning during February and March (NMFS 2010b). Peak tributary abundance is usually in February, with variable abundance through March and an occasional showing in April (ODFW and WDFW 2009b). Spawning in LCR can occur soon after freshwater entry (ODFW and WDFW 2009b). Eulachon spawn in the mainstem Columbia River and usually spawn every year in the Cowlitz River, with inconsistent runs and spawning events occurring in the Gray's, Elochoman, Lewis, Kalama, and Sandy rivers (ODFW and WDFW 2009b). Though eulachon have been observed migrating up the Columbia River, spawning has not been documented in the mainstem above RM 80 (Romano *et al.* 2002).

Several aspects of eulachon biology indicate that large aggregations of adult eulachon are necessary to maintain the species' normal reproductive output. Eulachon are a short-lived, high-fecundity, high-mortality forage fish, and such species typically have extremely large population sizes. Eulachon are broadcast spawners and typically prefer spawning areas with coarse-sandy substrate. Most adults die after spawning. Estimates of fecundity range from 7,000 to 60,000 eggs per female and survival from egg to larva may be less than 1% (NMFS 2010b). After fertilization, the eggs settle to the bottom and adhere to river substrates, typically pea-sized gravel and coarse sand (Hart and McHugh 1944). Incubation occurs for about 30 to 40 days depending on water temperature (ODFW and WDFW 2009b).

Young eulachon larvae are about 0.2 to 0.3 inches in length and are rapidly flushed to the ocean, often within days of hatching, subsisting on their yolk sac during this downstream dispersal (ODFW and WDFW 2009b). After the yolk sac is depleted, eulachon feed on pelagic plankton. Larvae rear in the pelagic zone and experience high mortality rates during their transition to the juvenile phase. Among such marine species, conditions of high fecundity and high mortality may lead to random "sweepstake recruitment" events where only a small minority of spawning individuals contribute to subsequent generations. It is thought that large population sizes are necessary for viability because: (1) there is a critical threshold density of adult eulachon that must be present for successful reproduction (2) there must be enough offspring to counteract high in-river egg and larval mortality and larval mortality in the ocean, and (3) there must be enough offspring to buffer against variation in local environmental conditions (NMFS 2010b).

Eulachon spend the majority of their life in salt water and little is known about their marine ecology (Hay and McCarter 2000), although it is likely that juvenile eulachon rear in near-shore marine areas at moderate or shallow depth (Barraclough 1964) and feed on pelagic plankton, including euphausiids (krill). As they grow at sea, they tend to utilize waters of greater depths and have been found as deep as 2,050 feet (Allen and Smith 1988).

Adult eulachon range in size from 5 to 12 inches and are planktivorous in the ocean, but stop feeding when returning to fresh water to spawn (McHugh 1939, Hart and McHugh 1944). The homing instinct of eulachon (returning to birth streams) is not clear, but it is postulated that larvae may spend weeks to months in nearby estuarine environments where they grow significantly in size and may develop the capacity to imprint on large estuaries and eventually home to these areas as adults (McCarter and Hay 1999, Hay and McCarter 2000).

Spatial Structure and Diversity. There are no distinct differences among eulachon throughout the range of the southern DPS. However, the BRT did separate the DPS into four subpopulations in order to rank threats they face. These are the Klamath River (including the Mad River and Redwood Creek), the Columbia River (including its tributaries), the Fraser River, and the BC coastal rivers north of the Fraser River up to, and including, the Skeena River. No detailed analysis has been conducted yet to determine southern DPS eulachon population structure below the DPS level.

Abundance and Productivity. Quality data on current population sizes for eulachon are lacking; however, in 2010 NMFS determined that although eulachon are a relatively poorly monitored species, the weight of the available information indicated that an abrupt decline in the abundance of the southern DPS throughout its range had occurred (NMFS 2010b).

Limiting Factors and Threats. As discussed in the *Federal Register* listing notice (NMFS 2010b), the primary factors resulting in the decline of the southern DPS of eulachon are the destruction, modification, or curtailment of habitat and an inadequacy of existing regulatory mechanisms. NMFS also identified climate-induced changes in ocean conditions as the most significant threat and climate-induced changes to freshwater habitat as a moderate threat to eulachon throughout the range of the DPS (NMFS 2010b). Other factors identified as low to moderate threats included dams and water diversion projects, dredging, commercial and recreational fisheries, predation or disease, and bycatch of eulachon in other commercial fisheries, depending on when and/or where they occur (NMFS 2010b).

Southern DPS of Green Sturgeon.

On April 7, 2006, NMFS listed the southern DPS of North American green sturgeon (hereafter referred to as "green sturgeon") as a threatened species (NMFS 2006b).

Upon completion of a status review, NMFS determined that green sturgeon comprise two DPSs that qualify as species under ESA: 1) a northern DPS, consisting of populations 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).

Description and Geographic Range. The southern DPS consists of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River. Information on their oceanic distribution and behavior indicates that green sturgeon make generally northern migrations—even occurring in numbers off Vancouver Island (NMFS 2006b). A mixed stock assessment assigned about 70-90 percent of the green sturgeon present in the Columbia River estuary and Willapa Bay to the southern DPS. The stock composition in Grays Harbor is about 40 percent southern DPS (Israel *et al.* 2009).

Life history. Green sturgeon—like all sturgeon—are a long-lived, slow-growing species. Adult green sturgeon typically migrate into freshwater beginning in late February and spawn from March to July. Green sturgeon females produce 60,000-140,000 eggs. Green sturgeon larvae are different from all other sturgeon because they lack a distinct swim-up or post-hatching stage and are distinguished from white sturgeon by their larger size, light pigmentation, and size and shape of the yolk sac. First feeding occurs 10 days after they hatch, and metamorphosis to juveniles is complete at 45 days. The larvae grow fast, reaching a length of 66 mm and a weight of 1.8 grams in three weeks of exogenous feeding. Larvae hatched in the laboratory are photonegative and exhibit hiding behaviors after the onset of exogenous feeding. The larvae and juveniles are nocturnal. Juveniles appear to spend 1-3 years in freshwater before they enter the ocean (NMFS 2006b).

Green sturgeon are the most marine-oriented of North American sturgeon species. Juveniles are able to enter estuarine waters after only 1 year in freshwater. While rearing in freshwater, 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 (NMFSe). 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 percent, 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 nonnatal 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 LCR are most likely feeding, but, to date, all stomachs examined (n>50) have been empty (Rien as cited in Grimaldo and Zeug 2001).

Green sturgeon disperse widely in the ocean between their freshwater life stages. Tagged fish from the Sacramento River have been captured primarily to the north in coastal and estuarine waters. While there is some bias associated with this information (which was retrieved primarily from commercial fishing), a northern migration is also supported by the large concentrations of green sturgeon entering the Columbia River estuary, Willapa Bay, and Grays Harbor. These fish tend to be immature; however, some mature fish and at least one ripe fish have been found in the LCR (Adams *et al.* 2002).

Spatial Structure and Diversity. The only known spawning population of green sturgeon in the southern DPS is found in the Sacramento River. Based upon observations incidental to winter-run Chinook monitoring at the Red Bluff Diversion Dam, Tehama County, green sturgeon adults and juveniles occur throughout the upper Sacramento River. Adult green sturgeon have been observed in the Feather River (Beamesderfer *et al.* 2005) and are thought to also enter the Bear River, a tributary of the lower Feather River (Corps, BPA, USBR 2007). However, there are no confirmed reports of green sturgeon reproduction in the Feather River. The CDFG (2002) reported that Oroville Dam limits access to potential spawning habitat, and warm water releases from the Thermalito Afterbay reservoir may increase temperatures to levels that are unsuitable for spawning and incubation in the Feather River. Adult green sturgeon have also been captured in the San Joaquin River Delta (Adams *et al.* 2002). Moyle *et al.* (1992) suggested the presence of green sturgeon in the delta is evidence that green sturgeon are spawning in the San Joaquin River. However, there are no documented observations of green sturgeon in the San Joaquin River upstream of the delta.

Diversity in green sturgeon populations can range in scale from genetic differences within and among populations to complex life-history traits. One of the leading factors affecting the diversity of the southern DPS of green sturgeon is the loss of habitat due to impassable barriers such as dams. As described above, several tributaries to the Sacramento River have been blocked and have therefore almost certainly reduced the DPS' diversity. Although this DPS migrates over long distances, its spawning locations are small and have been greatly affected by human activities.

Abundance and Productivity. Juvenile entrainment data from the Sacramento-San Joaquin Delta pumping facilities of the Central Valley Project and State Water Project provide an indication of how green sturgeon abundance has changed since 1968. The estimated average number of green sturgeon entrained and killed each year at John Skinner Fish Facility prior to 1986 was 732; from 1986 on, the average number decreased to 47. At the Tracy Fish Collection Facility, the average prior to 1986 was 889; from 1986 on the number decreased to 32 (NMFS 2006b). A substantial decrease in entrainment of green sturgeon was seen at both facilities. Furthermore, the decrease in numbers of green sturgeon entrained in these facilities occurred while water export levels at both facilities have increased substantially, i.e., more water was pumped but fewer green sturgeon were entrained.

Quality data on current population sizes and trends for green sturgeon does not exist. 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 percent 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.

Limiting Factors. 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 2006b). 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 2006b).

Southern Resident Killer Whales.
The southern resident killer whale DPS was listed as endangered under the ESA on November 18, 2005 (NMFS 2005c).

Description and Geographic Range. Killer whales are the world's largest dolphins and the listed Southern Resident DPS overlaps in range in the northeastern Pacific Ocean with other whale populations classified as transient, resident, and offshore populations. The southern resident killer whale DPS consists of three pods, identified as J, K, and L pods. 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. 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).

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). 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. 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. 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). There have been four sightings of Southern Resident killer whales within the Columbia River plume (NMFS 2008c). The information on the rangewide status of the species is generally representative of the status of the species in coastal waters.

Life History. Southern resident killer whales are a long-lived species, with late onset of sexual maturity (NMFS 2008c). Females produce a low number of surviving calves over the course of their reproductive lifespan (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.

NMFS (2008) summarized information regarding the diets of Southern Resident killer whales. Southern Resident killer whales are known to consume 22 species of fish and one species of squid. A long-term study of southern resident killer whale diet identified salmon as their preferred prey (97 percent of prey consumed during spring, summer and fall). 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 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.

Spatial Structure and Diversity. The Southern Resident killer whale DPS is composed of a single population that is found throughout the coastal waters of Washington, Oregon, and Vancouver Island and known to travel as far south as central California and as far north as Chatham Strait, Southeast Alaska. From late spring to early autumn, Southern Residents spend considerable time in the Salish Sea; with concentrated activity around the San Juan Islands, and then move south into Puget Sound in early autumn. Pods make frequent trips to the outer coast during this time. Although the entire Southern Resident killer whale DPS has the potential to occur along the outer coast at any time during the year, occurrence along the outer coast is more likely from late autumn to early spring.

The estimated effective size of the population (based on the number of breeding individuals under ideal genetic conditions) is very small, <30 whales or about 1/3 of the current population size (Ford et. al. 2011b). The small effective population size, the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration (Ford *et al.* 2011b). In addition, the small effective population size may contribute to the lower growth rate of the Southern Resident population in contrast to the Northern Resident population (Ford *et al.* 2011b, Ward *et al.* 2009).

Abundance and Productivity. As of the 2011 census, there were 26 whales in J pod, 20 whales in K pod and 42 whales in L pod, for a total of 88 whales. The historical abundance of Southern Resident killer whales is estimated from 140 whales (based on removals of animals for public display; (Olesiuk *et al.* 1990) up to 400 whales as used in population viability analysis (PVA) scenarios (Krahn *et al.* 2004). Over the last 28 years (1983-2010), population growth has been variable, averaging 0.3 percent per year (standard deviation ± 3.2 %, [NMFS 2011b].

A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3 percent for 28 years (NMFS 2008c). In light of the recent average growth rate of 0.3 percent, this recovery criterion has not yet been met (NMFS 2011b) and the recent low population growth rate is not sufficient to achieve recovery. There are also several demographic factors of the southern resident population that are cause for concern, namely the small number of breeding males (particularly in J and K pods), reduced fecundity, decreased sub-adult survivorship in L pod, and the total number of individuals in the population (NMFS 2008c).

Limiting Factors. The final recover plan for southern resident killer whales identifies several factors that may be limiting recovery (NMFS 2008c). These are quantity and quality of prey (particularly their primary prey, Chinook salmon), exposure to toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting in concert to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of southern residents, all of the threats identified are potentially limiting improvements in their population dynamics (NMFS 2008c).

2.2.2 Status of Critical Habitat

We review the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

2.2.2.1 Salmon and Steelhead

The ESA requires NMFS to designate critical habitat, to the maximum extent prudent and determinable, for species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time of listing if the agency determines that the area itself is essential for conservation.

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support[3]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTS); evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited

[3] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NMFS 2003).

availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

NMFS has designated critical habitat for 12 of the 13 salmon and steelhead species that may be affected by the proposed action. Critical habitat includes the stream channels within the designated stream reaches, and extends laterally to the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Critical habitat in lake areas is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of ordinary high water, whichever is greater. In estuarine and nearshore marine areas, critical habitat includes areas, contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters relative to mean lower low water. 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.

Critical habitat designations for Snake River basin ESUs (SR spring/summer Chinook, SR fall Chinook, and SR sockeye) were defined in (NMFS 1993) for all SR mainstem and tributary subbasins occupied by these respective species. Critical habitat was also designed for the Columbia River mainstem migration corridor for each of these ESUs as follows: "The Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) and including all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake River.." Because the Odessa proposed action will have no effect to critical habitat areas in the Snake River basin outside of the Columbia River migration corridor, this opinion will not list those critical habitat areas or discuss them further.

Critical habitat was designated for the Snake River steelhead DPS and all other listed upper Columbia River, middle Columbia River, lower Columbia River (except coho salmon), and Willamette River anadromous salmonid ESUs and DPSs in September 2005 (NMFS 2005a). Designation of critical habitat for the LCR coho salmon ESU is currently under development by NMFS.

As part of the designation process NMFS convened CHARTs to evaluate the current status of the ESU's habitat and identify threats to habitat health. [4] In determining which areas should be critical habitat, the CHARTs identified the PCEs that are essential for the conservation of the species. PCEs for these ESUs and DPSs are those sites and habitat components that support one or more life stages, including (1) freshwater spawning sites, (2) freshwater rearing sites, and (3) freshwater migration corridors. The ESUs addressed in the final critical habitat rule and CHART reports share many of the same rivers and estuaries and have similar life history characteristics and, therefore, many of the same PCEs. These PCEs include sites essential to support one or more life stages of the ESU (sites for spawning, rearing, migration and foraging). These sites in turn contain physical or biological features essential to the conservation of the ESU (for example, spawning gravels, water quality and quantity, side channels, forage species).

---

[4] The lower and upper Columbia River CHART's assessment reports are available at NMFS' website at http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/2005-Biological-Teams-Report.cfm.

NMFS identified the following PCEs for the twelve ESUs and DPSs of Columbia basin salmonids for which it designated critical habitat in 2005 (NMFS 2005a).

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

The CHART identified habitat-related human activities that affect PCE quantity and/or quality. The primary categories of habitat-related activities identified by the CHART are (1) forestry, (2) agriculture, (3) channel modifications/diking, (4) road building/maintenance, (5) urbanization, (6), dams, (7) irrigation impoundments and withdrawals, and (8) wetland loss/removal. All of these activities have PCE-related impacts because they have altered one or more of the following: stream hydrology, flow and water-level modifications, fish passage, geomorphology and sediment transport, temperature, dissolved oxygen, vegetation, soils, nutrients and chemicals, physical habitat structure, and stream/estuarine/marine biota and forage.

At the time critical habitat designations became final (September 2005), NMFS' 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. Of the 525 watersheds evaluated, 382 were assigned a high rating, 93 a medium rating, and 50 a low rating. Many of the high value watersheds encompassed the mainstem Columbia River migration corridor due to its importance to both juvenile and adult salmon and steelhead populations. The CHART reports all noted that, "After reviewing the best available scientific data for all of the areas within the freshwater and estuarine range of Columbia River basin salmon and steelhead, the CHART concluded that the Columbia River corridor was of high conservation value to the respective ESUs and DPSs. The CHART reports noted that this corridor connects every watershed and population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a particularly important area for salmon and steelhead as both juveniles and adults make the critical physiological transition between life in freshwater and marine habitats" (ISAB 2000, Marriott *et al.* 2002).

NMFS (2005a) designated all sections of the Columbia River from its confluence with the Okonagan River to the Pacific Ocean as critical habitat for one or more of the salmonid ESUs considered in this opinion. . The essential features of freshwater rearing areas are water quality, water temperature, cover/shelter, riparian vegetation and food. The essential features of freshwater migration corridors potentially affected by the proposed action are substrate, water quality, water velocity, temperature, riparian vegetation, food, and cover/shelter.
Similar to the Snake River basin discussed above, the Odessa proposed action will not have adverse effects to critical habitat areas in tributary subbasins of the Columbia River because these are outside of the hydrologic influence of the proposed action. As a result, this opinion will not list tributary critical habitat areas or discuss them further. The effects analysis performed in Section 2.4 below will analyze the effects to critical habitat for the Columbia River migration corridor, including the estuarine habitat in the lower Columbia River, only. The following section briefly defines the boundaries and stream lengths for the Columbia River migration corridor that are likely to be affected by the proposed action for each salmon ESU and DPS with designated critical habitat. The habitat area definitions and designated stream lengths were taken from the 2005 NMFS CHART report (NMFS 2005d). 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 under a separate rule making process. Ratings for the LCR coho salmon ESU are currently under development.

Upper Columbia River Spring Chinook
Designated critical habitat within the Columbia River extends from the mouth of the Methow River downstream to the Pacific Ocean.

Upper Columbia River steelhead
Designated critical habitat within the Columbia River extends from the mouth of the Methow River downstream to the Pacific Ocean.

Middle Columbia River steelhead
Designated critical habitat within the Columbia River extends from the mouth of the Yakima River downstream to the Pacific Ocean.

Snake River steelhead
Designated critical habitat within the Columbia River extends from its confluence with the Snake River to the Pacific Ocean.

Columbia River Chum
Designated critical habitat within the Columbia River extends from its confluence with the White Salmon River to the Pacific Ocean. Columbia River chum also spawn in the Columbia River, their critical habitat includes freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.

Lower Columbia River Chinook
Designated critical habitat within the Columbia River extends from its confluence with the Hood River to the Pacific Ocean.

Lower Columbia River coho
Critical habitat has not been designated for LCR coho salmon at this time.

Lower Columbia River steelhead
Designated critical habitat within the Columbia River extends from its confluence with the Hood River to the Pacific Ocean.

Upper Willamette Chinook
Designated critical habitat within the Columbia River extends from its confluence with the Willamette River to the Pacific Ocean.

Upper Willamette River steelhead.
Designated critical habitat within the Columbia River extends from its confluence with the Willamette River to the Pacific Ocean.

2.2.2.2 Non-Salmonid Species

Southern DPS Pacific Eulachon
On October 20, 2011 NMFS published a rule designating critical habitat for Pacific eulachon (NMFS 2011c). Within the action area, the lower Columbia River from the mouth upstream to Bonneville Dam is designated as critical habitat, and, along with its tributaries, is noted to support the largest known spawning run of eulachon.

Essential Features. In developing critical habitat, NMFS developed a list of physical or biological features essential for conservation of Pacific eulachon, including:
Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubations

Freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted

Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. (Juveniles -phytoplankton, copepod eggs, copepods, and other small zooplanktons; Adults - euphausiids and copepods)

Of these, the mainstem of the lower Columbia in the action area provides 1) spawning and incubation sites and 2) a large migratory corridor to spawning areas in the tributaries (NMFS 2011c).

Southern DPS Green Sturgeon
Critical habitat was designated for the southern DPS of green sturgeon on October 9, 2009 (NMFS 2009b). It includes about 320 miles of freshwater river habitat, 897 square miles of estuarine habitat, 11,421 square miles of marine habitat, 487 miles of habitat in the Sacramento-San Joaquin Delta, and 135 square miles of habitat within the Yolo and Sutter bypasses (Sacramento River, California). The critical habitat designation includes the Columbia River estuary below RM 46, the maximum extent of saltwater intrusion, and coastal waters within the 60-fathom depth, including the Columbia River plume.

Primary Constituent Elements. As part of our designation process, NMFS convened CHARTs to identify habitat features essential to the conservation of the species and provide a biological assessment of these features within the range of the species. The CHART recognized that the different systems occupied by green sturgeon at specific stages of their life cycle serve distinct purposes and thus may contain different PCEs. The CHART identified the following PCEs for freshwater riverine systems, estuarine areas, and coastal marine waters:

- For freshwater riverine systems:
  - (1) abundant food resources
  - (2) substrate of proper type or size
  - (3) water flows
  - (4) water quality
  - (5) migration corridors
  - (6) habitat depth
  - (7) sediment quality

- For estuarine habitats:
  - (1) food resources
  - (2) water flow
  - (3) water quality
  - (4) migration corridors

(5) habitat depth
(6) sediment quality

- For nearshore coastal marine habitats:
  (1) migration corridors
  (2) water quality
  (3) food resources

Of the estuarine habitat area, PCEs that are potentially affected by the proposed action, the mainstem of the lower Columbia in the action area provides water flow and a migratory corridor.

Southern Resident Killer Whale
Critical habitat for the Southern Resident killer whale DPS was published November 29, 2006 (NMFS 2006c). Critical habitat includes about 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. Based on the natural history of the southern residents and their habitat needs, NMFS 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
(3) passage conditions to allow for migration, resting, and foraging.

Southern Resident critical habitat does not occur in the coastal waters near the Columbia River. As such, designated critical habitat does not overlap with the action area considered for this consultation, nor are there any discernable changes to the physical environment that occur in this area that could be correlated to the operation of the Odessa Proposed Action. The Proposed Action will not affect critical habitat for southern resident killer whales and will not be considered further in this consultation.

2.3 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

As presented in Section 1.4, the Action Area is defined as including the mainstem Columbia River from John W. Keys III Pump-Generating Plant extending downstream to its confluence with the Pacific Ocean, including the Columbia River estuary and plume. All of the species considered in this opinion occur within a portion of the action area and/or are affected by conditions in the action area (e.g. killer whales are affected by the abundance of Chinook salmon prey, which are affected by conditions in the action area).

2.3.1 Columbia River Basin

The Columbia River watershed occupies an area about 260,000 square miles in the northwestern United States and southwestern Canada and is bounded by the Rocky Mountains to the east and north, the Cascade Range on the west, and the Great Basin to the south (Figure 16). The Columbia River originates at Columbia Lake on the west slope of British Columbia's Rocky Mountains, flows south from Canada into the U.S., and then west to the Pacific Ocean, forming the border between Oregon and Washington. At its mouth near Astoria, Oregon, the Columbia River's total length is about 1,214 miles. The Rocky and Cascade mountain ranges produce numerous tributaries, including several large tributaries including the Kootenai, Flathead and Pend Oreille, Snake, Yakima, and Willamette rivers.

Runoff from forested slopes of the Rocky Mountains in British Columbia, western Montana, and northern Idaho dominates the Columbia Basin's water supply. Most of the annual precipitation occurs in the winter as snow. Basin snowpack melts in the spring and early summer, resulting in heavy, prolonged flows during the summer months with the peak flow usually occurring in mid-June. About 60 % of the natural runoff in the basin occurs May through July. Average annual runoff at the mouth of the Columbia River is about 198 million acre-feet. Within the U.S., only the Missouri-Mississippi River system has more runoff.

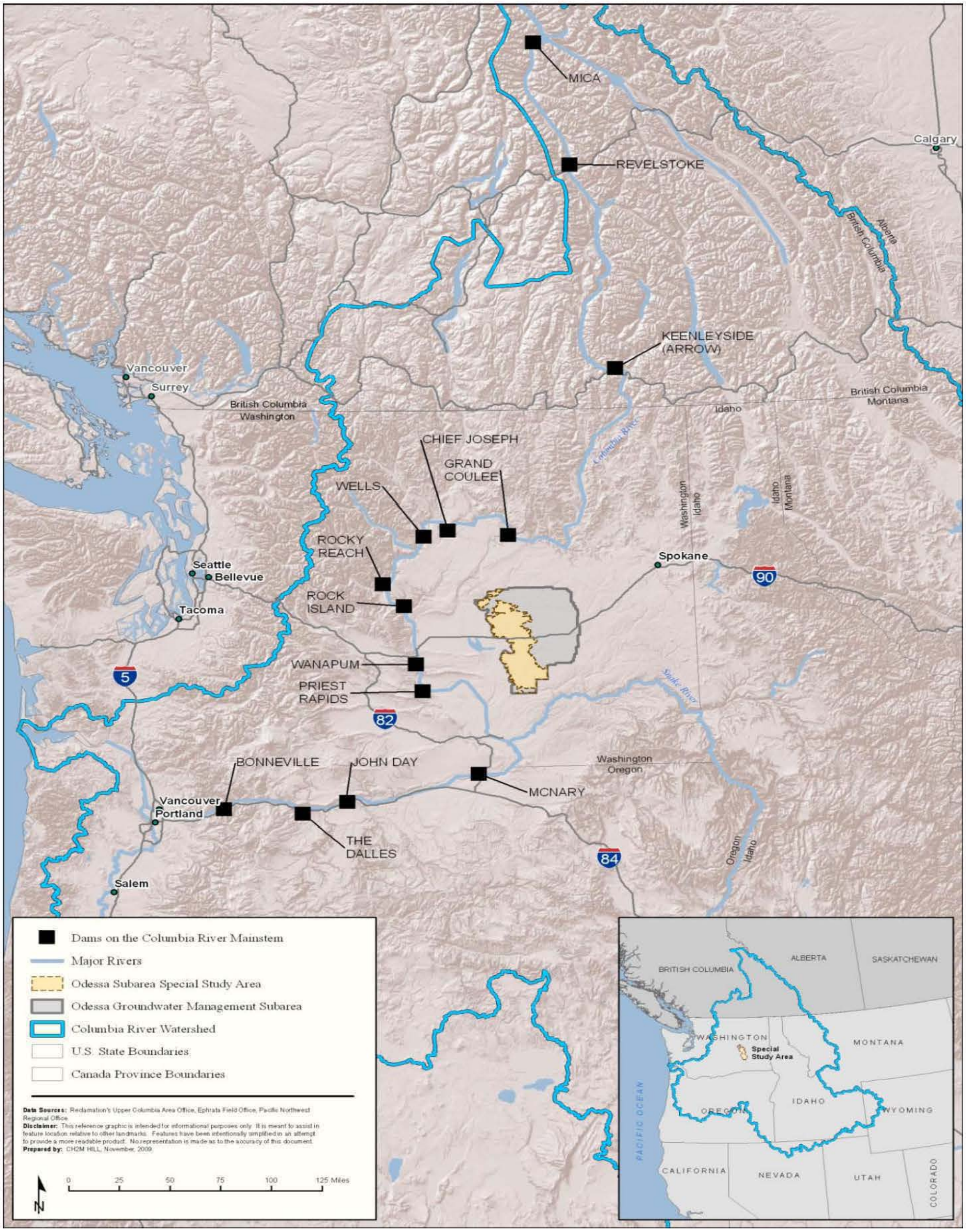


Figure 16.Columbia River basin, showing the mainstem dam locations and the location of the Columbia Basin Project.

Source.(Reclamation 2012a)

2.3.1.1 Columbia River System Development

Water development of the Columbia basin dates to the 1850s. Initially, water was developed primarily to serve irrigated agriculture, primarily via small diversion structures and canals. By the turn of the 20th Century, it was recognized that storage systems were needed to provide water when native flows were insufficient to meet demands. While a handful of dams had been constructed in the basin, passage of the Reclamation Act in 1902 denotes the first wave of large-scale irrigation storage development in the basin. Early on, irrigation storage was developed primarily in Idaho's Snake River valley. By 1920, demand for electricity quickly led to plans to develop the Columbia River's hydroelectric potential. Rock Island Dam, the first hydroelectric dam built on the Columbia River, first produced electricity in 1933. Thus began an era of rapid development, largely by the U.S. Government.

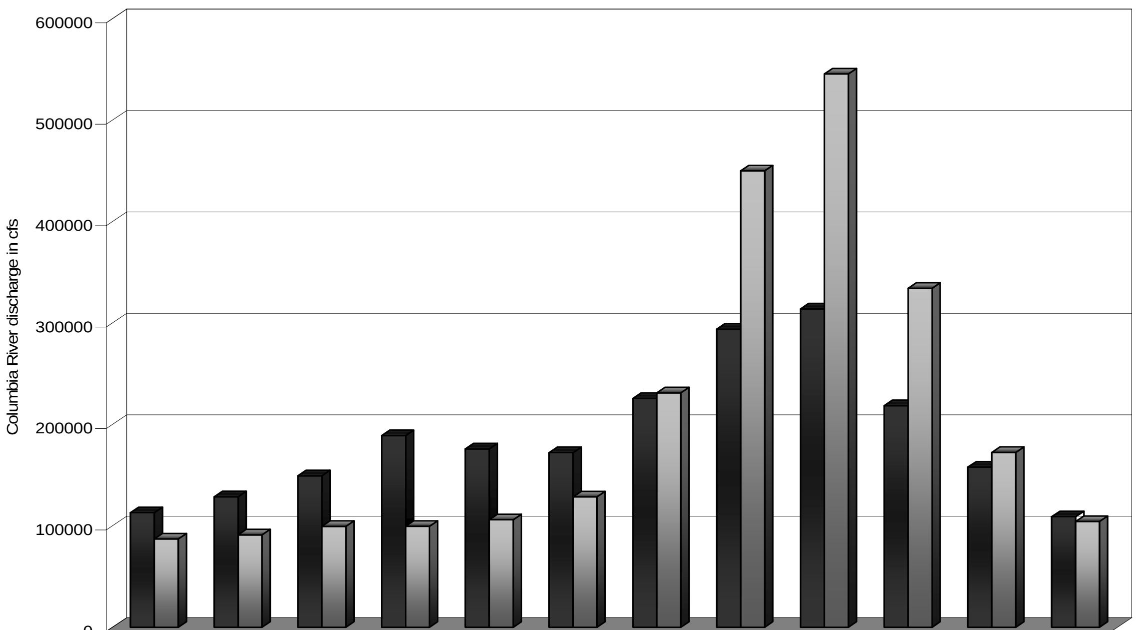
Today, there are nine dams on the U.S. portion of the mainstem Columbia River: Grand Coulee, Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum, Priest Rapids, McNary, John Day, The Dalles, and Bonneville; and three dams on the Canadian portion: Mica, Revelstoke, and Keenleyside. In combination with hydroelectric projects in the Columbia basin's tributaries, a total of 38,670 megawatts of hydroelectric capacity has been installed, providing about 70% of the region's total power generation. Along with hydropower development, large storage reservoirs (often including hydroelectric facilities as well) have been developed to provide higher flows, and thus higher electrical production, during periods of low natural flows and high electrical power and/or high irrigation demands. These facilities range from Jackson Lake, in the headwaters of the Snake River in Grand Teton National Park, Wyoming, to Lake Koocanusa on the Kootenay River straddling the U.S. – Canada border. Altogether, water storage facilities in the Columbia basin have a storage capacity of almost 50 Maf, about one quarter of the river's total annual flow at its mouth (Volkman 1997). In sum, water development in the Columbia basin has resulted in a dramatic change in the river's annual hydrograph (Figure 17), greatly reducing flows during May through July while increasing fall and winter flows.

Currently, water use in the Columbia basin reduces the annual flow at Bonneville Dam by about 12.4 Maf, about 5.5 Maf of which is the consumptive use from Reclamation's 23 irrigation projects in the basin (NMFS 2008b). In aggregate, streamflow depletions have contributed to the decline of Columbia basin salmon species and may pose an impediment to recovery. In 2008, we identified the following adverse effects of spring and early summer flow depletions.

> *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* (NMFS 2008b).

Figure 17 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: NMFS 2008.



	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

Prior to the steep declines in salmon populations in the 1970s and 1980s, water storage reservoirs in the Columbia River basin were operated primarily to serve power generation, water supply, and flood control needs in the basin. Following the listings of Snake River sockeye and Snake River fall Chinook in the early 1990s, FCRPS project operations were modified to improve the survival of migrating juvenile fish. NMFS adopted a set of flow objectives that, when met, would be expected to improve juvenile dam-passage survival and directed the Federal dam operating agencies (Reclamation and the Corps) to modify operations at their large water storage facilities in an attempt to meet those objectives as frequently as possible. As a result, winter drafts for power generation were constrained and unallocated storage volumes in large storage reservoirs were allocated to salmon flow augmentation. Flood control operations at Libby Dam, owned and operated by the Corps, and Hungry Horse Dam, owned by Reclamation, were modified in a manner that increases spring flows in average and below average water years. Reclamation further enhanced summer flows by leasing water in Idaho. In combination with other actions (e.g. voluntary spill and surface passage systems), these actions have had a substantial effect on juvenile fish survival through the Columbia River.

The Hanford Fall Chinook Protection Program Agreement ("protection agreement," Grant PUD 2004) was developed to protect fall Chinook spawning, incubation, and juvenile rearing in the Hanford Reach of the Columbia River. One key feature of this agreement is to limit spawning and redd creation in channel areas that cannot be kept wet throughout incubation by managing flows to minimize fall Chinook spawning above the water elevation occurring at a flow of 70 kcfs at Vernita Bar, a major spawning location downstream from Priest Rapids Dam. The protection level for redds established under the spawning provisions of this agreement can range from 50 to 70 kcfs. The redd protection flow for the rearing season is determined by a final red count in late November. The minimum instantaneous flow required below Priest Rapids Dam under this agreement is 36 kcfs except when maintenance of other operations of the agreement requires a higher flow. The protection agreement also includes provisions to limit flow fluctuations to protect fry while they are rearing in the Hanford Reach.

2.3.1.2 Factors Affecting Juvenile Fish Survival through the Columbia River

Dams within the migratory corridor that were constructed without effective passage systems now serve as the upstream limit of accessible habitat for anadromous fish. Today, the mainstem migratory corridor ends at Chief Joseph Dam on the Columbia River and Hells Canyon Dam on the Snake River. At dams where passage has been provided, they affect fish passage survival, particularly for outmigrating juveniles and steelhead kelts. Efforts to improve juvenile passage survival since dam construction, and especially since listing of most of the Columbia basin's anadromous salmonids beginning in the mid-1990s, have greatly improved juvenile outmigration survival rates (Williams *et al.* 2005).

Migration 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. Dams within the migratory corridor have converted much of the once free-flowing river into a stair-step series of slow pools. Today, median travel times for yearling Chinook from Lower Granite Dam on 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 (Raymond 1979) when fish encountered only the four mainstem dams (Williams *et al.* 2005). Increased travel times (compared to historical conditions) will continue to occur because of slower water velocities caused by the reservoirs and reduced spring flows, and delays associated with passing the dams themselves. The operation of recently constructed surface passage routes (in addition to spilling water through conventional spillbays) at the mainstem Snake and LCR dams appears to have further reduced the travel times of migrating smolts, especially for steelhead smolts (Faulkner *et al*. 2010).

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 and ocean (which likely affects predator/prey relationships),[5] depleting energy reserves, potentially causing metabolic problems associated with smoltification (the process of metabolic, behavioral, and morphological changes required to allow juvenile fish to move from freshwater

[5] 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. Also, the predation rates of avian and fish predators vary seasonally. For example, Caspian terns and double-crested cormorants in the Columbia estuary are known to consume more salmon and steelhead in May than in April (Roby 2011).

to saltwater environments), and for some steelhead and all Chinook salmon, contributing to residualism (a loss of migratory behavior).

Dam Passage Survival

A substantial proportion of juvenile salmon and steelhead can be killed while migrating through dams. Collisions with structures and abrupt pressure changes as they pass through turbines and spillways directly kill and injure fish. Dam passage also kills fish indirectly, through non-fatal injury and disorientation, which leave fish more susceptible to predation and disease. 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 %. Mortality rates for juveniles passing through project spillways, sluiceways and other surface routes are generally the lowest, typically 2% or less. However, substantially higher spillway mortalities have been measured through spillways at several mainstem projects (Ferguson *et al.* 2005).[6] A significant rate of juvenile mortality (about 3-5%) can occur in project forebays, just upstream of the dams (Axel *et al.* 2003; Ferguson *et al.* 2005; Hockersmith 2008), where fish can be substantially delayed (median of 15-20 hours) before passing through the dam (Perry *et al.* 2007).[7] 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).

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 % (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 smolt-to-adult return ratios (SARs) from in-river migrants with different juvenile migration histories showed that, for some stocks in some

---

[6] 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.

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

years, fish bypassed at more than one dam 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 multiply bypassed spring-summer Chinook salmon and hatchery steelhead had lower SARs 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). 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 these spillway gates, 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, resulting in higher densities of smolts and predatory fishes near the dams. To reduce delay, surface bypass systems have been installed at all of the mainstem Columbia and Snake River dams in the migratory corridor except Wells and Rock Island dams on the Columbia River. Surface passage is provided by – removable spillway weirs (RSWs), temporary spillway weirs (TSWs), and surface bypass channels, including ice and trash sluiceways and corner collectors.

Where available, surface passage routes (systems that pass water and fish directly from the surface of the forebay) 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).

Restoring and improving fish passage is one of NMFS' primary recovery strategies and providing surface passage routes for outmigrating juveniles has been a focus of dam passage improvement over the past decade.

Juvenile Salmon Transportation Program

In 1975, following a decade of research that led to the conclusion that 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 (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.

About 60-90% of spring migrating smolts (spring/summer Chinook and steelhead) in the Snake River basin are transported annually (Table 5), although almost all fish (99%) were transported during the low water year conditions of 2001 (Williams *et al.* 2005). By 2007, new surface passage systems and court-ordered spill operations substantially reduced transport rates. About 37% of yearling spring Chinook and 41% of steelhead smolts were transported between 2007 and 2011. (Faulkner 2012).

Measures Currently in Place to Improve Juvenile Passage Survival
Among the measures taken to improve juvenile salmon passage survival at mainstem dams have been improvements in operations (e.g. spill, spill patterns), modifications to dam works (e.g. surface spill systems, improved [fish friendly] turbine runners, turbine screens and juvenile bypass systems), predator control programs, and juvenile collection and transportation systems to avoid dam passage. Other operational changes have been developed to increase flows during the juvenile passage season (April through August) by requiring large storage reservoirs to be near their upper rule curve elevation [8] by April 10 for the spring migration period (April 10 to June 30) and near full by July for the summer migration period (July 1 to August 31). In addition, specified volumes are drafted from several reservoirs, including Lake Roosevelt, Dworshak Reservoir, the upper Snake River (several Reclamation reservoirs and leases), Lake Koocanusa, and Hungry Horse Reservoir. A total of about 4.3 Maf of water stored in these reservoirs annually are delivered for flow augmentation within the action area during the summer juvenile migration season.[9] About 2.6 Maf of this volume comes from upper Columbia River storage, of which 1.0 Maf is Canadian storage.

2.3.1.3 Factors Affecting Adult Fish Survival through the Columbia River

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 all of the dams in the migratory corridor - the eight mainstem FCRPS projects in the lower Columbia and lower Snake 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 and dam passage survival is very high. Measured as numbers observed at Bonneville Dam and at McNary Dam and corrected for known harvest and estimated straying rates, adult conversion rates for steelhead and Chinook salmon observed in 2011 range from about 81% for Snake River spring-summer Chinook to nearly 94% for Upper Columbia River steelhead. Nonetheless, salmon may have difficulty finding ladder entrances,

[8] The U.S. Army Corps of Engineers has established storage limits for winter operations to ensure that adequate storage is available to limit the damage from potential flooding. These rule curves vary by month and anticipated runoff, typically reaching their lowest storage level by April 1.
[9] By mutual agreement, portions of this flow augmentation water (up to about 0.4 Maf) may be delivered in September for an array of purposes.

and fish 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, by 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 turbine-passage 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 higher through these systems than through turbine units, and 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 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.

Delay, Fallback and Reascension

Migrating adults are also affected by changes in flow. At high spill rates, adults may delay entering fish ladders as high flows mask the signals from fishway entrances. Caudill *et al.* (2007) showed that adult passage delay reduced the likelihood of survival to spawning. High flows also increase the incidence of fallback. Fallback is a fish behavior in which an adult is observed passing a dam more than once. Falling back has also been shown to decrease the likelihood of survival to spawning (Boggs *et al.* 2004) and is a likely contributor to the survival effects noted by Caudill *et al.* (2007).

2.3.1.4 Mainstem Water Quality

Water quality characteristics of the Columbia River are affected by an array of land and water use developments. Water quality characteristics of particular concern to species considered in this opinion are: water temperature, turbidity, total dissolved gas, and chemical pollutants.

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 Columbia River (Figure 18).[10] As shown in Figure 18, 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.

[10] 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.

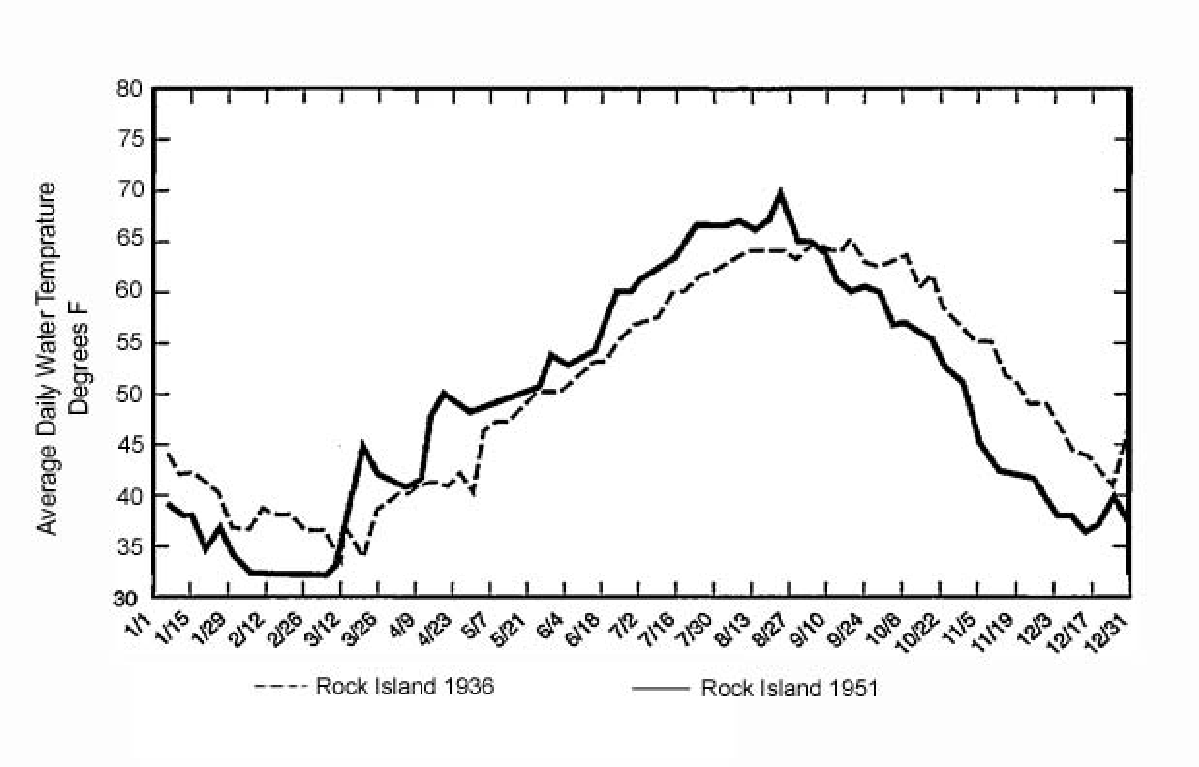


Figure 18. Annual temperature cycles at Rock Island Dam on the Columbia River before (1936) and after (1951) Grand Coulee Dam was in operation.
Source: Coutant 1999.

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 rates of predatory fish thereby increasing the consumption of smolts. Spawn timing is also highly dependent on water temperatures and delayed fall cooling may delay adult migration and spawning.
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.

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 2007). The influence of this and other large-scale environmental variations are discussed in Section 2.3.3 of this document.

Turbidity
Flow regulation and reservoir existence reduces turbidity in the Columbia River. Reduced turbidity can increase predator success through improved prey detection and increased foraging distances. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia River migratory corridor.

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 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 19, if the dissolved gas is recorded as 120% of saturation at the surface, then the concentration at 0.5 m is reduced to 115% of saturation and by 2 m depth, TDG falls to 100% of saturation. Thus, fish at depth benefit from depth compensation.

TDG Control Efforts. Current reservoir operations typically limit gas-generating, high-spill events to a few days or weeks during high-flow years. (Figure 19) 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.

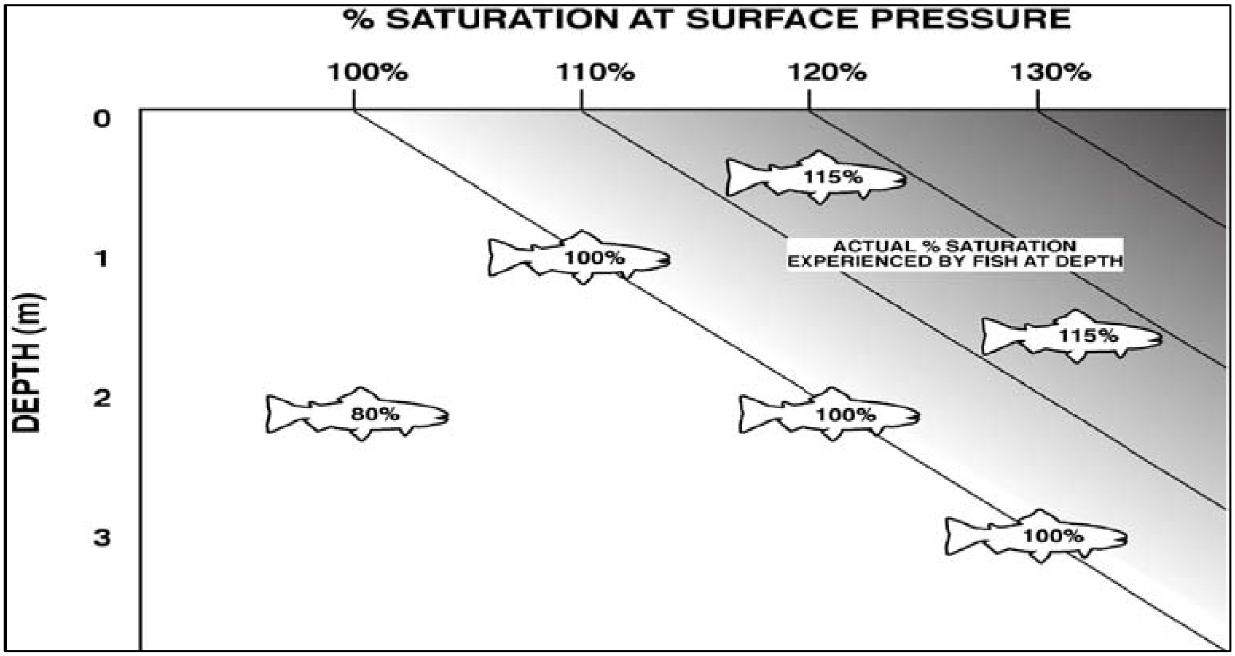


Figure 19. Compensatory effects of depth (hyperbaric pressure) on fish exposed to supersaturated water

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 basin 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.

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 2001). This data also indicates that juvenile salmonids in the Columbia River estuary have contaminant body burdens in the range where laboratory studies show that sublethal effects can 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 on fish survival and/or condition due to exposure to pollutants in the Columbia River and estuary is likely.

2.3.1.5 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).

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). 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 by delaying and concentrating juveniles. Northern pikeminnow predation throughout the Columbia River 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 concentrated in the LCR from The Dalles reservoir downstream, where about 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 about 200 million hatchery and wild juvenile salmonid migrants in the system annually.

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 Bonneville Power Administration (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 about 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 about 4 million fewer juvenile salmonids consumed by pikeminnow each year.

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 2000b). 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 2000b). 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 2000b).

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, studies that are more recent have indicated that there are smallmouth bass hotspots (e.g., The Dalles Dam tailrace) that may be worth further investigation for predator management options.

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 2000b). 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 LCR. In 1998, Collis *et al.* (2003) estimated that Caspian terns nesting on Rice Island consumed about 12.4 million juvenile salmonids, or about 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, about 15 miles downstream and near the ocean and a wider prey base, which resulted in a successful reduction in predation of juvenile salmonids by about 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, about 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). About 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 Passive Integrated Transponder (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 about 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 about 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).

Pinniped Predation

The overall abundance of pinnipeds (California sea lions and Steller sea lions) on the west coast has increased since the mid-1970s is expected to continue doing so for the foreseeable future (Angliss and Allen 2009). It is clear that salmon and steelhead contribute substantially to the diets of pinnipeds in the lower Columbia River and estuary – especially in the spring and late-summer and fall seasons when Chinook salmon are most abundant (Scordino 2010), but because the proportion of the pinniped populations that reside in the LCR and estuary is not known, the impact to ESA listed salmon and steelhead cannot be quantified. However, based on their foraging habits and generally increasing numbers, NMFS expects that salmon and steelhead losses will continue to increase slightly until pinniped populations reach their carrying capacity.

A more quantified assessment of impacts is possible in the Columbia River immediately downstream of Bonneville Dam. Marine mammal predation has increased dramatically during the 2000s in the tailrace below Bonneville Dam (Keefer et al. 2012 and Stansell et al. 2012).

Since 2003, a minimum of between 82 to 166 individual pinnipeds, primarily California sea lions with a few Stellar sea lions, have been observed feeding immediately below the dam, often near the powerhouse fishway entrances. The abundance of California sea lions decreased from a high of 104 individuals in 2003 to a recent low of 39 individuals in 2012. Steller sea lion abundance has generally increased during the same period of time and has ranged from 73 to 89 individuals the past three years (2010 to 2012). A few Harbor seals (0 to 3) have been observed each year as well (Stansell et al. 2012).

Stansell et al. (2012) estimated, based on visual observations of adult fish consumption downstream from Bonneville Dam and adult fish ladder counts, that pinnipeds consumed between 2.4% and 4.7% of the adult salmonids passing the dam between January 1 and May 31 (2006 and 2010). The estimated adult losses decreased in 2011 to 1.8%, and decreased again in 2012 to 1.4%. The great majority of these adults are known to be spring Chinook salmon, with winter run steelhead also being affected (Keefer et al., 2012 and Stansell et al., 2012).

Keefer et al. (2012) re-evaluated previous radio-telemetry data (1996-1998, 2000-2004, 2006-2007, and 2009-20010) from 100s of adult spring and summer-run Chinook salmon released downstream of Bonneville as an alternative means of assessing the losses of adult salmon to pinnipeds feeding immediately below Bonneville Dam. They estimated that prior to 2002, an average of 98.4% of tagged adult Chinook salmon entered the Bonneville tailrace and 98.9% of these fish successfully passed upstream of the dam. Beginning in 2002, and average of 96.3% entered the tailrace area and 97.8% successfully passed upstream. The average difference between the two period indicates that losses to pinnipeds may be around 3.6% from the downstream release point to the Bonneville tailrace) and about 2.2% from the tailrace to the fishways. The latter tailrace to fishway estimates are on the low end of the total consumption estimates based on visual observations (Keefer et al., 2012 and Stansell et al., 2012). Keefer et al. (2012) found that predation risks differ amongst Chinook salmon populations because of differences in run timing (exposure to pinnipeds) with the highest proportional predation rates occurring in the winter (defined in the study as January 1 to March 18) or early spring migrants (late March and early April).

Recent attempts to reduce pinniped predation by hazing and by installing excluder devices at fishway entrances have met with limited success. However, NMFS 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 reduce pinniped related impacts to migrating adult spring-run Chinook, compared to recent loss estimates. NMFS reauthorized the lethal removal of certain individually identifiable California sea lions on March 15, 2012 (NMFS 2012a).

In summary, overall pinniped predation has likely increased, but to an unquantifiable extent, and this trend will continue until sea lion populations reach their carrying capacity. Below Bonneville dam, recent losses of spring Chinook and winter steelhead to pinnipeds appears to have leveled off, or is decreasing slightly; likely as a result of hazing / lethal removal efforts and competition between the larger Steller sea lions (which have recently increased in abundance) and the smaller California sea lions (which have recently decreased in abundance). We would expect this trend to continue as long as the hazing / removal program continues to be implemented.

2.3.1.6 Disease

Columbia Basin salmonids co-exist with a range of viruses, bacteria, fungi, and parasites, collectively known as pathogens, which 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 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.

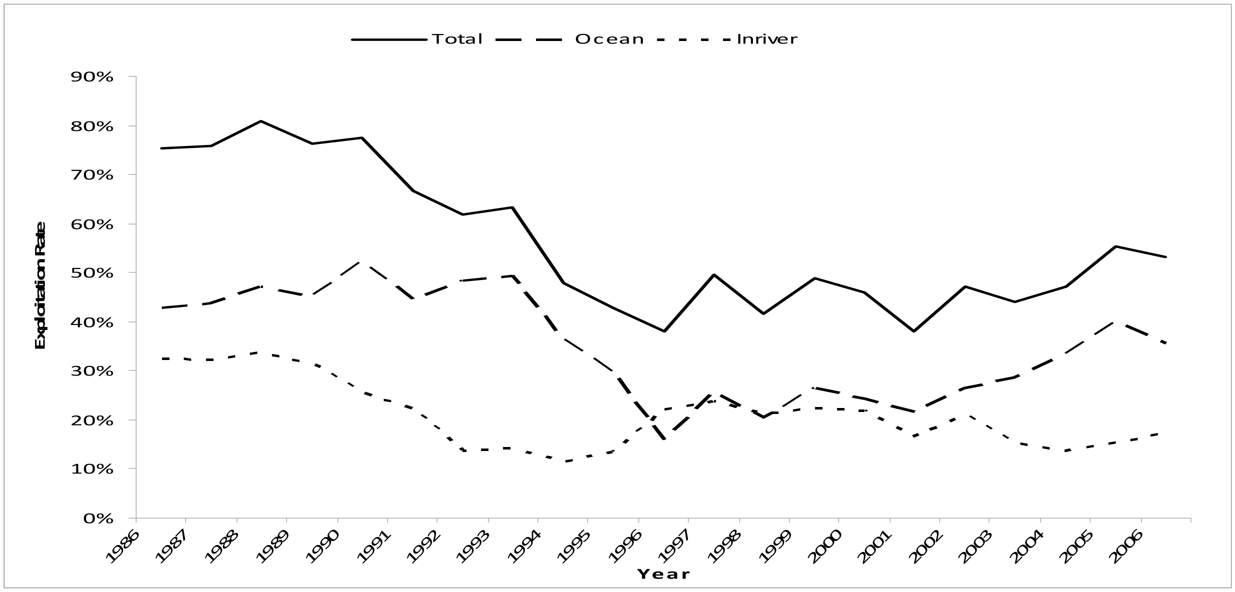
2.3.1.7 Harvest Effects

Salmon are a highly desirable food fish and salmon are harvested both in the Pacific Ocean and as they ascend inland rivers. Harvest rates vary by species and have generally declined since the late 1980s as regulatory controls have increased. As an example, the total exploitation rate of Snake River fall Chinook averaged 75% from 1986 to 1991, and 45% from 1992 to 2006 (Figure 20). Future harvests are expected to remain at the recent lower rates through 2018 (NMFS 2008b)

Historically, excessive harvest, especially in the late nineteenth and early twentieth centuries, was a significant factor in the decline of Columbia River salmon runs and contributed to the current status of the species (NRC 1996).

Figure 20. Ocean and In-river Exploitation Rates for Snake River fall Chinook**.**

Source: NRC 1996.



2.3.1.8 Hatchery Effects

Today, because up to 90% of the inland habitat available to some salmon and steelhead ESUs in the Columbia Basin has been lost or degraded (Brannon *et al.* 2004), fish produced by hatcheries comprise the majority of the annual returns to the basin for some species (CBFWA 1990).

The primary purpose of the nearly two hundred hatchery programs that operate in the Columbia Basin is to compensate for fish production losses caused by Federal, 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, hatchery programs have increased 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, NMFS requires the submission of new Hatchery Genetic Management Plans (HGMPs) and evaluates those plans to ensure such risks are minimized.

2.3.2 Factors Affecting Fish Survival in the Columbia Estuary and Plume

2.3.2.1 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 about 4 miles seaward and the Washington coastline about 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.* 2005). 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 if estuarine habitat provides 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), these changes are likely to have had a negative effect on fish condition and survival. 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.

2.3.2.2 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. Although modeling studies have shown how Columbia River flows affect the structure of the plume during outmigration periods, critical threshold flows are uncertain. Research is ongoing to document important relationships between juvenile salmon growth and survival during this stage of their life history.

2.3.3 Factors Likely to Affect the Status of the Species in the Future

This section considers the likely changes in the environmental baseline that could affect the species considered in this opinion over the foreseeable future. We project anticipated conditions in the environmental baseline as far as currently available information allows, about 70 years. Primary among the conditions likely to change over the life of the action are the climate, ocean acidification, and the human population. The sections below identify the anticipated changes in the environmental baseline and the likely effects of those changes on the species considered in this opinion.

2.3.3.1 Climate Change Limiting Factors and Threats

Likely changes in temperature, precipitation, wind patterns, and sea level height have implications for survival of Lower Columbia River salmon and steelhead in both their freshwater and marine habitats.

Effects of Climate Change on Salmon and Steelhead

NMFS’ most recent synopsis of anticipated climate changes and their likely effect on salmon survival and recovery in the Columbia basin was most recently described in the Lower Columbia

River Recovery Plan (NMFS 2012b, Section 4.7). This information is summarized in the following paragraphs.

Freshwater Environment. Climate records show that the Pacific Northwest has warmed about 1.0 °C since 1900 or about 50% more than the global average warming over the same period. The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1 to 0.6 °C per decade. Although total precipitation changes are predicted to be minor (+ 1 to 2 %), increasing air temperature will alter the snowpack, stream flow timing and volume, and water temperature in the Columbia Basin. Climate experts predict the following physical changes to rivers and streams in the Columbia Basin:

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snowpack will diminish, and stream flow volume and timing will be altered. More winter flooding is expected in transient[11] and rainfall-dominated basins.

Historically transient watersheds, such as those in which Gorge and some Cascade populations spawn and rear, will experience lower late summer flows. Figure 21-A shows the expected pattern of streamflow in the White Salmon River, which is a transient watershed that currently exhibits a November-December peak hydrograph caused by rain and an April-May peak that is associated with melting snow. In future years, the April-May snowmelt-driven peak is expected to be greatly reduced or eliminated. Figure 21-B shows the expected pattern of flows in the Kalama River, which is more rainfall-driven and currently does not exhibit a distinct spring peak. Future flows are expected to increase in the winter and decrease in the spring, but the general rainfall-driven pattern will continue. Figure 21-C shows the flow pattern in the Columbia River at Bonneville Dam. The mainstem Columbia River hydrograph is strongly influenced by spring snowmelt in Canada and in the western Rocky Mountains. In the future, the spring freshet is expected to occur earlier, with fall and winter flows increasing, and summer and early fall flows decreasing.

[11] Transient watersheds have streamflow that is strongly influenced by both direct runoff from rainfall and springtime snowmelt because surface temperatures in winter typically fluctuate around the freezing point. Over the course of a given winter, precipitation in transient watersheds frequently fluctuates between snow and rain depending on relatively small changes in air temperature (Mantua *et al.* 2009).

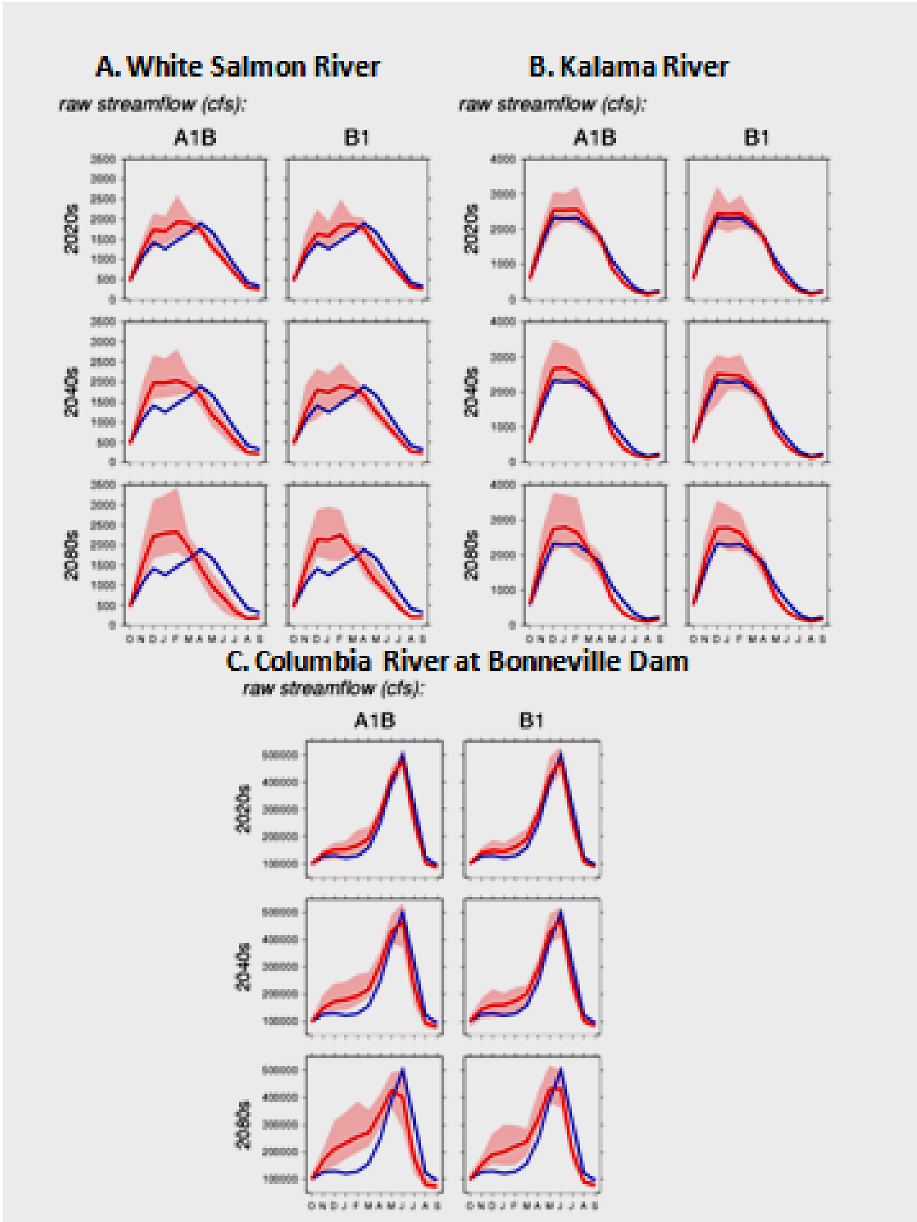


Figure 21A,B & C. Projected average monthly streamflow (cfs) for the White Salmon River (A), the Kalama River (B), and Columbia River at Bonneville Dam (C)

Historical average streamflow is shown in blue and the projected streamflow for the 2020s, 2040s and 2080s is shown in red, along with a shaded range of simulation results. Projections are made under two anthropogenic aerosol and greenhouse gas emission scenarios: A1B corresponds to "moderate" and B1 corresponds to "low" emissions during the 21st century. Figures are from the University of Washington Climate Impacts Group and are available at: http://www.hydro.washington.edu/2860/products/sites

> Summer and fall water temperatures will continue to rise, with an increase of less than 1 °C expected by the 2020s but an increase of 2 to 8 °C predicted by the 2080s. By the 2080s, the number of subbasins with a maximum weekly water temperature that exceeds 21.5 °C is expected to double, and thermal barriers greater than 21 °C are expected to increase in duration from 1 to 5 weeks in the 1980s to 10 to 12 weeks in the 2080s.

These changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon and steelhead distribution, behavior, growth, and survival. Although the magnitude and timing of these changes currently are poorly understood and specific effects are likely to vary among populations, the following effects on listed salmon and steelhead in freshwater are likely:

- Winter flooding in transient and rainfall-dominated watersheds may scour redds, reducing egg survival.

- Warmer water temperatures during incubation may result in earlier fry emergence, which could be either beneficial or detrimental, depending on location and prey availability.

- Reduced summer and fall flows may reduce the quality and quantity of juvenile rearing habitat, strand fish, or make fish more susceptible to predation and disease.

- Reduced flows and higher temperatures in late summer and fall may decrease parr-smolt survival.

- Warmer temperatures will increase metabolism, which may either increase or decrease juvenile growth rates and survival, depending on availability of food.

- Overwintering survival may be reduced if increased flooding reduces suitable habitat.

- Timing of smolt migration may be altered such that there is a mismatch with ocean conditions and predators.

- Higher temperatures during adult migration may lead to increased mortality or reduced spawning success as a result of lethal temperatures, delay, increased fallback for Gorge populations at Bonneville dam, or increased susceptibility to disease and pathogens.

The degree to which phenotypic or genetic adaptations may partially offset these effects is being studied but currently is poorly understood.

Estuarine Environment. Climate change also will affect salmon and steelhead in the estuarine and marine environments. Effects of climate change on salmon and steelhead in estuaries include the following:

- Warmer waters in shallow rearing habitat may alter growth, disease susceptibility, and direct lethal or sublethal effects.

- Increased sediment deposition and wave damage may reduce the quality of rearing habitat because of higher winter freshwater flows and higher sea level elevation.

- Lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of salmonid prey and predators.

- Increased temperature of freshwater inflows and seasonal expansion of freshwater habitats may extend the range of warm-adapted non-indigenous species that are normally found only in freshwater.

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

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

These continuing changes are expected to alter primary and secondary productivity, the structure of marine communities, and in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids currently is poorly understood. A mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may reduce marine survival rates. Ocean warming also may change migration patterns, increasing distances to feeding areas.

2.3.3.2 Ocean Acidification Limiting Factors and Threats

Ocean acidification is a predictable consequence of rising atmospheric carbon dioxide (CO_2) concentrations. When dissolved in water, CO_2 forms carbonic acid. Recent trends of increasing atmospheric CO_2 concentrations work to decrease ocean pH levels creating challenges to some marine organisms. Current estimates indicate atmospheric CO_2 has increased nearly 40% from preindustrial levels (IPCC 2007). Despite this increase in atmospheric CO_2, waters in the Pacific Ocean remain supersaturated with calcium carbonate, which buffers the effects of carbonic acid. However, as the trend of CO_2 emissions continues, calcium carbonate undersaturation is likely to occur. There is evidence to indicate that reductions in calcium carbonate will impact the survival of key marine organisms that rely on a calcium carbonate exoskeleton as undersaturation leads to advanced shell dissolution (Orr *et al.* 2005).

Current information indicates ocean acidification impacts are first expected to occur in high latitudes where water temperatures are coolest (Fabry et al 2008). Undersaturation of calcium carbonate would likely have negative consequences for shelled zooplankton (pteropods) that contribute to the diet of Pacific salmon, and many other marine organisms. Modeling efforts using current atmospheric CO_2 emission trends indicate undersaturation in waters within the range of pacific salmon are likely to occur over the next 50 to 100 years (Orr *et al.* 2005). This scenario could potentially lead to reduced food supply for Pacific salmon, but the likelihood of this occurring is highly dependent on future CO_2 trends, water temperatures, and species adaptability. Ocean acidity has varied in the geological past, but the potential for marine organisms to adapt to increasing ocean acidity are not well known (Doney et al 2009).

Laboratory studies on salmonid prey taxa have generally indicated negative effects of increased acidification, but how this translates to their population dynamics and to survival of salmon and steelhead is uncertain. A recent modeling paper explored the ecological impacts of ocean acidification and other impacts of climate change and concluded that salmon landings in the Pacific Northwest and Alaska were likely to be reduced (Fabry *et al.* 2008).

2.3.3.3 Summary of Likely Impacts of Climate Change and Ocean Acidification

The recent five-year status report for salmon and steelhead in the Pacific Northwest (Ford ed. 2011) includes a summary of likely effects of climate changes on Pacific Northwest salmon and steelhead. Table 8 is reproduced from Table 76 of Ford *et al.* (2011) and summarizes the main climate change effects and indicates their certainty of occurrence and magnitude. This table addresses all listed salmon and steelhead in the Pacific Northwest, so some effects (e.g., some terrestrial climate effects on forest and riparian structure) are more relevant to interior Columbia Basin species. Ford *et al.* (2011) point out that we need to consider the cumulative impacts across the salmon life-cycle and across multiple generations. Because these climate effects are multiplicative across the life cycle and across generations, small effects at individual life stages can result in large changes in the overall dynamics of populations. This means the mostly negative effects predicted for individual life history stages will most likely result in a substantially negative overall effect of climate change on Pacific Northwest salmonids over the next few decades.

Table 6. Summary of expected climate effects on Pacific Northwest ESUs. Effect ratings are: + +, strongly positive;+,positive;0,neutral; -negative, , strongly negative. Certainty level combines the certainty of the physical change with the certainty of the effect. Source: Stout *et al. (*2011).

Habitat	**Physical Change**	**Process Affecting Salmon**	**Effect on Pacific Northwest Salmonid ESUs**	**Certainty**
Terrestrial	Warmer, drier summers	Increased fires, increased tree stress & disease affect LWD, sediment supplies, riparian zone structure	- - to 0 Largest effects likely to be felt in Interior Columbia populations, particularly in areas at lower and mid- elevations	Low
	Earlier peak flow	Potential migration timing mismatch	-- to 0 Largest effects in ‘transition’	Moderate

Habitat	Physical Change	Process Affecting Salmon	Effect on Pacific Northwest Salmonid ESUs	Certainty
			areas that move from a snow-melt dominated hydrograph to rain-driven	
	Increased floods	Redd disruption, juvenile displacement, upstream migration	- - to 0 Largest effects in ‘transition’ areas that move from a snow-melt dominated hydrograph to rain-driven	Moderate
	Higher stream temperature	Thermal stress, restricted habitat availability, increased susceptibility to disease and parasites	- - to – Largest effects likely in currently high temperature areas of the Interior Columbia and low elevation areas	Moderate
Estuarine	Higher Sea Level	Reduced availability of wetland habitats	-- to – Largest effects on ESUs with a life history highly dependent upon relatively long-term rearing in estuarine and tidally influenced areas.	High
	Higher water temperature	Thermal stress, increased susceptibility to disease and parasites	-- to – Largest effects on ESUs with highly estuarine-dependent life cycles and ESUs subject to stress at earlier life stages	Moderate
	Combined effects	Changing estuarine ecosystem composition and structure	-- to +	Low
Marine	Higher ocean temperature	Thermal stress, shifts in migration, susceptibility to disease & parasites	-- to – Effects likely to vary by ESU, dependent upon ocean distribution	Moderate
	Intensified upwelling	Increased nutrients (food supply), coastal cooling, ecosystem shifts; increased offshore transport	0 to ++ Effects likely to vary by ESU and correspondence of outmigration with upwelling patterns.	Moderate
	Delayed	Food timing mismatch	- - to 0	Moderate

Habitat	Physical Change	Process Affecting Salmon	Effect on Pacific Northwest Salmonid ESUs	Certainty
	spring transition	with outmigrants, ecosystem shifts	Effects likely to vary by ESU dependent upon correspondence of outmigration with upwelling patterns.	
	Increased acidity	Disruption of food supply, ecosystem shifts	-- to – Effects likely to vary by ESU, dependent upon age and size at outmigration and ocean distribution	Moderate
	Combined effects	Changing composition and structure of ecosystem; changing food supply and predation	-- to + Effects likely to vary by ESU dependent upon age and size at outmigration and ocean distribution	Low

2.3.3.4 Human Population Growth and Water Demands

Between 1985 and 2005, the total human population in Washington state increased by 44%, from 4.38 million to 6.29 million, a 1.8% annual growth rate. At this rate of growth, the population would double in 35 years (USGS 2010). During the same period, total water withdrawals (surface and groundwater) in Washington grew from 5,180 Million gallons per day (Mgd) to 5,780 Mgd. Surface water withdrawals grew from 3,850 Mgd to 4,280 Mgd, an annual growth rate of about 0.5%. The majority of surface water withdrawals are used for irrigated agriculture, which grew from 2,370 Mgd to 2,890 Mgd between 1985 and 2005, an annual growth rate of 1%. Since 1985, the per capita demand for surface water withdrawals has declined from 879 gallons per day to 680 gallons per day. Thus, even though per capita demand has decreased, overall water withdrawals have increased in Washington; and this is probably the case for water use throughout the Columbia River Basin.

2.4 Effects of the Action on Species and Designated Critical Habitat

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.4.1 Effects on Hydrology

As previously noted, most water withdrawals in the environmental baseline occur during the growing season (April through October). The baseline diversions and other water management activities (e.g., flood control and power generation) have resulted in substantial reductions in Columbia River flows in May, June and July, when the great majority of juvenile salmonids are migrating to the ocean (Figure 17).

Unlike the vast majority of baseline water withdrawals for irrigation, the proposed action would withdraw water from the Columbia River primarily during October and store that water in Banks Lake for use the following April through October. This means that water withdrawals from the Columbia River would take place after the primary juvenile migration season.

Compared to the post development hydrograph (Figure 17), the proposed action would decrease the volume of water discharged to the Columbia River below Grand Coulee Dam by a volume of 164,000-acre feet during the month of October. Applied across the month, the action would reduce flows by a monthly average of 2,700 cfs throughout October. This effect is expected in all years once the project is fully operational.

It should be noted that the 2,700 cfs value is not the maximum rate of pumping. Because the cost of electricity is typically lowest at night, it is likely that the instantaneous reduction in Grand Coulee Dam would vary diurnally, with the majority of the outflow reduction occurring at night. Due to the re-regulating operation of Chief Joseph Dam, which defines the upstream terminus of occupied salmon habitat, the anticipated diurnal fluctuation in Grand Coulee discharge likely to occur under the proposed action would have no effect on Columbia basin salmonids or their designated critical habitats. An average flow reduction of 2,700 cfs during October reasonably approximates the likely hydrologic effect of the proposed action in the portion of the Columbia River occupied by salmon and steelhead.

October is one of the more stable months in the hydrologic record, meaning the spread in monthly flows from highest to lowest is small. The relative scale of the proposed water withdrawal would vary by water year (wet, dry, average) and location. The proposed 2,700 cfs flow reduction would equal a decrease of about 4.2%, immediately downstream from Chief Joseph Dam during a dry water year to about 2.1% immediately downstream from Bonneville Dam during a wet water year (Table 7).

Table 7. Current mean October flows at Chief Joseph, Priest Rapids, McNary and Bonneville dams
Under wet (10% exceedence), normal (50% exceedence), and dry (90% exceedence) water years and the anticipated change in flows under the Odessa proposed action. Spouce:Staff.

Project	**10% exceedence**		**50% exceedence**		**90% exceedence**	
	Flow (cfs)	% change	Flow (cfs)	% change	Flow (cfs)	% change
Chief Joseph	82757	3.26	72149	3.74	64223	4.20
Priest Rapids	88559	3.05	77519	3.48	69069	3.91
McNary	123023	2.19	103650	2.60	95585	2.82
Bonneville	128377	2.10	109804	2.46	100158	2.70

On average, current flows in October are nearly 30% higher than estimated undeveloped flows (Figure 17). Average flows resulting from this proposal are expected to be about 110,300 cfs, 26% higher than undeveloped flows.

In years when unexpected conditions prevent diversion of the proposed 164,000 acre-feet in October, Reclamation would divert water from the Columbia River during the months of November through March to make up the shortfall. If the November through March diversions were needed, the amount would be limited to a monthly maximum of 21,000 acre-feet (a monthly average flow reduction downstream from Grand Coulee Dam of about 350 cfs) as long as chum salmon elevation targets were being met downstream of Bonneville Dam. The diversion would be 6,000 acre-feet (about 100-cfs monthly average flow) when the chum spawning water surface elevation targets were not being met. The 21,000 acre-foot diversion would reduce average monthly flows about 0.19% to 0.26% at McNary Dam and 0.20% to 0.26% at Bonneville Dam, depending on the month. The smaller diversions in this time period, if they were to occur, would have much smaller effects on the currently elevated flow conditions during the November to March period.

2.4.1.1 Estimated Effects on River Depth and Velocity

Streamflow affects fish condition, abundance, and productivity through its influence on habitat characteristics, primarily water depth and velocity (Raleigh et al. 1986). The proposed reduction in river flow would affect river depths and velocities differently throughout the action area as the relative effects on flow and channel morphometry change. We have chosen to look most closely at the Hanford reach, which is an unimpounded section of the mainstem Columbia River. [12] While flow in this reach is regulated by upstream dam operations, a free flowing river extends for about 50 miles from Priest Rapids Dam to the head of McNary Dam pool. Due to this unimpounded condition and the relatively larger proposed flow reduction in Columbia River flows upstream from its confluence with the Snake River, the Hanford Reach would exhibit the largest changes in depth and velocity anticipated from the action in the action area. This reach has a USGS gaging station that facilitates estimating depth and velocity over a range of flows (Station No. 12472800). Our estimates of depth and velocity effects are based on the rating table and USGS field measurements for this station.

River stage (water surface elevation) varies with discharge and the largest effects on river depth and velocity would occur under low flow conditions. Between 1990 and 2008, the minimum daily mean flow in October was 38,300 on October 7, 2008. A 2,700 cfs flow reduction at such low flows would reduce average channel depth by 0.43 ft. or 5.2 inches. A flow reduction of 350 cfs would reduce average channel depth by 0.06 ft. or 0.72 inch. At 38,300 cfs, the proposed 2,700 cfs flow reduction would reduce average channel velocity at the gage site by about 0.1 fps, from 2.12 to 2.02 fps . It should be noted that these are conservative estimates, as these estimated effects would be expected to diminish as overall flows increase above 38,300 cfs. At more normal flows, the effects on depth and velocity would be less than these estimates.

---

[12] Effects would be slightly larger at the base of Chief Joseph Dam but data are not readily available at that location to facilitate analysis.

Below Bonneville Dam, depth and velocity conditions are influenced by tides. The tide accounts for several feet in elevation change at Portland (Corps 2004) and over ten feet in the estuary (Kukulka and Jay 2003). The Corps determined that a 2,700 cfs flow reduction was below the sensitivity of its model, but estimated such a flow reduction would change river stage by only a couple hundredths of a foot at Portland, OR, and only during short intervals in the tidal cycle (Corps 2012). The influence of the tide in the lower river is such that reversal in flow occurs during incoming tidal cycles. These tidal effects dwarf the effects of a 2,700 cfs flow reduction on depth and water velocity in the lower river and estuary.

2.4.2 Effects on Water Temperature

To estimate the effects of the proposed action on water temperatures, Reclamation modeled the temperatures of Grand Coulee discharges with and without the proposed action using the CEQUAL model. The calibrated CEQUAL model run used an hourly timestep between Julian days 275 and 305 (October 1 through 31st) and simulated water temperatures that would occur with an additional 2,700-cfs flow reduction in discharge. Model outputs were analyzed for both midnight and noon outflow temperatures.

Results of the CEQUAL model simulations showed that outflow water temperatures would be slightly cooler under the proposed action than the current condition. Reducing Columbia River flows in the fall would result in a 0.03 °F cooling effect, on average, with an expected temperature change range of 0.16 °F decrease to 0.05 °F increase in temperature as an October monthly average. This very small effect is within the scale of modeling error and instrument accuracy. Thus, there would be no meaningful change in river temperature (i.e. large enough to elicit a biological response) with the proposed change in flow.

2.4.3 Effects on Listed Salmonid ESUs and DPSs and Designated Critical Habitats

This section describes the effects of Reclamation’s proposed action on 13 ESA-listed salmon ESUs and steelhead DPSs (collectively “species”) and their designated critical habitats.

Because these 13 species enter or use the action area at various locations downstream from Grand Coulee Dam, the area of analysis for each species includes those river reaches it occupies that overlap with the action area.

Table 8 shows types of sites, essential physical and biological features designated as PCEs, and the life stages of ESA-listed salmon and steelhead each PCE supports in the Columbia River downstream of Chief Joseph Dam to the mouth of the Columbia River, including PCEs for Snake River basin ESUs and the SR steelhead DPS. Chapter 19 of the *Comprehensive Analysis* (Corps *et al.* 2007a) describes the geographic extent, conservation role, and current condition of designated critical habitat for each of the species listed in Table 8, and those descriptions are hereby incorporated into this opinion. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species’ conservation.

Table 8. Site types, essential primary constituent elements (PCEs), and species life stage each PCE supports for the Columbia River downstream of the Snake River confluence.

Site and PCE	Essential Physical and Biological Features	Species Life Stage Supported
Upper Columbia River Spring Chinook		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult
Upper Columbia River steelhead		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Middle Columbia River steelhead		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Snake River Spring/Summer Chinook		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Snake River Fall Chinook		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Snake River Sockeye		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and Adult
Freshwater rearing	Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile
Snake River steelhead		
Freshwater migration Freshwater	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity,	Juvenile and Adult

Site and PCE	Essential Physical and Biological Features	Species Life Stage Supported
rearing	forage, natural cover	Juvenile
Lower Columbia River Chinook Salmon		
Freshwater rearing	Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile
Freshwater migration	Water quality and quantity, natural cover	Juvenile and Adult
Columbia River Chum		
Freshwater spawning	Water quality and quantity, spawning substrate	Adult
Freshwater rearing	Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile
Freshwater migration	Water quality and quantity, natural cover	Juvenile and Adult
Lower Columbia River steelhead		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Upper Willamette River Chinook Salmon		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile
Upper Willamette River steelhead		
Freshwater migration Freshwater rearing	Water quality and quantity, natural cover Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile and Adult Juvenile

For brevity, we present our estimated effects by life-stage (e.g. adult spawning migration, juvenile rearing) in detail, followed by brief ESU by ESU estimates of effects. Columbia River chum salmon are the only listed species with spawning areas in the Columbia River mainstem (in the tailrace of Bonneville Dam). We discuss chum spawning and incubation effects in Section 2.4.3.11.

2.4.3.1 Effects of proposed action on adult migration behavior

We use salmon and steelhead adult migration behavior studies and our estimated effects on hydraulic characteristics (e.g. depth and velocity) to assess the likely effects of this action on adults.

The spring/summer Chinook adult spawning run past Bonneville Dam typically begins in April, which is outside the period of the proposed flow reductions. However, small numbers of spring Chinook salmon pass Bonneville Dam in March (typically less than 1% of the run), when flow reductions of up to 350 cfs are proposed. Studies on how flow affects the rate at which fish pass through the impounded reaches of the Columbia River have found that fish passed fastest in low flow years and slowest in high flow years, although migration rates were generally not correlated with river discharge within a given year (Keefer *et al*. 2004). This supports a conclusion that a 350 cfs flow reduction in March would not slow the passage of adult spring/summer Chinook. Also, based on passage timing very few fish would be affected.

Fall Chinook salmon begin arriving at Bonneville Dam in August, continue to migrate through the mainstem Columbia River into November. The passage timing of these fish overlaps with the proposed reduction of 2,700 cfs in October and 350 cfs in November. Fall Chinook salmon migrations occur during the fall low-flow season. A radio tracking study of the fall Chinook salmon adult migration was conducted in 2001, one of the lowest flow years over the last 70, found that migration rates from Bonneville Dam to McNary Dam increased significantly, as discharge decreased (Keefer et al. 2004). The data also indicated that the migration rate was faster in 2001 when compared to other, higher discharge years. These data support a conclusion that the proposed flow reduction is not likely to have a negative effect on the migration behavior of adult fish.

Summer steelhead typically begin arriving at Bonneville Dam typically in June, the run peaks from mid-July through mid-September, and continues through October. Some of these fish exhibit a protracted migration and some may not pass McNary Dam until March of the following year. The passage timing of these fish overlaps with the proposed flow reduction of 2,700 cfs in October and 350 cfs in November through March. Keefer (2004) found that steelhead migration rates in Columbia River reservoirs were not generally correlated with river discharge. Temperature appeared to have a larger effect, with migration rate decreasing as temperature increased, however, the proposed flow reductions are not likely to have a large enough effect on temperature to elicit a biological response (see Section 2.4.2 above). Available data support a conclusion that the proposed flow reduction is not likely to negatively affect the migration behavior of summer steelhead. Winter-run steelhead migrate past Bonneville dam in small numbers from December through April (between 2007 and 2011 winter runs ranged from about 1000 to 4000 fish past Bonneville Dam). While little information is available on winter-run steelhead migration behavior in the Columbia River, assuming a similar behavioral response to that demonstrated by summer-run steelhead, it is reasonable to conclude that there would be even smaller effects resulting from the very small changes in flows (up to 350 cfs) and temperatures (negligible) that would occur from November to March under the proposed action.
Post spawned steelhead attempting seaward migration are commonly referred to as “kelts”. Like juvenile salmonids, adult steelhead kelts must navigate downstream through the Columbia River

to the Pacific Ocean. Kelts migrate in the spring, mainly during April-June although small numbers are observed in March. The information we know about their passage timing is from observing their passage through the juvenile bypass systems, which are installed at Bonneville Dam in early March and at McNary Dam in early April. Repeat spawning (iteroparity) rates in Columbia River steelhead populations above McNary Dam have been reported between 2% and 4% while rates in unimmpounded tributaries below Bonneville Dam have been reported as high as 17% (Wertheimer and Evans, 2005). Few kelts are likely to be present in the mainstem Columbia in March. A flow reduction of 350 cfs in March would decrease the velocity of the river in the unimpounded Hanford Reach of the Columbia River by a maximum of .01 fps and the river depth by .72 inches, which should not affect their survival. The change in velocity and depth below Bonneville Dam would be far less due to tidal influence and tributary inputs. These small changes in velocity and depth are not expected to have any significant effect on kelt survival through the mainstem Columbia River.

2.4.3.2 Effects of the proposed action on juvenile migration and rearing behavior

The vast majority of juvenile salmon and steelhead are not actively migrating (i.e., observed passing multiple dams) during October and November, while the juvenile bypass systems are still operating. [13] However, some ocean-type juveniles for Interior Columbia ESUs/DPSs enter the bypass system as soon as the screens are deployed in late March. Although there are no data on the movements or biological requirements of these fish during December through mid-March, their presence in the reservoirs indicates that at least some individuals are “rearing” in the mainstem. Individuals from most Interior Columbia River ESUs/DPSs have been observed in the Columbia River estuary during December through March, indicating that the estuary provides winter rearing habitat for most of these species.

One exception to this general pattern is juvenile chum salmon, which often begin to migrate as fry as early as March, immediately after emergence. Spawning, incubation, emergence, and emigration by the Lower Gorge population of Columbia River chum salmon largely takes place in the river reach below Bonneville Dam. Thus, emigrating juvenile chum salmon are likely to be affected by flow reductions of up to 350 cfs.

As described above, the effects of a 350 cfs flow reduction on depth and velocity in the Columbia River below Bonneville Dam is complicated by tidal influence. The Corps’ considers the likely effects of a 2,700 cfs flow reduction on river depth and velocity downstream from Bonneville Dam to be below the sensitivity of its hydraulic model and estimated that it would likely change the river stage by only several hundredths of an inch and only during certain times of the tidal cycle (Corps 2012). A 350 cfs flow reduction during November through March would have an even smaller, likely negligible effect. Thus, a maximum 350 cfs flow reduction in March would likely have a negligible effect on the migration rate and arrival timing in the estuary of chum salmon.

Few, if any juvenile salmonids from the other species considered in this opinion are actively migrating during the proposed action time frame (October through March), although, as

[13] The turbine intake screens and juvenile bypass systems at FCRPS dams are typically deployed by April 1 and remain in continuous operation through December 15 each year.

mentioned above, some would be rearing in the mainstem reaches or the lower Columbia River/estuary and Snake River fall Chinook or residualized interior basin steelhead could similarly be rearing in some of the mainstem reservoirs. Because these fish are not actively migrating, the effect of a flow reduction on juvenile travel time or estuary arrival timing is not likely to be affected. Of more importance at this time of year is the potential effect the proposed flow reduction might have on rearing habitat (changes in the river velocity and depth) and how these changes would likely affect juvenile behavior or the value of this habitat.

The maximum change in river velocity that is anticipated by the 2,700 cfs flow reduction was a reduced velocity in a free flowing Hanford reach of the river by 0.1 ft/sec. Chinook salmon can discriminate flow velocities of 0.017 fps (Feist and Anderson 1991) and are capable of detecting and responding (rheotrophic response) to constant velocity of 0.08 fps (Feist and Anderson 1991). Since fish could detect and respond to the change in flow, we will analyze how fish are likely to respond to this change in depth and velocity and assess whether there is suitable habitat available to support juvenile rearing under the changed conditions. Habitat suitability index curves were used to determine the likely habitat preferences of Chinook salmon, and steelhead (rainbow trout).

- Juvenile Chinook salmon tend to select water velocities of 0 to 2 ft/s with an optimal range of 0 to <1.3 ft/s at depth of $\geq$ 0.5ft (Raleigh et al. 1986).
- Rainbow trout juveniles (a surrogate for rearing steelhead) tend to select water velocities of 0 to 2 ft/s and a wide range of depths. Bustard and Narver (1975) found that Age 0 steelhead in Carnation Creek, British Columbia preferred depths to 1.5 ft., while Age 1+ steelhead preferred depths greater than 3 ft. Other studies found that juvenile rainbow trout were found to occupy a wide variety of depths, some as deep as 20 feet (Raleigh et al 1984).

Shrivell (1994) studied the response of juvenile Chinook and coho salmon to changes in stream flow. He found that juvenile Chinook responded by changing their position in the water column and the water velocities they occupied in response to changes in stream flow. The mean distance of the positions occupied to the water's edge was the same at all streamflows. The fish accomplished this by moving laterally to maintain a constant distance from the shoreline as streamflow changed. Shrivell (1994) concluded that juvenile coho and Chinook salmon will move to find suitable microhabitat following a change in streamflow.

The proposed flow reduction of 2,700 cfs would reduce average water velocity by about 0.1 ft/sec in free-flowing sections of the Columbia River upstream from – and less than 0.1 ft/sec downstream from its confluence with the Snake River. Rearing salmonids are expected to respond to this change by altering their position, moving laterally to maintain a relatively constant distance from the shoreline. Under the proposed action, suitable habitat would move slightly toward the middle of the river, but not decline and rearing juveniles would likely move with habitat suitability. It is not anticipated that the proposed flow changes would substantially reduce available habitat, nor substantially interfere with normal juvenile behaviors.

Because mainstem reservoirs are held at relatively constant elevations, juvenile rearing within these environments would be also largely unaffected. At most, reductions of up to 5.2 inches would be expected in the tailrace of each mainstem dam.

Potential effects on shallow water habitat used by juvenile salmonids rearing downstream of the tailrace of Bonneville Dam would be even less affected by the proposed flow reductions because:

- They make up a progressively smaller percentage of flows as additional tributaries, including the Willamette, join the mainstem Columbia River
- The lower Columbia spreads out in its estuarine floodplain below RM 55 (RKm 88) so the corresponding change in water depth would also be smaller
- The estuary is, by definition, tidally influenced so water depth rises and falls several feet each day.

As discussed in Section 2.4.2, there would be no meaningful change in river temperature (i.e., large enough to elicit a biological response from rearing juvenile salmonids) with the proposed change in flow.

2.4.3.3 Effects on the Proposed Action on Potential for Recovery

The proposed action would divert an average additional 164,000 acre-feet of Columbia River water for out-of-stream consumptive use. Due to the necessary reliance of the agricultural users on water resource allocation decisions, this action, for all practical purposes, would remove this water from future consideration for instream uses such as salmon recovery once committed. For this reason, the proposed action would be expected to reduce the amount of water potentially available in the basin for allocation to benefit salmon.

At present, NMFS considers securing additional water to improve salmon migration and survival to be one of many important tools for salmon recovery (UCSRB 2007; NMFS 2009, 2011d, and 2012). Thus, it is important that sufficient water resources remain available as a viable recovery tool. However, the importance of future river flows for salmon recovery is relative to other measures that affect the survival and productivity of salmon throughout their life cycle. For example, surface passage routes (with training spill) are proving effective in reducing juvenile migration delay in the migration corridor (Faulkner et al. 2010); one of the adverse effects of system-wide spring and early summer flow reductions. Hence, the relative benefit of securing additional water resources as a recovery measure is relatively reduced (at least for reducing juvenile migration delays in the mainstem migration corridor), though not eliminated.

There are upwards of 50 Maf of water stored in the basin, available from the active storage capacity of up-river reservoirs. The great majority of this water is already allocated for flood control, irrigation storage, or other human uses. Much of the remaining storage is already being used to augment summer flows to enhance migration conditions for juvenile salmonids migrating in the Columbia River basin or to reduce water temperatures in the Snake River during the summer for migrating juvenile and adult salmon and steelhead. The proposed action would divert an additional 0.33% of the total active storage capacity (50 Maf) to out-of-stream use.

Water conservation and use in the Columbia River Basin is, and will continue to be, a focus of natural resource planning for the future (e.g., the Columbia River Treaty Review process). Salmon recovery takes place in the context of this broader consideration of water management. Ongoing research will also improve information about the recovery needs of salmonids in the

Columbia Basin, especially in the estuary, and will inform water resource planning. The significance of this proposed action is evaluated within this broader context.

2.4.3.4 Upper Columbia River Spring Chinook Salmon

The endangered UCR spring Chinook salmon ESU consists of populations that spawn and primarily rear outside of the action area in tributaries entering the Columbia River below Chief Joseph Dam and upstream of Rock Island Dam. Adults and juveniles depend on the Columbia River migration corridor from the Methow confluence to the Pacific Ocean, which NMFS has designated as critical habitat. A limited amount of juvenile rearing takes place within the Columbia River.

The proposed flow reductions would take place during October and November through March. Small numbers of UCR spring Chinook adults are likely to be in the Columbia River during March, and small numbers of juveniles are likely to be in the mainstem Columbia River and estuary during October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Based on information presented regarding adult and juvenile responses, the proposed flow changes (Sections 2.4.3.1 and 2.4.3.2) could have minor effects on fish behavior, but are unlikely to negatively affect the condition or survival of adult or juvenile spring Chinook migrating or rearing in the mainstem Columbia River or estuary.

Critical Habitat
This ESU has about 524 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.5% of the average flow at McNary Dam in October and 0.32% to 0.21% during November to March and would have only negligible effects on water quantity and quality in adult and juvenile migration (and for juveniles, rearing) areas (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.5 Upper Columbia River Steelhead

The threatened Upper Columbia River steelhead DPS consists of populations that spawn and primarily rear outside of the action area in tributaries entering the Columbia River below Chief Joseph Dam and upstream of the Yakima River. Adults, kelts, and juveniles depend on the mainstem Columbia River as a migration corridor and for juveniles, a rearing corridor from the Methow confluence to the Pacific Ocean, which NMFS has designated as critical habitat.

The proposed flow reductions would take place during October and November through March. A substantial number of upstream migrating UCR steelhead adults are likely to be in the action area during October, a few kelts will be present in March, and small numbers of juveniles during October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26%

during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Based on information presented regarding adult and juvenile proposed flow changes (Sections 2.4.3.1 and 2.4.3.2) could have minor effects on fish behavior, but are unlikely to have negative effects on the survival or condition of adult or juvenile steelhead migrating or rearing in the mainstem Columbia River or estuary.

Critical Habitat
This DPS has approximately 524 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November to March and would have only negligible effects on water quantity and quality in adult and juvenile migration (and for juveniles, rearing) areas (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.6 Middle Columbia River Steelhead

The threatened Middle Columbia River (MCR) steelhead DPS consists of populations that spawn and primarily rear outside of the action area in tributaries entering the Columbia River between the Yakima and Wind rivers in Washington (inclusive), and upstream of the Hood River in Oregon. Adults, kelts, and juveniles depend on the mainstem Columbia River as a migration and for juveniles, rearing corridor from the Yakima River confluence to the Pacific Ocean, which NMFS has designated as critical habitat.

The proposed flow reductions would take place during October, and November through March. A substantial number of upstream migrating MCR steelhead adults are in the action area year-round, small numbers of kelts are present in March, and small numbers of juveniles are present October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Based on information presented regarding adult, kelt, and juvenile responses, the proposed flow changes (Sections 2.4.3.1 and 2.4.3.2) could have minor effects on fish behavior, but are unlikely to negatively affect the condition or survival of adult, kelt, or juvenile steelhead migrating or rearing in the mainstem Columbia River or estuary.

Critical Habitat
This DPS has approximately 335 miles of occupied riverine and estuarine designated critical habitat in the action area.

The proposed flow depletions are about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November to March and would have only negligible effects on water quantity and quality in adult and juvenile migration (and for juveniles, rearing) areas (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.7 Snake River Spring/Summer Chinook Salmon

The threatened SR spring/summer Chinook salmon ESU consists of populations that spawn and primarily rear outside the action area in the Imnaha, Salmon, Grande Ronde, and Clearwater rivers and tributaries, which enter the Snake River between Hells Canyon and Lower Granite dams. Adults and juveniles depend on the mainstem Columbia River as a migration and for juveniles, rearing corridor from the Snake River confluence downstream to the Pacific Ocean, which NMFS has designated as critical habitat.

The proposed flow reductions would take place during October and November through March. Small numbers of SR spring/summer Chinook adults are likely to be in the action area during March and small numbers of juveniles during October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26% during November to March) and would cause very small changes in habitat suitability (velocity, depth/ area, and temperature). Based on information presented regarding adult and juvenile behavior to the proposed flow changes (Sections 2.4.3.1 and 2.4.3.2), effects on the survival, condition, or behavior of adult spring/summer Chinook adults or juveniles rearing in the mainstem Columbia River or estuary would be small.

Critical Habitat

This DPS has about 325 miles of occupied riverine and estuarine designated critical habitat in the action area. This migratory corridor habitat is not likely to be negatively affected because the proposed flow depletions are estimated to be only about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November to March when some juvenile spring Chinook may be rearing in the mainstem Columbia River or estuary. These flow reductions will not affect a change in temperature, and cause small changes in depth (up to - 5.2 inches), and velocity (up to -0.1 ft/sec) as discussed in Section 2.4.3.2.

2.4.3.8 Snake River Fall Chinook Salmon

The threatened SR fall Chinook salmon ESU consists of a single population that spawns and to some extent rears outside the action area in the Snake River below Hells Canyon Dam and in the lower reaches of the Grand Ronde, Imnaha, Salmon, and Clearwater rivers. Adults and juveniles depend on the mainstem Columbia River as a migration, and for juveniles, rearing corridor from the Snake River confluence downstream to the Pacific Ocean, which NMFS has designated as critical habitat.

The proposed flow reductions would take place during October and November through March. Substantial numbers of SR fall Chinook adults are in the mainstem Columbia River during October and November, and small numbers of juveniles during October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26% during November to March) and would cause very small changes to habitat suitability (velocity, depth/wetted area, and temperature). Based on information presented regarding adult and juvenile response, the proposed flow changes (Sections 2.4.3.1 and 2.4.3.2) could have minor effects on fish behavior, but are unlikely to negatively affect the condition or survival of adult or juvenile fall Chinook migrating or rearing in the mainstem Columbia River or estuary.

Critical Habitat
This DPS has about 325 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November to March and would have only negligible effects on water quantity and quality in adult and juvenile migration (and for juveniles, rearing) areas (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.9 Snake River Sockeye Salmon

The endangered SR sockeye salmon ESU presently consists of a single population that spawns and rears outside of the action area in Redfish Lake, located in Idaho's Sawtooth Valley. Juvenile and adult SR sockeye salmon from this population depend on the mainstem lower Columbia River, which NMFS designated as critical habitat, primarily as a migration corridor between spawning and rearing areas in Snake River tributaries and the ocean.

The proposed additional flow reductions during October to March would not be likely to overlap with the periods when SR sockeye are in the action area. Adults migrate upstream to the Snake River during June through July and juveniles emigrate to the ocean during May through June.

The proposed hydrologic change to the Columbia River is small, relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November through March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Based on the unlikely presence adults and juveniles during the proposed flow reductions, the likelihood that they would affect the behavior, condition, or survival of SR sockeye adults or juveniles is negligible.

Critical Habitat
This ESU has about 325 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are estimated to be only about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November through March and would have only negligible effects on water quantity or quality in adult and juvenile migration areas, especially during months when SR sockeye salmon would be present.

2.4.3.10 Snake River Basin Steelhead

The threatened SR steelhead DPS consists of populations that spawn and primarily rear outside of the action area in tributaries of the Snake River. Adults, kelts, and juveniles depend on the mainstem Columbia River as a migration and for juveniles, rearing corridor from the Snake River confluence downstream to the Pacific Ocean, which NMFS designated as critical habitat.

The proposed flow reductions would take place during October, and November through March. A substantial number of upstream migrating SR steelhead adults, a few kelts, and a small number of juveniles are likely to be in the action area during October through March.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.5% of the average flow at McNary Dam in October and between 0.19% and 0.26% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Based on information presented regarding adult, kelt, and juvenile responses, the proposed flow changes (Sections 2.4.3.1 and 2.4.3.2) could have minor effects on fish behavior, but are unlikely to negatively affect the condition or survival of adult, kelt, or juvenile steelhead.

Critical Habitat
This DPS has approximately 325 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.5% of the average flow at McNary Dam in October and 0.19% to 0.26% during November to March and would have only negligible effects on water quantity and quality in adult and juvenile migration (and for juveniles, rearing) areas (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.11 Columbia River Chum Salmon

The threatened CR chum salmon ESU consists of populations that spawn and rear in the mainstem and tributaries of the Columbia River in Washington and Oregon. Chum salmon from the Lower Gorge and Washougal populations use areas in the mainstem below Bonneville Dam for spawning, and all use it as a migration corridor to the estuary. NMFS designated the action area below the confluence of the White Salmon River, Washington, as critical habitat for this species.

The proposed flow reductions would take place during October and November through March. Columbia River chum salmon adults migrate upstream during the months of October through December. Peak spawning in the Columbia River tributaries and mainstem occurs in November, but begins in late October in some years and can continue into January. Eggs incubate and then juveniles emerge from the redds (egg nests) as yolk sac fry during February through May, quickly moving downstream to the estuary where they are assumed to rear for several months before ocean entry.

Migration and spawning of CR chum salmon adults in the action area would overlap with the proposed flow reduction of 2,700 cfs in October and 350 cfs during November through January. Also, the incubation, and emigration, and estuarine rearing periods overlap with the latter period.

Currently the FCRPS is operated to provide adequate conditions for chum spawning in the mainstem Columbia River in the area of the Ives Island complex, which is located about two miles downstream of Bonneville Dam. The specific operation is to provide a tailwater elevation of about 11.5 feet beginning the first week of November (or when chum arrive) to allow fish access to mainstem spawning habitat and nearby tributaries. Once redds have become established, the tailwater elevation below Bonneville Dam is managed to maintain water over the established redds until juvenile emergence is complete.

The proposed action has the potential to affect chum salmon spawning, rearing, and migration because all of these life-history stages and activities occur within the action area. The timing of the hydrologic change (i.e., October reductions of 2.4% below Bonneville Dam) overlaps with chum salmon adult migration and mainstem spawning. The anticipated 2.4% flow reduction in October corresponds with active adult migration and early spawning for this ESU. This small relative change in flow is not likely to affect the behavior adult migrating fish (Section 2.4.3.1). However, it is likely to adversely affect individual spawners by reducing the availability of suitable habitat in the shallow mainstem spawning areas.

The proposed contingent withdrawals during November through January could reduce the availability of suitable spawning habitat or the ability to maintain flow over established, incubating redds in the shallow mainstem spawning areas. The proposed withdrawals represent 2.4% (October) and 0.26% to 0.19% (November through March) of the average monthly flows in the lower Columbia River below Bonneville Dam. In the event the contingent withdrawals occurred at a time chum spawning flows downstream from Bonneville Dam were not being met, withdrawals would be limited to 100 cfs, a 0.07% reduction in flows, which would negligibly affect spawning and incubating chum.

We conclude that the proposed action would negatively affect a small number of individual fish in a small number of years, spawning in mainstem areas below Bonneville Dam because flows are infrequently managed in October for chum spawning. Spawning adults, incubating eggs and emigrating fry would be negligibly affected in the event November through March contingent withdrawals occurred.

Critical Habitat

This ESU has about 167 miles of occupied riverine and estuarine designated critical habitat in the action area. This migratory corridor habitat is not likely to be negatively affected because the proposed flow depletions are small, estimated to be only about 2.4% of the average monthly flow at Bonneville Dam in October and between 0.26% and 0.19% during November through March. Outside of the October flow alteration period, the magnitude of any effects from flow alterations on this ESU's essential features of critical habitat would be negligible. The proposed action's likely effects on chum salmon spawning critical habitat in October would be small and adverse, and short in duration. The proposed action would not have any long-term impact on the spawning habitat, which is usually not available in October. The last week in October is the very beginning of chum spawning in the mainstem CR and only in infrequent years. The normal spawning operation begins in November.

2.4.3.12 Lower Columbia River Chinook Salmon

The threatened LCR Chinook salmon ESU consists of populations from the Columbia River and its tributaries from its mouth, upstream to the Hood River on the Oregon side, and the White Salmon River on the Washington Side. This ESU also includes Chinook salmon from the Willamette River upstream to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River. Adults and juveniles depend on the mainstem Columbia River, from the White Salmon River confluence to the Pacific Ocean, as a migration and for juveniles, rearing corridor between tributary spawning and rearing areas. NMFS has designated the Columbia

River from the confluences of the Hood River (Oregon) and the White Salmon River (Washington) downstream to the Pacific Ocean as critical habitat for this ESU.

The proposed flow reductions would take place during October and November through March. Spring-run adults from this ESU are likely to be in the action area during March and tule (early) and bright (late) fall-run adults in October. Small numbers of juveniles are likely to be in the estuary (mainstem below Bonneville) during October and November through March (Thom et al. 2012).

The proposed hydrologic change to the CR is small relative to the overall flow in the river (about 2.4% of the average flow at Bonneville Dam in October and 0.20% to 0.26% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). The effect would be further reduced in the unimpounded reach below Bonneville Dam as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides (Section 2.4.3.2).

Critical Habitat
This ESU has approximately 170 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are estimated to be only about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November through March and would have negligible effects on water quantity and quality (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.13 Lower Columbia River Coho Salmon

The threatened LCR coho salmon ESU consists of populations that spawn and rear outside of the action area in tributaries entering the CR from its mouth, upstream to the Hood River on the Oregon side and the White Salmon River on the Washington Side. This ESU also includes coho salmon from the Willamette River upstream to Willamette Falls, Oregon. Adults and juveniles depend on the mainstem CR as a migration and for juveniles, rearing corridor between spawning and rearing in lower Columbia tributaries and the Pacific Ocean.

The proposed flow reductions would take place during October and November through March. Substantial numbers of LCR adult Coho salmon are present in the action area during October and small numbers of juveniles in October through March (Thom et al. 2012).

The proposed hydrologic change to the CR is small relative to the overall flow in the river (about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). Coho migration and rearing habitat effects would be further reduced in the unimpounded reach below Bonneville Dam as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides (Section 2.4.3.2).

Critical Habitat
NMFS has not designated critical habitat for this ESU.

2.4.3.14 Lower Columbia River Steelhead

The threatened LCR steelhead LCR DPS consists of populations that spawn and rear outside of the action area in tributaries entering the CR between the Cowlitz and Wind rivers in Washington, and between the Willamette and Hood rivers in Oregon. This DPS also includes steelhead from the Willamette River upstream to Willamette Falls, Oregon. Adults, kelts, and juveniles depend on the mainstem CR, from the Hood River confluence to the Pacific Ocean, as a migration and for juveniles, rearing corridor. NMFS has designated the CR from the confluences of the Hood River (Oregon) and the White Salmon River (Washington) downstream to the Pacific Ocean as critical habitat for this ESU.

The proposed flow reductions would take place during October and infrequently in November through March. Some adult, kelt, and juvenile LCR steelhead are in the action area throughout this period.

The proposed hydrologic change to the Columbia River is small relative to the overall flow in the river (about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). The effect would be further reduced in the unimpounded reach below Bonneville Dam as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides (Section 2.4.3.2).

Critical Habitat
This DPS has approximately 101 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November through March and would have negligible effects on water quantity and quality (Sections 2.4.3.1 and 2.4.3.2).

2.4.2.15 Upper Willamette River Chinook Salmon

The threatened UWR Chinook salmon ESU consists of spring-run Chinook populations that spawn and rear outside of the action area in the Clackamas River and the Willamette River and its tributaries upstream of Willamette Falls. Adults and juveniles depend on the mainstem CR, from the Willamette River confluence to the Pacific Ocean, as a migration and for juveniles, rearing. NMFS has designated the CR from the confluence of the Willamette River (Oregon) downstream to the Pacific Ocean as critical habitat for this ESU.

The proposed flow reductions would take place during October and November through March. Small numbers of spring-run adults from this ESU are likely to be in the action area during March and small numbers of juveniles in October through March (Thom et al. 2012).

The proposed hydrologic change to the CR is small relative to the overall flow in the river (about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). The effect would be further reduced in the reach below Bonneville Dam as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides (Section 2.4.3.2).

Critical Habitat

This ESU has approximately 101 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November through March and would have negligible effects on water quantity and quality (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.16 Upper Willamette River Steelhead

The threatened UWR steelhead DPS consists all naturally spawned populations of winter-run steelhead that spawn and rear outside of the action area in the Willamette River, Oregon, and its tributaries upstream to the Calapooia River, inclusive. Adults, kelts, and juveniles depend on the mainstem CR, from the Willamette River confluence to the Pacific Ocean, as a migration and for juveniles, rearing corridor. NMFS has designated the CR from the confluence of the Willamette River (Oregon) downstream to the Pacific Ocean as critical habitat for this DPS.

The proposed flow reductions would take place during October and infrequently in November through March. UWR steelhead adults are present in the action area in October, some kelts are present in March, and small numbers of juveniles during October through March.

The proposed hydrologic change to the CR is small relative to the overall flow in the river (about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November to March) and would cause very small changes in habitat suitability (velocity, depth/wetted area, and temperature). The effect would be further reduced in the unimpounded reach below Bonneville Dam as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides (Section 2.4.3.2).

Critical Habitat

This DPS has approximately 101 miles of occupied riverine and estuarine designated critical habitat in the action area. The proposed flow depletions are about 2.4% of the average flow at Bonneville Dam in October and 0.2% during November through March and would have negligible effects on water quantity and quality (Sections 2.4.3.1 and 2.4.3.2).

2.4.3.17 Effects on Pacific Eulachon

The listed range of the Southern DPS of Pacific Eulachon includes populations that spawn in the CR and its tributaries. Adult and juvenile eulachon from these populations use the LCR for spawning, rearing, and as a migration corridor to the ocean. NMFS has designated the CR migration corridor from below Bonneville Dam to the Pacific Ocean as critical habitat for this species.

Under the proposed action, the contingent flow reductions during November through March could occur when eulachon are present. Eulachon adults enter the CR during the months December to May with peak entry and spawning during February and March (NMFS 2010c). Incubation occurs for about 30 to 40 days depending on water temperature (ODFW and WDFW 2009b). Young eulachon larvae are swept to the ocean often within days of hatching (ODFW and WDFW 2009b). These time periods of adult migration, spawning, incubation and larval out-migration correspond with the proposed average monthly flow reduction of 350 cfs during November through March.

The proposed 350 cfs flow reduction represents 0.20% to 0.26% of the average monthly flow in the LCR at Bonneville Dam, and would constitute an even smaller proportion of total flow below the confluence of the Willamette River. The change in the river's velocity and depth from these flow reductions would be far less than the tidal effect on the lower river (fractions of an inch compared to several feet). The effects of these very small changes in habitat suitability (velocity, depth, area, and temperature) on the survival, condition, or behavior of these fish are expected to be insignificant.

Critical Habitat
This DPS has approximately 101 miles of occupied riverine and estuarine designated critical habitat in the action area. This migratory corridor habitat is not likely to be negatively affected because the proposed flow depletions are small, estimated to be between a reduction in flow at Bonneville Dam of between 0.20% and 0.26% during November through March when Pacific eulachon may be migrating, spawning or rearing in the mainstem LCR. The Corps estimated that a 2,700 cfs flow reduction in the CR near Portland would change the river stage by only a couple hundredths of a foot and only during small portions of the tidal cycle (Corps 2012). These small hydrologic changes are not likely to significantly affect water depth, velocity, or temperature characteristics in any meaningful way.

2.4.3.18 Effects on Green Sturgeon

Green sturgeon encounter the effects of the proposed action in the reach from Bonneville Dam to the mouth of the CR. Withdrawals at Grand Coulee would not be detectable in the CR plume. Adult and subadult green sturgeon are known to be found below Bonneville Dam during October and in lesser numbers during February and March when the proposed withdrawals would reduce monthly average flows by 2.4% (October) and 0.2% (February and March). The effect would be further reduced with distance below Bonneville Dam as the river spreads out over its estuarine floodplain, as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides. These changes are not likely to directly affect individual green sturgeon, and any effects through changes in their habitat (described below in the context of effects on PCEs of designated critical habitat) would be insignificant.

Effects to Green Sturgeon Critical Habitat
NMFS has identified PCE for green sturgeon within the action area: migratory corridors (for unimpeded passage to access feeding areas, holding areas, thermal refugia, and passage back out

to the ocean); food resources (for growth and development of subadult and adult green sturgeon); water quality (including temperature, salinity, oxygen content, and other chemical characteristics to support normal behavior, growth, and viability of all life stages); water depth (a diversity of depths for shelter, foraging, and migration of subadult and adult individuals); and sediment quality (i.e., chemical characteristics need for normal behavior, viability and growth) (NMFS 2009b).[14] Effects of the proposed action on these PCEs are described in the following paragraphs.

Migratory Corridors. Pathways that allow safe and timely passage among and between areas designated as critical habitat are a PCE of the designated critical habitat. The proposed action would reduce flows below Bonneville Dam by about 2.4% during October and 0.2% in November through March. The effect would be further reduced as tributaries including the Willamette discharge into the lower Columbia, as the river spreads out over its estuarine floodplain, and under the influence of incoming tides such that the proposed action would have insignificant effects on this PCE.

Food Resources. The PCEs of critical habitat in estuarine areas include "[a]bundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages" (NMFS 2009b). The guts of eight individuals taken in 2000 and nine taken in 2003 in Willapa Bay contained ghost shrimp (*Neotrypaea californiensis*), fish (including lingcod, *Ophiodon elongates*), Dungeness crab (*Cancer magister*), crangonid shrimp, and small amounts of polychaetes, clams, and amphipods (Dumbauld et al. 2008). The same authors present the only information available on feeding habitats in the Columbia River based on two green sturgeon landed in 2004 and 2005 that had identifiable items in their stomachs—mostly crangonid shrimp. Federal storage and release operations throughout the Columbia Basin could indirectly affect the PCE of food in the estuary and plume. However, sand flats are extensive in the lower estuary and the prey items listed above are found at various locations. In surveys conducted for the Columbia River Data Development Program in 1981, the sand shrimp (*Crangon franciscorum*) dominated the motile macroinvertebrate assemblage in the estuary in terms of density and standing crop (Jones et al. 1990). Dungeness crab (*C. magister*) were also prominent at the entrance of the estuary and in the channel bottom in the seaward region of the estuarine mixing zone. There is no known causal connection between the availability of these species and FCRPS flow operations to date and no evidence that the slight changes in the LCR hydrograph as a result of the proposed action would negatively affect the PCE of food resources.

Water Quality. The flow reductions associated with the proposed action are expected to have a very small effect on water temperatures immediately downstream from Grand Coulee Dam that is within the scale of modeling error and instrument accuracy. Thus, there would be no meaningful difference change in river temperature (i.e., large enough to elicit a biological response) with the proposed changes in flow. Therefore, the proposed action is not likely to negatively affect the PCE of water quality.

[14] NMFS identified flow as a PCE in the context of adult migrations to upstream spawning areas in the Sacramento River and the Sacramento-San Joaquin Delta, California, but did not specify this parameter as a PCE in non-natal estuaries such as the lower Columbia River.

Water Depth: The proposed action would reduce water depths by less than 0.1 ft. Subadult and adult green sturgeon require a diversity of depths in estuarine areas for shelter, foraging, and migration. Although little is known of habitat use in the lower Columbia, Kelly et al. (2007)

tagged and tracked five subadults (larger than 100 cm total length) and one adult in San Francisco Bay. Their sample size was too small to "clearly parse out preferred habitats (shallow or deep, high or low relief, etc.)," but the subadults typically remained in water shallower than 10 m. The authors differentiated non-directional movements (moving slowly while making frequent changes in direction and speed, or not moving at all), which were close to the bottom and accounted for 64% of all observations, from directional movements. The latter consisted of continuous swimming in the top 20% of the water column, holding a steady course for extended periods.

These patterns of habitat use by subadult green sturgeon in San Francisco Bay, where they are thought to remain for a number of years, feeding and growing before beginning their oceanic phase, may be different than those of subadults in the Columbia River estuary. In either case, the small hydrologic changes expected under the proposed action are unlikely to negatively affect access to either shallow bottom or near surface waters that might be used by subadults or adults. The proposed action is not likely to negatively affect the PCE of water depth.

Sediment Quality. The PCE of sediment quality for green sturgeon in estuarine areas could be affected by chemical contaminants from local or upstream sources. The proposed action is unlikely to affect sediment transport or chemical contaminant loads such that it changes the concentration or distribution of contaminants within green sturgeon critical habitat. The proposed action would therefore have no effect on the PCE of sediment quality.

2.4.3.19 Effects on Southern Resident Killer Whales

Southern Resident killer whales consume a variety of fish and one species of squid, but salmon, especially Chinook, are their primary prey (NMFS 2008c). Ongoing and past diet studies conduct sampling during spring, summer, and fall months in inland waters of Washington State and British Columbia (i.e., Ford and Ellis 2006; Hanson et al. 2010). Therefore, our knowledge of diet is specific to inland waters north of the Columbia basin. Less is known of their diet off the Pacific Coast, where they would encounter Chinook produced in the Columbia basin. However, chemical analyses support the importance of salmon in the year-round diet of Southern Residents (Krahn et al. 2002; Krahn et al. 2007). The predominance of Chinook salmon in the Southern Residents' diet when in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that Southern Residents predominantly consume Chinook salmon when available in coastal waters.

Southern Resident killer whales do not occur within the action area for this consultation and therefore, direct effects of the proposed action are not anticipated. The proposed action could indirectly affect Southern Residents by reducing the quantity of their prey (UCR spring, SR spring/summer, SR fall, LCR, and UWR Chinook salmon) if it affected fish survival or productivity. However, as described in Sections 2.4.3.1 through 2.4.3.12, NMFS expects that the proposed flow reductions will have insignificant effects on the survival, condition, or behavior of individuals from any of these Chinook salmon ESUs.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Act.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on salmonid populations and PCEs, because similar activities have occurred in the recent past and have had adverse effects. 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, future, non-Federal actions are likely to include human population growth, additional water withdrawals, and changing 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 NMFS 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.

In 2006, Washington enacted legislation creating the Columbia River Basin Development Account to support new water supplies for both instream and out-of-stream uses. Under that account, WDOE's Office of the Columbia River (OCR) is actively investigating an array of new water developments that total about 6 Maf. While the state of Washington is investigating several new storage projects, the state estimates it needs about 1 Maf in new water storage to meet demands through 2030 (State of Washington, Department of Ecology 2011). Newly developed storage under this program is to be apportioned between instream and out-of-stream uses (1/3 of new storage for improving streamflows to benefit fish and 2/3 of new storage for new out-of-stream uses).

In the state of Oregon, community groups like the Columbia Basin Development League, and regional agricultural interests, are pursuing strategies that include additional development of Columbia River water.

We anticipate that some new water projects will be pursued, but most water developments incur Federal permitting obligations, such as Corps CWA Section 404 permits, and would be subject to future consultations. We are not aware of any specific plans for additional water developments in the action area that qualify as cumulative effects and are "reasonably certain to occur".

The fact that water use is growing more slowly than the population is indicative of greater water use efficiencies (See Section 2.3.3.4). While further water use efficiency improvements are likely, NMFS anticipates that if population trends continue, additional water demands would lead to additional water withdrawals throughout the life of the proposed action. Public awareness of the effects of development on the environment is increasing and public agencies are increasingly working to reduce development's impacts on the natural environment. NMFS is hopeful this trend will continue.

The extent to which future water withdrawals would adversely affect listed salmonids in the Columbia basin (as well as eulachon and green sturgeon) is difficult to predict with any certainty at this time, as effects would vary with the magnitude and timing of the withdrawal and the extent to which seasonal precipitation patterns are altered by climate change effects (see Section 2.3.3). Furthermore, large storage facilities will likely require their own ESA-consultations, and are therefore precluded from consideration under cumulative effects.
The state of Washington has provided $1 million to fund a habitat improvement project on Hardy Creek to benefit LCR chum spawning. The objective of this habitat project is to provide approximately 25,000 square feet of spawning habitat suitable for this species. Off-stream habitat for this species has been demonstrated to be very productive because it generally has a more stable water supply, provides a greater degree of shelter from predators, and is less prone to natural disturbance than the mainstem CR environment. In the event logistical or permitting issues preclude Hardy Creek as a restoration site, then another project site that will be sought and improved. Because this action is fully funded, the site identified, and the likelihood of success is high due to its similarity to other recent projects, NMFS considers this action sufficiently likely to occur that its likely effects are cumulative effects for this opinion.

2.6 Integration and Synthesis for Salmon and Steelhead Species

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we will add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

Reclamation's proposed diversion of 164,000-acre feet of CR water would result in average October flow depletions of about 2,700 cfs in almost every year. In the few years, when Banks Lake cannot be refilled with October diversions alone, 100 to 350 cfs would be diverted sometime during the November to March period until the entire 164,000 acre feet drawdown of Banks Lake has been refilled (Section 1.3).

As described in Section 2.4 (Effects of the Action), flow reductions of 2,700 cfs in October are not likely to substantially affect individual adult migrants or alter constituent elements of their designated critical habitat. The October flow reductions would slightly reduce water depths and velocities for chum salmon spawning in the island complex below Bonneville Dam. November to March flow reductions of up to 350 cfs are expected to be substantially smaller than effects related to October flow reductions. No discernible effect would be expected for adult steelhead holding over in mainstem habitat during the winter months before resuming their migration to their natal streams (or hatcheries) to spawn.

With respect to juvenile migrants, actively migrating smolts of all Columbia basin ESUs are generally not present in the action area during October and would not be affected by the proposed 2,700 cfs flow reduction. Migrating chum salmon fry would be affected (in late February or March) when flow reductions of up to 350 cfs would infrequently occur. Juveniles from many ESUs (especially Lower Willamette and LCR Chinook and coho salmon ESUs) rear in the estuary downstream of Bonneville dam during the October to March period. Flow reductions in October would result in small changes in water depth (one inch or less) likely causing juvenile salmonids to move to adjacent habitat with suitable depths and velocities. Smaller and infrequent flow reductions in the November to March period should have much smaller overall effects on the behavior of juvenile salmonids rearing in these areas when they do occur.

As described in Section 2.3 (Environmental Baseline) although May, June, and July flows have been substantially reduced by the combined effects of water management facilities and operations throughout the basin, flows in the CR during October are almost 30% larger than those that would occur absent all the water developments in the basin and November to March flows are similarly enhanced compared to likely historical flows. In addition, ocean tides typically result in CR surface elevations naturally varying by several feet each day in rearing areas downstream of Bonneville Dam masking the hydrologic effects of this action in the estuary. The proposed action would not substantially alter these conditions.

However, water withdrawals and storage operations have implications for recovery. The water the Odessa project would divert from the Columbia in October to refill irrigation drafts of Banks Lake has potential value to salmonids were it to remain available for possible shifting to the migratory season. Thus, diversion of this water to irrigation needs would reduce the volume of water that could contribute to recovery of ESA-listed salmonids species as contemplated in regional recovery plans (NMFS 2007; NMFS 2009c, 2011c, and 2012b). These plans generally call for actions to increase spring flows as a means of both restoring ecosystem function resulting from the historical spring freshet in the river, estuary, and plume and improving juvenile migration and early ocean survival rates for spring migrants. This effect is also important in light of the current status of these listed salmonids and their designated critical habitat, as discussed above in Section 2.2. The proposed action could also potentially affect the system's flexibility to respond to future climate change.

Improving flow conditions in the CR is an important element in recovery plans. NMFS is obligated to be cautious when considering actions that could have adverse effects on survival and recovery and uses conservative assumptions and the precautionary principal to evaluate such potential effects. Thus, while it is not clear whether the water that would be allocated to irrigation under the proposed action could be directed and timely delivered to salmon recovery, we conservatively resolve this uncertainty in favor of the listed species and conclude that the water would likely be available and beneficial for recovery.

Changing conditions in the environmental baseline (see Section 2.3.3), including climate change and ocean acidification, together with continuing cumulative effects from use of senior water rights and human population growth (see Section 2.5), are all likely to contribute some level of additional stresses on fish habitats. We anticipate that these effects would be mostly adverse. Future water developments present a more immediate risk, but most such developments would require ESA consultations and their effects would be considered then.

While the proposed action has the potential to adversely affect recovery for listed salmonids, we do not find those effects to constitute an appreciable reduction in the likelihood of recovery nor reduce the value of designated or proposed critical habitat for the conservation of the species. This is because the volume of water diverted is a small percentage of total river flow in October through March (which are about 30% higher than historical flows during these months) and the recovery need for the water that would be diverted is small relative to other potential sources of water and other recovery measures may further reduce the importance of additional water to recovery. As existing salmonid recovery plans indicate, there are many limiting factors to be addressed for recovery representing a variety of potential recovery scenarios.

As described in Section 2.5 above, a project to enhance CR chum spawning habitat in Hardy Creek should improve conditions (increased adult spawning habitat and fry production) for the population of chum salmon spawning in areas below Bonneville Dam, although NMFS does not rely on this project for its ESA conclusion for Chum salmon and its critical habitat.

2.7 Conclusions for Salmon and Steelhead Species

Upper Columbia River Spring Chinook Salmon

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the UCR spring Chinook salmon ESU ; or (2) adversely modify or destroy its designated critical habitat.

Upper Columbia River Steelhead

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the UCR steelhead DPS; or (2) adversely modify its designated critical habitat.

Middle Columbia River Steelhead
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the MCR steelhead DPS; or (2) adversely modify or destroy its designated critical habitat.

Snake River Spring/Summer Chinook Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the SR spring/summer Chinook salmon ESU; or (2) adversely modify or destroy its designated critical habitat.

Snake River Fall Chinook Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the SR fall Chinook salmon ESU; or (2) adversely modify or destroy it designated critical habitat.

Snake River Sockeye Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the SR sockeye salmon ESU; or (2) adversely modify or destroy its designated critical habitat.

Snake River Steelhead
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the SR steelhead DPS; or (2) adversely modify or destroy it designated critical habitat.

Columbia River Chum Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the CR chum salmon ESU; or (2) destroy or adversely modify its designated critical habitat.

Lower Columbia River Chinook Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent

actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the LCR Chinook salmon ESU; or (2) adversely modify or destroy its designated critical habitat.

Lower Columbia River Coho Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the LCR coho salmon ESU. Critical habitat for this species has not been designated.

Lower Columbia River Steelhead
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the LCR steelhead DPS; or (2) adversely modify or destroy its designated critical habitat.

Upper Willamette River Chinook Salmon
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the UWR Chinook salmon ESU; or (2) adversely modify or destroy its designated critical habitat.

Upper Willamette River Steelhead
After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to (1) jeopardize the continued existence of the UWR steelhead DPS; or (2) adversely modify or destroy its designated critical habitat.

2.8 Concurrence Statements for Non-Salmonid Species

Pacific Eulachon
As discussed in Section 2.4.3.17, Pacific eulachon are not present in the CR in October and therefore will not be affected by the proposed October flow reduction of 2,700 cfs. Adults, incubating eggs, and young eulachon larvae are present from December through May. Given the infrequent withdrawals during the November to March period, hydrologic changes in the LCR below Bonneville Dam resulting from the proposed action are not likely to affect water depth or velocity characteristics such that there are negative effects on spawning, incubation, or migration. In addition, winter flows have increased substantially compared to levels expected prior to water development. As a result, the effect of monthly average 350 cfs reductions in flows below Bonneville Dam on Pacific Eulachon or the habitat on which they depend is likely to be insignificant.

NMFS therefore concurs with Reclamation's determination that the Odessa Project, and its associated water depletions from October through March, is not likely to adversely affect the Southern DPS of Pacific Eulachon.

Southern DPS Green Sturgeon

As discussed in Section 2.4.3.18, subadult and adult green sturgeon are known to be present in the CR estuary during October, with lesser numbers present during February and March. The proposed flow reductions are not likely to negatively affect individual green sturgeon and any effects on migratory corridors, food resources, water quality, water depth, or sediment quality are likely to be insignificant because the hydrologic changes in the estuary resulting from this action not expected to affect water depth or velocity characteristics in any measurable way and flows are substantially higher than those expected in the absence of water development.

NMFS therefore concurs with the Reclamation's determination that the Odessa Project, and its associated water depletions from October through March, is not likely to adversely affect the Southern DPS of North American green sturgeon.

Southern Resident Killer Whales

As described in Section 2.4.3.19, Southern Resident killer whales are not present in the action area, but could be adversely affected through a reduction in the availability or quality of adult Chinook salmon produced from the Columbia basin. Section 2.7 documents NMFS conclusions that the proposed action is not likely to jeopardize the continued existence of the affected Chinook salmon ESUs or adversely modify or destroy their designated critical habitat. Based on those conclusions and the analyses that precede them, the effects of the proposed flow reductions are unlikely to significantly reduce the availability or quality of adult Chinook salmon in the ocean.

NMFS therefore concurs with the Reclamation's determination that the Odessa Project, and its associated water depletions from October through March, is not likely to adversely affect the Southern Resident killer whale DPS.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered.[15] Section 7(b)(4) and Section

[15] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as "an intentional or negligent act or omission which creates the

7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.9.1 Amount or Extent of Take

For all salmonid species other than chum salmon, the likely adverse effects are to their recovery prospects and therefore do not indicate a current likelihood of take. For chum salmon, implementing the proposed action is likely to cause only a small amount of take, if any, through minor interference with chum salmon spawning, incubation and emigration downstream from Bonneville Dam. As described in Section 2.4.3.11, the effects of the proposed action on spawning, incubating, and emigrating chum salmon would be masked by the systematic operation of the FCRPS, which is managed to protect chum spawning and because the proposed action would reduce potential flow reductions to minimize effects on chum in the event FCRPS operations could not achieve the flow target. For this reason, we cannot estimate a number of individuals, including incubating eggs, that are likely to be harmed by the proposed action (although no lethal take is anticipated). Instead, NMFS estimates the extent of take as the amount of water Reclamation diverts under the proposed action while chum protection targets (Bonneville tailwater elevation or CR flow at Bonneville Dam) are not being met.

2.9.2 Effect of the Take

In Section 2.7, NMFS determined that the level of anticipated take is not likely to jeopardize the continued existence of the listed species or destroy or adversely modify designated critical habitat for any of the salmon or steelhead considered in this opinion.

2.9.3 Reasonable and Prudent Measures

“Reasonable and prudent measures” are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

As described above, through the consultation process, Reclamation adjusted the timing of its proposed diversions to minimize the potential for taking listed species. The proposed action does not include any increases in withdrawals from the CR during the juvenile salmon migration season (April through August) when take would be likely. To insure that actual operations remain consistent with the proposed action considered in this opinion, Reclamation must monitor and report to NMFS the timing and extent of water withdrawals from the Columbia River attributable to the proposed action.

likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the Service’s interpretation of the term.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Reclamation or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of Section 7(o)(2) would likely lapse.

2.9.4.1 Monitoring and Reporting Daily Diversions

Reclamation shall continue to monitor the daily flows out of Grand Coulee dam, the net amount of water pumped from the Columbia River to Lake Roosevelt, and the elevation of Banks Lake. Each year, Reclamation shall provide a written annual record of last complete water year's operations. This report shall include end-of-month elevations of Banks Lake and the net diversions from Lake Roosevelt. As new phases of the proposed action are complete and operational, Reclamation shall provide to NMFS notice of the anticipated change in diversion requirements resulting from that phase of the proposed action.

2.10 Conservation Recommendations

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

Reclamation and Columbia Basin Project irrigation districts are actively engaged in substantial efforts to conserve water. Given the importance of water to both instream and out-of-stream uses, we encourage Reclamation to continue seeking water use efficiencies**.**

2.11 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

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

This analysis is based, in part, on the EFH assessment provided by Reclamation (2012a) and descriptions of EFH for Pacific coast salmon contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce (PFMC 1999).

3.1 Essential Fish Habitat Affected by the Project

Essential fish habitat (EFH) has been designated for Federally managed groundfish, coastal pelagics, Chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch), and Puget Sound pink salmon (O. gorbuscha) fisheries within the waters of Washington, Oregon, Idaho, and California (PFMC 1999). Congress defined EFH in the Magnuson-Stevens Act (MSA), as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The EFH guidelines from NMFS further interpret the EFH definition as:

- Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate;
- Substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities;
- Necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and
- "Spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

3.1.1 Salmon Essential Fish Habitat

Appendix A to Amendment 14 of the Pacific Coast Salmon Plan (PFMC 1999) listed EFH for Chinook salmon and coho salmon in the Snake and Columbia Rivers downstream from Chief Joseph Dam on the Columbia River and Hells Canyon Dam on the Snake River. EFH was delineated by 4th field hydrologic unit codes (HUCs). A HUC is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as delineated by the USGS on State Hydrologic Unit Maps. The fourth level of classification is the cataloging unit, the smallest element in the hierarchy of hydrologic units, representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. The final rule of "Fisheries Off West Coast States; West Coast Salmon Fisheries; Amendment 14; Essential Fish Habitat Descriptions for Pacific Salmon" was published in 1999 (PFMC 1999). It codifies the EFH identifications and descriptions for freshwater and marine habitats of Pacific salmon managed under the Salmon Fishery Management Plan (FMP), including Chinook, coho, and pink salmon.

This MSA consultation considers both ESA-listed and non-listed Chinook and coho salmon ESUs that spawn, rear, and/or migrate in the action area.

For this consultation, the action area with regard to EFH consultation includes the farthest upstream point at which Federally managed salmon smolts enter (or adults exit) the mainstem Columbia River downstream of Chief Joseph Dam downstream to the farthest point at the Columbia River estuary for which designated EFH for Chinook and coho salmon might be influenced by the proposed action (See USBR BA Table 38 for more detailed information).This action area encompasses eight 4th field HUCs beginning just downstream from Chief Joseph Dam and progressing downstream in the Columbia River to its mouth (Table 9).

Table 9. Approximate HUC starting and ending points in the EFH action area.

HUC	Hydrologic Unit Name	From	To
17020005	Columbia River – Chief Joseph Dam	Chief Joseph Dam at RM 545.0 (Impassible Barrier)	Entiat River confluence at RM 483.7
17020010	Upper Columbia – Entiat River	Entiat River confluence at RM 483.7	Wanapum Dam at RM 415.0
17020016	Upper Columbia – Priest Rapids	Wanapum Dam at RM 415.0	Mouth of Snake River at RM 324.4
17070101	Mid Columbia – Lake Wallula	Mouth of Snake River at RM 324.4	John Day Dam at RM 215.6
17070105	Mid Columbia – Hood	John Day Dam at RM 215.6	Bonneville Dam at RM 146.1
17080001	Lower Columbia – Sandy River	Bonneville Dam at RM 146.1	Mouth of Willamette River at RM 101.5
17080003	Lower Columbia – Clatskanie River	Mouth of Willamette River at RM 101.5	Jones Beach at RM 47
17080006	Lower Columbia River	Jones Beach at RM 47	Mouth of Columbia River at RM 0

3.2 Effects on Essential Fish Habitat

Based on information provided in the BA (Reclamation 2012) and the analysis of effects presented in the ESA portion of this document (Section 2.4 Effects of the Action), NMFS concludes that the proposed action will not have adverse effects on EFH designated for:

- Upper Columbia River spring-run Chinook
- Snake River spring/summer-run Chinook
- Snake River fall-run Chinook
- Lower Columbia River Chinook
- Upper Willamette River Chinook
- Lower Columbia River coho

Effects on three unlisted ESUs of Chinook salmon were not evaluated in the preceding ESA consultation: Mid-Columbia River spring-run Chinook, Deschutes River summer/fall-run Chinook, and Upper Columbia River summer/fall-run Chinook. Discussion of these ESUs and the anticipated effects of the action on their EFH follow.

3.2.1. Middle Columbia River spring Chinook Salmon

The unlisted MCR spring Chinook salmon ESU consists of populations that spawn and rear in CR tributaries from the Klickitat River upstream to include the Yakima River (excluding the Snake River basin). MCR spring Chinook salmon are stream-type fish (like Snake River spring Chinook salmon) that typically rear for at least one year in fresh water tributaries before migrating to the ocean. They return to their natal streams as adults during the spring months, and spawn in the late summer or fall. Middle Columbia River spring Chinook salmon migrate from their natal streams through the CR primarily in April, May, and June. A small percentage of these migrating fish spend additional time rearing in the CR estuary during the summer months (See Section 2.4.3.2) and some individual fish are likely to be present in the estuary from October through March, when the proposed flow reductions would take place. The effects of this action on MCR spring Chinook salmon habitat in the mainstem CR and estuary are expected to be similar to those previously described for SR spring/summer Chinook salmon (see Section 2.4.3.7) and will not adversely affect essential fish habitat.

3.2.2. Deschutes River Summer/Fall Chinook Salmon

The unlisted Deschutes River summer/fall Chinook salmon ESU consists of a single population that spawns and rears in the Deschutes River, Oregon. Deschutes River summer/fall Chinook salmon are ocean-type fish (like Snake River fall Chinook salmon and Upper Columbia River summer/fall Chinook salmon) that typically rear for only a few months in fresh water tributaries (or mainstem rearing areas) before migrating to the ocean. They return to their natal streams as adults during the summer and fall months, and spawn in the fall. Deschutes River summer/fall Chinook salmon migrate from their natal streams through the CR primarily in May and June. Some of these fish likely rear in the CR estuary over the summer months (See Section 2.4.3.2) and some portion of these fish are likely to be present in the estuary from October through March, when the proposed flow reductions would take place. The effects of this action on Deschutes River summer/fall Chinook salmon habitat in the mainstem CR and estuary are expected to be similar to those previously described for SR fall Chinook salmon (see Section 2.4.3.8) and will not adversely affect essential fish habitat.

3.2.3. Upper Columbia River summer/fall Chinook Salmon

The unlisted UCR summer/fall Chinook salmon ESU consists of populations that spawn and rear in the mainstem CR and the lower reaches of selected tributaries upstream of the confluence with the SR to Chief Joseph Dam. UCR summer/fall Chinook salmon are ocean-type fish (like SR fall Chinook salmon and Deschutes River summer/fall Chinook salmon) that typically rear for only a few months in fresh water tributaries (or mainstem rearing areas) before migrating to the ocean. They return to their natal streams as adults during the summer and fall months, and spawn in the fall. Upper Columbia River summer/fall Chinook salmon migrate from their natal streams through the CR primarily in May, June, July, and August, but small numbers of juveniles are likely present in the mainstem CR from September through April as well. In addition, some juveniles likely rear in the CR estuary over the summer months (See Section 2.4.3.2), and some portion of these fish are likely to be present in the estuary from October through March when the proposed flow reductions would take place. The effects of this action on UCR summer/fall Chinook salmon habitat in the mainstem CR and estuary are expected to generally be similar to those previously described for SR fall Chinook salmon (see Section 2.4.3.8). However, a closer examination of potential effects to one population, which spawns and rears in the Hanford Reach of the mainstem CR is warranted.

The Hanford Reach population of UCR summer/fall Chinook salmon spawns and rears in the last free-flowing reach of the CR above the estuary, between the tailrace of Priest Rapids Dam and the head of the McNary pool. This population is of special significance to regional and international fisheries managers because it is one of the most productive mainstem spawning areas for fall Chinook in the CR basin and supports the largest spawning population for fall Chinook salmon in the Pacific Northwest.

Under the proposed action, the flow reductions during October to March overlap all freshwater life stages of UCR summer/ fall Chinook salmon in the Hanford Reach of the CR. Adults migrate during the months of August through November. Spawning typically begins in mid- to late October and peaks in early to mid-November. Incubation occurs from late October through April. Juvenile rearing occurs from March to July in the Hanford Reach and fish continue to rear while migrating through the mainstem Columbia River and in the estuary. The migration and spawn timing of this population of UCR summer/fall Chinook salmon adults overlaps substantially with the proposed action flow reduction of 2,700-cfs in October. Also, the spawning, incubation, rearing, and migration timing of these fish overlaps with the potential November through March flow reductions of up to 350 cfs.

The Hanford Fall Chinook Protection Program Agreement ("protection agreement," Grant PUD 2004) was developed to provide adequate conditions for fall Chinook spawning, incubation, and juvenile rearing in the Hanford Reach of the CR. One key feature of this agreement is to limit spawning and redd creation in channel areas that cannot be kept wet throughout incubation by managing flows to minimize fall Chinook spawning above the water elevation occurring at a flow of 70 kcfs at Vernita Bar, a major spawning location downstream from Priest Rapids Dam.

The protection level for redds established under the spawning provisions of this agreement can range from 50 to 70 kcfs. The redd protection flow for the rearing season is determined by a final red count in late November. The minimum instantaneous flow required below Priest Rapids Dam under this agreement is 36 kcfs except when maintenance of other operations of the agreement requires a higher flow. The protection agreement also includes provisions to limit flow fluctuations to protect fry while they are rearing in the Hanford Reach.

The proposed action has the potential to affect fall Chinook salmon spawning, rearing, and migration for this ESU because all of these life-history stages and activities occur within the action area and may be present while diversions are taking place. Because spawning occurs when the proposed action flow reductions would occur, the proposed action could adversely affect EFH. The anticipated 2.5% flow reduction in October corresponds with the early spawning period and active adult migration period for this ESU and could reduce the availability of suitable habitat conditions in the mainstem spawning areas.

Effects on flows and river elevations below Priest Rapids dam were discussed earlier in Section 2.4.1. The largest relative effects of the proposed action on EFH in the Hanford reach would occur under low flows. Between 1990 and 2008, the minimum daily mean flow in October was 38,300 on October 7, 2008. A 2,700 cfs flow reduction at such low flows would reduce average channel depth by 0.43 ft. or 5.2 inches. A flow reduction of 350 cfs would reduce average channel depth by 0.06 ft. or 0.72 inch.

At 38,300 cfs, the proposed 2,700 cfs flow reduction would reduce average channel velocity at the gage site by about 0.1 fps, from 2.12 to 2.02 fps.

Because migrating adults do not appear to be adversely affected by decreasing flows in the mainstem Columbia River, we conclude that the proposed action would not adversely affect adult migration EFH.

In summary, based on the above analysis, NMFS concludes that Reclamation's proposed action could adversely affect spawning EFH for UCR Chinook salmon in the Hanford Reach of the CR to the extent that proposed flow reductions cause Priest Rapids flows to fall below those specified by the Hanford Fall Chinook Protection Program Agreement.

3.3 Essential Fish Habitat Conservation Recommendations

As discussed in Section 3.2.1 above, the proposed action could interfere with protective operations for the Hanford reach population of fall Chinook and adversely affect EFH in October during the lowest flow years. We therefore recommend that in the event that daily average discharge at Priest Rapids Dam falls below 40,000 cfs, from the first Sunday after October 15 through March 31, pumping to supply irrigation water to lands served by the Odessa subarea project or to refill Banks Lake, be curtailed.

NMFS expects that fully implementing this EFH conservation recommendation would protect, by avoiding or minimizing the adverse effects described in Section 3.2.3 above, about 55 miles (~25,000 acres) of designated EFH for Pacific coast salmon.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is Reclamation. Other interested users include the state of Washington, WDOE, and Odessa subarea irrigators. Individual copies of this opinion were provided to Reclamation. This opinion will be posted on the NMFS Northwest Region web site (http://www.nwr.noaa.gov). The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

5. REFERENCES

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status Review for the North American green sturgeon. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 49 pp.

Allen, M.J. and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Department of Commerce, NOAA Technical Report. NMFS-NWFSC-66.

Angliss, P.P. and B. M. Allen. 2009. Alaska marine mammal stock assessments, 2008. NOAA Technical Memorandum NMFS-AFSC-193. April 2009.

Antolos, M., D.D. Roby, D.E. Lyons, K. Collis, A.F. Evans, M. Hawbecker and B.A Ryan. 2005. Caspian tern predation on juvenile salmonids in the mid-Columbia River. Transactions of the American Fisheries Society 134:466-480.

Arkoosh, M.R., E. Casillas, E. Clemons, B. McCain, and U. Varanasi. 1991. Suppression of immunological memory in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from an urban estuary. Fish and Shellfish Immunology 1:261-277.

Arkoosh, M.R., E. Casillas, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998. Increased susceptibility of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from a contaminated estuary to the pathogen *Vibrio anguillarum*. Transactions of the American Fisheries Society 127:360-374.

Arkoosh, M.R., E. Clemons, M. Myers, and E. Casillas. 1994. Suppression of B-cell mediated immunity in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) after exposure to either a polycyclic aromatic hydrocarbon or to a polychlorinated biphenyls. Immunopharmocology and Immunotoxicology 16(2):293-314.

Axel, G.A., E.E. Hockersmith, M.B. Eppard, B.P. Sandford, S.G. Smith, and D.B. Dey. 2003. Passage behavior and survival of hatchery yearling Chinook salmon passing Ice Harbor and McNary Dams during a low flow year, 2001. Report to the U.S. Army Corps of Engineers by the National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Bain, D. 1990. Examining the validity of inferences drawn from photo-identification data, with special reference to studies of the Killer Whale (Orcinus orca) in British Columbia. Report of the International Whaling Commission, Special Issue 12:93-100, 1/1/1990.

Baird, R.W. 2000. The killer whale: foraging specialization and group hunting. Pages 127-153 in J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead, editors. Cetacean Societies: Field Studies of Dolphins and Whales. The University of Chicago Press, Chicago, Illinois, 1/1/2006.

Barraclough 1964. Barraclough, W.E. 1964. Contribution to the marine life history of the eulachon (*Thaleichthys pacificus).* Journal of Fisheries. Research Board of Canada. 21:1333-1337.

Beamesderfer, R.C. 1992. Reproduction and early life history of northern squawfish, *Ptychocheilus oregonenesis*, in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241

Beamesderfer, R.C., B.E. Rieman, L.J. Bledsoe, and S.Vigg. 1990. Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304

Beamesderfer, R.C., D.L. Ward, and A.A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake Rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908

Beamesderfer R.C.P., G. Kopp, and D. Demko. 2005. Review of the distribution, life history and population dynamics of green sturgeon with reference to California's Central Valley. S. P. Cramer and Associates, Inc. Gresham, OR.

Beamesderfer, R.C.P. M.L. Simpson, and G.J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes, 79:315-337.

Beamis WE, Kynard B. 1997. Sturgeon rivers: an introduction to acipensiform biogeography and life history. Environmental Biology of Fishes, 48:167–183.

Bennett, D. and C. Peery. 2003. Biological effects of Snake River thermal regimes on endangered species in the lower Snake River. Report prepared for the U.S. Army Corps of Engineers by Normandeau Associates, Bedford, New Hampshire.

Bennett, D.H. and Naughton, G.P. 1999. Predator abundance and salmonid prey consumption in tailrace and forebay of Lower Granite Dam. Completion report to U.S. Army Corps of Engineers by the Department of Fish and Wildlife Resources, University of Idaho, Moscow.

Bentley, W.W., and H.L. Raymond. 1976. Delayed migration of yearling Chinook salmon since completion of Lower Monumental and Little Goose Dams on the Snake River. Transactions of the American Fisheries Society 105(3):422-424.

Berejikian, B.A. and M.J. Ford. 2004. Review of relative fitness of hatchery and natural salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-61, 28p.

Bevan, D., J. Harville, P. Bergmna, T. Bjornn, J. Crutchfield, P. Klingeman and J. Litchfield. 1994. Snake River Recovery Team: Final Recommendations to National Marine Fisheries Service. May 1994.

Beyer, J.M., G. Lucchetti, and G. Gray. 1988. Digestive tract evacuation in northern squawfish (*Ptychocheilus oregonenesis*). Canada Journal of Fisheries and Aquatic Sciences 45:548-553.

Bigg, M. 1982. An assessment of killer whale (Orcinus orca) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission 32:655-666, 1/1/1982.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, et al. 1990. Social organization and genealogy of resident Killer Whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12:383-398, 1/1/1990.

Bjornn, T.C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, Sockeye Salmon (*Oncorhynchus nerka*). Transactions of the American Fisheries Society, 97 (4): 360-373.

Boggs, C.T. and C. A. Peery. 2004. Steelhead (*Oncorhynchus mykiss*) kelt abundance, condition, passage and survival in the lower Snake and Columbia Rivers, 2003. Report to the U. S. Army Corps of Engineers by the Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow.

Boggs, C. T., M. L. Keefer, C. A. Peery, T. C. Bjornn, L. C. Stuehrenberg. 2004. Fallback, Reascension, and Adjusted Fishway Escapement Estimates for Adult Chinook Salmon and Steelhead at Columbia and Snake River Dams. Transactions of the American Fisheries Society, 133: 932-949.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-68, 246p.

Brannon, E., M. Powell, T. Quinn, and A. Talbot. 2004. Population structure of Columbia River basin Chinook salmon and steelhead trout. Reviews in Fisheries Science, 12:99-232.

Budy, P., G.P. Thiede, N. Bouwes, C.E. Petrosky, H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. North American Journal of Fisheries Management 22(1):35-51

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC- 27.

Busch, S., P. McElhany, and M. Ruckelshaus. 2008. A comparison of the viability criteria developed for management of ESA-listed Pacific salmon and steelhead. Northwest Fisheries Science Center.

Bustard and Narver 1975. Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon(Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Journal of Fisheries Research Board of Canada. 32:667-680.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995a. Chemical contaminant exposure and physiological effects in out-migrant juvenile Chinook salmon from urban estuaries of Puget Sound, Washington. Proceedings of Puget Sound Research '95. Puget Sound Water Quality Authority, Olympia, Washington.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995b. Estuaries chemical contaminant exposure and physiological effects in out-migrant juvenile Chinook salmon from selected urban estuaries of Puget Sound, Washington. Proceedings of the 1994 Northeast Pacific Chinook and Coho Salmon Workshop: Salmon Ecosystem Restoration: Myth and Reality edited by M. Keefe. American Fisheries Society, Oregon Chapter, Corvallis, Oregon.

Casillas, E. B-T. L. Eberhard, T.K. Collier, M.M. Krahn, and J.E. Stein. 1998a. Hylebos fish injury study: round 2, part 3: exposure of juvenile Chinook salmon to chemical contaminants specific to the Hylebos Waterway: Tissue concentrations and biochemical responses. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Casillas, E. 1999. Role of the Columbia River estuary and plume in salmon productivity. Proceedings of the Northwest Power Planning Council Ocean Symposium. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Caudill, C. C., W. R. Daigle, M. L. Keefer, C. T. Boggs, M. A. Jepson, B. J. Burke, R. W. Zabel, T. C. Bjornn, and C. A. Peery. 2007. Slow dam passage of adult Columbia River salmonids associated with unsuccessful, migration: delayed negative effects of obstacles or condition dependent mortality? Canadian Journal of Fisheries and Aquatic Sciences. 64:979-995.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Review of the history, development, and management of anadromous fish production facilities in the Columbia River Basin. CBFWA, Portland, Oregon.

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing. 129p.

Collis, K. D.D. Roby, C. Couch, G. Dorsey, K. Fisher, D.E. Lyons, A.M. Myers, S.K. Nelson, R.M. Suryan, A. Evans, and M. Hawbecker. 2003. Caspian tern research on the lower Columbia River. Draft 2003 season summary. Prepared for the Bonneville Power Administration and the Interagency Caspian Tern Working Group, Portland, Oregon.

Collis, K., D.D. Roby, D.E. Lyons, Y. Suzuki, J.Y. Adkins, L. Reinalda, C. Hand, N. Hostetter, A. Evans, and M. Hawbecker. 2007. Research, monitoring, and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Draft 2006 season summary report to the Bonneville Power Administration and U.S. Army Corps of Engineers, Portland, Oregon

Collis, K., D.D. Roby, D.P. Craig, S. Adamany, J. Adkins, and D.E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society 131:537-550.

Cooney, T. and M. Ford. 2007. Snake River Fall Chinook: Summary of Status and Hatchery Considerations. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Corps (U.S Army Corps of Engineers). 2004. Portland-Vancouver Harbor Information Package, Second Edition. U.S. Army Corps of Engineers, Portland District. Portland, Oregon.

Corps (U.S. Army Corps of Engineers), BPA (Bonneville Power Administration), and USBR (U.S. Bureau of Reclamation). 2007. Comprehensive analysis of the Federal Columbia River Power System and mainstem effects of Upper Snake and other tributary actions. Corps, Portland, Oregon, 8/1/2007.

Corps. 2012. E-mail communication with Peter Dickerson of the U.S. Army Corps of Engineers regarding the ability of existing hydraulic models to measure the effect of a 2700 cfs flow reduction on the water surface elevation of the Columbia River.

Coutant, C.C. 1999. Perspectives on temperature in the Pacific Northwest's fresh waters. Oak Ridge National Laboratory. Oak Ridge, TN. ORNL/TM-1999/44.

Doney, S. C., V. J. Fabry, R. A. Feely, and J. A. Klepas. 2009. Ocean Acidification: The other CO2 Problem. Annual Review of Marine Science. Vol. 1, 169-192.

Dumbauld, B.R, D.L. Holden, and O.P. Langness. 2008. Do Sturgeon limit burrowing shrimp populations in Pacific Northwest Estuaries? Environmental Biology of Fishes 83:283-296.

Ebel, W. J., D. L. Park, and R. C. Johnson. 1973. Effects of transportation on survival and homing of Snake River Chinook salmon and steelhead trout. Fisheries Bulletin 71(2):549-563.

Ebel, W. 1980. Transportation of Chinook salmon, *Oncorhynchus tshawytscha*, and steelhead, *Salmo gaurdneri*, smolts in the Columbia River and effects on adult returns. Fisheries Bulletin 78:491-505.

Erickson, A.W. 1978. Population studies of killer whales (Orcinus orca) in the Pacific Northwest: a radio-marking and tracking study of killer whales. Marine Mammal Commission, Washington, D.C., 9/1/1978.

Fabry, J. F., B. A. Seibel, R. A. Feely, J. C. Orr. 2008. ICES Journal of Marine Science. Impacts of ocean acidification on marine fauna and ecosystem processes. Volume 65, Issue 3, 414-432.

Faler, M.P., L.M. Miller, and K.I. Welke. 1988. Effects of variation in flow on distribution of northern squawfish in the Columbia River below McNary Dam. North American Journal of Fisheries Management 8:30-35.

Falter, C.M. 1969. Digestive rates and daily rations of northern squawfish in the St. Joe River, Idaho. Doctoral dissertation, University of Idaho, Moscow.

Faulkner, J.R., S.G. Smith, W.D. Muir, D.M. Marsh, and J.G. Williams. 2010. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2010. Report of Research by Fish Ecology Division, Northwest Fisheries Science Center for U.S. Department of Energy, Bonneville Power Administration. Project 199302900. December 2010.

Faulkner, J.R., S.G. Smith, W.D. Muir, D.M. Marsh, and R.W. Zabel. 2012. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2011. Report of research to U.S. Department of Energy, Bonneville Power Administration. Project 199302900. February 2012.

Feist, B. E. and J. J. Anderson 1991. Review of fish behavior relevant to fish guidance systems. Annual Report of Research. Fisheries Research Institute, School of Fisheries, University of Washington, Seattle, WA.

Ferguson, J. W., G. M. Matthews, R. L. McComas, R. F. Absolon, D. A. Brege, M. H. Gessel, L. G. Gilbreath. 2005. Passage of Adult and Juvenile Salmonids through Federal Columbia River Power System Dams. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-64, 184 p.

Ferguson, J. W., B. P. Sanford, R. E. Reagan, L. Gilbreath, E. Meyer, R. Ledgerwood, N. S. Adams. 2007. Bypass system modification at Bonneville Dam on the Columbia River improved the survival of juvenile salmon. Transactions of the American Fisheries Society. Volume:136, Pages: 1487-1510.

Fisher, T., and Hinrichsen, R. 2006. Abundance-based trend results for Columbia Basin salmon and steelhead ESUs. Bonneville Power Administration, Portland, OR.

Ford, J. K.B. and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales (*Orcinus orca*) in British Columbia. Marine Ecology Press Series 316: 185-199.

Ford, J.K.B., Ellis, G.M. & Balcomb, K.C. 2000. Killer Whales: The Natural History and Genealogy of Orcinus orca in British Columbia and Washington State, 2nd edition. UBC Press, Vancouver, British Columbia.

Ford, J. K., Ellis, G. M., Olesiuk, P. F., & Station, P. B. 2005. Linking prey and population dynamics: did food limitation cause recent declines of ‘resident’ killer whales (Orcinus orca) in British Columbia? Canadian Science Advisory Secretariat Research Document 2005/42.

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

Ford, M.J., B. Hanson, J. A. Hempelmann, K. L. Ayres, C. K. Emmons, G. S. Schorr, R. W. Baird, K. C. Balcomb, S. K. Wasser, K. M. Parsons and K. Balcomb-Bartok. 2011. Inferred Paternity and Male Reproductive Success in a Killer Whale (Orcinus orca) Population. J. of Heredity. Vol. 102, Iss. 5, pp 537-553. Oxford Journals.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-69, 105p.

Friesen, T.A., and D.L. Ward. 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake Rivers. North American Journal of Fisheries Management 19:406-420.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 618.

Gadomski, D.M., M.G. Mesa, and T.M. Olson. 1994. Vulnerability to predation and physiological stress responses of experimentally descaled juvenile Chinook salmon, *Oncorhynchus tshawytscha*. Environmental Biology of Fishes 39:191-199.

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

Grant PUD (Grant County Public Utility District). 2004. Hanford Reach Fall Chinook Protection Agreement. Article of FERC license for operation of the Priest Rapids Project.

Gray, G.A. and D.W. Rondorf. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 *in* G.E. Hall and M.J. Van Den Avyle, editors. Reservoir fisheries management strategies from the '80s. American Fisheries Society, Southern Division, Bethesda, Maryland.

Grimaldo, L., and S. Zeug. 2001. IEP Resident Fish Project Work Team hosts meeting on green sturgeon. IEP Newsletter 14(4):19-32, 9/1/2001.

Hanson, M. Bradley, Robin W. Baird, John K.B. Ford, et al. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research 11: 69-82.

Hay, D.E. and P.B. McCarter. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario.

Hart, J. L. and J. L. McHugh. 1944. The Smelts (Osmeridae) of British Columbia. Fisheries Research Board of Canada Bulletin No. 64.

Hockersmith, E. E. 2008. Passage behavior and survival for radio-tagged subyearling chinook salmon at Lower Monumental Dam, 2007, funded by USACE Walla Walla District, Contract No. W68SBV92844866, 9/1/2008.

ICTRT (Interior Columbia Technical Recovery Team). 2003. Independent Populations of Chinook, Steelhead, and Sockeye for Listed Evolutionarily Significant Units within the Interior Columbia Domain.

ICTRT. 2005. Viability criteria for application to Interior Columbia Basin salmonid ESUs. Northwest Fisheries Science Center.

ICTRT. 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs. Northwest Fisheries Science Center. March 2007. 91 p. + Appendices and Attachments.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

ISAB (Independent Scientific Advisory Board). 2000. The Columbia River Estuary and the Columbia River Basin Fish and Wildlife Program. Report of the ISAB dated November 28, 2000.

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

Israel, J. A and B. May. 2007. Mixed Stock Analysis of Green Sturgeon from Washington State Coastal Aggregations. Final Report. Genomic Variation Laboratory Department of Animal Science, Meyer Hall, UC Davis, Davis CA.

Israel, J. A., K. J. Bando, E. C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences. Vol. 66: 1491–1504.

Jones, K.K., C. A. Simenstad, D. L. Higley, and D. L. Bottom. 1990. Community structure, distribution, and standing stock of benthos, epibenthos, and plankton in the Columbia River Estuary. Progress in Oceanography, 25:211-241.

Jones, R., R. Turner, B. Farman, T. Tynan, L. Kruzic and M. Chilcote. 2011. Updated Evaluation of the Relatedness of Pacific Northwest Hatchery Programs to 18 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments Listed under the Endangered Species Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region, Portland, Oregon.

Keefer, M. L., C. A. Peery, T. C. Bjornn, M. A. Jepson, and L. C. Stuehrenberg. 2004. Hydrosystem, Dam, and Reservoir Passage Rates of Adult Chinook Salmon and Steelhead in Columbia and Snake River. Transactions of the American Fisheries Society, 133:6, 1413-1439.

Keefer, M.L., R.J. Stansell, S.C. Tackley, W.T. Nagy, K.M. Gibbons, C.A. Peery, and C.C. Caudill. 2012. Use of radiotelemetry and direct observations to evaluate sea lion predation on adult Pacific salmonids at Bonneville Dam. Transactions of the American Fisheries Society, 141:5, 1236-1251.

Kelly, J.T., A.P. Klimley, and C.E. Crocker. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay estuary, California. Environmental Biology of Fishes 79:281-295.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act. NOAA Tech. Memo., NMFS-NWFSC-54, U.S. Department of Commerce, Seattle, Washington.

Krahn, M.M, M.J. Ford, W.F. Perrin, et al. 2004. 2004 status review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-62, 73p, 12/1/2004.

Krahn, M.M., M.B. Hanson, R.W. Baird, et al. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin 54:1903-1911, 1/1/2007.

Kukulka, T., and D. A. Jay. 2003. Impacts of Columbia River discharge on salmonid habitat: II. Changes in shallow-water habitat. Journal of Geophysical Research, 108, 3294 doi 10.1029/2003JC001829.

LCREP (Lower Columbia River Estuary Program). 1999. Comprehensive conservation and management plan, volume 1. LCREP, Portland, Oregon.

LCFRB. 2004. Lower Columbia Salmon Recovery and Fish and Wildilife Subbasin Plan. Volume I - Regional Plan. Lower Columbia Fish Recovery Board. December 15, 2004.

LCFRB. 2010. Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, Chapters 1-4. Lower Columbia Fish Recovery Board, Olympia, WA.

Lohn, Robert. 2006. Guidance on informal consultations and preparation of letters of concurrence. January 30, 2006, memorandum from D. Robert Lohn to consultation biologists.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change 102:187-223

Marriott, D., and 27 contributors. 2002. Lower Columbia River and Columbia River Estuary Subbasin Summary. Report Prepared for the Northwest Power Planning Council, dated May 17, 2002.

McCarter, P. B. and Hay, D. E. 1999. Distribution of spawning eulachon stocks in the central coast of British Columbia as indicated by larval surveys. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat Research document 99/177. Ottawa, Ontario.

McLain, J. 2006. Memo from J. McLain (NMFS) to Southern Distinct Population Segment of North American, green sturgeon consultation guidance RE: The likely distribution of the southern distinct population segment of North American green sturgeon in SWR Waters, 12/18/2006. California. NMFS, Southwest Region, Long Beach, California.

McClure, M., T. Cooney and the Interior Columbia Technical Recovery Team (ICTRT). 2005. Memorandum To: NMFS NW Regional Office, Co-managers and Other Interested Parties re: Updated Population Delineation in the Interior Columbia Basin.

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

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward and T. Whitesel. 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. Willamette/Lower Columbia Technical Recovery Team. March 31.

McElhany, P., T. Backman, C. Busack, S. Kolmes, J. Myers, D. Rawding, A. Steel, C. Stewart, T. Whitesel, and C. Willis. 2004. Status evaluation of salmon and steelhead populations in the Willamette and Lower Columbia river basins. Willamette/Lower Columbia Technical Recovery Team. July 2004.

McElhany, P., M. Chilcote, J. Myers, R. Beamesderfer. 2007. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. National Marine Fisheries Service Northwest Fisheries Science Center. September 2007.

McHugh 1939. McHugh J. L. 1939. *The eulachon*. Progress Report of the Pacific Biological Station, Nanaimo, B.C. and Pacific Fisheries Experimental Station, Prince Rubert, B.C. 40: 17-22.

Mellema, Mary. 2012. Technical Report: Columbia River Surface Water Quantity: Odessa Subarea Special Study EIS. November 2012.

Mesa, M.G., and T.M. Olson. 1993. Prolonged swimming performance of northern squawfish. Transactions of the American Fisheries Society 122:1104-1110.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile Chinook salmon. Transactions of the American Fisheries Society 123:786-793

Mighetto, L., W.J. Ebel. 1994. Saving the salmon: A history of the US Army Corps of Engineers' efforts to protect anadromous fish on the Columbia and Snake Rivers. Historical Research Associates, Seattle, Washington.

Moser, M.,L. and S.T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology Fishes 79:243-253.

Moyle, P.B., P.J. Foley, and R.M. Yoshiyama. 1992. Status of green sturgeon, Acipenser medirostris, in California. Final Report submitted to the National Marine Fisheries Service. University of California, Davis. 11 pp.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2003. Historical population structure of Willamette and lower Columbia River basin Pacific salmonids. Willamette/Lower Columbia River Technical Recovery Team report.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. U.S. Dept. Commer., NOAA Tech. Memo. NMFSNWFSC- 73, 311 p.

NMFS (National Marine Fisheries Service). 1991. Endangered and Threatened Species: Enadangered Status for Snake River Sockeye Salmon. Final rule. Federal Register: Vol. 56, No. 224, pp 58691-58624.

NMFS. 1992. Endangered and Threatened Species; Threatened Status for Snake River Spring/Summer Chinook Salmon, Threatened Status for Snake River Fall Chinook Salmon. Final rule. Federal Register: Vol. 57, No 78, pp. 14658-14663.

NMFS. 1993. Designated Critical Habitat: Snake River Sockeye Salmon, Snake River Spring/Summer Chinook Salmon, and Snake River Fall Chinook Salmon. Federal Register, Vol. 58, No. 247, pp. 68543-68554.

NMFS. 1997a. Endangered Species Act Section 7 biological opinion on permit application number 96-697 by Inland Land, Inc., for construction of a pumping facility on the Columbia River. National Marine Fisheries Service, Northwest Region. Portland, OR.

NMFS. 1997b. Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead. Final rule. Federal Register: Vol. 62, No. 159, pp. 43937-43954.

NMFS. 1999a. Designated critical habitat: revision of critical habitat for Snake River spring/summer chinook salmon. Federal Register 64(205):57399-57403, 10/25/1999.

NMFS. 1999b. Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington and Oregon. Final Rule and Notice of Determination. Federal Register: Vol 64, No. 53, 14517.

NMFS. 1999c. Endangered and Threatened Species: Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon; Final rule. Vol. 64 No. 57, pp 14508-14517.

NMFS. 2000a. Endangered Species Act – Section 7 Consultation Biological Opinion for reinitiation of consultation on operation of the Federal Columbia River Power System, including the juvenile fish transportation program, and 19 Bureau of Reclamation projects in the Columbia basin. NMFS, Portland, Oregon.

NMFS. 2000b. White paper: predation on salmonids relative to the federal Columbia River power system. NMFS, Northwest Fisheries Science Center, Seattle, Washington.

NMFS. 2000c. Endangered and Threatened Species: Final Rule Governing Take of 14 Threatened Salmon and Steelhead Evolutionarily Significant Units (ESUs). Final Rule. Federal Register: Vol. 65, No. 132. pp. 42422-42481.

NMFS. 2001. Potential impacts of toxic contaminants in salmonids and prey from the Columbia River estuary. Draft. NMFS, Northwest Fisheries Science Center, Seattle, Washington.

NMFS. 2003. Advance Notice of Proposed Rulemaking to Designate Critical Habitat for 20 Listed Evolutionarily Significant Units of Pacific Salmon and Steelhead. Advance Notice of Proposed Rulemaking; request for information. Federal Register: Vol. 68, No. 188, p. 55926.

NMFS. 2005a. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho; Final rule. Federal Register: Vol. 70, No. 170, pp. 52630-52858.

NMFS. 2005b. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. Final Rule. Federal Register: Vol. 70, No. 123, 37160.

NMFS. 2005c. Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales. Final Rule. Federal Register: Vol. 70, No. 222, p. 69903.

NMFS. 2005d. Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams (CHART) for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead. NOAA Fisheries, Protected Resources Division, Portland, Oregon.

NMFS. 2006a. Endangered and Threatened Species; Final listing determinations for 10 Distinct Population Segments of West Coast Steelhead. Final Rule. Federal Register: Vol. 71, No. 3, pp. 834-862.

NMFS. 2006b. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register, Vol. 71, No. 67, 17757.

NMFS. 2006c. Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale. Final Rule. Federal Register Vol. 71, No. 229, 69054.

NMFS. 2007. Endangered and Threatened Species; Recovery Plans. Notice of Availability. Federal Register: Vol. 72, No. 194, pp. 57303-57307.

NMFS. 2008. Recovery plan for Southern Resident killer whales (Orcinus orca). NMFS, Northwest Region, Seattle, Washington, 1/17/2008.

NMFS. 2008a. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Action in the Upper Snake River Basin above Brownlee Reservoir. Consultation Conducted by: NOAA National Marine Fisheries Service, Northwest Region. May 5, 2008.

NMFS 2008b. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions. NOAA National Marine Fisheries Service, Northwest Region. May 5, 2008.

NMFS. 2008c. Recovery Plan for Southern Resident Killer Whales (Orcinus orca). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS. 2008d. National Marine Fisheries Service Endangered Species Act (ESA) Section 7 Consultation and Magnuson-Stevens Act Essential Fish Habitat (EFH) Consultation. (Consultation #2008/00486). March 11, 2008. 55 pages.

NMFS. 2008e. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on the re-issuance of regional general permit 3, authorizing 23 maintenance activities in Suisun Marsh, Solano County.

NMFS. 2009a. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of Eulachon. Proposed rule; 12–month petition finding; request for comments. Federal Register: Vol. 74, 52300.

NMFS. 2009b. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon; Final Rule. Federal Register: Vol. 74, No. 195, p. 52300.

NMFS. 2009c. Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. NMFS Northwest Region, Portland, Oregon. 260 pages.

NMFS. 2010a. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program. May 20, 2010. F/NWR/2010/02096.

NMFS. 2010b. Endangered and Threatened Wildlife and Plants: Threatened status for southern distinct population segment of eulachon. Federal Register Vol 75, No. 52, 13012.

NMFS. 2010c. Status Review Update for Eulachon in Washington, Oregon, and California. NOAA National Marine Fisheries Service, January 21, 2010. 443 pp.

NMFS. 2011a. Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead, 50 CFR Parts 223 and 224, Federal Register: Vol 76, No. 157, 50448-50449.

NMFS. 2011b. Southern Resident Killer Whales (*Orcinus orca*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Northwest Regional Office, Seattle, WA. January 2011.

NMFS. 2011c. Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon. Final Rule. Federal Register Vol. 76, No. 203, 65324.

NMFS. 2011d. Columbia River Estuary ESA Recovery Plan Module for salmon and steelhead. National Marine Fisheries Service, Northwest Region.

NMFS. 2012a. Endangered Species Act Section 7(a)(2) Consultation Supplemental Biological Opinion Supplemental Consultation on Reducing the Impacts on At-risk Salmon and Steelhead by California Sea Lions in the Area Downstream of Bonneville Dam on the Columbia River, Oregon and Washington (Consultation#: 2011/05874) February 29, 2012. 22 pages.

NMFS. 2012b. Proposed ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. April 2012.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

ODEQ (Oregon Department of Environmental Quality). 2007. Guidance for assessing bioaccumulative chemicals of concern in sediment. ODEQ, Portland, Oregon.

ODFW (Oregon Department of Fish and Wildlife). 2010. Upper Willamette Conservation and Recovery Plan for Chinook and Steelhead (Proposed October 22, 2010) Oregon Department of Fish and Wildlife.

ODFW and NMFS. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead Final- August 5, 2011.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2009a. 2009 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. Joint Columbia River Management Staff.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2009b. Joint Staff Report Concerning Stock Status and Fisheries for Sturgeon and Smelt. December 7, 2009. 46 pp.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. Re. Int. Whal. Commn. (special issue) 12:209-244.

Orr, J. C., V. J. Fabry, L. Aumont, L. Bopp, S. C. Doney, R. A. Feely, A. Gnanadeskan, N. Gruber, A. Ishida, F. Joos, R. M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R. G. Najjar, G. K. Plattner, K. B. Rodgers, C. L. Sabine, J. L. Samiento, R. Schlitzer, R. D. Slater, I. J. Totterdell, M. F. Weirig, Y, Yamanaka, And A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437:681-686.

Park, D.L. 1969. Seasonal changes in downstream migration of age-group 0 Chinook salmon in the upper Columbia River. Transactions of the American Fisheries Society 98:315-317.

Perry, R.W., A. Braatz, M. Novick, J. Lucchesi, G. Rutz, R. Koch, J. Schei, N. Adams, and D. Rondorf. 2007. Survival and migration behavior of juvenile salmonids at McNary Dam, 2005. Final report of research to the U.S. Army Corps of Engineers, by the U.S. Geological Survey, Western Fisheries Research Center, Cook, Washington.

PFMC. 1999. Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. Appendix A to Amendment 14 to the Pacific Coast Salmon Plan. Pacific Fishery Management Council, Portland, Oregon. March.

PGE (Portland General Electric). 1997. Fish Runs and the PGE Hydroelectric System: Willamette Falls, Sandy River, Clackamas River, and Deschutes River. 52 pp.

Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120(4):405-420.

Poe, T.P., M.G. Mesa, R.S. Shively, and R.D. Peters. 1994. Development of biological criteria for siting and operation of juvenile bypass systems: implications for protecting juvenile salmonids from predation. Proceedings of a symposium on fish passage responsibility and technology. American Fisheries Society Annual Meeting 1993:169-176

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. U.S. Fish and Wildlife Service, U.S. Department of the Interior. FWS/OBS-82/10.60. January 1984.

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Chinook salmon. U.S. Fish Wildlife Service Biological Report 82(10.122). 64 pp.

Raymond, H.L. 1968. Migration rates of yearling Chinook salmon in relation to flows and impoundments in the Columbia and Snake Rivers. Transactions of the American Fisheries Society 97:356-359.

Raymond, H.L. 1969. Effect of John Day reservoir on the migration rate of juvenile Chinook salmon and steelhead in the Columbia River. Transactions of the American Fisheries Society 98(3):513-514.

Raymond, H.L. 1979. Effects of dams and impoundments on migrations of juvenile Chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108(6):505-529.

Raymond, H.L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer Chinook salmon and steelhead in the Columbia River basin. North American Journal of Fisheries Management 8(1):1-23.

Reclamation (U.S. Bureau of Reclamation). 2004a. Final Environmental Impact Statement Banks Lake Drawdown. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region. Boise, Idaho and Ephrata, Washington. May 2004. 300 pages plus appendices.

Reclamation 2004b. Banks Lake Drawdown Record of Decision. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region. Boise, Idaho. June 29, 2004.

Reclamation. 2012. Biological Assessment of Effects to Species and Critical Habitat for Thirteen Anadromous Salmon ESUs, Pacific Eulachon, Green Sturgeon, and Killer Whales in the Columbia River Basin from Implementation of the Modified Partial Groundwater Irrigation Replacement Alternative (Alternative 4A), Odessa Subarea Special Study, Columbia Basin Project, Washington. October 2012.

Reclamation and WDOE (U.S. Bureau of Reclamation and Washington Department of Ecology). 2012. Final Environmental Impact Statement: Odessa Subarea Special Study, Columbia Basin Project, Washington. August 2012.

Reisenbichler, R.R., J.D. McIntyre, M.F. Solazzi, and S.L. Landina. 1992. Genetic variation in steelhead of Oregon and northern California. Transactions of the American Fisheries Society 121: 158-162.

Rich, W. H. 1920. Early history and seaward migration of Chinook salmon in the Columbia and Sacramento rivers. Bulletin of the Bureau of Fisheries 37:1-74

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458

Rien T., R. Farr and J. North. 2002. Green sturgeon population characteristics in Oregon. Oregon Department of Fish and Wildlife, Sport Fish Restoration Project F-178-R, Portland, Oregon.

Roby, D.D., D.E. Lyons, D.P. Craig, K. Collis, and G.H. Visser. 2003. Quantifying the effects of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology 81:250-265.

Roby, D.D., principal investigator, and 13 others. 2011. Impacts of avian predation on salmonids smolts from the Columbia and Snake Rivers. 2004-2009 synthesis report. USACE. Walla Walla, WA.

Romano, M.D., Howell, and T.A. Rien. 2002. Use of Artificial Substrate to Capture Eulachon (Thaleichthys pacificus) Eggs in the Lower Columbia River. 14 pp.

Ruggerone, G. T. 1986. Consumption of Migrating Juvenile Salmonids by Gulls Foraging below a Columbia River Dam. Transactions of the American Fisheries Society 115: 736-742.

Ryan, B.A., M.C. Carper, T.M. Gossen, M.G. Callaizakis, A.S. Cameron, E.P. Nunnallee, B.P. Sanford, and G.M. Matthews. 2006. Detection of passive integrated transponder (PIT) tags on piscivorous bird colonies in the Columbia River Basin, 2003-2005. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Sandford, B.P., and S.G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River basin anadromous salmonids, 1990–1997. Journal of Agricultural, Biological, and Environmental Statistics 7(2):243–263.

Sauter, S.T., R.M. Schrock, J.H. Petersen, and A.G. Maule. 2004. Assessment of smolt condition: biological and environmental interactions. Final report: the impact of prey and predators on juvenile salmonids. U.S. Geological Survey, Cook, Washington.

Scordino, Joe. 2010. West coast pinniped program investigations on California sea lion and Pacific Harbor seal impacts on salmonids and other fishery resources. Report to the Pacific States Marine Fisheries Commission. PSMFC, Portland, Oregon, 1/1/2010.

Shirvell, C.S. 1994. Effect of changes in streamflow on the microhabitat use and movements of sympatric juvenile coho (Oncorhynchus kisutch) and Chinook salmon *(0.* tshawytscha) in a natural stream. Canadian Fish and Aquatic Science. 51 : 1644-1 652.

Stansell, R.J., K.M. Gibbons, W.T. Nagy, and B.K. van der Leeuw. 2012. 2012 Field Report: evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2012. October 4, 2012.

Steigenberger, L.W. and P.A. Larkin. 1974. Feeding activity and rates of digestion of northern squawfish (*Ptychocheilus oregonensis*). Journal of Fisheries Research Board of Canada 31(4):411-420.

Stout, H.A., P.W. Lawson, D. Bottom, T. Cooney, M. Ford, C. Jordan, R. Kope, L. Kruzic, G.Pess, G. Reeves, M. Scheuerell, T. Wainwright, R. Waples, L. Weitkamp, J. Williams and T. Williams. 2011. Scientific conclusions of the status review for Oregon Coast coho salmon (*Oncorhynchus kisutch*). Draft revised report of the Oregon Coast Coho Salmon Biological Review Team. NOAA/NMFS/NWFSC, Seattle, WA.

Tabor, R.A., R.S. Shively, and T.P. Poe. 1993. Predation of juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management 13:831-838.

Thom, R., N. Sather, G.C. Roegner, and D.L. Bottom. 2012. Columbia Estuary Ecosystem Restoration Program 2012, Synthesis Memorandum, Draft. Prepared by Pacific Northwest National Laboratories (Batelle), and NOAA for U.S. Army Corps of ‘Engineers, Portland, Oregon. July 2012.

Thomas, D.W. 1981. Historical analysis of the Columbia River estuary: an ecological approach. Columbia River Estuary Study Taskforce, Astoria, Oregon

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. Prepared for the National Oceanic and Atmospheric Administration National Marine Fisheries Service and the U.S. Fish and Wildlife Service, Portland, OR. August.

U.S. Geological Survey (USGS). 2010. Water use trends in Washington 1985-2005. Fact Sheet 2010-3057. Washington Water Science Center. Tacoma, WA.

Van Hyning, J.M. 1973. Factors affecting the abundance of fall Chinook salmon in the Columbia River. Research Report of Fisheries Commission of Oregon 4(1):3-87.

Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S-L Chan, T. L. Collier, B.B. McCain and J.E. Stein. 1993. Contaminant exposure and associated biological effects in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from urban and nonurban estuaries of Puget Sound. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-8, 112p.

Vigg, A. and C.C. Burley. 1991. Temperature dependent maximum daily consumption of juvenile salmonids by northern squawfish (*Ptychocheilus oregonensis*) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48:2491-2498.

Vigg, S., T.P. Poe, L.A. Prendergast, and H.C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternate prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:421-438.

Volkman, J.M. 1997. A River in Common: The Columbia River, the Salmon Ecosystem, and Water Policy. Report to the Western Water Policy Review Advisory Commission. National Technical Information Service.

Wainwright, T. C., M. W. Chilcote, P. W. Lawson, T. E. Nickelson, C. W. Huntington, J. S. Mills, K. M. Moores, G. H. Reeves, H. A. Stout, L. A. Weitkamp. 2008. Biological recovery criteria for the Oregon Coast coho salmon evolutionarily significant unit. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-91, 199 p.

Waples, R. S., R. P. Jones, Jr., B. R. Beckman, and G. A. Swan. 1991. Status review for Snake River fall Chinook salmon, United States Department of Commerce, National Oceanic and Atmospheric Administration.

Ward, D.L., J.H. Petersen, and J.J. Loch. 1995. Index of predation of juvenile salmonids by northern squawfish in the lower and middle Columbia River and the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Ward, E.J., E.E. Holmes, K.C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. J. of Applied Ecology: Vol 42, Iss. 3, pp 632-640.

WDFW (Washington Department of Fish and Wildlife). 2010. WDFW Salmonid Stock Inventory (SaSI) database. Data submitted by WDFW in response to the five-year status review of listed species.

WDFW (Washington Department of Fish and Wildlife). 2010a. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board. May 28, 2010.

WDOE. 2004. Memorandum of Understanding Concerning the State of Washington's Columbia River Initiative. December 2004.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.K. Teel, R.G. Kope, and R.S. Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California. September 1995.

Wertheimer, R.H., and A.F. Evans. 2005. Downstream passage of steelhead kelts through hydroelectric dams on the lower Snake and Columbia Rivers. Transactions of the American Fisheries Society 134:853-865.

Williams, J.G., S.G. Smith, R.W. Zabel, W.D. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R.A. McNatt, and S. Achord. 2005. Effects of the Federal Columbia River Power System on salmonid populations. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-63, 150 p

Willson, M.F., R.H. Armstrong, M.C. Hermans, and K Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., Juneau, AK.

WRI (Willamette Restoration Initiative). 2004. Draft Willamette Subbasin Plan. Prepared for The Northwest Power and Conservaton Council. May 28, 2004.

Zimmerman, M.P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:1036-1054.