Endangered Species Act
Section 7 Consultation

BIOLOGICAL ASSESSMENT

Reintroduction of Bull Trout (*Salvelinus confluentus*) to the Clackamas River, Oregon

As Proposed by:

U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office

and the
Oregon Department of Fish and Wildlife

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1. INTRODUCTION 6
1.1 Project History 6
1.2 Related Biological Opinions in the Action Area 12
1.2.1 Clackamas River Hydroelectric Project Consultation 12
1.2.2 Willamette Basin Project Consultation 13
1.3 Reintroduction Feasibility Assessment 14
2. DESCRIPTION OF THE PROPOSED ACTION 18
2.1 Annual Donor Stock Availability 19
2.2 Numbers and Life Stages Proposed for Transfer 21
2.3 Donor Stock Collection and Timing 22
2.4 Release Locations and Timing 23
2.4.1 Principle Components Analysis 24
2.5 Disease Screening 25
2.5.1 Baseline Disease Assessment 25
2.5.2 Annual Protocols for Disease Screening 26
2.6 Action Area 27
2.7 Section 10(j) of the ESA 27
2.7.1 Geographic Boundaries of the 10(j) Designation 29
2.9 Monitoring and Evaluation 32
2.9.1 Reintroduction Effectiveness 33
2.9.2 Donor Population Status 35
2.9.3 Impacts to Listed Anadromous Salmonids 35
2.10 Adaptive Management of the Reintroduction Project 43
2.10.1 Adaptive Management Applied to Impacts to Salmon and Steelhead 45
2.11 Scientific Take Associated with Monitoring 49
3. STATUS OF THE SPECIES AND CRITICAL HABITAT 50
3.1 Rangewide Status of the Species 50
3.2 Life Histories, Factors for Decline & Population Trends 51
3.2.1 Upper Willamette River (UWR) Chinook Salmon 51
3.2.2 Lower Columbia River Chinook Salmon 62
3.2.3 Lower Columbia River Coho Salmon 66
3.2.4 Lower Columbia River Steelhead 69
3.3 Factors Affecting All Listed Salmon and Steelhead Species in the Estuary and Nearshore Ocean Environment 73
3.4 Climate Change 74
3.5 Summary of general range wide status of all four listed anadromous fish 75
3.6 Critical Habitat for Columbia & Willamette Basin Salmonids 75
3.6.1 Critical Habitat for Upper Willamette River (UWR) Chinook Salmon 77
3.6.2 Critical Habitat for LCR Chinook 79
3.6.3 Critical Habitat for LCR Steelhead 80
4. ENVIRONMENTAL BASELINE 81
4.1 Historical Populations of Anadromous Salmonids in the Clackamas Subbasin 84
4.1.1 Spring-run Chinook Salmon 84
4.1.2 Fall-run Chinook Salmon 85

4.1.3 LCR Coho Salmon 85
4.1.4 LCR Steelhead 85
4.2 Current status of ESA-Listed Salmon and Steelhead in the Subbasin 86
4.2.1 UWR (spring-run) Chinook Salmon 86
4.2.2 LCR (fall-run) Chinook Salmon 88
4.2.3 LCR Coho Salmon 88
4.2.4 LCR Steelhead 90
4.3 Limiting Factors and Threats to Recovery 93
4.4 Environmental Conditions 93
4.4.1 Habitat Access 93
4.4.2 Water Quantity/Hydrograph 95
4.4.3 Water Quality 97
4.4.4 Physical Habitat Characteristics 99
4.5 Hatchery Programs 101
4.6 Harvest 101
4.7 Status of PCEs of Designated Critical Habitat in the Clackamas Subbasin 102
5. EFFECTS OF THE ACTION 109
5.1 Species Interactions 110
5.2 Bull Trout Diet and Feeding Behavior 112
5.2.1 Juvenile Diet and Feeding Behavior 112
5.2.2 Sub-adult Diet and Feeding Behavior 112
5.2.3 Adult Diet and Feeding Behavior 113
5.2.4 Skagit River Bull Trout Study 114
5.2.5 Piscivory by Other Native Fish Species 115
5.3 Clackamas River Forage Base and Importance of Anadromous Prey Base 115
5.4 Geographic Areas of Vulnerability for Salmon and Steelhead 116
5.5 Expert Science Panel Workshop 118
5.6 Monitoring, Adaptive Management, and Flexibility under 10(j) Designation 123
5.7 Scientific Take Associated with Monitoring 123
5.8 Summary of Effects to Listed Salmon and Steelhead and Critical Habitat 123
5.8.1 Upper Willamette Spring Chinook Salmon 125
5.8.2 Lower Columbia Winter Steelhead 128
5.8.3 Lower Columbia Coho Salmon 129
5.8.4 Lower Columbia Fall Chinook Salmon 129
5.8.5 Effects to Critical Habitat 130
6. CUMULATIVE EFFECTS 132
6.1 Hatchery Operations 133
6.2 Non-Federal Timber Harvest 133
6.3 Recreation 134
6.4 Urban and rural development 134
6.5 Water supply 135
7. CONCLUSIONS 136
8. LITERATURE CITED 137
9. APPENDICES 151
9.1 Appendix A: Assessing Potential Impacts of a Proposed Reintroduction of Bull Trout on ESA-Listed Salmon and Steelhead in the Clackamas River 151

9.2 Appendix B: Baseline Food Web Assessment of the Upper Clackamas River Basin Prior to Reintroduction of Bull Trout 197

Table of Figures

Figure 1-1 Historic and current bull trout distribution in the Willamette Basin 5
Figure 1-2 Historic bull trout distribution in the Clackamas River 10
Figure 1-3 Suitable habitat patches in the upper Clackamas River 16
Figure 2-1 Bull trout length frequency during seven months of collections at Round Butte Dam……..……23
Figure 2-2 Principal components analysis of the upper Clackamas Subbasin patches……25
Figure 2-3 Nonessential experimental population area for bull trout showing release locations in the upper Clackamas River……31
Figure 2-4 Clackamas reintroduction project oversight committees……32
Figure 2-5 Decision framework for managing impacts to anadromous salmonids……..…47
Figure 2-6 High and low risk scenarios for anadromous salmonids……47
Figure 2-7 High risk impact scenarios with high and low certainties……...48
Figure 2-8 Low risk impact scenarios with high and low certainties……...48
Figure 3-1 Map of historical populations in the UWR Chinook ESU……..52
Figure 3-2 Three-dimensional representation of genetic difference, showing similarity of UWR Chinook stocks and their distinctness from Lower Columbia Chinook stocks……53
Figure 3-3 Historical abundance of wild spring Chinook salmon returns to the Willamette River……...55
Figure 3-4 Total Willamette spring Chinook returns, (hatchery and wild fish combined) ……..56
Figure 3-5 Current risk status of UWR spring Chinook salmon populations……...58
Figure 3-6 Critical habitat in the Clackamas subbasin……78
Figure 3-7 Critical habitat in the Lower Willamette/Columbia River corridor……79
Figure 4-1 Map of the Clackamas River Subbasin……...82
Figures 4-2 Patterns of land ownership and land use/land cover in the Clackamas subbasin…..83
Figure 4-3 Estimated annual abundance of natural-origin Clackamas spring Chinook, 1958-2007……..87
Figure 4-4 Estimated abundance of natural-origin late-run Clackamas coho, 1958-2005……...90
Figure 4-5 Estimated abundance of natural-origin Clackamas late-run winter steelhead, 1958-2005……..92
Figure 4-6 PGE hydroelectric dams on the mainstem Clackamas River……..94
Figure 4-7 Simulated daily mean water temperatures in the Clackamas River below River Mill Dam for existing and no-dam scenarios, August 2000 – September 2001……98
Figure 5-1 Areas of potential vulnerability to salmon and steelhead juveniles from bull trout predation in the Clackamas River……117
Figure 5-2 Mean scores of the potential impact of bull trout on salmon and steelhead population extinction probability……120
Figure 5-3 Sum of scores of the potential impact of bull trout on salmon and steelhead population extinction probability, across 5 panelists (A-E) and by salmonid species….121
Figure 5-4 Individual panelist scores of bull trout impact on salmon and steelhead populations after 100 years of bull trout reintroduction.....122

Table of Tables

Table 2-1 Monitoring and Evaluation for Phases 1-3……...40
Table 2-2 Project components and timelines for Phase 1: years 2011 – 2017……..42
Table 3-1 Historical populations in the UWR Chinook salmon ESU……...51
Table 3-2 Percentage of returning adult spring Chinook salmon that emigrated to saltwater as yearlings…….54
Table 3-3 UWR Chinook salmon life history timing……55
Table 3-4 Abundance, productivity, and trends of UWR Chinook populations……...57
Table 3-5 Risk of extinction categories for populations of UWR Chinook……..58
Table 3-6 Historical populations in the LCR Chinook salmon ESU……62
Table 3-7 Risk of extinction (in 100 years) for populations of LCR Chinook salmon…….63
Table 3-8 Historical populations in the LCR coho salmon ESU……..66
Table 3-9 Risk of extinction in 100 years categories for populations of LCR coho…….67
Table 3-10 Historical populations in the LCR steelhead ESU……..70
Table 3-11 Risk of extinction categories for populations of LCR steelhead……71
Table 3-12 Factors considered by Columbia Basin CHARTs to determine the conservation value of occupied watersheds……76
Table 3-13 Major factors limiting the conservation value of designated critical habitat for those species with designated critical habitat……77
Table 4-1 Critical habitat PCEs and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the Clackamas subbasin under the environmental baseline……104
Table 5-1 Summary Table of Extinction Risk and Effects of Proposed Action on 4 Species of Salmon and Steelhead……..126

1. INTRODUCTION

This document constitutes the Fish and Wildlife Service's (Service) biological assessment (BA) on the proposed reintroduction of bull trout (*Salvelinus confluentus*) to the Clackamas River. This BA considers the proposed reintroduction's effects on listed species and critical habitat under the National Marine Fisheries Service's (NMFS) jurisdiction in accordance with section 7 of the Endangered Species Act ESA) of 1973, as amended (16 U.S.C 1531 et seq.). The Oregon Department of Fish and Wildlife (ODFW) is jointly proposing the action with the Service and formally supports the action described in this BA based on revisions to the Clackamas River Subbasin Plan approved by the State's Fish and Wildlife Commission in September 2010. The U.S. Forest Service, Mt. Hood National Forest (USFS), also supports the proposed action and is a key collaborator in the project given that the reintroduction will occur entirely within the Mt. Hood National Forest. We consider the NMFS to be a cooperator in the project based on the section 7 consultation requirements and close coordination required in the planning and implementation of the proposed action. Additional cooperators include the Confederated Tribes of the Warm Springs of Oregon (CTWSRO), co-manager of the proposed bull trout donor stock in the Deschutes Basin, and Portland General Electric (PGE), owner and operator of the Clackamas River Hydroelectric Project.

Our BA is based in large part on several documents including the *Clackamas River Bull Trout Reintroduction Feasibility Assessment* published in December 2007 (Shively et al. 2007), our proposed rule on the *Establishment of a Nonessential Experimental Population of Bull Trout in the Clackamas River, Oregon* published in December 2009 (74 FR 65045), and our draft Environmental Assessment (DEA) published concurrently with the proposed rule (USFWS 2009). This BA also utilizes extensive information from the report *Assessing Potential Impacts of a Proposed Reintroduction of Bull Trout on ESA-Listed Salmon and Steelhead in the Clackamas River* (Marcot et al. 2008), and the NMFS September, 2010 biological opinion to the Federal Energy Regulatory Commission (FERC) on the *Operation of Portland General Electric's Clackamas River Hydroelectric Project Under its New License* (NMFS 2010).

1.1 Project History

Bull trout were a historic component of the native fish assemblage in the Clackamas River Subbasin, a major tributary in the Willamette River Basin. Once abundant and widely distributed throughout the subbasin, bull trout are now locally extirpated (Shively et al. 2007). On November 1, 1999, we published a final rule to list bull trout within the coterminous United States as threatened under the Act (64 FR 58910). This final rule served to consolidate the five separate distinct population segment (DPS) listings into one coterminous U.S. DPS listing. We published a draft recovery plan for the Columbia River, Klamath River, and St. Mary-Belly River segments on November 29, 2002 (67 FR 71439) and the Coastal Puget Sound and Jarbidge River segments on July 1, 2004 (69 FR 39950 and 69 FR 39951, respectively). The draft recovery objectives are:

(1) Maintain current distribution of bull trout within core areas as described in recovery unit chapters and restore distribution where recommended in recovery unit chapters;

(2) Maintain stable or increasing trends in abundance of bull trout;

(3) Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies; and

(4) Conserve genetic diversity and provide opportunity for genetic exchange.

Draft recovery criteria specific to the Willamette River Recovery Unit (USFWS 2002) follow:

(1) Distribution criteria will be met when bull trout are distributed among five or more local populations in the recovery unit: four in the Upper Willamette River core area and one in the Clackamas River core habitat.

(2) Abundance criteria will be met when an estimated abundance of adult bull trout is from 900 to 1,500 or more individuals in the Willamette River Recovery Unit, distributed in each core area as follows: 600 to 1,000 in the Upper Willamette core area and 300 to 500 in the Clackamas River core habitat.

(3) Trend criteria will be met when adult bull trout exhibit stable or increasing trends in abundance in the Willamette River Recovery Unit, based on a minimum of 10 years of monitoring data.

(4) Connectivity criteria will be met when migratory forms are present in all local populations and when intact migratory corridors among all local populations in core areas provide opportunity for genetic exchange and diversity.

Restoring bull trout to historic habitat is a major recovery goal and objective listed in the Service's Draft Recovery Plan (USFWS 2002) and it is particularly relevant to habitats in the western portion of the species' range due to the extensive loss of distribution and the documented extirpation of multiple bull trout populations. The Willamette River, a tributary of the lower Columbia River, has experienced extirpations of bull trout from four major subbasins, including the Clackamas River (Fig. 1). Although the overall recovery strategy is to reduce and minimize threats affecting bull trout and their habitat in the Willamette River Basin, the magnitude of bull trout extirpations, combined with the size of the basin and low probability of natural recolonization, will likely require reintroductions. Reestablishment of bull trout in the Clackamas River will help to achieve distribution in the Clackamas River core habitat (recovery criterion 1 and recovery objective 1) and will increase abundance of adult bull trout in the Willamette River Recovery Unit (recovery criterion 2 and recovery objective 2).

In the early 1990s, fisheries managers from the ODFW and the USFS recognized bull trout had not been observed in Clackamas River creel surveys for three decades. As a result, a multi-year effort was undertaken in the upper reaches of the watershed to determine if the species was still extant. The effort was unsuccessful as were similar efforts to document presence that occurred throughout the mid-to late 1990s. A review by ODFW in 1998 of historical records and anecdotal accounts suggested bull trout distribution once extended from North Fork Reservoir upstream to the Big Bottom area of the mainstem Clackamas River, as well as the lower

Collawash River and the lower Oak Grove Fork of the Clackamas River (Fig. 2). No information is available on historical abundance or the location of bull trout spawning and rearing areas.

Extirpation was likely due to many of the same factors that led to the decline in the species across its range including migration barriers from hydroelectric and diversion dams, direct and incidental harvest in sport and commercial fisheries, targeted eradication with bounty fisheries, and habitat and water quality degradation from forest management and agricultural activities (Shively et al., 2007). The last confirmed record of a bull trout in the Clackamas River was in 1963 (Stout 1963) although anecdotal reports of observations continued through the early 1970s.

To determine the current suitability of habitat in the Clackamas River Subbasin, and the availability of an appropriate donor stock, a peer-reviewed feasibility assessment was completed by members of the Clackamas River Bull Trout Working Group (CRBTWG) in 2007. The CRBTWG formally convened in 2004, for the purpose of exploring the possibility of reintroducing bull trout into the Clackamas River Subbasin as part of overall recovery efforts for the species. The group is comprised of representatives from the Service, ODFW, USFS, NMFS, U.S. Geological Survey (USGS), and other major stakeholders including PGE, CTWSRO, and Confederated Tribes of the Grand Ronde Reservation (CTGRR).

The *Clackamas River Bull Trout Reintroduction Feasibility Assessment* (Feasibility Assessment) (Shively et al. 2007) determined that a reintroduction of bull trout into the upper Clackamas River is feasible based on the following factors:

(1) There is a high level of confidence that bull trout have been locally extirpated from the Clackamas River Subbasin;

(2) The causes for their decline have been sufficiently mitigated;

(3) High quality habitat is available in sufficient amounts;

(4) Nearby donor stocks are unlikely to naturally recolonize;

(5) Suitable donor stocks are available that can withstand extraction of individuals;

(6) Nonnative brook trout presence is restricted to a small portion of the suitable habitat and is not a likely threat; and,

(7) A diverse and abundant fish assemblage would serve as a sufficient prey base with no obvious threats posed by bull trout to these species.

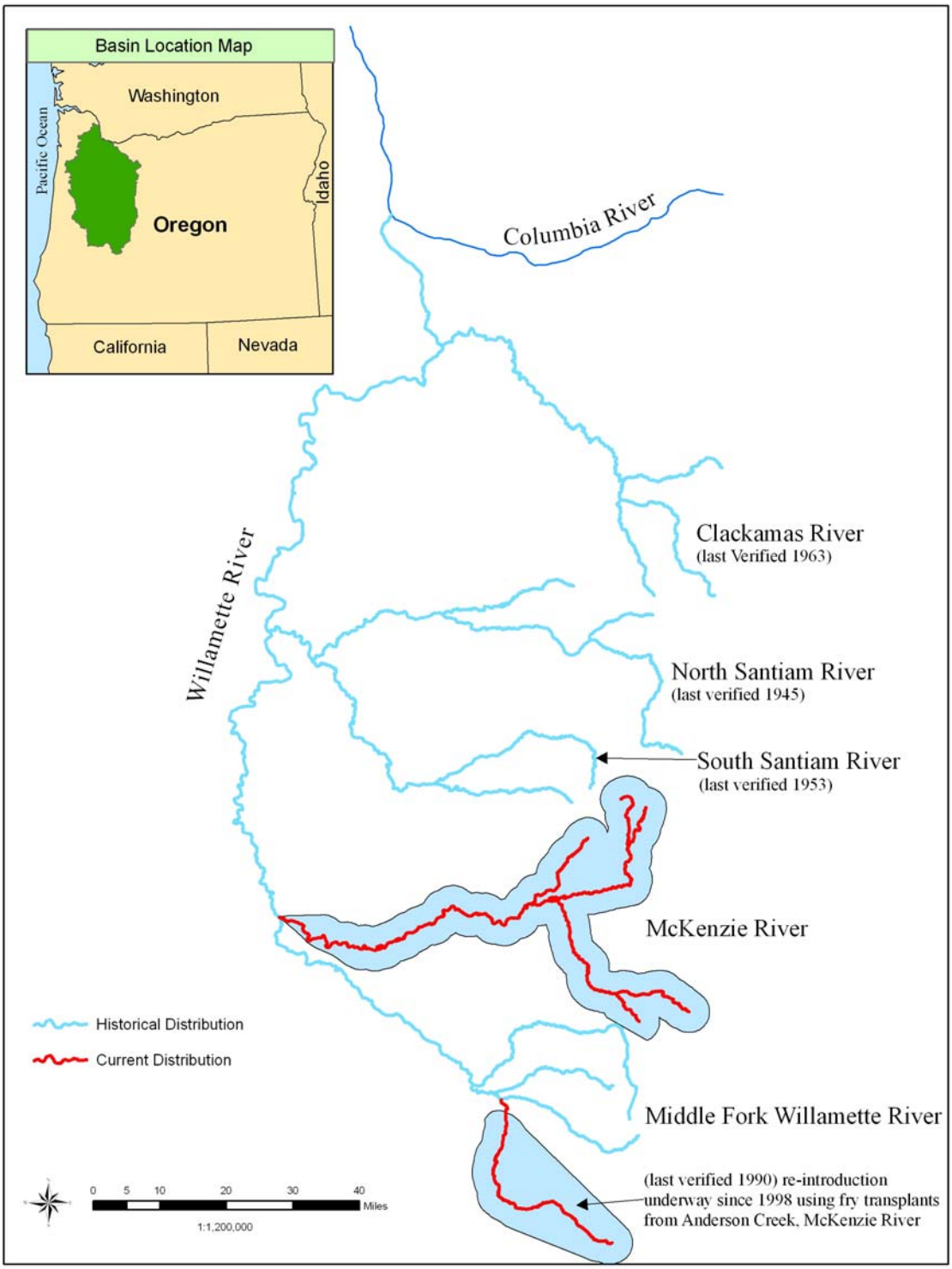


Figure 1-1 Historic and current bull trout distribution in the Willamette Basin

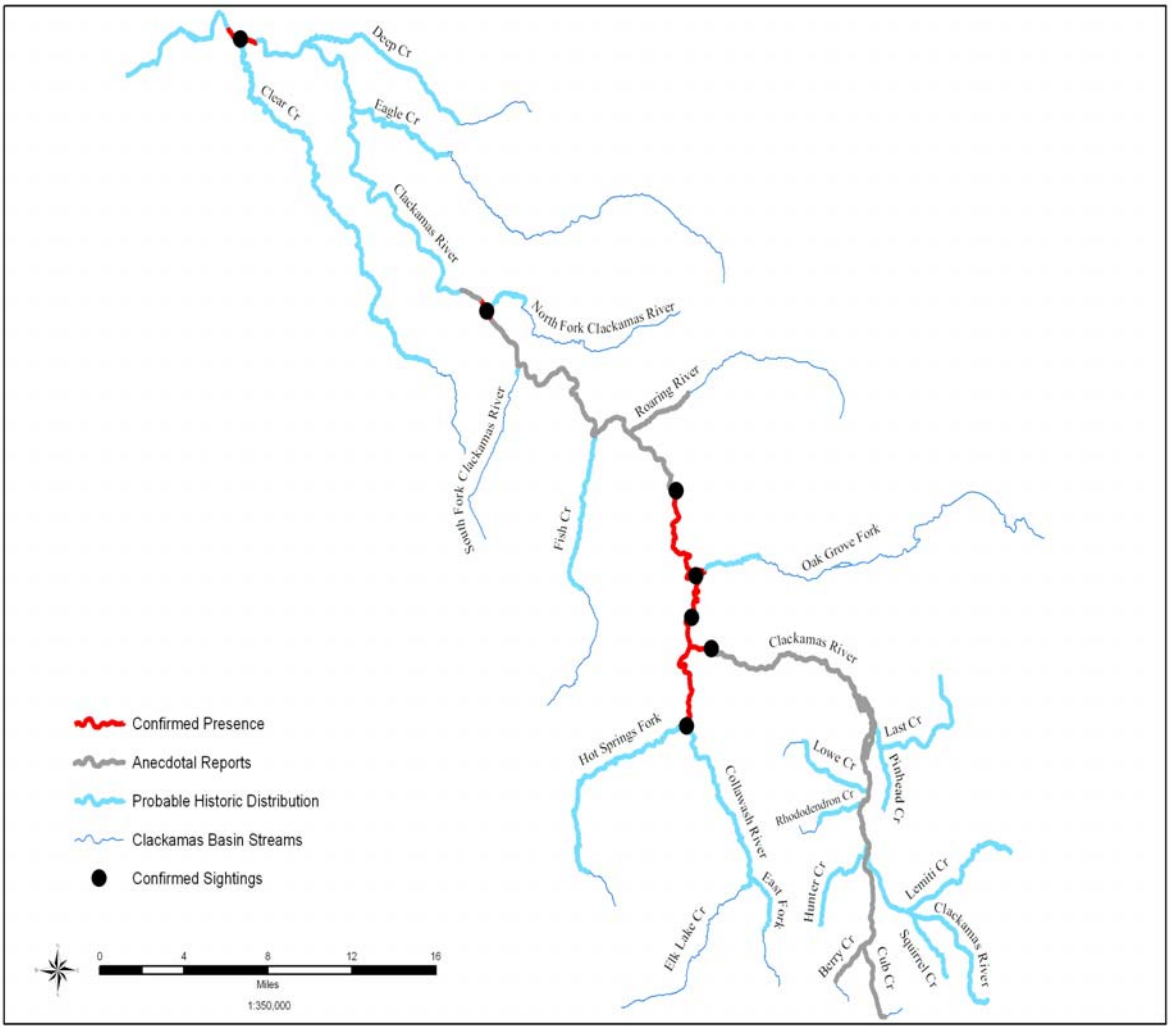


Figure 1-2 Historic Bull Trout Distribution in the Clackamas River (Shively et al. 2007)

Following publication of the Feasibility Assessment, the Clackamas Manager's Committee, comprised of managers from the participating agencies/organizations of the CRBTWG, expressed support for moving forward with development of a proposed action, with the Service and ODFW designated as the lead agencies. Concurrently, the Manager's Committee also assessed administrative alternatives for moving the proposed action forward, ultimately electing a federal rule-making process that would designate a reintroduced bull trout population in the Clackamas River as nonessential experimental under section 10(j) of the ESA.

The proposed action was developed in 2008 and 2009, which included stakeholder meetings that were conducted by the Service and ODFW in the fall of 2008. On December 9, 2009, we published a proposed rule (74 FR 65045) and draft Environmental Assessment (DEA) (USFWS 2009) prepared pursuant to the National Environmental Policy Act of 1969, as amended (NEPA),

which analyzed the potential environmental impacts associated with the proposed reintroduction. The publication of these documents initiated a 60-day public comment period which closed on February 9, 2009.

Based in part on the public comments received, and input and assistance from ODFW, USFS, NMFS, PGE and other project cooperators, we are currently developing the final rule and environmental assessment. We are concurrently coordinating with CTWSRO on utilization of Metolius River bull trout as a donor stock for the Clackamas reintroduction. In August 2010, CTWSRO Tribal Council passed a resolution supporting the utilization of Metolius river bull trout for donor stock for the FY 2011 reintroduction project. Out-year project approval from CTWSRO is contingent upon an annual review and approval process through the Tribes Department of Natural Resources.

Another important administrative step required by the State of Oregon was to amend the Clackamas River Subbasin Plan to include a reintroduction of bull trout to the Clackamas River. The proposed amendment stated the following: *Amend Oregon Administrative Rule (OAR) 635-500-0880(2) as proposed by staff to: 1) Acknowledge the status of Clackamas bull trout has been determined; and 2) Direct staff to pursue reintroduction of bull trout in the Clackamas consistent with achieving the desired status of listed anadromous salmonid populations as identified in the Lower Columbia Conservation and Recovery Plan (OAR 635-500-6575).* On September 2, 2010, the State of Oregon's Fish and Wildlife Commission voted unanimously to support the proposed amendment to the Clackamas River Subbasin Plan. The amended language was drafted jointly by the USFWS and the Clackamas District ODFW.

It is our intent to complete remaining administrative requirements, including final rule making, final EA, and completion of formal consultation with NMFS, during the winter of 2010/2011. We plan to begin the transfer of fish from the Metolius River to the Clackamas River in May 2011.

1.2 Climate Change and Bull Trout Recovery Planning

Bull trout require very cold water for spawning and incubation. Suitable spawning habitat is often found in accessible higher elevation tributaries and headwaters of rivers. However, impacts on hydrology associated with climate change are related to shifts in timing, magnitude and distribution of peak flows that are also likely to be most pronounced in these high elevation stream basins (Battin et al. 2007). The increased magnitude of winter peak flows in high elevation areas is likely to impact the location, timing, and success of spawning and incubation for the bull trout and Pacific salmon species. Although lower elevation river reaches are not expected to experience as severe an impact from alterations in stream hydrology, they are unlikely to provide suitably cold temperatures for bull trout spawning, incubation and juvenile rearing.

As climate change progresses and stream temperatures warm, thermal refugia will be critical to the persistence of many bull trout populations. Thermal refugia are important for providing bull trout with patches of suitable habitat during migration through or to make feeding forays into areas with greater than optimal temperatures.

There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. It is also likely that the intensity of effects will vary by region (ISAB 2007) although the scale of that variation may exceed that of States. For example, several studies indicate that climate change has the potential to impact ecosystems in nearly all streams throughout the State of Washington (ISAB 2007, Battin et al. 2007, Rieman et al. 2007). In streams and rivers with temperatures approaching or at the upper limit of allowable water temperatures for bull trout, there is little if any likelihood that bull trout will be able to adapt to or avoid the effects of climate change/warming. There is little doubt that climate change is and will be an important factor affecting bull trout distribution. As its distribution contracts, patch size decreases and connectivity is truncated, bull trout populations that may be currently connected may face increasing isolation, which could accelerate the rate of local extinction beyond that resulting from changes in stream temperature alone (Rieman et al. 2007). Due to variations in land form and geographic location across the range of the bull trout, it appears that some populations face higher risks than others. Bull trout in areas with currently degraded water temperatures and/or at the southern edge of its range may already be at risk of adverse impacts from current as well as future climate change. Reintroductions of bull trout to historical habitat, especially high quality habitats in streams with significant groundwater resources, will be critically important for the species conservation, recovery and persistence into the future.

1.2 Related Biological Opinions in the Action Area

1.2.1 Clackamas River Hydroelectric Project Consultation

In September 2010, NMFS issued a non-jeopardy, no-adverse modification to critical habitat, biological opinion (BO) to the Federal Energy Regulatory Commission (FERC) and their designated non-federal representative, PGE, on issuance of a new license to operate the Clackamas River Hydroelectric Project (FERC No. 2195) in the Clackamas River Subbasin, Oregon (NMFS 2010). The proposed action by FERC/PGE, and the subsequent BO by NMFS, was based in large part on the Clackamas River Settlement Agreement (Settlement Agreement) which represents negotiated settlement between 33 local, state, and federal agencies and not-for-profit organizations (PGE 2006a). The consultation assessed impacts of the proposed action on four threatened species of anadromous salmonids and their designated critical habitat including: Upper Willamette Chinook salmon, Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, and Lower Columbia River steelhead.

The proposed action, based on the Settlement Agreement, includes a comprehensive program of salmon protection measures and actions that will be implemented in a phased approach over the term of the license. To minimize effects of the new FERC license on listed species and designated critical habitat, PGE proposed to implement Protection, Mitigation, and Enhancement measures (PMEs) as conditions of the license. A detailed description of these activities and PMEs can be found in the Settlement Agreement (PGE 2006a) and NMFS (2010).

Associated with their new license, PGE will establish the Clackamas River Hydroelectric Project Mitigation and Enhancement Fund (Mitigation Fund) to support – either directly or in

combination with matching funds from other sources - habitat mitigation and enhancement measures for Project-related impacts on native anadromous and non-anadromous fish populations of the Clackamas River not otherwise addressed by specific resource PME measures identified in the new FERC license or elsewhere in the Settlement Agreement. Measures may include projects that enhance and improve wetlands, riparian and riverine habitats, and aquatic species connectivity that may be affected by the continued operation of the Project. Resource projects may be associated with identified PME measures carried out pursuant to the terms of the Settlement Agreement.

Within six months after issuance of a new license, PGE will establish the Mitigation Fund. The Fund will be a tracking account maintained by PGE with any accrued interest credited to the Fund. The total amount, excluding interest, to be credited to the Fund shall be $8.0 million, stated in 2006 dollars. Most of the fund, $7.5 million, will be dedicated to Resource Projects of the types that benefit native anadromous fish populations in the Clackamas River Basin or support the fish passage program unless by consensus, the Mitigation Fund Committee approves use of some of this amount to support projects that will benefit native non-anadromous species.

One important component of the Settlement Agreement and the new FERC license is the requirement that PGE, following fish passage and operational improvements stipulated in their new license, meet a 97 percent (+/- 2.5 percent) project-wide survival standard for downstream migrating juvenile salmon and steelhead from the top of their project (North Fork Dam forebay) to the bottom (Rivermill Dam tailrace). If this survival standard is not met, PGE is obligated to continue fish passage improvements and modifications until the standard is met.

1.2.2 Willamette Basin Project Consultation

In July, 2008, NMFS and the Service issued separate BOs to the U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration, collectively called the Action Agencies, on the continued operation and maintenance of the Willamette Project, a system of 13 flood control dams in the Willamette Basin (USFWS 2008) (NMFS 2008b). The NMFS concluded the proposed action was jeopardy to several evolutionarily significant units (ESUs) of threatened salmon and steelhead in the Willamette Basin. As a result of the jeopardy determination NMFS prepared a reasonable and prudent alternative (RPA) to the proposed action that called for a series of mitigation and minimization measures to address adverse impacts from the continued operation and maintenance of the Willamette Project. Implementation of the RPA is underway and current discussions may speed its implementation. The Willamette Project has little direct influence on salmon and steelhead in the Clackamas River since there are no U.S. Army Corps of Engineers projects in the Clackamas Subbasin. However, Chinook salmon in the Clackamas River are part of the Upper Willamette River spring Chinook ESU and thus were included in NMFS' effects analysis and RPA actions to mitigate and minimize impacts to the ESU. The Service's BO analyzed the proposed action, as modified by the NMFS to the proposed action. The Service's BO determined the proposed action, as modified by the NMFS RPA, would not jeopardize threatened bull trout or endangered Oregon chub, nor would it adversely modify bull trout critical habitat.

1.3 Reintroduction Feasibility Assessment

The CRBTWG initiated a Clackamas River bull trout reintroduction feasibility assessment in 2004. The Feasibility Assessment focused on the biological feasibility rather than social or economic feasibility, or implications to other species from a reintroduction. In addition, the Feasibility Assessment did not address whether or not a reintroduction should be done or how it should be done. The Feasibility Assessment examined four questions adapted from Epifanio et al. (2003):

1. Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?

2. Is there suitable habitat remaining, what conditions or stressors currently prevent bull trout from occupying suitable habitats, and have these been corrected?

3. Is suitable habitat expected reasonably to be recolonized through natural processes if conditions are improved?

4. Is a suitable or compatible donor population(s) available that can itself tolerate some removal of individuals?

The Feasibility Assessment was completed in December 2007 (Shively et al. 2007) and can be found at the following web link:

http://www.fws.gov/oregonfwo/Species/Data/BullTrout/ReintroductionProject.asp

The following briefly summarizes the primary findings of the Feasibility Assessment: The CRBTWG has a high confidence that bull trout have been extirpated from the Clackamas River Subbasin because extensive sampling targeting bull trout presence occurred from the 1990s to 2004. The factors leading to the decline of bull trout began in the early 20th Century and extended into the 1970s. The primary factors for their decline include migration barriers from hydroelectric and diversion dams, direct and incidental harvest in sport and commercial fisheries, targeted eradication with bounty fisheries, and habitat and water quality degradation from forest management and agricultural activities. A more detailed explanation of bull trout extirpation in the Clackamas River Subbasin is provided in Appendix B of the Feasibility Assessment (Shively et al. 2007). The causative factors responsible for the decline and extirpation of bull trout in the Clackamas River Subbasin are believed to be sufficiently remedied so as not to impede or negatively influence the reintroduction effort.

Suitable habitat for bull trout was examined using a tiered approach. Bull trout require very cold water for spawning and rearing. The portion of the Clackamas River Subbasin providing suitable bull trout spawning and rearing habitat today is located in the Clackamas River mainstem and its tributaries upstream of the Collawash River confluence. This portion of the Subbasin contains approximately 70 miles of suitable spawning and rearing habitat configured into six separate habitat patches (Figure 3). Habitat patches range in size, configuration, and condition. The most downstream habitat patch occurs along the mainstem Clackamas River known as Big Bottom. This unique and complex reach of the river provides suitable spawning

and rearing habitat, and would also likely serve as an important foraging area for bull trout. Other habitat patches occur either adjacent to or up to a maximum distance of approximately six river miles upstream into the headwaters of the subbasin.

A donor stock should be comprised of fish that most closely resemble the bull trout that historically inhabited the Clackamas River (e.g., genotype, phenotype, behavior, and life history expression). However, because little is known about the biology and evolutionary history of bull trout that historically occupied the Clackamas River, and no genetic material is available for analysis, the CRBTWG was limited to an assessment of biological information from other local populations, existing studies of the evolution and biogeography of bull trout, information derived from historical harvest data from the Clackamas River, and recent regional bull trout genetic analyses.

Genetic studies of bull trout indicate the existence of at least two major evolutionary lineages; Coastal and Interior. Other studies have suggested additional genetic assemblages within the Interior lineage (Spruell et al. 2003, USFWS 2008 unpublished data). By exploring issues associated with life history strategy, metapopulation dynamics, biogeography, and genetic considerations, the CRBTWG identified bull trout populations in the Coastal lineage as the best source for a donor population. Any of the Coastal lineage bull trout populations are likely to carry the genetic material to preserve and protect the "coastal" lineage regardless of localized and specific adaptations. Although these local adaptations are important, each of the populations is likely to contain the evolutionary potential that is characteristic of the Coastal evolutionary lineage. However, in a further refinement, the CRBTWG determined that donor populations from lower Columbia River tributaries would be most appropriate due to their geographic proximity to the historical bull trout population in the Clackamas River and because genetic studies indicate these populations are more closely related to one another than to other Coastal lineage populations (USFWS 2008, unpublished data). The potential lower Columbia River donor populations of bull trout include fish in five river basins: the Willamette, Hood, Lewis, Deschutes, and Klickitat river basins (Shively et al. 2007). These populations are located a considerable distance away from the Clackamas River Subbasin and in many cases the presence of migration barriers makes natural recolonization highly unlikely.

Specific benchmarks have been developed concerning the minimum bull trout population size necessary to maintain genetic variation important for short-term fitness and long-term evolutionary potential. Rieman and Allendorf (2001) concluded that an average of 100 spawning adults each year is required to minimize risks of inbreeding in a bull trout population and that 1,000 spawning adults each year will likely prevent loss of genetic diversity due to genetic drift. This later value of 1,000 spawning adults may also be reached with a collection of local populations among which gene flow occurs. The CRBTWG utilized these general benchmarks in the Feasibility Assessment to assess potential risk to each of the five potential donor stocks in the lower Columbia River from the loss of individuals, recognizing that risk increases as donor populations near 100 spawning adults and diminishes as populations approach 1,000 spawning adults (Shively et al. 2007).

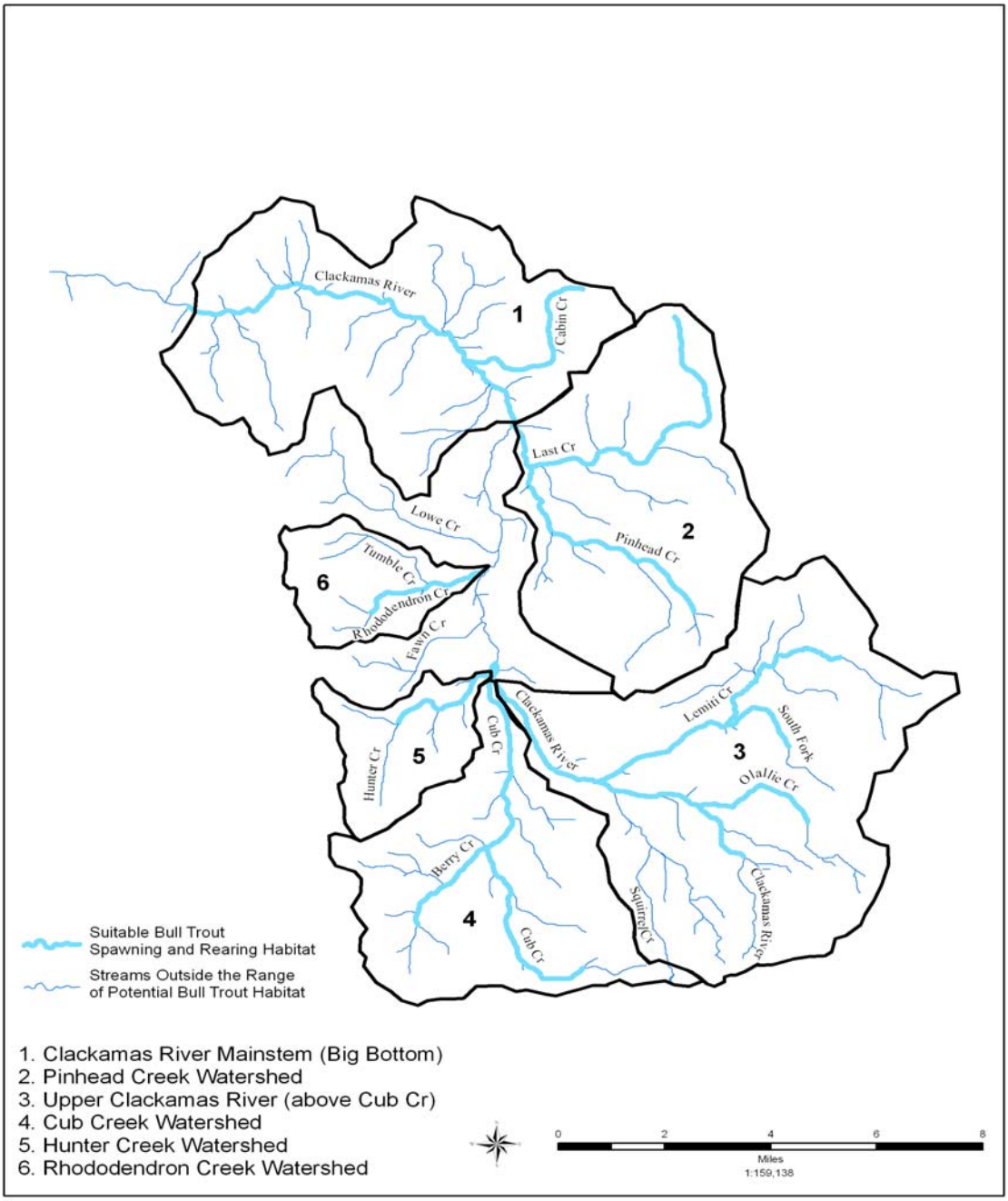


Figure 1-3 Suitable Habitat Patches in the Upper Clackamas River (*from* Shively et al. 2007).

When the Feasibility Assessment was completed in December 2007, bull trout from two of the five river basins, the Lewis River and Deschutes River, contained groups of interacting local populations that exceeded 1,000 spawning adults. For the Lewis River Basin, this included the combined Pine Creek and Rush Creek populations that occur above Swift Dam. For the Deschutes River Basin, this included the three interacting populations present in the Metolius River Subbasin. Since publication of the Feasibility Assessment there have been declines in adult spawner abundance in both the Lewis and Deschutes river bull trout groups, with the Lewis River population dropping significantly in 2007 and 2008, to its current estimated adult spawner abundance of 379 individuals (Doyle 2009). Although the Deschutes River (Metolius River Subbasin) bull trout population has also decreased over the last two years, the CRBTWG considered this population to be the least at risk of the potential donor stocks. Furthermore, per Rieman and Allendorf (2001), the total number of annual spawning adults is sufficiently large enough (approximately 1,000 spawning adults) to protect against the loss of genetic diversity from genetic drift.

In summary, our Feasibility Assessment concluded that there is a high level of confidence bull trout have been extirpated from the Clackamas River and that factors leading to their extirpation have been largely ameliorated. The Feasibility Assessment further concluded that there is sufficient high quality habitat available and the forage base to support a reintroduction, and that the limited presence of non-native brook trout is not a substantial threat. Several suitable donor stocks were identified that could support, with low population risk, the extraction of individuals for translocation to the Clackamas River. Finally, nearby extant populations were determined to be unlikely to naturally recolonize the Clackamas River due to geographic distance and/or isolation due to migratory barriers.

2. DESCRIPTION OF THE PROPOSED ACTION

The action is a joint proposal with the State of Oregon to reintroduce bull trout into the Clackamas River. As part of this proposal, on December 9, 2009, we formally proposed designation of a nonessential experimental population of bull trout in the Clackamas River under section 10(j) of the ESA (74 FR 65045). As the primary landowner in the upper Clackamas River where the reintroduction will occur, the USFS Mt. Hood National Forest is our primary cooperating agency, along with NMFS, PGE, and the CTWSRO, co-manager of bull trout in the Metolius River Subbasin which is the source of our preferred donor stock for the reintroduction.

The goal of the proposed action is to re-establish a self-sustaining bull trout population of 300-500 spawning adults in the Clackamas River by 2030 that contributes to the conservation and recovery of bull trout in the Willamette Basin and to overall recovery criteria outlined in the Draft Bull Trout Recovery Plan (USFWS 2002). For this project we define a self-sustaining population as one that maintains a minimum adult annual spawner abundance of 100 individuals (see Section 1.3 above regarding minimum effective population size), contains a high level of genetic diversity representative of the donor stock, and requires little or no additional transfers. The numerical goal of 300-500 adult spawners is consistent with draft recovery planning targets for abundance (Section 1.1 above). Although the amount of suitable habitat in the Clackamas River suggests there is sufficient capacity to support a population of this size, bull trout distribution across the species' range, even within areas of suitable habitat, is patchy and thus the true capacity of the Clackamas Subbasin for bull trout is unknown.

To implement the reintroduction of bull trout to the Clackamas River we propose to utilize a single donor stock from the Metolius River in Central Oregon. We will collect fish of various life stages (initially juvenile, subadult, and adult) consistent with project numerical goals and in proportion to donor availability (see Section 2.1 below) from genetically identifiable groupings of bull trout in the Metolius River. Three major genetic bull trout groupings are present in the Metolious: (1) Whitewater River; (2) Jefferson and Candle Creeks; and, (3) Canyon, Heising, and Jack Creeks (DeHaan et al. 2008).

Due to limited knowledge regarding the status of bull trout in the Whitewater River, and per a request from CTWSRO, we propose to limit potential donor impacts by not targeting individuals specifically in the Whitewater River. However, collections of bull trout from the mainstem Metolius River and Lake Billy Chinook may include some individuals from the Whitewater River due to the fact they would be physically indistinguishable from bull trout from the other two genetic groupings.

We propose to annually translocate multiple life stages of bull trout directly from the Metolius River to the upper Clackamas River via a three-phased adaptive management approach (Section 2.9 below) until either: (1) an evaluation of the program shows the goal of the project has been met, or is on a trajectory to be met through natural reproduction based on monitoring and evaluation; (2) mid-process outcome evaluation suggests the reestablishment of bull trout is unlikely (i.e., the project is not showing success); or (3) monitoring and evaluation indicates unacceptably high population level impacts are occurring to federally listed salmon and steelhead in the Clackamas River. The three phases of the project are outlined below:

Phase One (2011-2017): This will be the key active management and learning phase. The release strategy varies with the life stage being reintroduced and may be modified as necessary based on monitoring results. Older life stages captured in Lake Billy Chinook or at Round Butte Dam's fish collection facility will be released initially in the mainstem Clackamas River in patch 1 (Figure 3 above). Juveniles (and fry if utilized in the future), will likely be planted in all suitable patches on a rotating basis.

Phase Two (2018-2024): Based on Phase One monitoring and evaluation, adaptively manage the implementation strategy to favor more successful life stages and preferred habitat patches. If Phase One is determined to be unsuccessful, reevaluate components of the reintroduction strategy such as donor stock, release locations and timing, life-stages and numbers transferred, to inform whether to significantly modify or discontinue the project.

Phase Three (2025-2030): By the year 2030 (or sooner if goals and objectives are achieved) discontinue active management and stop implementation. Continue to implement a post-treatment monitoring and evaluation program.

2.1 Annual Donor Stock Availability

The numbers and life stages of donor stock to be transferred from the Metolious River to the Clackamas River were developed by members of the CRBTWG and members of the Deschutes Bull Trout Working Group (DBTWG). The DBTWG includes members that manage and/or contribute to monitoring of bull trout and bull trout habitat in the Metolius River Subbasin (ODFW, CTWSRO, USFS, PGE, Service). Members of these two working groups assembled on March 13, 2008, to discuss and develop donor stock availability criteria that will inform the number of bull trout available on an annual basis from the Metolius River for the first seven years (Phase 1) of the reintroduction. Members of the Clackamas and Deschutes working groups that met on the issue of donor availability will be subsequently referred to as the donor advisory group.

The donor stock availability criteria, ultimately developed to minimize risk to the donor stock, represent the maximum number of individuals that could be removed annually based on the recent population status of bull trout in the Metolius River. Should the status of bull trout in the Metolius River significantly change, these criteria will be reevaluated by the Service, ODFW, CTWSRO and other members of the donor advisory group.

Of primary concern to both the Deschutes and Clackamas bull trout working groups is continued viability of bull trout populations within the Metolious River. To that end, the lead implementing agencies of the Project (the Service and ODFW) are committed to an adaptive management framework for the project (Section 2.9 below). All take of bull trout from the Metolius River will be assessed annually by the donor advisory group.

The advisory group support detailed below is dependent upon the adult spawning population in the Metolius River remaining above 800 individuals annually (based on full census redd counts),

including Whitewater River. The spawning population estimate peaked in 2004 at approximately 2,500 bull trout but has since dropped to approximately 900 adult spawners in 2008 (does not include Whitewater River bull trout which likely puts the total count over 1,000). If the adult spawning population drops below 800 individuals for a single year, the bull trout co-managers in the Deschutes Basin (ODFW and CTWSRO) and other members of the donor advisory group, will evaluate and provide further guidance to the Clackamas Project as to donor availability by life stage for subsequent years.

Availability of Adult and Subadult Life Stages for Transfer

For the purposes of our project, we characterize adult bull trout as individuals having spawned at least once or individuals staging for spawning in the Metolius River Arm of Lake Billy Chinook. Information suggests most bull trout in the Metolius River mature at age 5 although there is evidence some mature at age 4. Spawning (i.e., mature) bull trout in the Metolius River range in size from 230-824mm (9-32 inches) but most are 450-650mm (18-26 inches) (Ratliff et al. 1996). We define the subadult life stage as individuals two years old or older that have migrated from the Metolius River to Lake Billy Chinook and have not yet spawned. Given that most bull trout in the Metolius River mature at age five, subadult bull trout in Lake Billy Chinook will generally be two to four years of age. Studies suggest annual growth rates in Lake Billy Chinook are variable but generally subadult bull trout in Lake Billy Chinook will range from 150mm to 450mm (6-18 inches).

The donor stock advisory group determined up to a 100 adults and 100 subadults could be available for transfer to the Clackamas River annually provided the total number of adult spawners in the Metolius River maintains 800 or more individuals as called for in recovery criteria outlined in the Draft Recovery Plan (USFWS 2002). Maintaining 800 spawning individuals is generally consistent with the donor stock risk assessment in the Feasibility Assessment (Shively et al. 2007) which found low risk (from loss of individuals) to populations that maintain a spawning population size that approaches or exceeds 1,000 individuals. Adults and subadults will be captured annually by hook and line and/or trap nets in the Metolius River arm of Lake Billy Chinook from late April through mid-June. Adults and subadults may also be collected from the fish collection facility at Round Butte Dam (see section 2.3 below).

Availability of Fry and Juvenile Life Stages for Transfer

For the purposes of our project we define the juvenile life stage of bull trout as individuals that are age one to age three that are rearing in the Metolius River or tributaries of the Metolius River. Information from Metolius River bull trout studies suggest juvenile bull trout will generally range from 50mm to 200mm (2-8 inches).

The donor stock advisory group determined that up to 1,000 juveniles and up to 10,000 fry could be available for transfer to the Clackamas River annually provided the total number of adult spawners in the Metolius River maintains 800 or more individuals as called for in recovery criteria outlined in the Draft Bull Trout Recovery Plan (USFWS 2002), and that take of juveniles and fry is spread among multiple spawning tributaries (excluding direct take of individuals from Whitewater River per request from CTWSRO). In order to transfer as much of the genetic diversity as possible to the Clackamas River we intend to utilize donors from the majority of

Metolius River tributaries used by bull trout for spawning. However, the capacity and current number of spawners differs among tributaries and thus if we collect fish from tributaries rather then the mainstem Metolius River, the number of individuals removed from each tributary will be roughly commensurate with the number of adult fish spawning in each tributary. For example, we expect to transfer more donors from Jack Creek which averages more than 150 redds annually then from Heising Spring which averages less than 50 redds annually. The locations and proportions of collections will be determined annually in collaboration with the Donor Advisory Group. Collection of juveniles and fry, if the fry life stage is utilized for the Clackamas reintroduction in future years, will likely occur both in spawning tributaries and in the mainstem Metolius River.

2.2 Numbers and Life Stages Proposed for Transfer

Based on existing donor population levels and donor criteria discussed above, and discussions with the CRBTWG and other project stakeholders, we propose the following approximate numbers of fish by life stage to be transferred each year during phase one of the project. As noted previously, annual monitoring of the donor stock and the reintroduced fish in the Clackamas River will further inform future numbers and life stages for transfer. The numbers and life stages of fish for transfer will be reviewed annually by the donor advisory group, as well as the Implementation Logistics, and Monitoring and Evaluation committees associated with the project.

- Adults: Approximately 30 per year (equal numbers of males and females if sex can be identified) for the first 2 years. Continuation through phase one is dependent on monitoring and evaluation results and donor availability. For this project adults are considered to be greater than 450 mm (18 inches). No fish greater than 650 mm (26 inches) will be transferred to the Clackamas River. Emphasis will be placed on the collection and translocation of adults at the lower end of the adult size range.

- Subadults: Approximately 30 per year for the first 2 years. Continuation through phase one is dependent on monitoring and evaluation results and donor availability. For this project we consider subadults to be fish rearing in Lake Billy Chinook that are 250 mm – 450 mm (10-18 inches) in length.

- Juveniles (age 1, 2, 3): Approximately 1,000 per year. Continue through phase one depending on monitoring and evaluation results and donor availability. For this project we consider juveniles to be fish less than 250 mm (10 inches) that are rearing in the Metolius River or tributaries. No bull trout will be transferred to the Clackamas River that do not meet the minimum size for tagging with a PIT tag (approximately 70 mm for a 12 mm PIT tag).

We are not proposing to utilize fry during the first phase of the project, and their future use is contingent upon the success of older life stages, as determined by monitoring and evaluation. We are not proposing to utilize fry initially for the following reasons: 1) fry inherently have a high mortality rate thus high numbers are required to be transferred to confer survival to reproductive age; 2) fry can't be tagged effectively with current technology. We propose to PIT tag every

individual translocated to the Clackamas River for monitoring presence, migration patterns, distribution, survival and growth. The minimum length at which a fish can be PIT tagged is approximately 70 mm (2.75 inches) which precludes tagging fry; and 3) to capture the full genetic variability of a spawning population and associated run timing, outmigrating fry in the Metolius River would have to be collected throughout the spring beginning in late February and extending through May. Not only is this a labor intensive process, but access to release locations in suitable rearing habitat in the upper Clackamas River is typically blocked by snow until late spring. Therefore fry would need to be temporarily reared in a hatchery environment which, while feasible, is expensive, inherently risky, and labor intensive based on information from a bull trout captive rearing project at Leaburg Hatchery on the McKenzie River, Oregon (ODFW 2009).

Consistent with the adaptive management strategy of this project, following the initial two years of the project there will be a decision point at which time we will determine whether to continue subadult and adult transfers through phase one. The decision point will be informed by monitoring and evaluation and will be based primarily on whether older life stages are adapting and residing in the Clackamas River, and for mature fish, showing indications of reproduction and subsequent recruitment.

2.3 Donor Stock Collection and Timing

As noted above, all donor stock will come from the Metolius River Subbasin and from Lake Billy Chinook. Juvenile bull trout, defined as fish < 250 mm (10 inches), will be collected from the mainstem Metolius River and its tributaries including Jefferson, Candle, Canyon, Jack creeks and Heising Spring. Juveniles will not be taken directly from Whitewater Creek but may be collected for donor stock if mainstem Metolius River collections occur. Juvenile collections could occur any time spring through fall but will likely coincide with collections of adults and subadults which are most vulnerable for collection in May and June (D. Ratliff, PGE, personal communication, June 2010). Juvenile capture techniques will likely be refined over the course of the first few years of the project but will initially include minnow trapping, seine netting, dip-netting, hook and line angling, and if necessary to meet annual numerical goals, electrofishing.

In general, adults and subadults would be collected in the Metolius River arm of Lake Billy Chinook when they stage in the late spring and early summer (May and June) prior to migrating into the Metolius River. Collection techniques will be based on methods utilized by personnel on previous bull trout studies at Lake Billy Chinook, namely hook and line angling and Onieda trap netting. If monitoring and evaluation over the first several years of the reintroduction project indicates translocated adults are not remaining in the Clackamas River following a May/June release, or if they remain in the Clackamas River but do not show signs of spawning, then the timing of adult and subadult collections may be revisited by the project technical teams.

An alternative collection opportunity for adult and subadult bull trout now exists given the operation of the new fish collection facility at Round Butte Dam. From early December 2009 through June 30, 2010, over 300 bull trout entered the facility, most of which were 350 mm (13.8 inches) or larger (Fig. 2.1 below). Collection tanks associated with the operation of ODFW's Round Butte Hatchery are capable of holding subadult and adult bull trout (Don Ratliff, PGE,

personal communication, July 2010). Given that this is a relatively new opportunity, collections of adult and subadult bull trout via the Round Butte Dam fish collection facility, and the temporary storage of bull trout at ODFW's hatchery for subsequent transport to the Clackamas River, will require further discussion with the Clackamas project technical teams and the Donor Advisory Group (particularly PGE, CTWSRO, ODFW).

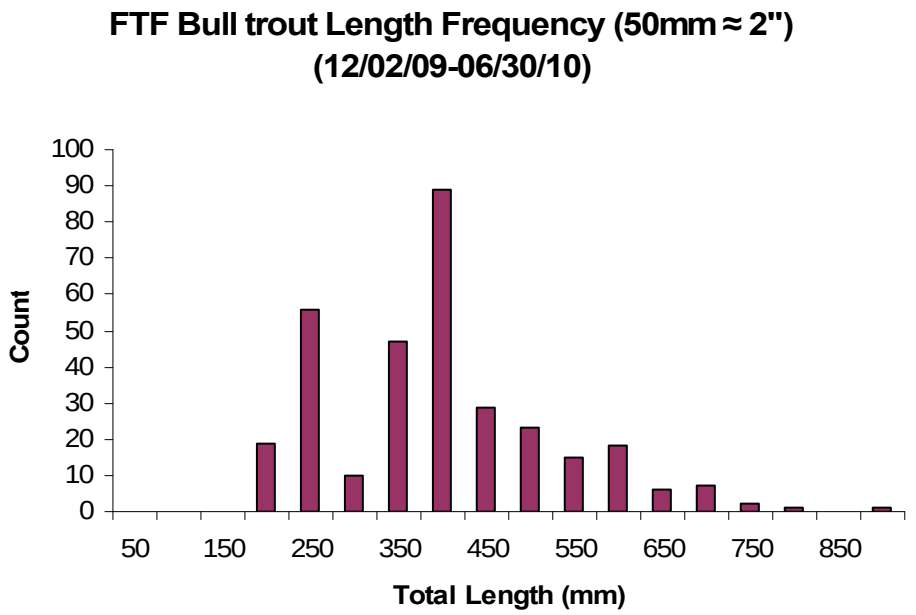


Figure 2-1 Bull trout length frequency during seven months of collections at Round Butte Dam

2.4 Release Locations and Timing

All bull trout will be released in habitat determined in the Feasibility Assessment (Shively et al. 2007) to be suitable for spawning and early juvenile rearing (Patches 1-6 in Figure 1-3 above). With the exception of the mainstem Clackamas River habitat in Patch 1, habitat in the remaining patches is not likely suitable for year-round occupancy by adult and subadult bull trout due to stream size. Given the behavior of migratory bull trout in other basins in Oregon and Washington, we do not expect adult and subadult bull trout to be present in the relatively smaller streams in patches 2-6 except during the fall spawning period, typically late August through early October. As a result, and due to the spring and early summer timing of donor stock collection (see section 2.3 above), releases of adults and subadults will occur only in Patch 1 or upstream of Patch 1 in the mainstem Clackamas River between Pinhead Creek and Cub Creek. Consistent with the adaptive management of the project, if monitoring over the first several years suggests the older life stages are leaving the Clackamas River Subbasin and not returning, a shift in release location and release timing may be considered. Bull trout juveniles, and fry if they are utilized in the future, will be released in all suitable streams (over a number of years) within habitat patches 1 thru 6 on a rotational basis.

Given the number of juveniles proposed for transfer on an annual basis (1,000) relative to the amount of suitable habitat available for stocking, and considering factors associated with monitoring these fish, we propose to limit annual stocking to two streams/patches within the area identified as suitable for spawning and early juvenile rearing. In addition, to account for annual environmental variability in the receiving habitat, fish condition, and to facilitate effective monitoring, we anticipate stocking the same two streams/patches for a minimum of two years before shifting stocking to two new suitable streams/patches. We intend to split the number of juveniles equally between the two patches each year; i.e., 500 juveniles will be translocated to each patch. We considered weighing the number of juveniles per patch by catchment size or stream volume, but decided that because there is no evidence that either of those factors would affect habitat suitability in patches there was no reason to do so. We anticipate choosing 2-4 release sites per patch as that would reduce handling stress (as opposed to utilizing more release sites per release trip).

2.4.1 Principle Components Analysis

To avoid arbitrarily choosing the initial two streams/patches for release, and to maximize our probability of reintroduction success by trying different streams within the range of suitable habitats, we conducted a principle components analysis (PCA) that considered differences in habitat variables between each of the upper subbasin patches. We used data collected by ODFW and the USFS to generate our analysis. We considered maximum water temperature ("Max_Temp"), minimum summer stream width ("Width_ft"), stream gradient ("Gradient_num"), basin area (in acres, "Basin_ac"), and the percent of the basin that fell within the High Cascade (vs. West Cascade) flow regime ("High_Cas"). The PCA generated relationships between each patch and habitat characteristic dimensions. Component loading is a measure of how much a particular variable (gradient, basin size, etc.) corresponds with the component. Dimension (or principal component) 1 is mostly a measure of summer stream width and basin size (both have high positive loadings), as well as gradient (high negative loading). Dimension 2 has large loadings of maximum temperature and percent of the watershed in the high cascades. Together, these two dimensions account for about 72% of the variance between the streams.

Based on where each basin falls relative to each dimension axis (Figure 2-2), Cub and Berry creeks appears similar in that both have higher summer temperatures (i.e., both fall near each other on the dimension 2 axis) whereas Pinhead and Last creeks are also fairly similar but have lower summer temperatures. Rhododendron and Hunter creeks are similar based on gradient (dimension 1) but are not particularly close to each other regarding temperature. While the Upper Clackamas patch appears to be distinct, note that the basin acreage is fairly large and includes the Upper Clackamas and Lemiti drainages; data was not available for the Upper Clackamas above its confluence with Lemiti Creek.

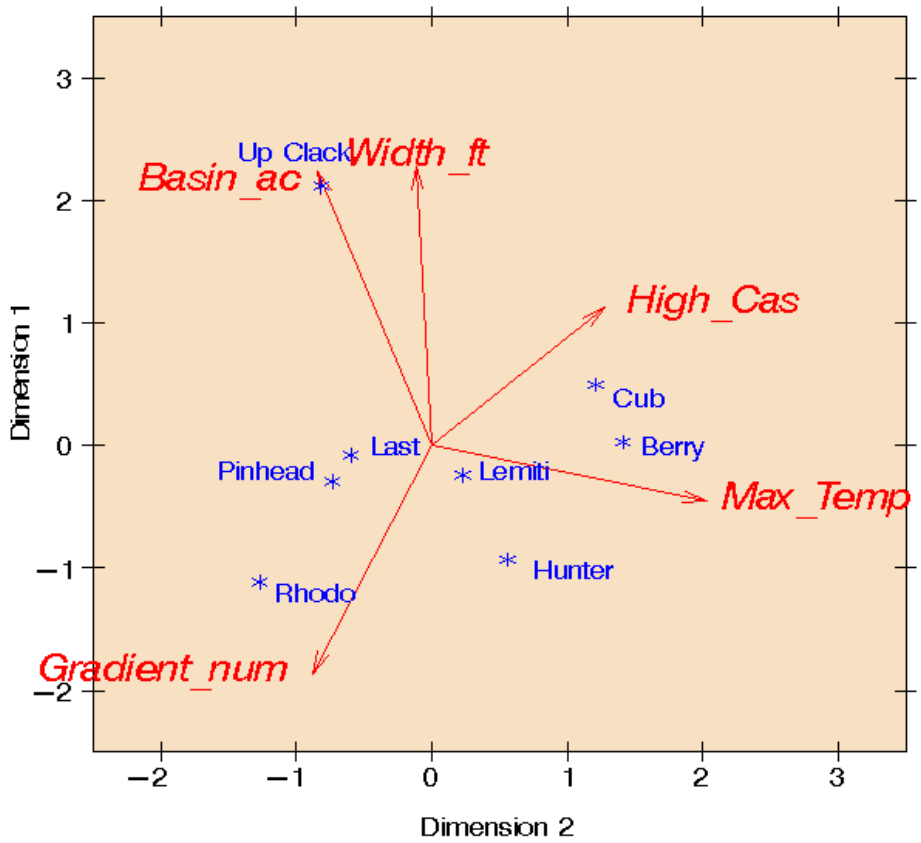


Figure 2-2 Principal components analysis of the upper Clackamas subbasin patches

In deciding which two patches to initially seed with translocated bull trout, it is logical to choose two patches that are on opposite ends of a PCA axis but that are still characterized by (what we assume to be) suitable bull trout habitat. For the first two to three years of phase one, we anticipate seeding the Pinhead/Last patch and the Cub/Berry patch, as these sites are opposite of each other on the dimension 2 axis (characterized by maximum temperature and high cascade flow regime) but still relatively similar in respect to dimension 1.

2.5 Disease Screening

2.5.1 Baseline Disease Assessment

Unwanted parasites and diseases frequently have been introduced through fish transfers (Hoffman and Schubert 1984). To avoid these unintended consequences, translocations of fishes between major river basins should be preceded by a thorough investigation into the potential transfer of pathogens from the donor source, as well as the resistance of the donor stock to any known pathogens present in the receiving habitat.

In order to assess and minimize the risk of disease transfer and the presence of pathogens in the Clackamas River we worked closely with ODFW Fish Health Service and staff from the Service's Lower Columbia River Fish Health Center. Our disease assessment utilized existing information from the Deschutes Basin (and Metolius subbasin) and new information that was collected from the Clackamas and Lewis rivers as part of the disease assessment. At the time of the assessment bull trout from the Lewis River, in addition to bull trout from the Metolius River, were being considered as potential donor stock for a reintroduction to the Clackamas River.

The results from our testing of fish from the Lewis and Clackamas rivers, combined with existing data from the Deschutes Basin (Engelking 2003) provided valuable information regarding (1) the risk of pathogen transfer to the Clackamas River from the Metolius or Lewis river donor stock; and, (2) the presence or absence of pathogens in the Clackamas River that may influence the health of donor stock from the Lewis or Metolius rivers. Based on the results, it appears the predominant pathogens of concern to a reintroduction of bull trout to the Clackamas River are Infectious Hematopoietic Necrosis Virus (IHNV) and *Renibacterium salmoninarum* (the causative agent of BKD). The State's expressed primary concern is introducing U-clade IHNV to the Clackamas River. U-clade INHV is present in the Deschutes Basin but has not been detected in bull trout from below or above the Pelton-Round Butte Project.

Based on our disease assessment there is no evidence that pathogens from potential donor stock or from the receiving environment will compromise the success of the reintroduction project. In addition, there does not appear to be undue risk to other native salmonids in the Clackamas River from a transfer of bull trout from either the Lewis or Metolius rivers. Despite these findings, annual disease screening of a representative sample of bull trout prior to transfer to the Clackamas River is warranted.

2.5.2 Annual Protocols for Disease Screening

Based on State requirements and recommendations from ODFW Fish Health Services (ODFW 2009), 60 ripe bull trout adults must be tested for virus the fall previous to transfer by collecting (non-lethal) and testing ovarian fluid and sperm. Although not required, it is preferable to have the samples come from individuals from more than one spawning tributary. In addition, each year of transfer will also require the testing (lethal) of 150 fry. Similar to the adult samples, it is preferable to have the samples come from more than one spawning tributary. As long as yearly test results for both fry and adults remain negative for U-clade IHN virus, the project is cleared by ODFW Fish Health Services to collect and transfer any life-stage of bull trout from within the Metolius River/Lake Billy Chinook system that calendar year. The testing, which will occur at Fish Health Services labs in Madras or Corvallis, will provide a 95 percent confidence of disease detection at a 2 percent incidence rate.

The two samples are temporally separated but offer the best possible life-stages from which to pick up the virus. Clearance of the population would have to occur on an annual basis such that the results of adults sampled in the fall are combined with results of fry testing from the following spring to clear the population for transfer during that year. For example, if adults are tested in the fall of 2010 and fry in early 2011, with no virus detected, then any life-stage of bull trout can be transferred to the Clackamas River that calendar year (2011).

2.6 Action Area

Although the release sites of translocated fish will be in the upper Clackamas River above the Collawash River confluence, the migratory nature of bull trout suggests the action area for this consultation should be represented by the entire Clackamas River Subbasin. The exception is the Oak Grove Fork above Timothy Lake Dam. The majority of the Oak Grove Fork watershed was not accessible to bull trout and anadromous salmonids historically due to an impassable natural barrier a short distance below the current dam site.

In addition, we determined during development of the proposed rule on the establishment of a nonessential experimental of bull trout, that even though the likelihood of bull trout migrating down to the Willamette River is very low, it remains a possibility. For that reason the action area for this consultation follows the 10(j) boundary that includes the Willamette River from Willamette Falls downstream to the confluence with the Columbia River, including the Multnomah Channel (see Section 2.7 below for a more detailed description).

2.7 Section 10(j) of the ESA

The 1982 amendments to the Act (16 U.S.C. 1531 et seq.) included the addition of section 10(j) which allows for the designation of reintroduced populations of listed species as "experimental populations." Under section 10(j) of the Act and our regulations at 50 CFR 17.81, the Service may designate as experimental a population of endangered or threatened species that has been or will be released into suitable natural habitat outside the species' current natural range (but within its probable historic range, absent a finding by the Director of the Service in the extreme case that the primary habitat of the species has been unsuitably and irreversibly altered or destroyed).

Before authorizing the release as an experimental population of any population (including eggs, propagules, or individuals) of an endangered or threatened species, and before authorizing any necessary transportation to conduct the release, the Service must find by regulation that such release will further the conservation of the species. In making such a finding the Service uses the best scientific and commercial data available to consider: (1) Any possible adverse effects on extant populations of a species as a result of removal of individuals, eggs, or propagules for introduction elsewhere; (2) the likelihood that any such experimental population will become established and survive in the foreseeable future; (3) the relative effects that establishment of an experimental population will have on the recovery of the species; and (4) the extent to which the introduced population may be affected by existing or anticipated Federal or State actions or private activities within or adjacent to the experimental population area.

Furthermore, as set forth in 50 CFR 17.81(c), all regulations designating experimental populations under section 10(j) must provide: (1) Appropriate means to identify the experimental population, including, but not limited to, its actual or proposed location, actual or anticipated migration, number of specimens released or to be released, and other criteria appropriate to identify the experimental population(s); (2) a finding, based solely on the best scientific and commercial data available, and the supporting factual basis, on whether the experimental population is, or is not, essential to the continued existence of the species in the wild; (3)

management restrictions, protective measures, or other special management concerns of that population, which may include but are not limited to, measures to isolate and/or contain the experimental population designated in the regulation from natural populations; and (4) a process for periodic review and evaluation of the success or failure of the release and the effect of the release on the conservation and recovery of the species.

Under 50 CFR 17.81(d), the Service must consult with appropriate State fish and wildlife agencies, local governmental entities, affected Federal agencies, and affected private landowners in developing and implementing experimental population rules. To the maximum extent practicable, 10(j) rules represent an agreement between the Fish and Wildlife Service, the affected State and Federal agencies, and persons holding any interest in land which may be affected by the establishment of an experimental population.

Under 50 CFR 17.81(f), the Secretary may designate critical habitat as defined in section 3(5)(A) of the Act for an essential experimental population. No designation of critical habitat will be made for nonessential populations. In those situations where a portion or all of an essential experimental population overlaps with a natural population of the species during certain periods of the year, no critical habitat will be designated for the area of overlap unless implemented as a revision to critical habitat of the natural population for reasons unrelated to the overlap itself.

Any population determined by the Secretary to be an experimental population will be treated as if it were listed as a threatened species for purposes of establishing protective regulations with respect to that population pursuant to Section 4(d) of the ESA. The protective regulations adopted for an experimental population will contain applicable prohibitions, as appropriate and exceptions for that population.

Any experimental population designated for a listed species (1) determined not to be essential to the survival of that species and (2) not occurring within the National Park System or the National Wildlife Refuge System, will be treated for purposes of section 7 (other than subsection (a)(1) thereof) as a species proposed to be listed under the Act as a threatened species. Any experimental population designated for a listed species that either (1) has been determined to be essential to the survival of that species, or (2) occurs within the National Park System or the National Wildlife Refuge System as now or hereafter constituted, will be treated for purposes of section 7 of the Act as a threatened species. Notwithstanding the foregoing, any biological opinion prepared pursuant to section 7(b) of the Act and any agency determination made pursuant to section 7(a) of the Act will consider any experimental and non-experimental populations to constitute a single listed species for the purposes of conducting the analyses under such sections.

The NEP designation for the reintroduction alleviates landowner and water-user concerns about possible land and water use restrictions by providing a flexible management framework for protecting and recovering bull trout, while ensuring that the daily activities of landowners and water-users are unaffected. Landowners and managers, and the general public, are more likely to accept bull trout in the Clackamas River adjacent to their lands with the regulatory flexibility provided by a NEP designation. The NEP designation also provides State and Federal agencies flexibility to manage the reintroduced population of bull trout in a manner consistent with the recovery of other ESA-listed species of salmon and steelhead present in the Clackamas River.

Experimental population special rules contain specific prohibitions and exceptions regarding the taking of individual animals. These special rules are compatible with routine human activities in the expected reestablishment area. Section 3(19) of the Act defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." If the NEP 10(j) rule is finalized as proposed, take of bull trout within the experimental population area will be allowed provided that the take is unintentional, not due to negligent conduct, or is consistent with State fishing regulations that have been coordinated with the Service. We expect levels of incidental take to be low because the reintroduction is compatible with existing activities and practices in the area. As recreational fishing for species other than bull trout is popular within the NEP area, we expect some incidental take of bull trout from this activity but, as long as it is in compliance with ODFW fishing regulations, and Tribal regulations on land managed by the CTWSRO, such take will not be a violation of the Act.

2.7.1 Geographic Boundaries of the 10(j) Designation

The NEP action area, which encompasses all potential release sites, will include the entire Clackamas River subbasin as well as the mainstem Willamette River, from Willamette Falls to its points of confluence with the Columbia River, including Multnomah Channel. The Willamette River's confluence with the Columbia River occurs at river mile (RM) 101, near the City of Portland. A secondary channel of the Willamette River, named the Multnomah Channel, branches off the Willamette River approximately three miles upstream from its confluence with the Columbia River. This secondary channel runs approximately 20 river miles along the west side of Sauvie's Island before joining the Columbia River at RM 86 near the town of St. Helens. The NEP boundary extends down the Multnomah Channel to its confluence with the Columbia River, as well as the mainstem Willamette River from Willamette Falls to its confluence with the Columbia River (Figure 2-1).

We define the upper portion of the Clackamas River Subbasin, the area where reintroduced bull trout can be expected to reestablish a viable population, as the headwaters down to and including the North Fork Reservoir (RM 30). Bull trout require cold, clean water in complex river and stream habitats with low levels of fine sediments. These habitat requirements are most stringent for the spawning and rearing life stages of bull trout. The portion of the Clackamas River Subbasin providing suitable spawning and rearing habitat today is limited to the mainstem and its tributaries in the very headwaters of the subbasin upstream of the Collawash River confluence. This portion contains a total of 70.1 river miles of suitable spawning and rearing habitat delineated into six separate habitat patches (Shively et al. 2007). These patches range in size, configuration, and condition. The most downstream patch occurs along the mainstem Clackamas River in an area known as Big Bottom. This unique and complex reach of the river provides suitable spawning and rearing habitat. The other patches occur either adjacent to or up to a maximum distance of 5.9 river miles upstream into the upper headwaters of the subbasin.

The upper Clackamas River contains a sufficient amount of habitat to support a self-sustaining population of bull trout (Shively et al. 2007). Based on migration patterns and seasonable habitat use observed in nearby extant bull trout populations, such as from the Lewis, McKenzie and Metolius subbasins, it is possible some reintroduced bull trout will utilize North Fork Reservoir.

Based on studies and observations of seasonal bull trout movements in other lower Columbia River bull trout populations, it is likely bull trout that overwinter in North Fork Reservoir would migrate upstream into the Clackamas River during spring and early summer.

The Service has broadened the action area beyond the expected reestablishment area to account for individual bull trout that may migrate past major hydroelectric operations on the Clackamas River. If bull trout migrate downstream of North Fork Dam (RM 30), they will do so through one of several mechanisms: via the existing fish bypass system, which deposits fish in the Clackamas River below River Mill Dam at RM 23; through spill over North Fork Dam; or, via entrainment through the turbines at North Fork Dam. The latter two mechanisms would result in bull trout occupying the river reach above Faraday Dam; these fish could move further down the river system via spill at Faraday Dam or through entrainment through the turbine units at Faraday Dam. Both avenues would deposit bull trout in Estacada Lake, the reservoir behind River Mill Dam. Similar to passage at Faraday Dam, bull trout occupying Estacada Lake could potentially migrate to areas below River Mill Dam by: (1) entrainment in spill provided through the recently constructed fish bypass chute to increase passage; (2) entrainment in spill due to large flow events; or (3) by entrainment through the turbine units.

Although the above information suggests pathways by which bull trout may migrate into the lower Clackamas River below River Mill Dam and into the mainstem Willamette River, we expect the likelihood of this occurrence to be low. Habitat conditions, in particular water temperatures, are not suitable for bull trout for much of the year in the lower Clackamas and Willamette rivers. In addition, observations of bull trout migration patterns and seasonal habitat use in other nearby extant populations suggest reservoirs, such as North Fork Reservoir, often inhibit most bull trout migration to downstream habitats.

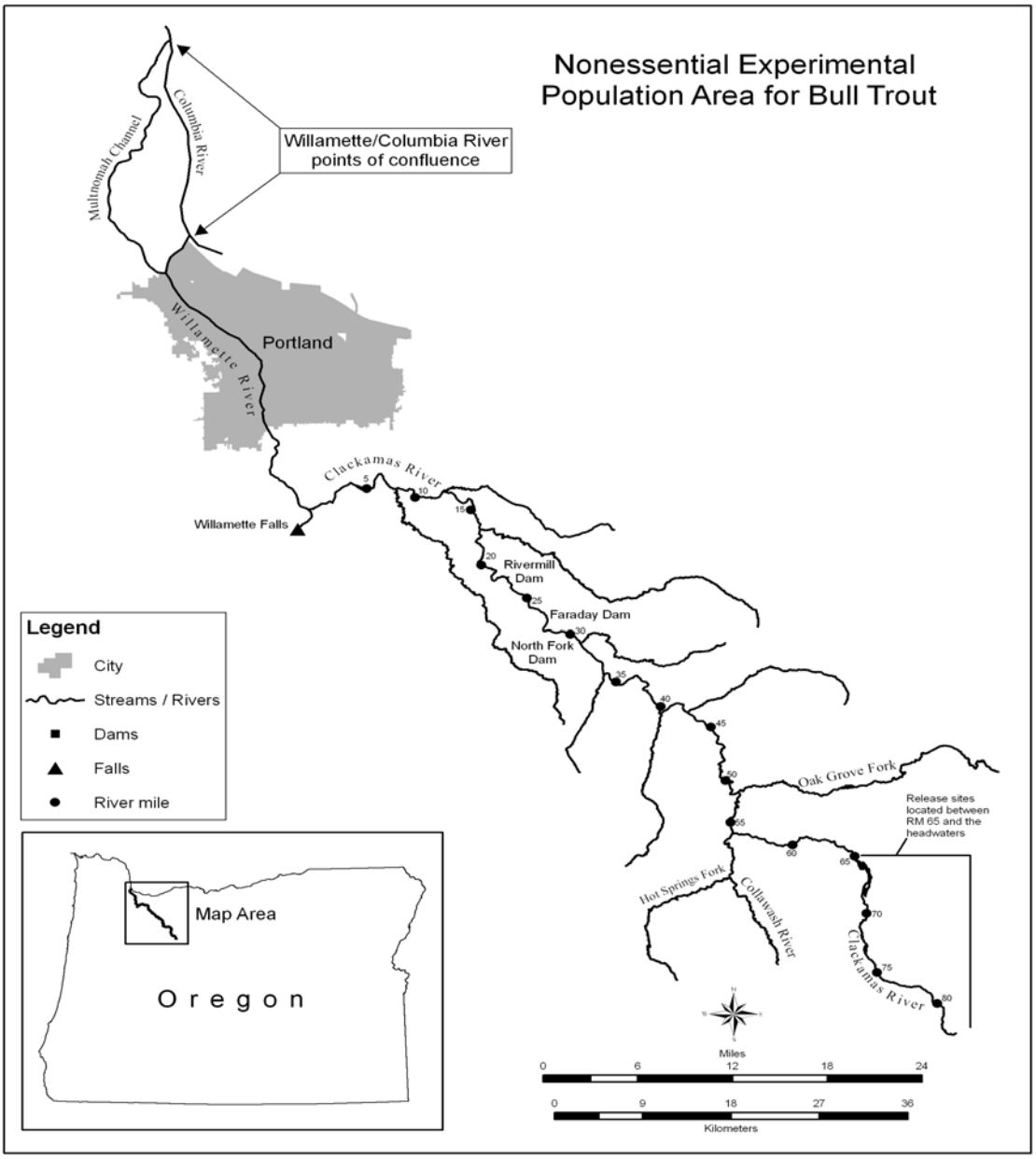


Figure 2-3 Nonessential experimental population area for bull trout showing release locations in the upper Clackamas River

2.8 Project Management Structure

The reintroduction project will be guided by several technical committees and a manager's committee previously noted in Section 1.1 above. The Clackamas Manager's Committee is represented by the Service, ODFW, USFS, CTWSR, PGE and NMFS. The Clackamas Implementation and Logistics Committee and the Clackamas Monitoring and Evaluation Committee are technical groups represented generally by fisheries biologists from the agencies noted above. Monitoring and evaluation of the project may involve additional entities such as the U.S. Geological Service (USGS) and the University of Washington.

During project planning the Manager's Committee met as frequently as three to four times a year. We expect once we start implementing the project that the committee would, at a minimum, meet annually or more frequently on an as-need basis. The technical committees will be responsible for all detailed and administrative tasks associated with the project including annual planning, disease screening, donor stock capture, tagging, transfer and release, monitoring and evaluation, funding, and annual reporting.

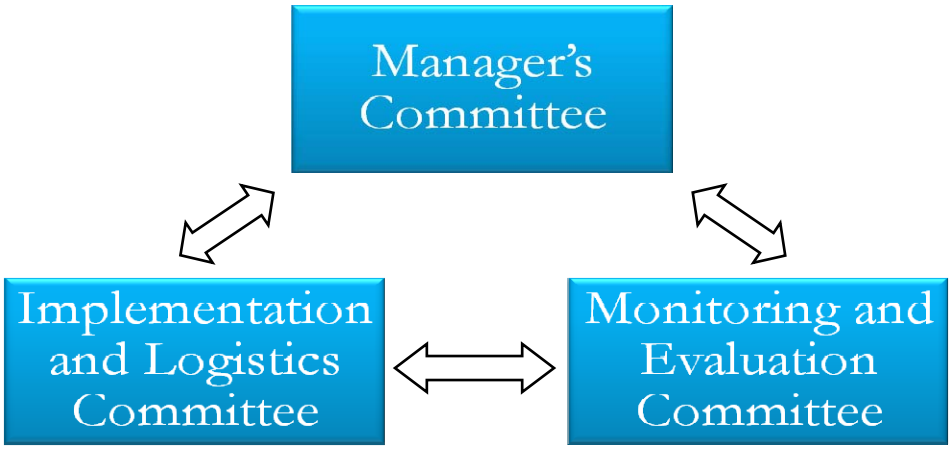


Figure 2-4 Clackamas Reintroduction Project oversight committees

2.9 Monitoring and Evaluation

Acknowledging the limited availability of information on fish introductions and reintroductions (Seddon et al. 2007), the Service and our project partners adopted a goal early in project development to document, learn and report on all the major phases of the project beginning with our feasibility assessment (Shively et al. 2007; Dunham & Gallo 2008), and extending through project planning and development, and implementation. One of the most critical aspects of this goal is to document the effectiveness of the reintroduction by evaluating components of the implementation strategy, including the utilization of habitats chosen for release of individuals, the numbers and life stages of donor stock, the genetic health of the recipient population,

documentation of reproduction and recruitment, and ultimately the establishment of a self-sustaining bull trout population.

In order to document and adaptively manage the project, a robust monitoring and evaluation program is necessary. Along with other project documentation, we expect the information gained from the monitoring and evaluation program will contribute significantly to other fish reintroductions, and specifically bull trout recovery projects that we anticipate will occur across the species range consistent with recovery guidance for the species (USFWS 2002). The monitoring and evaluation program has three major goals: 1) monitor and evaluate bull trout reintroduction effectiveness; 2) monitor and evaluate donor population status; and, 3) monitor and evaluate impacts to listed anadromous salmonids.

While the monitoring and evaluation goals are expected to remain constant for the duration of the project (phases 1-3), the objectives will be slightly different for each phase. These three major goals, and associated objectives for phase 1, are detailed below and summarized in Table 2-1 at the end of this section.

2.9.1 Reintroduction Effectiveness

The objectives of the effectiveness monitoring program for phase 1 of the project (2011-2017) are: 1) assess distribution and movement; 2) assess relative survival of translocated bull trout by monitoring presence and absence; 3) assess occurrence of spawning and reproduction; and 4) assess genetic health (as measured against the donor population). Successful reproduction in phase one of the project (2011-2017) would logically result in the incorporation of a monitoring component directed at assessing the distribution, movement, growth and survival of the initial cohorts of naturally produced bull trout. Monitoring activities in phase 2 (2018-2024) and phase 3 (2025-2030) will be informed by phase 1 monitoring and evaluation. Effectiveness monitoring of the project will be conducted jointly by the Service and ODFW, with assistance from the USFS and potentially USGS and the University of Washington.

2.9.1.1 Distribution and Movement

The goal of monitoring distribution and movement is to primarily determine the short and long-term response of different life stages of bull trout translocated from the Metolius River to the Clackamas River. Results from annual monitoring will contribute to the adaptive management of the project and potential refinement of the subsequent years' implementation strategy. Distribution and movement monitoring will include the following: 1) Assess how different life stages of translocated bull trout distribute and utilize the Clackamas River Subbasin; 2) Determine the extent to which juvenile bull trout distribute and utilize the habitat in which they are stocked and determine the extent to which they move into adjoining habitats that were not identified as suitable for spawning and early juvenile rearing; 3) Determine if older life stages (captured from Lake Billy Chinook) are more likely to exhibit a previous life history strategy (adfluvial) as compared to younger life stages that were captured from tributaries of the Metolius River prior to migrating downstream in the Metolius River to Lake Billy Chinook; 4) Determine if older life stages of bull trout utilize habitats lower in the Subbasin, particularly within PGE's Clackamas Hydro Electric Project, and if so, assess the timing into and out of these locations.

As noted above in section 2.2, we propose in the initial phase of the project to utilize juvenile, subadult and adult bull trout life stages, all of which will be PIT tagged. In addition to PIT tags, all adults and subadults for the first two years (see section 2.1 above for definitions of life stages) will be tagged with radio tags. Monitoring distribution and movement will occur primarily by fixed and mobile PIT tag readers and radio receivers.

2.9.1.2 Survival

The goal of presence and absence (i.e., occupancy) monitoring is to document relative survival of translocated fish and ultimately, successful natural reproduction. The focus of this monitoring component is on the juvenile life stage since older life stages will be radio tagged and thus their status should be readily obtainable during the years the tags are operational. Monitoring the presence and absence of juveniles will occur by several methods including, but not limited to, snorkel observations, minnow trapping, and PIT tag monitoring.

2.9.1.3 Spawning and Reproduction

The goal of this monitoring is to document successful reproduction, which is a major benchmark in the overall project goal of establishing a self-sustaining population of bull trout in the Clackamas River. Documenting reproduction will occur initially by monitoring PIT and radio-tagged individuals to assess upstream movement in the late summer and fall. Detections of bull trout moving into tributaries would trigger a subsequent effort to document the existence of redds which would be monitored for successful recruitment the following spring via snorkeling and/or fry emergence traps. Documenting adult movement into and out of spawning tributaries may include the utilization of a picket weir and trap, and/or a rotary screw trap, potentially in combination with PIT tag arrays and digital video. This monitoring component includes an assessment of which donor stock life stages are successful in contributing naturally produced progeny, and an evaluation of whether timing and location of releases of adult bull trout makes a difference in reproduction contribution.

2.9.1.4 Genetic Health

In 2007, staff from the Service's Conservation Genetics Laboratory, Abernathy Fish Technology Center, conducted a genetic health assessment of bull trout in the Metolius River Subbasin. The results indicated three related but distinct populations of bull trout in the Metolius River. The assessment also provided information related to the genetic health of these populations. A long-term goal of the Clackamas reintroduction project is to establish a self-sustaining population of bull trout that reflects the genetic diversity and overall genetic health of the founding donor stock from the Metolius River. In order to monitor our progress towards this goal, a small fin clip will be taken from all bull trout that are translocated to the Clackamas River and in the future, from naturally produced individuals. These samples will be stored and analyzed at the Conservation Genetics Lab for analysis towards the end of phase 1.

2.9.2 Donor Population Status

We intend to monitor donor stock status annually to determine if the population is free of pathogens of concern (see section 2.5 above), and to ensure the population maintains the minimum threshold of spawning adults to contribute as a donor stock to the Clackamas River reintroduction project. Bull trout in the Metolius River are monitored primarily by annual full census redd counts. These counts are conducted by ODFW, CTWSRO, USFS, PGE and Service staff. A fish to redd conversion factor derived from mark recapture studies in the Metolius River is used to estimate the annual adult spawning population size. This conversion factor was initially generated in the 1990s and is currently being tested in the field, with Service financial support, in 2009 & 2010.

In addition to the genetic monitoring of the recipient bull trout population in the Clackamas Subbasin, we will also replicate the Metolius bull trout genetic health assessment (discussed above) on the donor stock at an appropriate interval to ensure the loss of individuals via contribution towards the Clackamas reintroduction is not impacting the genetic health of the Metolius River donor stock. Specifics of monitoring the donor population status can be found in Table 2-1 below.

2.9.3 Impacts to Listed Anadromous Salmonids

During development of the proposed action, concerns were expressed by stakeholders that predation and competition from reintroduced bull trout may negatively impact federally listed anadromous salmonids, particularly juvenile life stages of steelhead trout, coho salmon, and Chinook salmon in the Clackamas River above North Fork Dam. Although our analysis in Chapter 5 (Effects) suggests the risk to anadromous salmonids from this action is low, we acknowledge the uncertainty and sensitivity around this issue. We believe it is important to assess uncertainty using appropriate tools and methods and then take steps necessary to reduce that uncertainty to an acceptable level while recognizing that it cannot be eliminated entirely.

In the development of this proposed action, we have addressed concerns over predation and competition to listed anadromous salmonids by sponsoring and funding an expert science panel workshop (see Chapter 5) specifically to assess the potential impacts of a Clackamas River bull trout reintroduction on listed anadromous salmonids (Marcot et al. 2008). Based on stakeholder input, we modified our initial proposed action to reduce the number and maximum sizes of older life stages of bull trout for transfer, and we committed to PIT tagging all fish transferred, including radio-tagging all older life stages the first two years. In addition, we funded, together with the USFS and PGE, a baseline food web investigation in the upper Clackamas River subbasin in order to establish a baseline for future monitoring of food web effects, particularly on salmon and steelhead, following the bull trout reintroduction (Lowery and Beauchamp 2010). We have also met numerous times with NMFS and PGE during the development of this proposed action in order to discuss methods that could be incorporated into the proposed action to reduce uncertainty and concern over impacts to listed anadromous salmonids. We further modified our proposed action

The monitoring of potential impacts to juvenile anadromous salmonids (Table 2-1 below) will generally focus on PGE's Clackamas Hyrdoelectric Project area since juvenile salmonids utilize project reservoirs, especially North Fork Reservoir, for rearing and because fish collection facilities to aid downstream migration of smolts necessarily concentrate the juvenile fish increasing their vulnerability to predation and/or avoidance of collection facilities due to the presence of a predator. These areas of increased vulnerability for anadromous juveniles are also areas we expect to be more able to detect a behavioral response by bull trout relative to areas upstream of North Fork Reservoir or in the lower Clackamas River below Rivermill Dam. Monitoring of the food web response upstream of North Fork Reservoir will occur towards the end of phase one when we will replicate the baseline work (see 2.9.3.1 below) conducted by Lowery and Beauchamp (2010).

We have developed this monitoring component with the intent of reducing uncertainty and informing future management decisions associated with the bull trout reintroduction program. In order to assess impacts to listed anadromous salmonids we propose to: 1) determine if adult and subadult bull trout occupy areas within the PGE hydro project during periods in which they could consume particularly high numbers of rearing or migrating juvenile salmon and steelhead; 2) if so, determine if survival rates of listed anadromous salmonid juveniles rearing in, or moving through the PGE hydro-project area change; and, 3) if survival rates of listed anadromous salmonids juveniles decline, determine the degree to which bull trout are responsible for the decline by utilizing field data, bioenergetics and life-cycle monitoring.

As outlined below in 2.10, adaptive management will guide how this project is implemented on an annual basis. The primary tool to accomplish adaptive management is monitoring. The monitoring of impacts to salmon and steelhead will provide valuable information that will inform how the project is implemented in future years, including numbers, life stages, and release locations of bull trout, as well as the disposition of individual fish should they be documented or observed staging near, within or immediately below juvenile salmonid bypass systems.

2.9.3.1 Pre-Project Baseline Food Web Investigations

Bull trout reintroduced to the Clackamas River will consume some listed anadromous salmonids (eggs, fry, juveniles), along with other resident native fish. However, there is significant uncertainty regarding the magnitude of impact and our ability to detect a response. In order to increase our ability to detect a food web response following a reintroduction of bull trout, we collaborated with USGS/University of Washington in 2009 and 2010 to conduct a baseline food web assessment in the upper Clackamas River subbasin (Lowery and Beauchamp 2010). While the following represents a summary of the assessment, the full report is hereby incorporated by reference. The primary purpose of the assessment was to provide a baseline for future food web response monitoring following a bull trout reintroduction. We anticipate this work will be replicated towards the end of phase one of the reintroduction. The objectives of the study were to determine how the upper Clackamas River food web currently functions by: 1) identifying temporal distribution patterns with an emphasis on important seasonal growth habitats for protected salmonids; 2) quantifying their feeding and growth performance within those habitats; 3) quantifying the consumption demand of other species within the food web that potentially

share common prey with anadromous salmonids; and 4) identifying the current predation risk to salmonids by predatory fish.

The study methods entailed documenting seasonal distribution, diet, size structure, growth, and abundance in the primary tributary habitats, and North Fork Reservoir. These data were used as inputs for bioenergetics model simulations to quantify seasonal feeding and growth performance by juvenile salmonids within these habitats in response to ambient thermal regime and food supply. The model simulations also calculated seasonal consumption rates on all prey categories to determine the current feeding rates and consumption demand for key prey eaten by each age class and species. These simulations were also applied to the other abundant species in the Clackamas River tributary habitats and North Fork Reservoir in order to assess the relative importance of competitive or predation-prey interactions within the existing fish community. Data was collected by use of backpack electrofishers, hydroacoustics, gillnetting, and snorkeling.

The following bullets summarize key findings from Lowery and Beauchamp (2010).

- Shorthead sculpins represented the greatest fraction of fish biomass in all lotic habitats examined suggesting that current habitat conditions are more favorable for sculpins than salmonids.

- Multiple life history patterns were documented for rearing juvenile salmonids including tributary resident rearing, fluvial, and adfluvial (North Fork Reservoir). Tributary residents reared in tributary streams or the Big Bottom area of the mainstem Clackamas River for 1-2 years. Fluvial juveniles migrated to mainstem Clackamas River habitats within 3-months of emergence. Adfluvial juveniles occupied North Fork Reservoir for 1-3 years.

- Spring Chinook salmon exhibited a predominantly adfluvial life history rearing strategy (North Fork Reservoir). After spring, Chinook were extremely rare in non-reservoir habitats.

- In contrast to spring Chinook salmon, coho salmon primarily utilized tributary habitats for rearing during the growing season. A second life history strategy was identified in which coho reared in tributaries and mainstem habitats spring through fall before moving downstream to North Fork Reservoir during winter.

- Steehead trout were predominantly tributary residents and mainstem residents with a small component rearing in North Fork Reservoir.

- Brown trout, juvenile coho salmon, rainbow trout, hatchery rainbow trout, largescale sucker, and mountain whitefish were captured every season in North Fork Reservoir. Largescale suckers were caught at the highest rates during all seasons of sampling.

- Shoreline snorkeling of North Fork Reservoir indicated extensive use of the littoral zone by juvenile Chinook and coho during spring, dace and sculpin during the summer, but no regular use of the littoral zone by any fish species in autumn and winter.

- Piscivory was uncommon in tributary habitats but it did occur. Coastal cutthroat trout were noted predating on mountain whitefish. Coho salmon and rainbow trout consumed sculpin, as did cutthroat trout.

- Piscivory in North Fork Reservoir was much more common than in tributary habitats with non-native fishes responsible for the majority of piscivory observed. Brown trout consumed Chinook salmon, sculpin and mountain whitefish in the summer and autumn. Hatchery rainbow trout consumed juvenile suckers in the spring and juvenile suckers, sculpins and mountain whitefish during autumn and winter. And wild rainbow trout consumed sculpin in autumn and winter.

- Of the potentially piscivorous salmonids in North Fork Reservoir, brown trout >300mm FL were the most important predator on juvenile Chinook salmon. Brown trout also consumed substantial amounts of mountain whitefish and sculpin. Seasonal consumption estimates translated into annual losses of 26,700 juvenile Chinook and unidentified salmon, which were also presumed to be Chinook. However, the predation estimates were highly sensitive to assumptions regarding the seasonal abundance of brown trout in the reservoir. Estimates of predation losses should be considered within the bounds of sampling limitations and analyses that were possible in the study. Predation losses likely represented an annual mortality rate of less than 10% of the juveniles Chinook salmon population that entered the reservoir. This scenario suggests that predation mortality for juvenile Chinook salmon and other salmonids appears to be relatively low in the reservoir under current conditions.

- Both small and large hatchery rainbow trout were significant predators of non-salmonid fishes such as suckers and sculpin.

- The primary forage base for bull trout that may utilize North Fork Reservoir would be the year-round supply of largescale suckers, juvenile Chinook salmon, mountain whitefish, hatchery rainbow trout, and sculpin, and the short-duration pulses of juvenile salmon and steelhead migrating seasonally into or out of the reservoir.

- Important gaps in knowledge remain regarding the role of the mainstem Clackamas above North Fork Reservoir as seasonal or year-round rearing and migratory habitat for juvenile anadromous salmonids and resident fishes. A more comprehensive evaluation of predation interactions within the Upper Clackamas River mainstem (where large predatory-sized fishes like bull trout are likely to reside), from the headwaters to North Fork Reservoir is recommended to establish current use and trophic interactions of juvenile salmon and steelhead and other resident fishes and provide context for monitoring and evaluation of the bull trout reintroduction project.

2.9.3.2 Modeling Potential Impacts to Salmon and Steelhead

As part of our proposed action, we propose to work with staff from the NOAA Science Center in Seattle (Michelle McClure), and further work with Dave Beauchamp (USGS/UW) regarding assisting the Service in modeling potential impacts from the bull trout reintroduction on listed

salmon and steelhead in the Clackamas River. An initial meeting, scheduled for early December 2010, will include Michelle McClure, and staff from USGS/FRESC (Jason Dunham), USGS/WA Cooperative Fish and Wildlife Research Unit (Dave Beauchamp), and USFWS.

Table 2-1 Monitoring and Evaluation for Phases 1-3

	Donor Stock Status (Implementation)	Clackamas Bull Trout Reintroduction Effectiveness (M&E)	Impacts to Listed Salmonids (M&E)
Phase 1: Years 1-7	D1. Does the donor stock population have the minimum threshold number of spawning adults required to continue donor stock removal? D2. Is the donor population disease-free?	B1. Do translocated adult and subadult bull trout remain in the upper Clackamas Basin (above River Mill Dam)? a. If yes, what is their seasonal distribution? b. If yes, is there evidence of spawning activity? If no, does changing the release timing/location provide a different result? B2. Do juveniles remain in the tributary streams they are outplanted to in the short-term or do they move relatively quickly out of or into other tributaries? a. If they stay, how are juveniles distributed within tributaries? B3. Which translocated life stages are successful in contributing naturally produced progeny in the Clackamas River? a. Do adults and subadults produce progeny in years 1-3 (and beyond)? b. Do translocated juveniles mature to produce progeny in years 4-7? B4. Is the level of genetic variation in the donor population adequately represented by translocated fish (years 4-7)?	S1. Do adult and subadult bull trout occupy areas in the PGE hydroproject during smolt migration periods in which they could consume particularly high numbers of juvenile salmon and steelhead? a. If yes, do survival rates of listed anadromous salmonids moving through the PGE hydro-project area change? b. If survival rates of listed salmonids decline, could bull trout be responsible for the magnitude of decline observed (i.e., bioenergetics analysis and life cycle modeling)?

	Donor Stock Status (Implementation)	Clackamas Bull Trout Reintroduction Effectiveness (M&E)	Impacts to Listed Salmonids (M&E)
Phase 2: Years 8-15	D3. Does the donor stock population have the minimum threshold number of spawning adults required to continue donor stock removal? D4. Is the donor population disease-free? D5. Are there any indications of deleterious impacts (genetic fitness or population abundance) to the donor population from removing individuals for translocation?	B5. What is the estimated population size of the reintroduced population? B6. Is the level of genetic variation in the donor population adequately represented by the Clackamas population? B7. What habitats do naturally produced and translocated bull trout utilize for spawning and rearing? B8. What life history strategies do naturally produced fish in the Clackamas exhibit? B9. How has the food web changed as a result of reintroducing bull trout into the Clackamas River basin?	S2. Do adult and subadult bull trout occupy areas in the PGE hydroproject during smolt migration periods in which they could consume particularly high numbers of juvenile salmon and steelhead? S3. What is the estimated level of bull trout predation on juvenile salmon and steelhead? S4. Are there potential indirect food-web effects of bull trout on salmon and steelhead?
Phase 3: Years 16 - 21	D6. Does the donor stock population have the minimum threshold number of spawning adults required to continue donor stock removal? D7. Is the donor population disease-free? D8. Were there long-term detrimental impacts (genetic fitness or population abundance) to the donor population from removing individuals for translocation?	B10. Is the level of genetic variation in the donor population adequately represented by the Clackamas population? B11. What is the effective population size and trend? B12. What is the structure of the Clackamas bull trout population?	S5. Do adult and subadult bull trout occupy areas in the PGE hydroproject during smolt migration periods in which they could consume particularly high numbers of juvenile salmon and steelhead? S6. What is the estimated level of bull trout predation on juvenile salmon and steelhead? S7. Are there potential indirect food-web effects of bull trout on salmon and steelhead?

Table 2-2 Project Components and Timelines for Phase 1: years 2011 – 2017

Project Component	Study Question Addressed	Time Frame
Operations and Logistics		
Monitoring of the donor population - Redd surveys throughout Metolius subbasin - Creel surveys in Lake Billy Chinook - Outmigrant screw-trap in Metolius River at Monty - Juvenile BT density monitoring at index reaches in spawning streams	D1	Ongoing annually, will continue throughout the life of the project
Disease screening for IHNV - Performed by the ODFW Fish Health Services labs in Madras or Corvallis - Will require 60 ripe bull trout adult (nonlethal) and 150 fry (lethal) even if fry aren't translocated	D2	Every year starting in 2009; adults – fall prior to translocation, fry – spring of translocation
Adult and subadult (>250 mm) collection from the Metolius basin (see also tagging, below) - Collected from Metolius arm of Lake Billy Chinook - Angling, collection at Round Butte Dam		May and June, starting 2011
Juvenile (<250 mm) collection from the Metolius basin (see also tagging, below) - Collected from the mainstem Metolius and tribs - Snorkel herding, seining, electrofishing		May and June, starting 2011
Hold fish prior to transport to the Clackamas basin - Adults and subadults: holding tanks at Round Butte Hatchery??? - Juveniles:???		May and June, starting 2011
Transport fish to the Clackamas basin		May and June, starting 2011
Release fish in Clackamas basin - Adults and subadults: Big Bottom - Juveniles: Big Bottom and upper basin patches (1-6) rotationally, 500 in each of two patches per year		May and June, starting 2011 2011-2012: Pinhead and Cub/Berry 2013-2014: Rhodo and Upper Clack 2015-2016: Hunter and Big Bottom
Half-duplex PIT tag all fish collected from the Metolius - Tag upon catch; use 23 mm tags for fish > 120 mm, use 12 mm tags for fish < 120 mm - Dorsal sinus for fish > 300 mm; body cavity for < 300 mm	B1.a-b, B2.a, S1	May and June, starting 2011 through all translocation years
Radio-tag all adults and subadults collected from the Metolius basin - Tag upon catch from Lake Billy Chinook - Maximize battery duration, using tag size dependent on fish size (2+ years battery life)	B1.a-b, S1	May and June, starting 2011 through 2012

Project Component	Study Question Addressed	Time Frame
Operations and Logistics		
Install fixed-station radio antennas in the Clackamas basin to track movements of adults and subadults (listed in order of priority): - Below River Mill Dam (1) - Head of North Fork Reservoir (2) - North Fork Reservoir collector (3) - Collawash confluence (4) - On Clack at Last Creek (5)	B1.a-b, S1	Install spring 2011, upload data every 7-10 days year-round (may be less in winter depending on movement) (May – Nov each year, starting 2011 through life of batteries)
Install half-duplex PIT tag arrays in the Clackamas basin to track all translocated fish: - At mouths of patches 2-6 tributaries (Fork of Last/Pinhead, Fork at Upper Clack/Cub-Berry, Hunter, Rhodo) and in the downstream bypass of the hydrofacilities	B1.a-b, B2.a, S1	Install spring 2011, upload data every 7-10 days year-round (may be less in winter depending on movement)
Look for evidence of spawning: - Assess radio and PIT tag data that may indicate fish moving to spawning habitat - Mobile tracking: ground and/or aerial tracking during spawning season (opportunistic observation of presence of redds or actively spawning fish)	B1.a-b	Mobile radio tracking: in conjunction with antennae maintenance, dependent on fish movement (aerial if necessary) Mid Aug – Oct, starting Fall 2011 – through end of Phase 1
Ground-based surveys to detect presence (survival) of juveniles and naturally produced progeny (night snorkeling and mobile PIT tag tracking) - GRTS (21 surveys of 50 m reaches per patch per RMEG guidelines) or census the two patches that juveniles were released in each year. - Based on locations of adults, may survey additional patches to survey for progeny	B2.a, B3.a-b	Summer of each year that juveniles are reintroduced, starting 2011 through end of Phase 1
Collect tissue samples for genetic analysis: - Fin clip all fish translocated from the Metolius - Collect fin clips from all unmarked BT found (during night snorkeling surveys, using dipnets, smolt traps, minnow traps) in the Clackamas to assess parentage (and determine which translocated life stage successfully reproduced depending on observed/assumed spawning behavior)	B3.a-b, B4	May – June, starting in 2011 with collection of fish to be translocated and during night snorkel surveys in summer in years 4 – 7 of Phase 1

2.10 Adaptive Management of the Reintroduction Project

A key component of our proposed action is the adaptive management of the bull trout reintroduction project, ranging from the annual numbers, life stages and collection methods of the donor stock, to the locations and timing of translocations (implementation strategy), and finally the management of bull trout in the Clackamas River relative to their potential impact on threatened salmon and steelhead. Our goal with this approach is to find the greatest efficiencies

and effectiveness with project implementation, while assuring no harm to the donor stock, and limiting negative impacts to other listed species in the Clackamas River subbasin.

The adaptive management of the bull trout reintroduction project will be based in part on guidance provided in the Department of Interior's technical guide to adaptive management (DOI 2009), hereby incorporated by reference. The guidance defines adaptive management as a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (DOI 2009).

Benefits if using adaptive management include:

- An adaptive approach provides flexibility to act in the face of uncertainty
- An adaptive management approach is learning based
- Adaptive management specifies what actions are to be taken and when
- Adaptive management encourages long-term collaboration among stakeholders
- Adaptive management promotes optimal decision making with the information available

In designing an adaptive management project, management alternatives should be included that will produce different responses and thereby promote learning. One way to structure alternatives for this purpose is to limit their number, and maximize differences among them (DOI 2009). To ensure clarity and transparency it is important to make the management options explicit. Ambiguity as to the alternatives under consideration can lead to conflict among stakeholders.

The learning that is at the heart of adaptive management occurs through a comparison of model-based predictions against estimated responses based on monitoring data. Well designed monitoring programs facilitate evaluation and learning in adaptive management. Monitoring programs should be designed from the outset to inform decision making with data that are relevant to the management issues in the adaptive management project.

In general, monitoring provides data in adaptive management for four key purposes:

- To evaluate progress toward achieving objectives
- To determine resource status, in order to identify appropriate management actions
- To increase understanding of resource dynamics via the comparison of predictions against survey data

- To enhance and develop models of resource dynamics as needed and appropriate

2.10.1 Adaptive Management Applied to Impacts to Salmon and Steelhead

As noted in Section 2.9.3 above, monitoring and evaluation will inform the adaptive management of this project, including the appropriate management of this experimental population of bull trout both during the period they are being reintroduced and post-project if we are successful in reestablishing a self-sustaining population in the Clackamas River.

The management decision to designate the reintroduced fish in the Clackamas River as a non-essential experimental population (NEP) was made to address concerns by stakeholders regarding the perceived or real regulatory burden associated with having another ESA listed species present in the Clackamas River subbasin, and potentially in the lower Willamette River. The NEP designation for the reintroduction alleviates landowner and water-user concerns about possible land and water use restrictions by providing a flexible management framework for protecting and recovering bull trout, while ensuring that the daily activities of landowners and water-users are unaffected. Landowners and managers, and the general public, are more likely to accept bull trout in the Clackamas River adjacent to their lands with the regulatory flexibility provided by a NEP designation. The NEP designation also provides State and Federal agencies flexibility to manage the reintroduced population of bull trout in a manner consistent with the recovery of other ESA-listed species of salmon and steelhead present in the Clackamas River.

As noted above, an adaptive approach provides flexibility to act in the face of uncertainty, is learning based, and specifies what actions are to be taken and when. To address uncertainty regarding impacts from the bull trout reintroduction on listed anadromous salmonids, we have developed a framework to facilitate management decisions on actions to be taken. Drafts of this framework were shared with stakeholders such as NMFS, PGE and ODFW, but no substantive comments were received. We expect this framework to be a "living framework" and that refinement and details, including timelines for when management actions would be taken, will be further coordinated with project stakeholders.

The framework (figure 2-5) is based on a suite of potential scenarios that are categorized as high risk and low risk to juvenile anadromous salmonids. Whether a management action is warranted is based on the level of certainty that a population level impact is occurring to listed anadromous salmonids, as determined by monitoring and evaluation. A high risk scenario with high certainty that a population level impact is likely occurring would lead to a management action. In contrast, a high risk scenario with low certainty that a population level impact is occurring would lead to a review by the Manager's Committee overseeing the reintroduction project. Likewise, a low risk scenario with high certainty that a population level impact is occurring would also lead to a review by the Manager's Committee, which may or may not result in a management action. Lastly, a low risk scenario with low certainty that a population level impact is occurring would result in no management action.

Although there are possible scenarios and resulting management actions that are not depicted in the framework below, we believe the scenarios and actions listed represent those most likely to

occur. The adaptive management of the project overall, and the dynamic nature of the decision framework, are expected to accommodate necessary changes over time. If the framework depicted in 2-5 is determined not to be protective enough by the Manager's Committee, future modifications of the framework may be necessary. The framework, along with high and low risk scenarios and resulting management actions, is provided below.

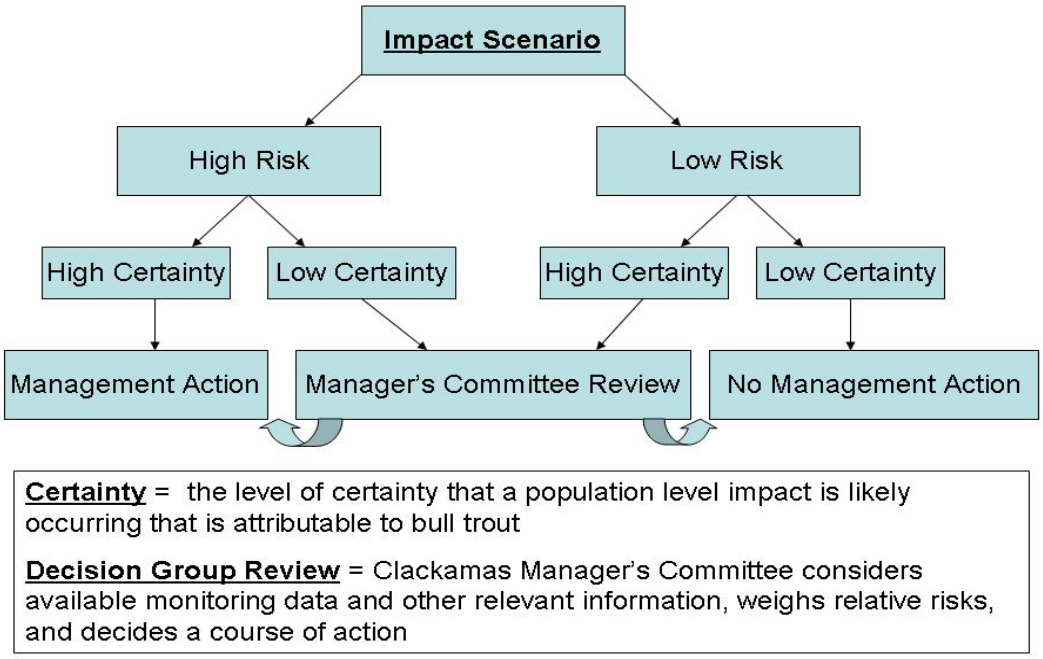


Figure 2-5 Decision framework for managing impacts to anadromous salmonids

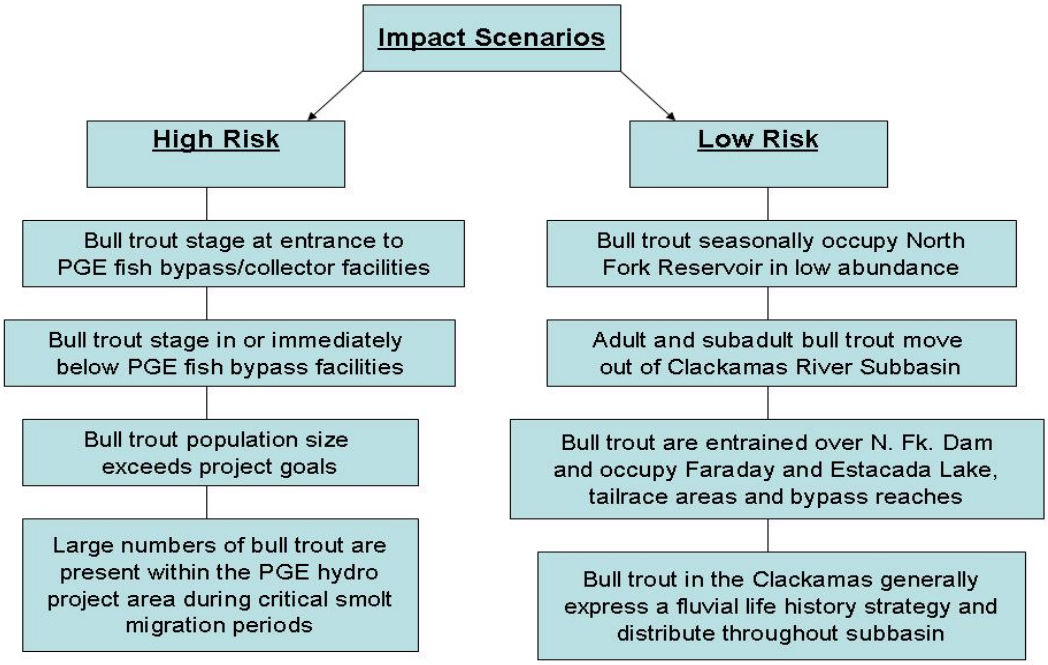


Figure 2-6 High and low risk scenarios for anadromous salmonids

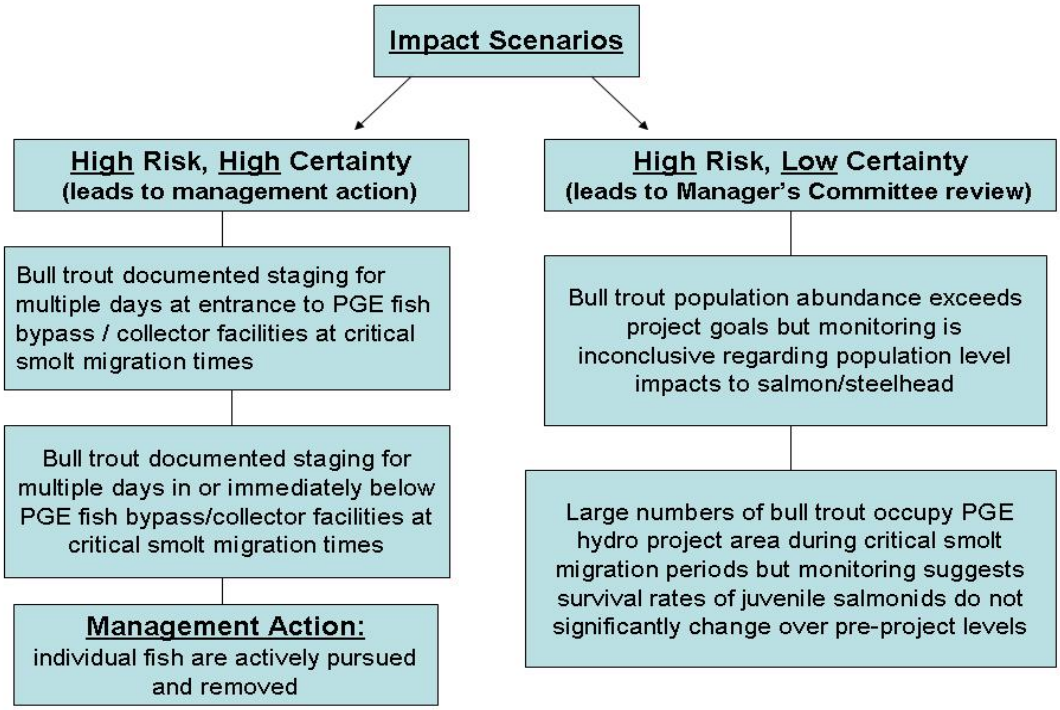


Figure 2-7 High risk impact scenarios with high and low certainties

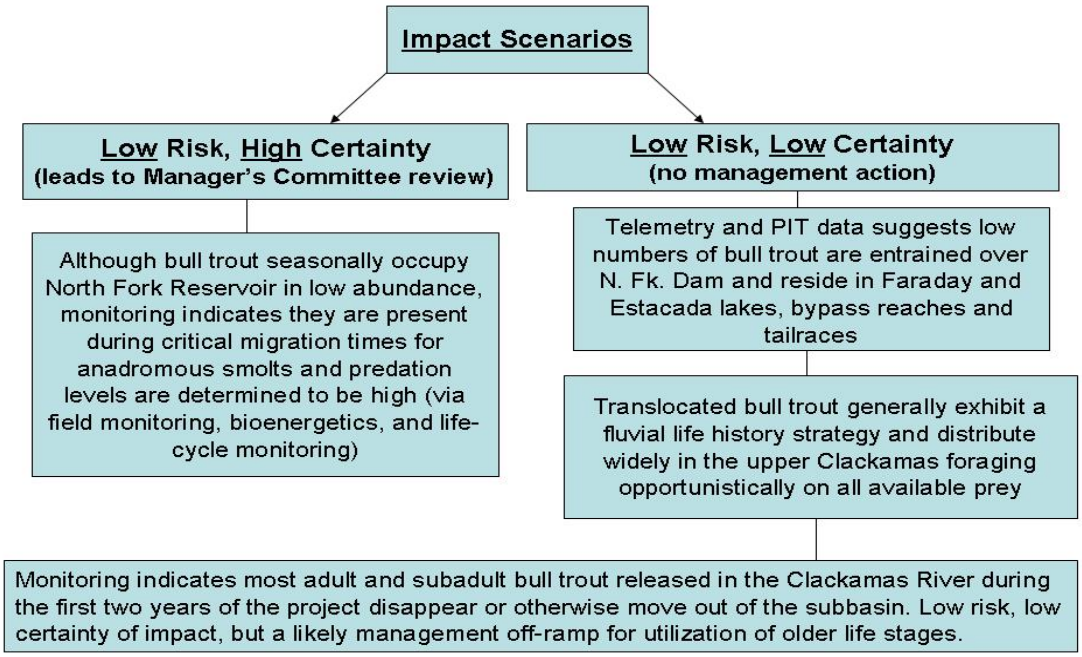


Figure 2-8 Low risk impact scenarios with high and low certainties

2.11 Scientific Take Associated with Monitoring

Annual monitoring of the bull trout reintroduction project will likely require a low level of incidental take of listed juvenile salmon and steelhead, as well as other native non-listed resident fish. We propose to cover programmatically, by way of this consultation, the incidental take of listed juvenile salmon and steelhead associated with monitoring the effectiveness of the bull trout reintroduction project. Methodologies for monitoring juvenile bull trout life stages that may cause take of juvenile salmon and steelhead include minnow trapping, backpack electroshocking, snorkeling, dip-netting, seining, redd surveys, and trapping via a rotary screw trap. Methodologies for monitoring older life stages will include snorkeling, radio telemetry, mobile and stationary PIT tag antennas. The effects of this take are described in Chapter 5.

3. STATUS OF THE SPECIES AND CRITICAL HABITAT

In order to utilize the best available information on the status and environmental baseline of listed anadromous salmonids in the Clackamas River for this BA, and to facilitate the development of the biological opinion (BO) from NMFS, the following two chapters rely largely on information contained in the recently issued BO from NMFS to FERC and PGE on issuance of a new license to PGE to operate the Clackamas River Hydroelectric Project (NMFS 2010).

In the BO to FERC and PGE, NMFS defined the biological requirements and current status of each affected listed species and the conservation role and current function of any designated critical habitat. For salmon and steelhead species, this involved comparing the status of each ESU and its component populations and major population groups (MPGs), or strata, to available viability criteria. Viability at the population scale was evaluated based on the viable salmonid population parameters of abundance, productivity, spatial structure, and diversity, which are used to assess population extinction risk (McElhany et al. 2000). At the MPG scale, viability was evaluated based on guidelines regarding how many and which populations should be at low risk for the MPG to be considered low risk. ESU or DPS viability was similarly evaluated based on guidelines that each MPG should be at low risk (WLCTRT and ODFW 2006).

In assessing status, NMFS started with the information used in its most recent decision to list for ESA protection the species, and also considered any more recent data that are relevant to the species' range-wide status. This step of the analysis portrays how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity and identifies potential causes of the species' decline.

The following sections briefly describe the current status of the 4 listed salmon and steelhead species present in the action area considered in this BA (listing status, general life history, and population dynamics) in a manner relevant to each species' biological requirements.

3.1 Rangewide Status of the Species

Four ESA-listed salmon and steelhead species (Table 3-1) are likely to be affected by this proposed action; Upper Willamette River (UWR) Chinook salmon, Lower Columbia River (LCR) Chinook salmon, LCR coho, and LCR steelhead. Following are descriptions of rangewide status for these four species.

Table 3-1 shows listing status and date, date of critical habitat designation, and relevant Federal Register notices, for the four species of salmon and steelhead likely to be affected by the proposed action considered in this BA. Critical habitat has been designated for all these species except LCR coho salmon.

Table 3-1 Historical populations in the UWR Chinook salmon ESU (Myers et al. 2006)

Stratum	Population*
Upper Willamette	Clackamas (C)
	Molalla
	North Fork Santiam (C)
	South Fork Santiam
	Calapooia
	McKenzie (C)(G)
	Middle Fork Willamette (C)

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2 Life Histories, Factors for Decline & Population Trends

The biological requirements, life histories, historical abundance, current viability, and factors contributing to the decline of salmon and steelhead species have been well documented. The following sections summarize relevant information from recent documents, most of which are available on the NMFS Northwest Regional or Northwest Fisheries Science Center websites (e.g., see Good et al. 2005; NMFS 2005a and 2006a; Myers et al. 2006; WLCTRT 2003 and 2004; WLCTRT and ODFW 2006; and McElhany el al. 2007).

3.2.1 Upper Willamette River (UWR) Chinook Salmon

3.2.1.1 ESU Description

The UWR Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon, as well as UWR Chinook from seven artificial propagation programs (NMFS 2005a). The seven artificial propagation programs considered part of the ESU are the McKenzie River Hatchery (Oregon Department of Fish and Wildlife (ODFW) stock # 24), Marion Forks/North Fork Santiam River (ODFW stock # 21), South Santiam Hatchery (ODFW stock # 23) in the South Fork Santiam River, South Santiam Hatchery (ODFW stock # 23) in the Calapooia River, South Santiam Hatchery (ODFW stock # 23) in the Molalla River, Willamette Hatchery (ODFW stock # 22), and Clackamas hatchery (ODFW stock # 19) spring-run Chinook hatchery programs (NMFS 2005a).

The Willamette/Lower Columbia Technical Recovery Team (WLCTRT) identified seven independent populations within this ESU, as shown in Table 3-1 and Figure 3-1 (Myers et al. 2006); all populations are part of the same stratum, or major population group (WLCTRT 2003).

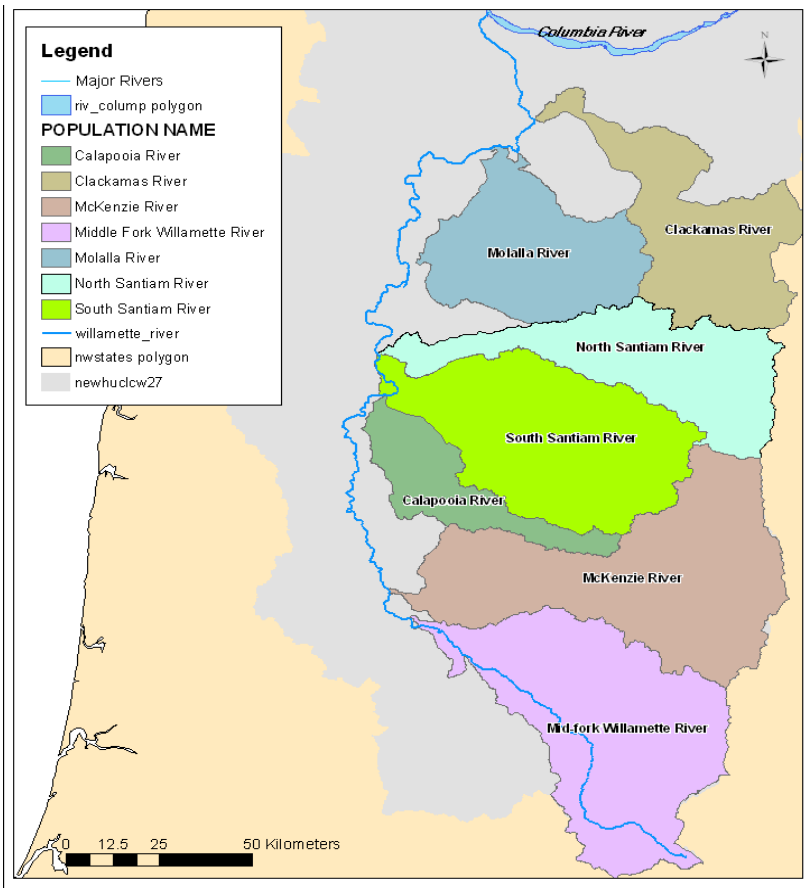


Figure 3-1 Map of historical populations in the UWR Chinook ESU (Myers et al. 2006)

UWR Chinook salmon are one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin. Historically (before the laddering of Willamette Falls), passage by returning adult salmonids over Willamette Falls (26.5 miles or 42.6 kilometers) was possible only during the winter and spring high-flow periods. The early run timing of Willamette River spring-run Chinook salmon relative to other lower Columbia River spring-run populations is viewed as an adaptation to flow conditions at the falls. Since the Willamette Valley was not glaciated during the last epoch, the reproductive isolation provided by the falls was probably uninterrupted for a considerable time and provided the potential for significant local adaptation relative to other Columbia River populations (Myers et al. 2006). UWR Chinook salmon still contain a unique set of genetic resources compared to other Chinook stocks in the W/LC Domain (Figure 3-2; also see Myers et al. 1998 and Myers et al. 2006).

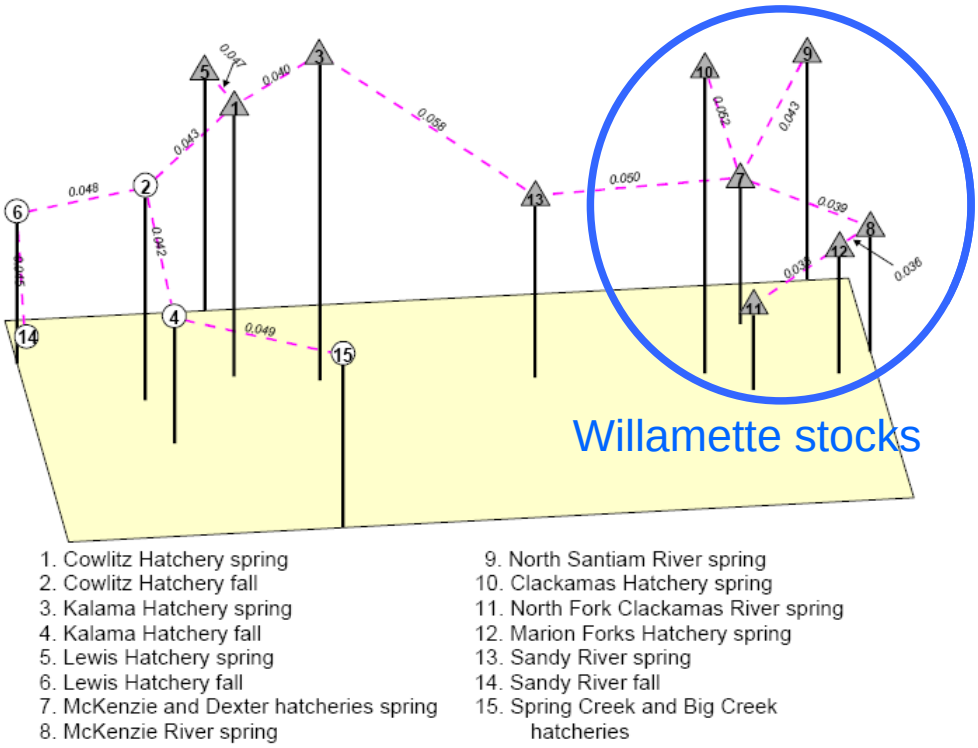


Figure 3-2 Three-dimensional representation of genetic difference, showing similarity of UWR Chinook stocks (indicated by proximity in the diagram) and their distinctness from Lower Columbia Chinook stocks (indicated by distance in the diagram). Figure adapted from Myers et al. 2006.

3.2.1.2 Life History

While adult UWR Chinook salmon begin appearing in the lower Willamette River in January, the majority of the run ascends the falls in April through May (Myers et al. 2006). Mattson (1963) discusses the existence of a late spring-run Chinook salmon that ascended the falls in June. These fish were apparently much larger and older (presumably six year olds) than the earlier part of the run. Mattson (1963) speculated that this portion of the run intermingled with the earlier-run fish on the spawning grounds and did not represent a distinct run. The disappearance of the June run in the Willamette River in the 1920s and 1930s was associated with a dramatic decline in water quality in the lower Willamette River.

Juvenile emigration patterns of the UWR Chinook salmon include traits from both ocean- and stream-type life histories. Smolt emigrations occur both as subyearlings, consistent with ocean-type life histories, and as yearlings, consistent with stream-type life histories, in the fall and spring (Schroeder and Kenaston 2004). While data are not available for all populations, available data indicate that the Clackamas, McKenzie, and Middle Fork Willamette populations have the greatest percentage of yearling migrants (Table 3-2).

Table 3-2 Percentage of returning adult spring Chinook salmon that emigrated to saltwater as yearlings (adapted from Schroeder and Kenaston 2004)

	Run Year	
Basin	2002	2003
Middle Fork Willamette*	94	
McKenzie	74	83
South Santiam	20	9
North Santiam	48	60
Clackamas	68	85

* Note that sample size for the Middle Fork Willamette was very small (18 fish), which could have resulted in a biased estimate.

Ocean distribution of this ESU is consistent with an ocean-type life history, with the majority of spring Chinook being caught off the coasts of British Columbia and Alaska. Spring Chinook from the Willamette River have the earliest return timing of all Chinook stocks in the Columbia Basin, with freshwater entry beginning in February. At present, adults return to the Willamette River primarily at ages 3 through 5 (ODFW 2008), with age 4 fish being most abundant. Historically, age 5 fish were most abundant, and spawning occurred between mid-July and late October. The current spawn timing of both hatchery and natural-origin UWR Chinook is September and early October (Schroeder and Kenaston 2004). Table 3-3 shows generalized life history timing for UWR Chinook salmon.

Table 3-3 UWR Chinook salmon life history timing. Light shading represents low-level abundance and dark shading represents higher abundance (after USACE et al. 2007). (Upstream migration in this table refers to adult presence in the mainstem Willamette and tributaries)

Month:	J	F	M	A	M	J	J	A	S	O	N	D
Upstream Migration												
Spawning in Tributaries												
Intragravel Development												
Juvenile Rearing												
Juvenile Out-migration												

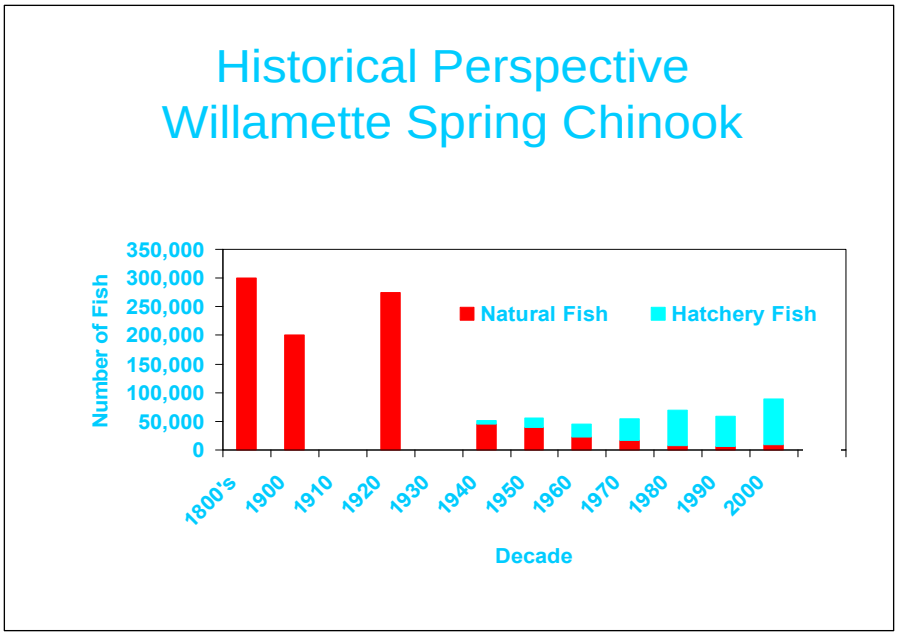


Figure 3-3 Historical abundance of wild spring Chinook salmon returns to the Willamette River. Abundances are averaged by decade (Myers et al. 2006)

3.2.1.3 Current Viability

Historically the Upper Willamette supported large numbers (perhaps exceeding 275,000 fish) of Chinook salmon (Figure 3-3) (Myers et al. 2006). While counts of hatchery- and natural-origin adult spring Chinook salmon over Willamette Falls since 1946 have increased (Figure 3-4), approximately 90 percent of the return is now hatchery fish. Current abundance of wild fish is estimated to be less than 10,000, with significant natural production occurring only in two populations – the Clackamas and the McKenzie (McElhany et al. 2007). The Clackamas and McKenzie are the only two watersheds in the ESU where sufficient habitat is still accessible and of sufficient quality to produce significant numbers of natural-origin spring Chinook.

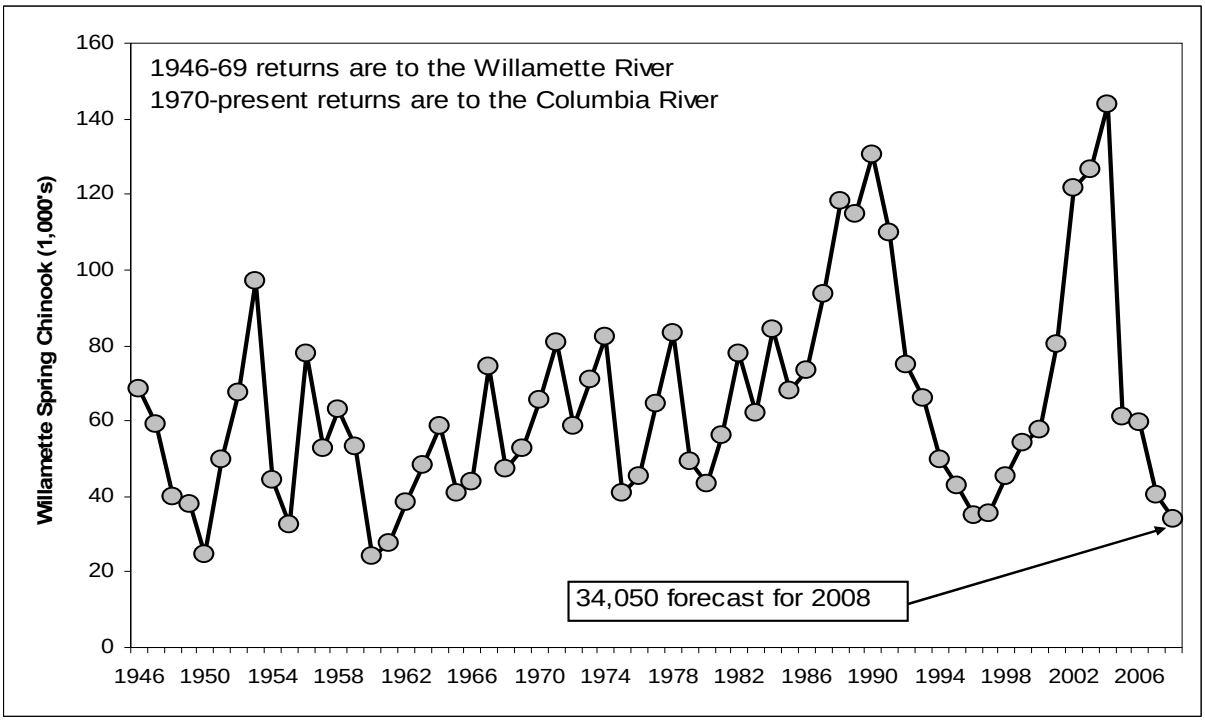


Figure 3-4 Total Willamette spring Chinook returns, (hatchery and wild fish combined) 1946-2007 and 2008 forecast[1] (ODFW 2008)

The majority of the natural-origin populations in this ESU have very low current abundances (less than a few hundred fish), and high proportions of hatchery-origin spawners. Quantitative estimates of trends in abundance and adult returns per spawner are available only for the Clackamas and McKenzie Chinook populations. In both cases, as shown in Table 3-4, while the long-term trend in abundance is slightly higher than 1.0, long-term median population growth rates (lambda) are negative, as are recruits per spawner (Table 3-4) (McElhany et al. 2007).

[1] Figure uses 2 datasets. Prior to 1970, estimates are for fish returning to the Willamette (do not include fish harvested in ocean and Columbia). For 1970 – present, estimates are for Willamette fish entering the Columbia River (do not include fish harvested in ocean).

Table 3-4 Abundance, productivity, and trends of UWR Chinook populations (source: McElhany et al. 2007). 95 percent confidence intervals are shown in parentheses

Population	Recent Natural Spawners			Long-Term Trend		Median Growth Rate		Recruits/spawner	
	Years[1]	No. [2]	pHOS [3]	Years	Value[4]	Years	λ[5]	Years	Value[6]
Clackamas	90-05	1656 (1122-2443)	47%	58-05	1.04 4 (1.033-1.055)	58-05	0.967 (0.849-1.102)	58-05	0.888 (0.667-1.182)
Molalla	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Calapooia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
McKenzie	90-05	2104 (1484-2983)	33%	70-05	1.017 (0.994-1.04)	70-05	0.927 (0.761-1.129)	70-05	0.705 (0.485-1.024)
MF Willamette	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Reported time series correspond to reported values in available information.
1 Years of data for recent means.
2 Geometric mean of natural-origin spawners.
3 Average recent proportion of hatchery-origin spawners
4 Long-term trends of natural-origin spawners (regression of log-transformed natural-origin spawner abundances against time).
5 Long-term median population growth rates after accounting for the relative reproductive success of hatchery-origin spawners compared to those of natural origin. The statistic is corrected for hatchery fish to model the growth rate of the natural population if there had been no hatchery supplementation (McElhany et al. 2007).
6 Geometric mean of recruits per spawner using all brood years in the analysis period.
N/A = not available

Stratum	Population	Extinction Risk Category
Upper Willamette	Clackamas	Low
	Molalla	Very High
	NF Santiam	Very High
	SF Santiam	Very High
	Calapooia	Very High
	McKenzie	Moderate
	MF Willamette	Very High

Table 3-5 Risk of extinction categories for populations of UWR Chinook (source: McElhany et al. 2007)

Extinction risk for each population over a 100-year time frame (Table 3-5 and Figure 3-5) was estimated qualitatively, based on criteria identified by the WLCTRT (McElhany et al. 2007). The rating system categorized extinction risk as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. Based on the results for each population, McElhany et al. (2007) determined that the risk of extinction for the ESU was "high."

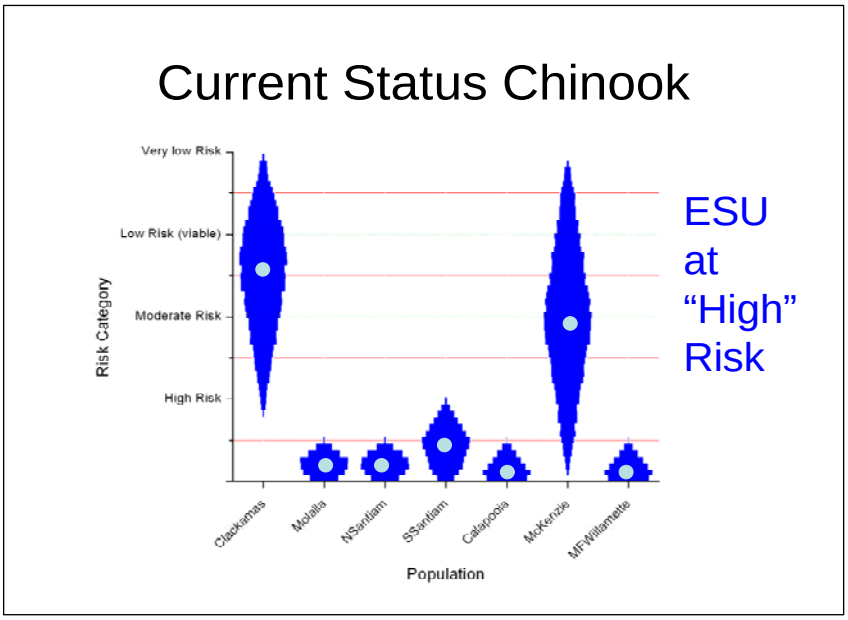


Figure 3-5 Current risk status of UWR spring Chinook salmon populations. Width of diamond corresponds with likelihood that the population is at status shown (McElhany et al. 2007)

All three of these metrics evaluate whether a population is maintaining itself, declining, or growing. A long-term trend > 1.0 indicates that population abundance is increasing over time, while a trend of <1.0 indicates abundance is decreasing. A median population growth rate (lambda) of 1.0 indicates a stationary population, lambda > 1.0 indicates that the population is growing, and lambda < 1.0 indicates a declining population. Similarly, recruits per spawner of 1.0 indicates that 100 parental spawners would produce 100 progeny that survive and spawn successfully, while values above and below 1.0 indicate that each parental spawner produces less than one successful spawner, or more than one successful spawner, respectively. The long-term trend calculation may be elevated by the way in which it includes the progeny of hatchery-origin spawners, whereas the lambda and recruits per spawner values assess how a population would perform in the absence of continued hatchery production (NMFS 2008; McElhany et al. 2007).

Spatial structure, or geographic distribution, of the North Fork Santiam, South Fork Santiam, McKenzie, and Middle Fork Willamette populations has been substantially reduced by the loss of access to the upper portions of those tributary basins due to flood control and hydropower development, including dams owned and operated by the Corps. It is likely that genetic diversity has also been reduced by this habitat loss. The habitat conditions conducive to salmon survival in the Molalla and Calapooia subbasins have been reduced significantly by the effects of land use, including forestry, agriculture, and development. Spatial structure of the Clackamas population remains relatively intact (McElhany et al. 2007).

The diversity of some populations has been further eroded by hatchery and harvest influences and degraded habitat conditions in lower elevation reaches, all of which have contributed to low population sizes (McElhany et al. 2007). As described above, historically UWR Chinook had diverse life history types, with greater variation in the age structure and timing of both returning adults and out-migrating juveniles. At present, the life history diversity of all UWR Chinook populations has been significantly simplified because there is less variation in ages and run timing. The healthiest populations (Clackamas and McKenzie) still have life history characteristics representative of historical runs, although interbreeding with hatchery fish has likely resulted in genetic introgression over the last 50 years.

3.2.1.4 Limiting Factors

The factors that have caused the decline of this ESU to its threatened status and that are limiting the ESUs' ability to recover include multipurpose dams, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. These factors are summarized briefly below. Of these factors, harvest is believed to have been reduced to a point where it is no longer limiting recovery, based on assessments by the ODFW as part of its recovery planning process. Additional information on limiting factors is described for individual populations in the environmental baseline section of this BA.

3.2.1.4.1 Tributary and Willamette River Mainstem Habitat

Habitat in the Willamette River mainstem and lower reaches of all tributaries to the Willamette River are moderately to severely degraded. Specific habitat concerns vary by subbasin but include reduced habitat complexity, reduced access to off-channel habitat, reduced floodplain function and connectivity, loss of holding pools, elevated water temperatures, insufficient stream flows, toxic water pollutants, and altered substrate compositions. Some tributaries have

numerous passage barriers. Habitat downstream of the dams has become the only area available for natural reproduction because so much of the ESU's historic habitat has been blocked by the Willamette Project dams. Habitat conditions above the dams in most of the upper tributaries, although not pristine, represent the best available habitat for spawning, incubation, and early rearing by spring Chinook (NMFS 2008).

3.2.1.4.2 Estuary Habitat

Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats used extensively by subyearling juvenile migrants. The ocean survival of yearling juveniles can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to yearling migrants during transition to the ocean phase of their lifecycle; yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007a). Although it is highly unlikely that fish from this ESU encounter Federal Columbia River Power System (FCRPS) mainstem projects, water management operations in the upper Columbia basin affect habitat and flow in the lower Columbia River, estuary, and plume (NMFS 2008).

3.2.1.4.3 Multipurpose Dams

The U.S. Army Corps of Engineers (Corps) operates 13 dams in the largest five Willamette tributaries for multiple authorized and incidental purposes, including flood control, irrigation water supply, municipal and industrial water supply, navigation, flow augmentation, hydroelectric power, recreation, fish and wildlife conservation, and system operation. Impacts of these dams include blocked passage, poor downstream water quality, entrapment and stranding due to flood control and power peaking operations, and degraded functioning of downstream habitat. These effects are discussed extensively in the environmental baseline section. Adult and juvenile UWR Chinook also migrate past several smaller hydropower projects located below the Corps dams, which are licensed by the FERC. These projects, which either have recently or are currently undergoing relicensing, are described in more detail in the environmental baseline section.

3.2.1.4.4 Harvest

UWR Chinook salmon are caught in ocean fisheries off southeast Alaska and northern Canada and in fisheries in the mainstem Columbia and Willamette rivers, and in Willamette River tributaries. The harvest rate on UWR Chinook salmon in ocean fisheries has averaged 11 percent in recent years. The total allowable harvest rate of unmarked Chinook in all freshwater fisheries is 15 percent, as specified in the Fisheries Management and Evaluation Plan (FMEP) for Willamette spring Chinook NMFS approved under ESA §4(d).[2] Only hatchery-origin Chinook (ODFW 2001), which can be harvested in all freshwater fisheries affecting Willamette

[2] Significant reductions in fishing rates below 15 percent do not appreciably affect wild escapement or long-term probabilities of survival and recovery because fishing no longer affects significant numbers of wild fish, especially at low run sizes (ODFW 2001)

spring Chinook. Actual freshwater harvest on natural-origin Chinook has ranged from 9 to 12 percent in recent years.

3.2.1.4.5 Hatcheries Management

Hatcheries have been used as a management tool in the Willamette River basin for over 100 years, including use as mitigation for production lost due to dams. Hatchery-origin fish now outnumber natural-origin spawners in nearly all populations. All six of the Chinook populations above Willamette Falls and, to a lesser degree, the Clackamas population, are at risk for genetic introgression due to the high proportions of hatchery-origin fish on the spawning grounds (NMFS 2008).

3.2.1.4.6 Predation

Yearling smolts are vulnerable to bird predation in the estuary (Fresh et al. 2005). In addition, spring Chinook are subject to pinniped predation when they return to the estuary as adults (NMFS 2008). Pikeminnows are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.1.4.7 Ocean & Climate

The analyses of UWR salmon and steelhead status in this BA generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poorer for most Columbia River salmonids than the long-term average, and future trends are unclear. Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.1.5 Summary of Rangewide Status for UWR Chinook Salmon

The UWR Chinook salmon ESU is currently at a high risk of extinction. Five of the seven populations in the ESU are currently at very high risk of extinction, with one population (the McKenzie) at moderate risk, and one (the Clackamas) at low risk. Natural production in these populations averages a couple thousand fish annually. Limiting factors for this ESU have come from multiple sources, including tributary dams, hydropower development, habitat degradation, hatchery effects, past harvest management, and predation.

The Willamette Project dams have blocked access to major portions of historical spawning habitat for four populations (the McKenzie, North Santiam, South Santiam, and Middle Fork), and downstream effects of the dams have also adversely affected these populations. Spring Chinook return to freshwater several months prior to spawning and require cool stream temperatures and adequate holding pools as they spend the summer maturing to eventually spawn in September and October. This over-summering habitat has been dramatically altered by the Willamette Project dams because they (1) block access to the cooler, headwater habitat that was used historically by adult Chinook and (2) expose Chinook confined to areas below Project dams to unnatural temperature regimes, which increase both adult and egg mortality.

3.2.2 Lower Columbia River Chinook Salmon

LCR Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from the mouth of the Columbia River upstream to and including the White Salmon River in Washington and the Hood River in Oregon, and including the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), as well as seventeen artificial propagation programs (NMFS 2005a). The LCR Chinook salmon ESU exhibits three major life history types: fall-run ("tules"), late fall-run ("brights"), and spring-run (Good et al. 2005).

The WLCTRT identified 32 historical independent populations within this ESU, divided into 6 major population groups as shown in Table 3-6 (Myers et al. 2006).

Table 3-6 Historical populations in the LCR Chinook salmon ESU (Myers et al. 2006)

Major Population Group	Population*
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, Lewis (C), Sandy (C,G)
Gorge Spring	(Big) White Salmon (C), Hood
Coastal Fall	Grays, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose
Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy
Cascade Late Fall	Lewis (C,G), Sandy (C,G)
Gorge Fall	Lower Gorge, Upper Gorge (C,G), (Big) White Salmon (C,G), Hood

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from non-endemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2.2.1 Current Viability

Data for this ESU are limited, but available data indicate that many populations currently have low abundance. Where data allow calculation of abundance trends for individual populations, those trends are mostly negative, some severely so. Assuming that the reproductive success of hatchery-origin fish has been equal to that of natural-origin fish, analysis indicates a negative long-term growth rate for all populations except the Coweeman River fall run (Good et al. 2005).

While the spatial structure of some populations in this ESU is similar to historical conditions, spatial structure of many populations has been significantly impaired either by numerous small

habitat blockages, tributary hydropower development (primarily in the White Salmon, Hood, Lewis, and Cowlitz rivers) or, for populations spawning above Bonneville Dam, by inundation of historic habitat. Diversity of most fall-run populations has been eroded by large hatchery influences and periodically low effective population sizes. In contrast, hatchery programs for spring Chinook salmon are preserving the genetic legacy of populations that were extirpated from blocked areas (WLCTRT 2004).

Extinction risk over a 100-year time frame (Table 3-7) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population. Overall, the extinction risk for the combined LCR Chinook ESU is high.

Table 3-7 Risk of extinction (in 100 years) for populations of LCR Chinook salmon. Sources: Washington's Lower Columbia Fish Recovery Board plan (LCFRB and NMFS 2006) and McElhany et al. (2007) for Oregon populations.

Type	Strata	Population	State	Extinction Risk Category
Spring	Cascade	Cowlitz	W	High
		Cispus	W	High
		Tilton	W	Very High
		Toutle	W	Very High
		Kalama	W	Very High
		NF Lewis	W	Very High
		Sandy	O	Moderate
	Gorge	(Big) White Salmon	W	Very High
		Hood	O	Very High
Fall	Coastal	Grays/Chinook	W	High
		Elochoman/Skamokawa	W	High
		Mill/Abernathy/Germany	W	High
		Youngs Bay	O	Very High
		Big Creek	O	Very High
		Clatskanie	O	High
		Scappoose	O	Very High
	Cascade	Lower Cowlitz	W	High
		Upper Cowlitz	W	Very High
		Toutle	W	High

Type	Strata	Population	State	Extinction Risk Category
		Coweeman	W	Moderate
		Kalama	W	High
		Lewis	W	Moderate
		Salmon	W	Very High
		Washougal	W	High
		Clackamas	O	Very High
		Sandy	O	Very High
	Gorge	Lower Gorge	W/O	High/Very High
		Upper Gorge	W/O	High/Very High
		(Big) White Salmon	W	High
		Hood River	O	Very High
Late Fall	Cascade	NF Lewis	W	Moderate
		Sandy	O	Low

3.2.2.2 Limiting Factors

Major factors limiting recovery are degraded habitat (esturarine and nearshore marine, floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream substrate, stream flow, and fish passage), hatchery-related adverse effects, and harvest-related adverse effects (PCSRF 2007). For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB and NMFS 2006)

3.2.2.2.1 Tributary Habitat

Widespread urban development and other land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats where fall Chinook salmon spawn and rear (NMFS 2008).

3.2.2.2.2 Estuary Habitat

Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats used extensively by subyearling juveniles, such as fall and late-fall LCR Chinook salmon. The ocean survival of yearling juveniles (juvenile Chinook from spring-run populations) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to yearling migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary

limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007a).

3.2.2.2.3 Multipurpose Dams

Federal Columbia River Hydropower System impacts on populations originating downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The five LCR Chinook salmon populations that spawn above Bonneville Dam have been affected by upstream and downstream passage at the dam and by inundation of tributary spawning habitat.

Tributary dams in the White Salmon, Hood, Lewis, Cowlitz, Sandy, and Clackamas basins have affected populations in those tributaries (NMFS 2008), although many of those effects are being addressed because of recent FERC re-licensing and associated ESA consultations. Removal of Condit Dam is expected to support restoration of the spring and fall run Chinook populations in the White Salmon River (NMFS 2006d). Removal of Powerdale Dam is expected to support the restoration of the spring and fall fun Chinook populations in the Hood River (NMFS 2005d). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the spring run (NMFS 2007b). Upstream and downstream passage facilities will be developed at the Cowlitz River Hydroelectric Project (NMFS 2004b), allowing restoration of the Cispus Spring run, Tilton spring run, and Upper Cowlitz spring and fall run populations. Removal of Marmot and Little Sandy dams in the Sandy Basin has improved access for spring Chinook salmon into the upper Sandy watershed (NMFS 2003b).

3.2.2.2.4 Harvest

LCR Chinook salmon are harvested in the Columbia River and its tributaries and in ocean fisheries off Oregon, Washington, and Canada. Permitted harvest rate limits for fall-run Chinook salmon have dropped from 65 percent just after listing to 42 in 2007. Harvest rates on spring-run fish have been reduced from 50 to 25 percent (NMFS 2008).

3.2.2.2.5 Hatcheries Practices

Hatchery management practices have reduced the diversity and productivity of natural populations in this ESU, especially the tule fall Chinook populations. For LCR spring Chinook salmon, virtually all production is of hatchery origin (NMFS 2008).

3.2.2.2.6 Predation

Yearling smolts from spring-run populations are vulnerable to bird predation in the estuary (Fresh et al. 2005). In addition, spring Chinook are subject to pinniped predation when they return to the estuary as adults (NMFS 2007a). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.2.2.7 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the

recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids and the long-term average and future trends are unclear (NMFS 2007a). Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.2.3 Summary

The LCR Chinook salmon ESU extinction risk is high. Many populations currently have low abundance and the long-term growth rate is negative for all but one population.

3.2.3 Lower Columbia River Coho Salmon

LCR coho salmon ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia up to and including the White Salmon and Hood rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as 25 artificial propagation programs (NMFS 2005a). Juvenile LCR coho salmon migrate to the ocean as yearlings from mid-April through the end of May with peak migrations during May. Adult LCR coho salmon typically migrate through the lower Columbia River from September through November.

The WLCTRT identified 24 historical populations in this ESU, grouped into three major population groups as shown in Table 3-8.

Table 3-8 Historical populations in the LCR coho salmon ESU (Myers et al. 2006)

STRATUM	Population
Coast	Grays, Elochoman, Mill Creek, Youngs Bay, Big Creek, Clatskanie, Scappoose Creek
Cascade	Lower Cowlitz, Coweeman, SF Toutle, NF Toutle, Upper Cowlitz, Cispus, Tilton, Kalama, NF Lewis, EF Lewis, Salmon Creek, Washougal, Clackamas, Sandy
Gorge	Lower Gorge, Washington Upper Gorge and (Big) White Salmon River, Oregon Upper Gorge and Hood River

3.2.3.1 Current Viability

Data on LCR coho salmon are limited. In most cases, populations have low current abundance and high proportions of hatchery-origin spawners. Spatial structure of most populations has been impaired either by loss of habitat, small blockages or major tributary hydropower development (primarily in the White Salmon, Hood, Lewis, and Cowlitz rivers). The diversity of populations has been eroded by large hatchery influences and periodically low effective population sizes. (The genetic legacy of the Lewis and Cowlitz River coho populations is preserved in ongoing hatchery programs.)

Extinction risk over a 100-year time frame (Table 3-9) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population. The ESU's extinction risk appears to be high.

Table 3-9 Risk of extinction in 100 years categories for populations of LCR coho (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB and NMFS 2006] and McElhany et al. [2007] for Oregon populations**)**

Stratum	Population	State	Extinction Risk Category
Coast	Grays	W	High
	Elochoman	W	High
	Mill Creek	W	High
	Youngs Bay	O	Very High
	Big Creek	O	Very High
	Clatskanie	O	High
	Scappoose	O	High
Cascade	Lower Cowlitz	W	High
	Coweeman	W	High
	SF Toutle	W	High
	NF Toutle	W	High
	Upper Cowlitz	W	Very High
	Cispus	W	Very High
	Tilton	W	Very High
	Kalama	W	High
	NF Lewis	W	High
	EF Lewis	W	High
	Salmon	W	Very High
	Washougal	W	High
	Clackamas	O	Low
	Sandy	O	High

Stratum	Population	State	Extinction Risk Category
Gorge	Lower Gorge	O/W	Very High/High
	WA Upper Gorge and White Salmon River	W	Very High
	OR Upper Gorge and Hood River	O	Very High

3.2.3.2 Limiting Factors

Major factors limiting recovery are degraded habitat (floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream substrate, stream flow, and water quality), hatchery-related adverse effects, and harvest-related adverse effects (PCSRF 2007). For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB and NMFS 2006).

3.2.3.2.1 Tributary Habitat

Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting coho salmon in most lower Columbia River subbasins, particularly in low to moderate elevation habitats (NMFS 2008).

3.2.3.2.2 Estuary Habitat

The ocean survival of yearling juveniles (such as LCR coho) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to coho migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007a).

3.2.3.2.3 Dams

Impacts of the Federal Columbia River Hydropower System on LCR coho populations spawning downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The two populations that spawn upstream of Bonneville Dam are affected by upstream and downstream passage at Bonneville Dam and by inundation of historic habitat (WLCTRT 2004 and McElhany et al. 2007).

Tributary dams in the White Salmon, Hood, Lewis, Cowlitz, Sandy, and Clackamas basins have affected populations in those tributaries (NMFS 2008), although many of those effects are being addressed as a result of recent FERC re-licensing and associated ESA consultations. Removal of Condit Dam by 2011 is expected to support restoration of the White Salmon River portion of the

WA Upper Gorge coho population (NMFS 2006d). Removal of Powerdale Dam is expected to support restoration of the Hood River portion of the OR Upper Gorge coho population (NMFS 2005d). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the North Fork Lewis River coho population (NMFS 2007b). Upstream and downstream passage facilities will be developed at the Cowlitz River Hydroelectric Project (NMFS 2004b), supporting restoration of the Cowlitz, Cispus, and Tilton coho populations. Removal of Marmot and Little Sandy dams in the Sandy Basin has improved passage for the coho population into the upper Sandy watershed (NMFS 2003b).

3.2.3.2.4 Harvest

Lower Columbia River coho are harvested in the ocean and in Columbia River and tributary freshwater fisheries of Oregon and Washington. Harvest rates on coho salmon prior to the 1990s fluctuated from approximately 60 to 90 percent, but have been reduced since listing to 15 to 25 percent (NMFS 2008).

3.2.3.2.5 Hatchery Practices

Hatchery management practices have reduced the diversity and productivity of natural populations throughout the Columbia River Basin. LCR coho salmon populations have been heavily influenced by hatchery production over the years (NMFS 2008).

3.2.3.2.6 Predation

As stream-type juveniles, coho are vulnerable to bird predation in the estuary (Fresh et al. 2005). Pikeminnow are also significant predators of stream-type migrants (Friesen and Ward 1999).

3.2.3.2.7 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.3.3 Summary

The LCR coho salmon ESU extinction risk is high. Most of the populations have low current abundance and high proportions of hatchery-origin spawners.

3.2.4 Lower Columbia River Steelhead

The LCR steelhead DPS includes all naturally produced steelhead in tributaries to the Columbia River between the Cowlitz and Wind Rivers (inclusive) in Washington and the Willamette and

Hood Rivers (inclusive) in Oregon, excluding steelhead in the upper Willamette River above Willamette Falls (NMFS 2006b). Ten artificial propagation programs are also included in the ESU. Two distinct races of steelhead, summer and winter, historically were and currently are found in the lower Columbia River (Myers et al. 2006).

The WLCTRT identified 23 historical populations within the DPS, which were divided into 4 major population groups as shown in Table 3-10 (Myers et al. 2006).

Table 3-10 Historical populations in the LCR steelhead ESU **(Myers et al. 2006)**

Major Population Group	Population*
Cascade Summer	Kalama (C), NF Lewis, EF Lewis (G), Washougal (C,G)
Gorge Summer	Wind (C), Hood
Cascade Winter	Lower Cowlitz, Coweeman, NF Toutle (C), SF Toutle, Coweeman, Upper Cowlitz (C,G), Lower Cowlitz, Cispus (C), Tilton, Kalama, NF Lewis (C), EF Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge Winter	Lower Gorge, Upper Gorge, Hood (C,G)

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2.4.1 Current Viability

Many populations in this DPS are small and have negative long- and short-term trends in abundance. In addition, for most populations the probability is high that the true growth rate is less than one (Good et al. 2005). Spatial structure of most populations has been impaired either by loss of habitat, small blockages or major tributary hydropower development (primarily in the Hood, Lewis, and Cowlitz rivers). The diversity of populations has been eroded by large hatchery influences; a number of the populations have a substantial fraction of hatchery-origin spawners and are thought to be largely sustained by hatchery production.

Extinction risk over a 100-year time frame (Table 3-11) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population. The extinction risk for this DPS appears to be high.

Table 3-11 Risk of extinction categories for populations of LCR steelhead (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB and NMFS 2006] and McElhany et al. [2007] for Oregon populations)

Type	Strata	Population	State	Extinction Risk Category
Summer	Cascade	Kalama	W	High
		NF Lewis	W	Very High
		EF Lewis	W	High
		Washougal	W	High
	Gorge	Wind	W	Moderate
		Hood	O	Very High
Winter	Cascade	Lower Cowlitz	W	High
		Coweeman	W	High
		NF Toutle	W	High
		SF Toutle	W	Moderate
		Upper Cowlitz	W	High
		Cispus	W	High
		Tilton	W	Very High
		Kalama	W	Moderate
		NF Lewis	W	High
		EF Lewis	W	High
		Salmon	W	High
		Washougal	W	High
		Clackamas	O	Low
		Sandy	O	High
	Gorge	Lower Gorge	W/O	High/High
		Upper Gorge	W/O	High/Moderate
		Hood	O	Moderate

3.2.4.2 Limiting Factors

Major factors limiting recovery are degraded habitat (floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream substrate, stream flow, water quality, and fish passage), and predation, competition, and disease

(PCSRF 2007). Limiting factors for this DPS are summarized below. For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB and NMFS 2006).

3.2.4.2.1 Tributary Habitat

Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats (NMFS 2008).

3.2.4.2.2 Estuary Habitat

The ocean survival of yearling juveniles (such as LCR steelhead) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to coho migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007a).

3.2.4.2.3 Multipurpose Dams

Impacts of the FCRPS on LCR steelhead populations spawning downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The four populations that spawn upstream of Bonneville Dam are affected by upstream and downstream passage at Bonneville Dam and by inundation of historic habitat (McElhany et al. 2007 and WLCTRT 2004). Winter steelhead populations have also been blocked from higher elevation spawning habitats by construction of FERC-licensed hydropower facilities (NMFS 2008), although many of those effects are being addressed because of recent FERC relicensing and associated ESA consultations. Removal of Marmot Dam has improved passage for the winter-run steelhead population into the upper Sandy River watershed (NMFS 2003b). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the North Fork Lewis winter-run steelhead population (NMFS 2007b). Upstream and downstream passage facilities will also be developed at the Cowlitz River Hydroelectric Project, supporting the restoration of the Upper Cowlitz, Tilton, and Cispus winter-run steelhead populations (NMFS 2004b).

3.2.4.2.4 Harvest

LCR steelhead are harvested in Columbia River and tributary freshwater fisheries in Oregon and Washington. Fishery impacts on wild LCR steelhead have been limited to less than 10 percent since the implementation of mark-selective fisheries in the 1980s (NMFS 2008).

3.2.4.2.5 Hatchery Practices

Hatchery management practices have reduced the diversity and productivity of natural populations throughout the Columbia River Basin (NMFS 2008).

3.2.4.2.6 Predation

Stream-type juveniles, especially steelhead smolts, are vulnerable to bird predation in the estuary (Fresh et al. 2005). Steelhead are also subject to pinniped predation when they return to the estuary as adults (NMFS 2007a). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.4.2.7 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in steelhead production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions (NMFS 2008).

3.2.4.3 Summary

The LCR steelhead DPS extinction risk is high. Many populations are small and have negative long- and short-term trends in abundance.

3.3 Factors Affecting All Listed Salmon and Steelhead Species in the Estuary and Nearshore Ocean Environment

The Columbia River estuary and plume provide habitat for major life stages of salmon and steelhead. The estuary is where juveniles and adults undergo the physiological changes needed to transition to and from saltwater (LCFRB and NMFS 2006). However, estuary and near-shore ocean environments have been changed by human activities. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, LWD floating downstream, and a shallow bar at the mouth of the Columbia River kept the environment dynamic. 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.

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of estuarine habitat and will continue to take actions under the Reasonable and Prudent Alternative (RPA) in the 2008 FCRPS Biological Opinion (NMFS 2008). For example, the safe passage of juvenile salmonids improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island, and relocation of terns to sites outside the Columbia Basin were completed in 2010. The double-crested cormorant colony, which has grown during that period, will be addressed by a management plan.

Although the northern pikeminnow (*Ptychocheilus oregonensis*) is a native predator of juvenile salmonids, development of the Columbia River hydropower system probably increased levels of predation. 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). System-wide, impacts are concentrated in the lower Columbia River from The Dalles Reservoir downstream (including the estuary), where northern pikeminnows are estimated to have consumed approximately 13 million of the 16.4 million salmonids consumed annually in the mainstem Columbia and Snake rivers. This estimate is 8 percent of the approximately 200 million hatchery and wild juvenile salmonid migrants in the system. 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 in the mainstem Columbia and Snake rivers, reducing predation mortality by an estimated 25 percent (Friesen and Ward 1999).

Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. These actions protect and restore riparian areas and the remaining high quality off-channel habitat, breach or lower dikes and levees to improve access to off-channel habitat, and reduce noxious weeds.

3.4 Climate Change

Climate change is likely to have negative implications for the conservation value of designated critical habitats in the Pacific Northwest (CIG 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007). Average annual Northwest air temperatures have increased by approximately 1° C since 1900 or about 50 percent more than the global average warming over the same period (ISAB 2007). The latest climate models project a warming of 0.1^{o} to 0.6^{o} C per decade over the next century. According to a literature review by the Independent Scientific Advisory Board (ISAB 2007), these effects may have the following physical impacts within the next forty or so years:

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

These changes will not be spatially homogeneous across the entire Columbia River Basin. Areas with elevations high enough to maintain temperatures well below freezing for most of the winter and early spring would be less affected. Low-lying areas that historically have received scant precipitation contribute little to total stream flow and are likely to be more affected. The ISAB

also identified the likely effects of projected climate changes on Columbia basin salmon. These long-term effects may include, but are not limited to, depletion of cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. To mitigate for the effects of climate change on listed salmonids, the ISAB (2007) recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures as well as protective hydropower mitigation measures. In particular, the ISAB (2007) suggests increased summer flow augmentation from large cool/cold storage reservoirs in the upper Columbia Basin to reduce water temperatures or to create cool water refugia in mainstem reservoirs and in the estuary; the protection and restoration of riparian buffers, wetlands, and floodplains; the removal of stream barriers; implementation of fish ladders; and assurance of high summer and autumn flows.

3.5 Summary of general range wide status of all four listed anadromous fish

In summary, the overall range wide status of LCR Chinook and coho salmon, UWR Chinook and LCR steelhead is poor. Populations are generally low in abundance and have negative trends. Extinction risks are high and range has been reduced.

3.6 Critical Habitat for Columbia & Willamette Basin Salmonids

NMFS has designated critical habitat for three of the four salmon and steelhead species that may be affected by the Proposed Action.[3] Critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line.[4] Within these areas, the PCEs essential for the conservation of these species are those sites and habitat components that support one or more life stages, including:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.
- 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.
- 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
- Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions

[3] Critical habitat has not been designated for Lower Columbia River coho salmon.
[4] In areas where ordinary high-water line has not been defined, the lateral extent is the bankfull elevation (i.e., the level at which water begins to leave the channel and move into the floodplain, generally reached at a discharge with a 1- to 2-year recurrence interval).

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.

- Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation (NMFS 2005b).

NMFS describes the conservation role that the designated critical habitat provides each species below. The Critical Habitat Analytical Review Teams (CHARTs) rated 525 occupied fifth field hydrologic units (referred to as Hydrologic Unit Code at the fifth field scale (HUC5)s or watersheds) in the Columbia River basin. The CHARTs gave each of these occupied watersheds a high, moderate, or low rating. High-value watersheds/areas are those with a high likelihood of promoting conservation, while low value watersheds/areas are expected to contribute relatively little. Conservation value was determined by considering the factors listed in Table 3-12.

Table 3-12 Factors considered by Columbia Basin CHARTs to determine the conservation value of occupied watersheds

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

Of the 525 occupied watersheds, 382 were assigned a high rating, 93 a moderate rating, and 50 a low rating. Ratings for the LCR coho salmon ESU are under development.

Many factors, both human-caused and natural, have contributed to the decline of salmon over the past century. Salmon habitat has been altered through activities such as urban development,

logging, grazing, power generation, water storage projects, and agriculture. These habitat alterations have resulted in the loss of important spawning and rearing habitat and the loss or degradation of migration corridors (Table 3-13). NMFS describes the specific PCEs that were applied for each reach of designated critical habitat in the action area within the Environmental Baseline Section 4.0. In the Environmental Baseline chapter, existing habitat conditions are considered in terms of its ability to support the designated PCEs.

Table 3-13 Major factors limiting the conservation value of designated critical habitat for those species with designated critical habitat. (PCSRF 2007)

Species	Major Limiting Factors
UWR Chinook salmon	Reduced access to spawning/rearing habitat Degraded water quality High water temperature Lost/degraded floodplain connectivity and lowland stream habitat Reduced streamflow
LCR Chinook salmon	Altered channel morphology and stability Reduced access to spawning/rearing habitat Loss of habitat diversity Excessive sediment High water temperature
LCR steelhead	Altered channel morphology and stability Lost/degraded floodplain connectivity and lowland stream habitat Reduced access to spawning/rearing habitat Excessive sediment High water temperature Reduced streamflow

3.6.1 Critical Habitat for Upper Willamette River (UWR) Chinook Salmon

The description below pertains to critical habitat for UWR Chinook salmon specific to the Clackamas River. The remaining subbasins included in this critical habitat designation are hereby incorporated by reference.

3.6.1.1 Clackamas Subbasin

Figure 3-6 shows the designation of critical habitat for UWR Chinook salmon in the Clackamas subbasin and its respective watersheds.

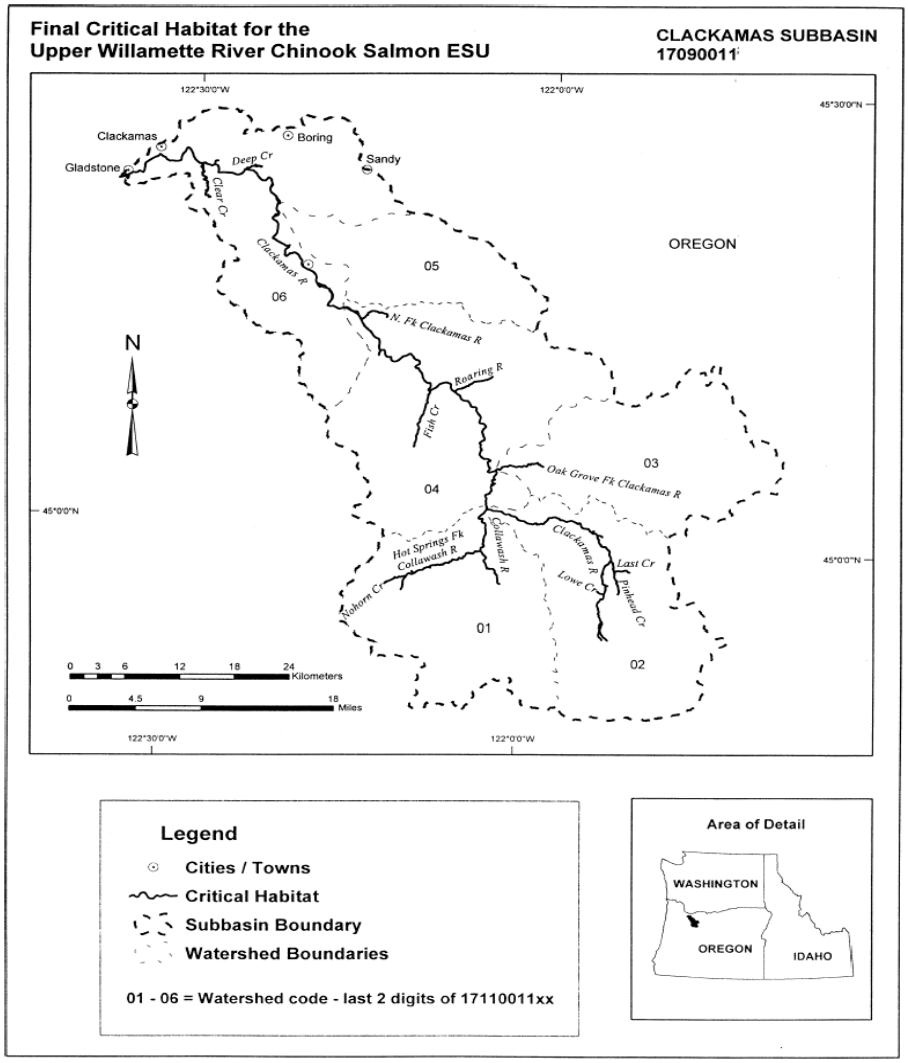


Figure 3-6
Critical habitat in the Clackamas subbasin

The CHART rated six watersheds in the Clackamas subbasin, numbered in Figure 3-6. Of the six watersheds reviewed, five were rated as having high conservation value and one was rated as having low conservation value. Those that received a high rating include Collawash River (1709001101), Upper Clackamas River (1709001102), Oak Grove Fork Clackamas River (1709001103), Middle Clackamas River (1709001104), and Lower Clackamas River watersheds (1709001106). The Eagle Creek watershed (1709001105) received a low rating (NMFS 2005e).

In its final designation of critical habitat, NMFS excluded the entire Eagle Creek watershed (1709001105) because the economic benefits of exclusion outweighed the benefits of designation. NMFS included the Clackamas River, Roaring River, and Collawash River in its critical habitat designations (NMFS 2005b).

3.6.1.2 Lower Willamette/Columbia River Corridor

Figure 3-7 shows the designation of critical habitat for UWR Chinook salmon in the lower Willamette/Columbia River corridor.

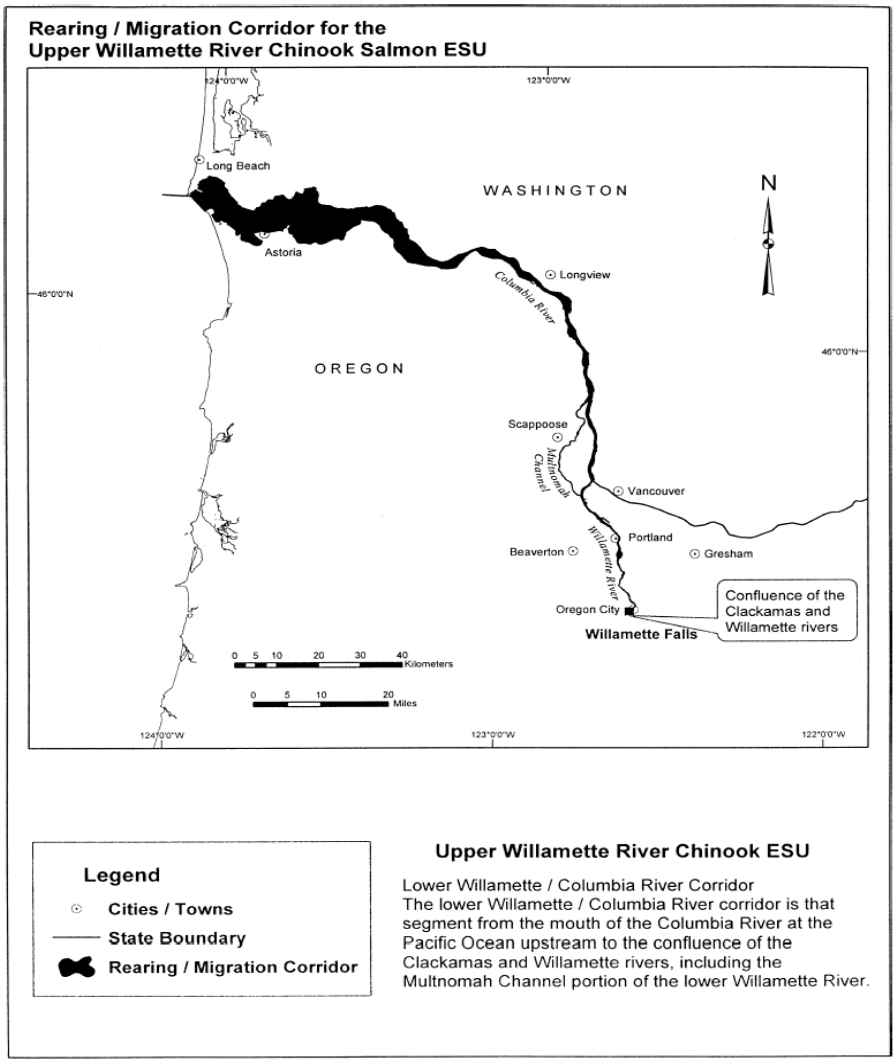


Figure 3-7
Critical habitat in the Lower Willamette/ Columbia River corridor

The CHART concluded that the Lower Willamette/Columbia River corridor was of high conservation value to the UWR Chinook ESU (NMFS 2005e). In its final designation, NMFS included the entire corridor as critical habitat (NMFS 2005b).

3.6.2 Critical Habitat for LCR Chinook

Detailed maps and information like that provided for UWR Chinook salmon in this BA can be found in NMFS 2005e. The following is a condensed version of that information.

Designated critical habitat for LCR Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy,

Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Lower Columbia, Grays/Elochoman, Clackamas, and Lower Willamette (NMFS 2005b). There are 48 watersheds within the range of this ESU. Four watersheds received a low rating, 13 received a medium rating, and 31 received a high rating of conservation value to the ESU. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 1,655 miles of habitat eligible for designation, 1,311 miles of stream are designated critical habitat.

3.6.3 Critical Habitat for LCR Steelhead

Detailed maps and information like that provided for UWR Chinook salmon in this BA can be found in NMFS 2005e. The following is a condensed version of that information.

Designated critical habitat for LCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Clackamas, and Lower Willamette (NMFS 2005b). There are 32 watersheds within the range of this DPS. Two watersheds received a low rating, 11 received a medium rating, and 29 received a high rating of conservation value to the DPS. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 2,673 miles of habitat eligible for designation, 2,324 miles of stream are designated critical habitat.

4. ENVIRONMENTAL BASELINE

The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal Projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). An environmental baseline that does not meet the biological requirements of a listed species may increase the likelihood that adverse effects of the proposed action will result in jeopardy to a listed species or in destruction or adverse modification of a designated critical habitat.

The environmental baseline is described in terms of the habitat features and processes necessary to support all life stages of each listed species within the action area. Each listed species considered in this BA resides in or migrates through the action area for some part of its life cycle. Thus, for this action area, salmon and steelhead depend on the habitat characteristics that support successful completion of the spawning, rearing, and freshwater migration life stages.

The Clackamas River enters the mainstem Willamette River at RM 25.1 (1.7 miles below Willamette Falls) after draining an area of 941 square miles, and is the fourth largest of the Willamette's tributaries. The Clackamas arises from the southern flank of Mt. Hood in the Cascade Mountains and has several major tributaries, including the Collawash River, Oak Grove Fork, and Fish Creek in the upper portion of its drainage network, and Eagle, Deep, and Clear creeks along the lower river (Figure 4-1). In all, 87 percent of the Clackamas Subbasin is forestland and 69 percent of the subbasin is in public ownership (Figures 4-2).

The upper portion of the Clackamas system, above River Mill Dam and Estacada, is characterized by moderate to high-gradient stream reaches within mountainous terrain, while more gently sloped stream channels and topography dominate in the lower portion. The upper portion of the subbasin is heavily forested and primarily within the Mt. Hood National Forest. The lower portion, below Estacada, is more highly developed, and includes a variety of forest, agricultural, rural-residential, urban, and industrial land uses. The degree of landscape alteration within the subbasin increases with proximity to urban areas near the Willamette River. Industrial uses of the river's lowlands, particularly near the Willamette, include food processing, recycling of volatile organic compounds, feedlot and dairy farm operations, and rock and aggregate mining. Estacada is the largest city entirely within the subbasin, although the Portland suburbs of Gladstone, Johnson City, and Oregon City are located near the mouth.

PGE operates a multi-dam hydroelectric complex within the Clackamas subbasin, with the lower-most dam (River Mill) at RM 23.3 of the mainstem Clackamas not far below the city of Estacada. PGE's Clackamas River Hydroelectric Project also includes Faraday Diversion and North Fork dams on the mainstem Clackamas (at RM 28.4 and 30, respectively), and two additional dams on the Oak Grove Fork above areas naturally accessible to anadromous fish. Fish passage facilities that PGE has constructed and maintained at their dams on the mainstem Clackamas River provide anadromous fish access to all historically occupied streams above River Mill Dam.

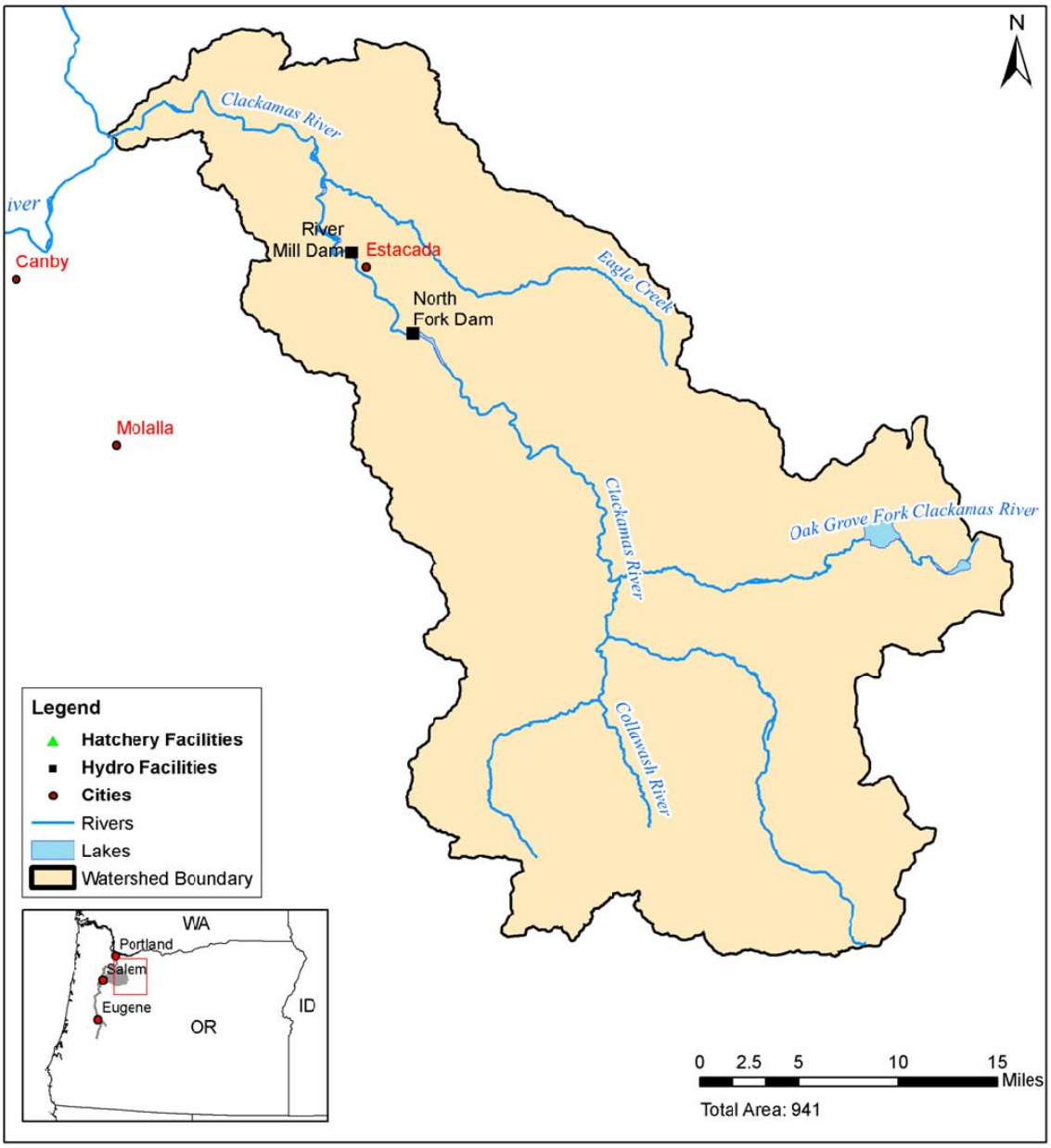
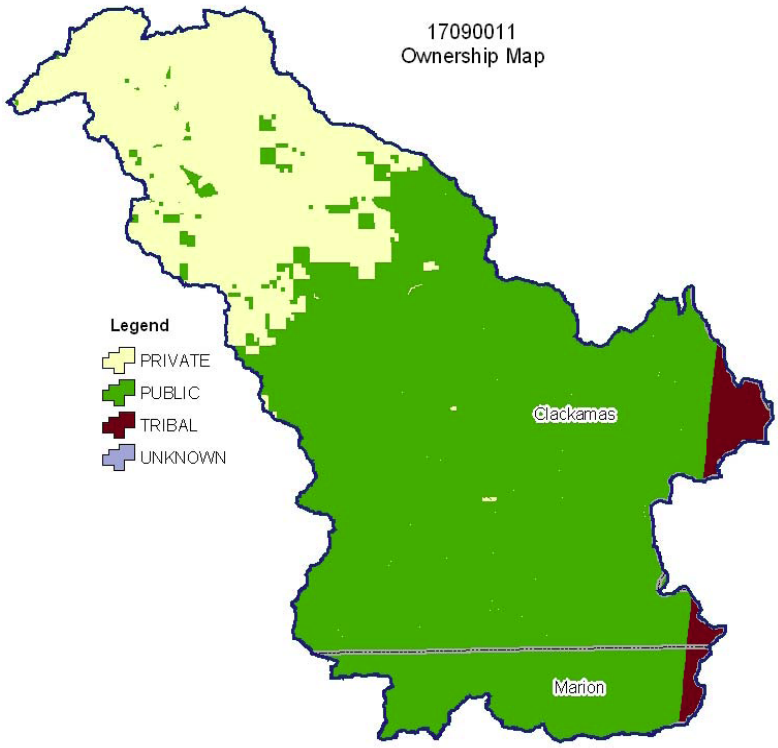
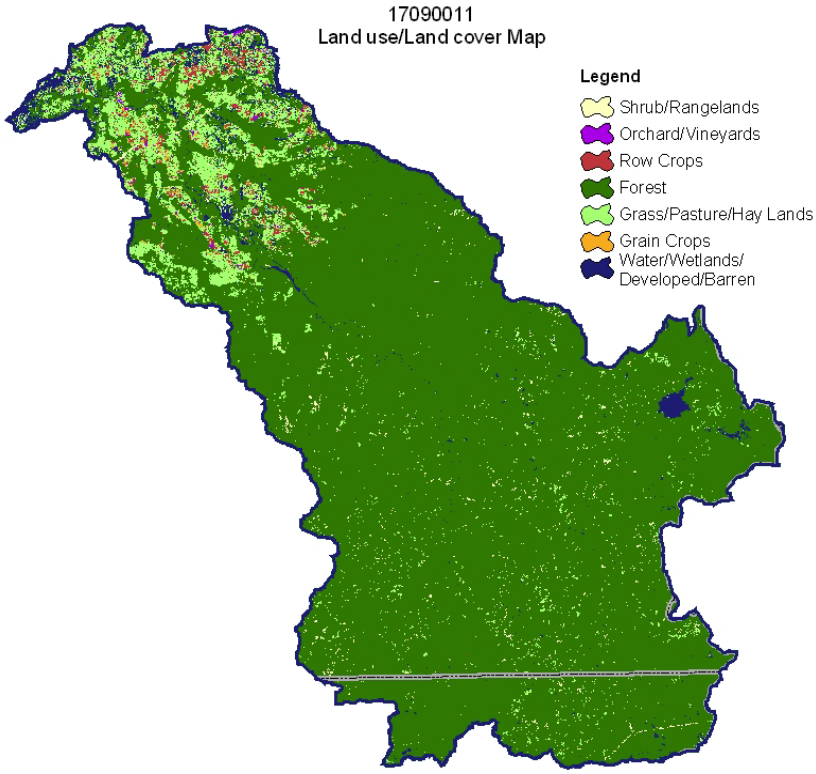


Figure 4-1 Map of the Clackamas River Subbasin





Figures 4-2 Patterns of land ownership (top) and land use/land cover (bottom) in the Clackamas subbasin (source: NRCS 2005)

4.1 Historical Populations of Anadromous Salmonids in the Clackamas Subbasin

The Clackamas subbasin once supported independent populations of wild anadromous salmonids from 4 ESA-listed evolutionary groups: LCR Chinook salmon, LCR coho salmon, LCR chum salmon, and LCR steelhead (Myers et al. 2006). Historical information on each population is incomplete, but all of them were once substantially more abundant than at present. LCR Chinook native to the subbasin included a spring-run population and a fall-run, both of which were severely depleted by the early to mid-1900s. The distribution and abundance of the historical chum salmon population were never documented.

4.1.1 Spring-run Chinook Salmon

Approximately 8,000 adult spring Chinook were harvested from the lower Clackamas River in 1893 and about 12,000 were taken in 1894 for hatchery broodstock (ODFW 1992). These numbers only partly reflect the historical productive capacity of the system, because many of the river's spring Chinook were also being harvested in fisheries on the lower Columbia River and portions of the annual runs were avoiding fisheries and hatchery operations to spawn naturally in the Clackamas subbasin. Most of the historical run is believed to have spawned in the Clackamas and its larger tributaries upstream of the current site of River Mill Dam, though Eagle Creek was also an important spawning stream (McIntosh et al. 1995). The majority of historical spring Chinook salmon production probably came from the mainstem Clackamas and Collawash rivers (Willis et al. 1960).

By the time early hydroelectric dams were constructed on the Clackamas, first Faraday Dam in 1904, then River Mill Dam in 1911, fishermen had already noticed severe declines in the subbasin's run of spring Chinook (Beamesderfer et al. 2001). These declines had likely been caused by over-fishing, early habitat damage in the lower Clackamas subbasin, and broodstock collections at temporary weirs that were operated by ineffective hatchery programs. The dams worsened the situation for the run by further impeding fish migrations to spawning areas in the upper subbasin and providing fish culturists an opportunity to use fish ladders to collect much of what remained of the natural salmon population for hatchery broodstock. For several years beginning in 1911, all spring Chinook salmon that reached River Mill Dam and entered its ladder were used as hatchery broodstock (Taylor 1999). From 1917-1939, fish access to areas above Faraday was blocked after that dam's ladder was destroyed by floodwaters (Taylor 1999).

Upstream passage was restored at the dams on the mainstem Clackamas in 1939, allowing anadromous salmonids to recolonize the upper subbasin (Beamesderfer et al. 2001). However, the spring Chinook run that became established above the dams after passage was improved was derived from a population in the lower subbasin strongly influenced by hatchery programs that frequently used broodstock from the UWR Chinook populations found above Willamette Falls. The spring Chinook population now found throughout the Clackamas subbasin is more closely related genetically to UWR Chinook than to the LCR Chinook presumed to have once been present (Myers et al. 2006).

4.1.2 Fall-run Chinook Salmon

A fall-run of LCR Chinook salmon was abundant historically in the Clackamas subbasin and apparently spawned in the mainstem river up to a point above the current site of North Fork Dam (Fulton 1968). However, this native population was extirpated during the 1930s as a consequence of severe water pollution problems in the mainstem Willamette River below Willamette Falls (Parkhurst et al. 1950). Dimick and Merryfield (1945) reported that the native run had entered the Willamette in September and October and spawned soon after entering the Clackamas River. In 1902, for example, approximately 10 million fall Chinook salmon eggs were collected between 22 September and 08 November at a hatchery weir constructed on the lower Clackamas, with peak collections on 15 October (Titcomb 1904). Assuming fecundities reported by Titcomb (~4,380 eggs/female) and that about half the 1902 run was female, returns of fall Chinook to the lower Clackamas River weir site exceeded 4,500 fish in that year.

Fall Chinook were actively reintroduced into the Clackamas subbasin after the severe water pollution problems in the lower Willamette were addressed by wastewater treatment and baseflow augmentation from the U.S. Army Corps of Engineers' (USACE) Willamette Project. Hatchery stocks derived from fall-run populations in other tributaries to the lower Columbia River were released into the subbasin from 1952 to 1981 in an effort to reestablish a natural run (Myers et al. 2006). Returns of fall Chinook to the Clackamas declined to low levels after the hatchery releases were terminated (McElhany et al. 2007).

4.1.3 LCR Coho Salmon

Abernethy (1886) reported that the coho salmon run in the Clackamas River lasted from mid-September to mid-December, and that it was about equal to the Chinook salmon run. Barin (1886) observed that coho in the system began spawning in about mid-January. Coho salmon passage at North Fork Dam historically was unimodal with a peak in mid-November, but run timing at the dam is now bimodal with peaks in September and January (Cramer and Cramer 1994). Of the 2 runs, the late run is thought to be native, while the early run is considered to be the result of hatchery introductions (Olsen et al.1992).

Recent Ecosystem & Diagnosis Treatment (EDT)-based analyses of the Clackamas subbasin suggest a historic capacity to produce a run of about 15,000 adult coho under average ocean survival conditions (WRI 2004). A compilation of data on the subbasin's coho from the late 1950s forward (Chilcote 2007) suggests that the subbasin produced many more wild coho than this during multiple years when ocean survival conditions were high.

4.1.4 LCR Steelhead

The Clackamas subbasin's native run of winter steelhead represents one of 23 historical, demographically independent populations of LCR Steelhead (Myers et al. 2006). Although information on the historical abundance of the Clackamas population are incomplete, they indicate that steelhead runs in the subbasin were once much larger than under current conditions. Recent EDT-based analyses of the Clackamas subbasin suggest a historic capacity to produce a

run of about 10,000 adult steelhead under average ocean survival conditions (WRI 2004). Because of their association with swifter flowing habitats, steelhead would have been distributed throughout much of the subbasin, and present even in areas that were not used by Chinook or coho salmon (Beamesderfer et al. 2001).

4.2 Current status of ESA-Listed Salmon and Steelhead in the Subbasin

4.2.1 UWR (spring-run) Chinook Salmon

4.2.1.1 Population Viability

The Clackamas population of UWR Chinook is considered to be at a relatively low risk of extinction based on an assessment of its abundance, productivity, spatial structure, and diversity (McElhany et al. 2007). Contributors to extinction risks that the Clackamas population faces within the subbasin include:

- reductions in diversity and productivity caused by a combination of genetic introgression from non-local hatchery stocks and a 22+ year period when the natural population was excluded from its natural habitats in the upper Clackamas subbasin (ODFW 2007);
- fish passage injury, mortality, and delay at the Clackamas River Hydroelectric Project;
- diminished habitat quality in the lower Clackamas subbasin; and
- potentially catastrophic events such as landslides or disease outbreaks caused by hatchery operations (WLCTRT 2003).

4.2.1.2 Abundance & Productivity

The natural-origin UWR Chinook in the Clackamas subbasin constitute one of only two populations out of seven (the McKenzie is the other) that appear abundant and productive enough not to be at high near-term risk of extinction (McElhany et al. 2007). Estimates of the annual abundance of wild Clackamas spring Chinook since 1958 (Chilcote 2007) (Figure 4-3) suggest a long-term (1958-2005) geometric mean of 902 spawners and a recent (1990-2005) geometric mean of 1,656 spawners (McElhany et al. 2007). Evidence indicates that runs in the Clackamas River have been reduced compared to historical levels. Since 1950, hatchery and wild adult returns to the Faraday-North Fork fish ladder (and River Mill Dam prior to 1957) have averaged 1,768 fish, with a high in 2004 of 13,030 fish and a low of 26 fish in 1957. NMFS (1998b) states that "available information suggests that spring Chinook salmon presently in the Clackamas River and Sandy Rivers are predominantly the result of introductions from the Willamette River ESU and are thus probably not representative of spring Chinook salmon found historically." These fish appear to experience lower rates of pre-spawn mortality than do the populations of UWR Chinook that lack access to habitats above the dams on other Willamette River tributaries, with annual rates of loss above North Fork Dam estimated at 9-26 percent (mean = 19 percent) from 2003-2005 (Schroeder et al. 2005). Hatchery and natural production of spring Chinook in the Clackamas River currently accounts for about 20 percent of the production potential in the Willamette River basin (NMFS 2000).

Although stray hatchery-origin fish with fin clips are sorted at a fish trap below Faraday Dam to prevent their entry into the upper Clackamas subbasin, ineffective marking (regenerated adipose fins that were originally clipped) by the large hatchery program in the lower subbasin allows sizeable numbers of hatchery-origin spawners to be passed upstream. Schroeder et al. (2005) found an average of 26 percent hatchery-origin fish among spring Chinook carcasses recovered from upper basin spawning grounds during 2003 and 2004. The proportion of hatchery-origin fish found decreased with increasing distance upstream from North Fork Dam (Schroeder et al. 2005).

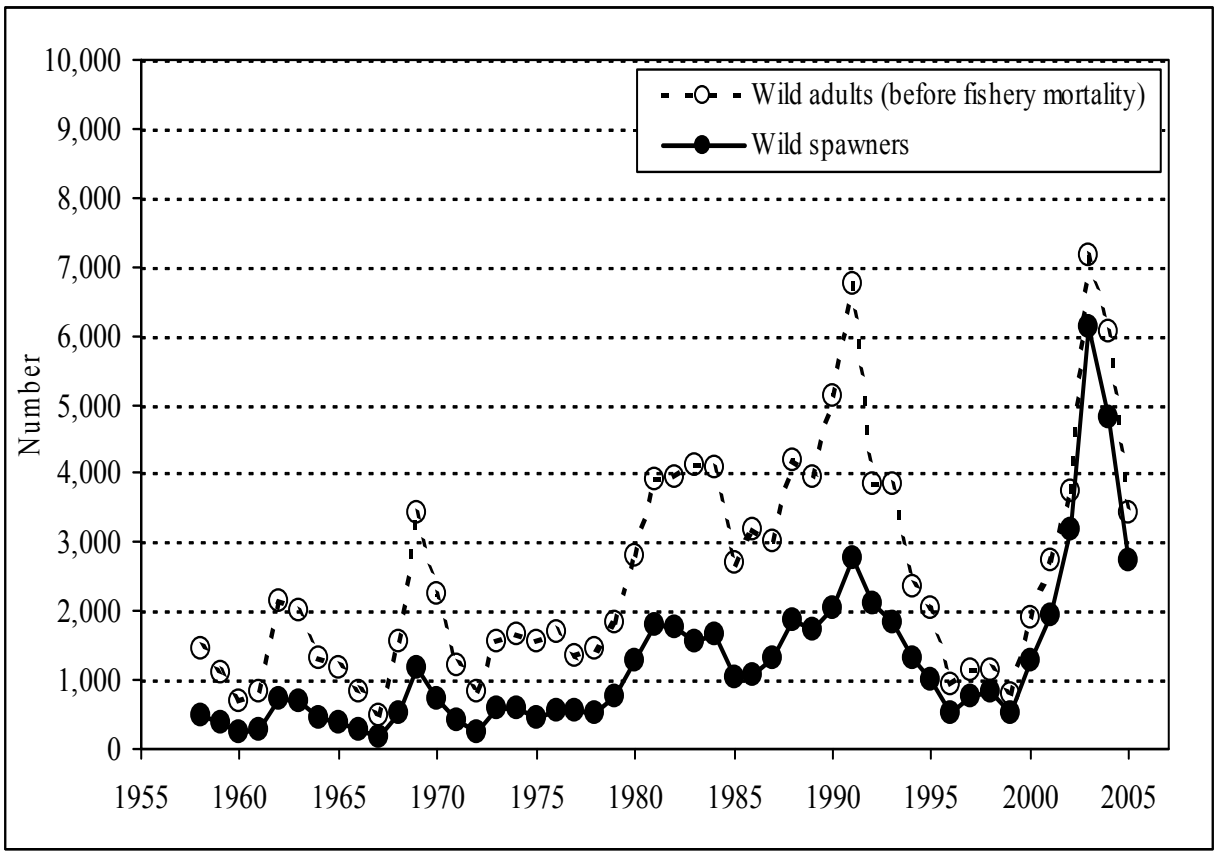


Figure 4-3 Estimated annual abundance of natural-origin ("wild") Clackamas spring Chinook, 1958-2007 (data source: Chilcote 2007)

4.2.1.3 Spatial Structure

The spatial structure of the Clackamas' spring Chinook population poses a low risk of extinction. Spring Chinook in the subbasin have access to nearly all of the areas that were available to the historical population (ODFW 2007). A portion of the historical rearing habitat for these fish has been inundated by the construction of PGE's three dams on the mainstem Clackamas, but rearing conditions within the reservoirs behind these dams are well used by juvenile Chinook (Beamesderfer et al. 2001). Mainstem habitats in the lower subbasin have been degraded, but are believed to have been secondary to upper basin habitats in importance to the historical population (ODFW 2007).

4.2.1.4 Diversity

Clackamas spring Chinook have likely experienced losses of diversity characteristic of a population at moderate risk of extinction (McElhany et al. 2007). As noted earlier, access to the productive spring Chinook habitat in the upper subbasin was eliminated for an extended period of time and the population has been genetically influenced by hatchery programs based on out-of-subbasin broodstocks. Life history traits of the current population, particularly the time of spawning, differ from those described for the historical population (ODFW 2007) and may be a poorer match to the habitat conditions found in the subbasin (Beamesderfer et al. 2001).

4.2.2 LCR (fall-run) Chinook Salmon

The fall run of Chinook salmon in the Clackamas subbasin has declined in the decades since hatchery supplementation ended, is quite small, and is not a primary focus of monitoring efforts. The Clackamas River is believed to have historically supported a large run of fall Chinook salmon (Fulton 1968, as cited in ODFW 1992). Fall Chinook salmon that currently are sustained by natural production in the Clackamas River are believed to have largely originated from hatchery tule stocks that were extensively released into the Clackamas River beginning in 1952, but the fall Chinook salmon may also include those that have strayed from other Willamette tributaries (ODFW 1992, Olsen et al. 1992, Kostow 1995). Native fall Chinook salmon historically spawned in the Clackamas River and migrated upstream past the present-day location of PGE's North Fork Complex dams. Natural escapement in the Clackamas River basin has averaged about 350 fish in recent years (ODFW 1998). The Clackamas population of LCR Chinook is in the very high extinction risk category.

Within the Clackamas subbasin, these fish are largely confined to the mainstem below River Mill Dam and the lower reaches of the major tributaries (Deep, Clear and Eagle creeks) to the lower river. Available data on the population's abundance are of uncertain reliability, and the population should be considered "extirpated or nearly so" (McElhany et al. 2007). The Hatchery Scientific Review Group (HSRG (2008) has estimated that average annual returns of natural-origin LCR (fall) Chinook to the Clackamas subbasin (~50 adults) are exceeded by the average number of stray hatchery-origin fish entering the subbasin from programs elsewhere in the Lower Columbia region (~70 adults).

4.2.3 LCR Coho Salmon

4.2.3.1 Population Viability

Natural-origin coho in the Clackamas subbasin appear to constitute one of only two LCR coho salmon populations in Oregon that have maintained significant natural production and genetic continuity with their historical predecessors. Based on an assessment of the Clackamas population's abundance, productivity, spatial structure, and diversity, McElhany et al. (2007) classified it as having a low to moderate risk of extinction. This

makes the Clackamas population the only one that might be considered viable within the entire LCR Coho ESU (McElhany et al. 2007). Contributors to extinction risks the population faces within the Clackamas subbasin include:

- habitat degradation in the lower subbasin (WRI 2004);
- reductions in diversity and productivity that may remain as legacies of intense commercial fisheries that have only recently become managed with a strong emphasis on conserving natural coho populations (Cramer and Cramer 1994; McElhany et al. 2007);
- imperfect fish passage at the Clackamas River Hydroelectric Project that is in the process of being improved; and
- high proportions of stray hatchery-origin coho in natural spawning areas within the lower subbasin (WLCTRT 2003).

4.2.3.2 Abundance & Productivity

The Clackamas River basin is thought to have historically supported a large coho salmon population (Abernethy 1886), which likely spawned throughout the basin. In their viability assessment of Clackamas coho, McElhany et al. (2007) rated the natural-origin population's abundance and productivity as reflecting a low extinction risk. Data compiled by Chilcote (2007) show that adult abundance dropped to very low levels during multiple years in the 1990s but has since rebounded to somewhat higher levels (Figure 4-4). The wild coho population currently in the Clackamas River is considered to be the last remaining viable wild salmon population in the Columbia River basin (ODFW 1992). Coho salmon returns to North Fork Dam between 1957 and 2000 averaged 1,876 fish. The largest return was 5,530 fish in 2001, and the smallest was 89 fish in 1996. The Clackamas population of LCR coho is in the low extinction risk category.

4.2.3.3 Spatial Structure

The spatial structure of the Clackamas coho population, which expanded after fish passage to the upper subbasin was restored in 1939, was rated by McElhany et al. (2007) as posing a low risk of extinction. The historical Clackamas coho population had access to an estimated 385 km of habitat (ODFW 2005). Virtually all (97 percent) of this habitat is now accessible to these fish (ODFW 2005), with limited losses of accessibility in higher order tributary streams, primarily due to watershed development in the lower subbasin (McElhany et al. 2007). Coho salmon spawn and rear downstream of the Project in the mainstem Clackamas River and in tributaries, including Eagle Creek and Deep Creek. Coho also spawn and rear within the Project between the River Mill and North Fork dams, and upstream of the Project in the mainstem Clackamas River and major tributaries. Large numbers of coho salmon rear in all three of the North Fork Complex reservoirs (Korn et al. 1967).

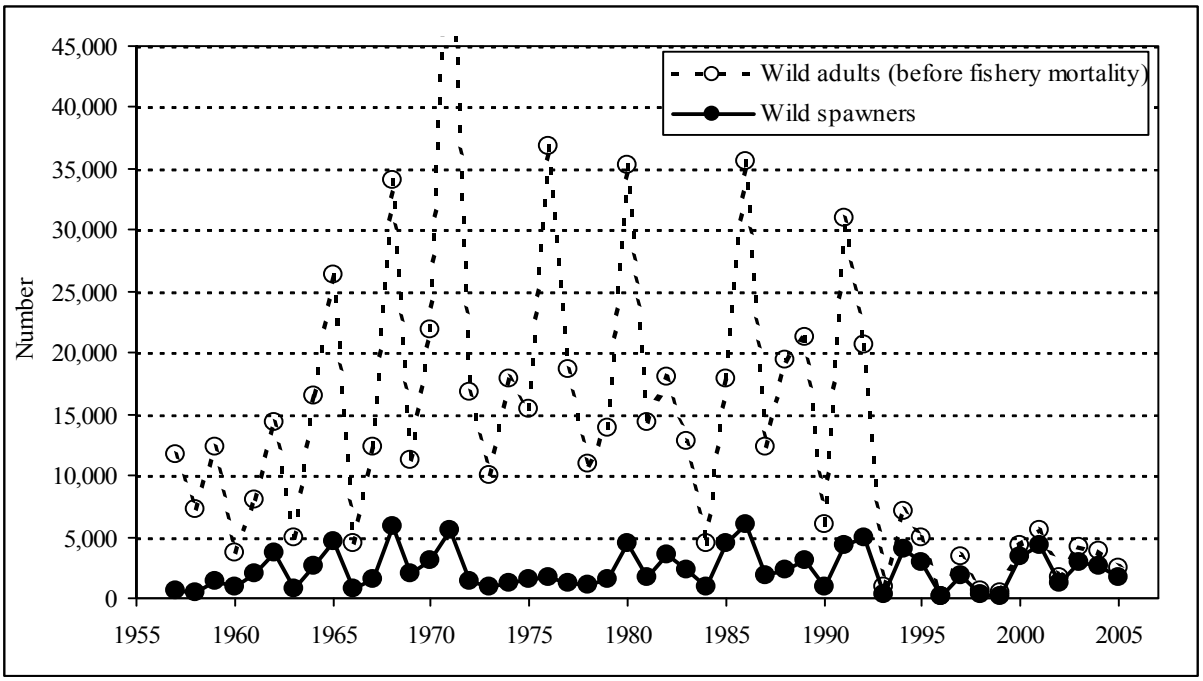


Figure 4-4 Estimated abundance of natural-origin ("wild") late-run Clackamas coho, 1958-2005 (data source: Chilcote 2007)

4.2.3.4 Diversity

McElhany et al. (2007) rated the diversity of the LCR Coho in the Clackamas subbasin as that of a salmonid population facing low to moderate risk of extinction, with concerns including changes in life history, recent abundance bottlenecks (see Figure 4-4), and high proportions of hatchery-origin fish using spawning areas in the lower subbasin. Cramer and Cramer (1994) observed that the wild population had experienced a shift to later adult return and spawn timing, hypothesizing that this caused a reduction in spawning distribution, later fry emergence, a shortened growing season, and changes in juvenile migration. They attributed the shift to severely high adult harvest rates. McElhany et al. (2007) suggest that these changes may reverse themselves in response to recent reductions in harvest rates. Stray early-run coho from Eagle Creek Hatchery account for half or more of the fish surveyed in spawning areas within the portion of the subbasin below the sorting facility at Faraday (McElhany et al. 2007), although in Clear Creek, a major tributary that enters the Clackamas below the sorting facility, no hatchery-origin spawners have been found with natural-origin fish (Suring et al. 2006).

4.2.4 LCR Steelhead

4.2.4.1 Population Viability

The population of LCR steelhead native to the Clackamas subbasin is in better condition than other Oregon populations within this DPS. An assessment of the Clackamas population's abundance, productivity, spatial structure, and diversity suggests a low to moderate risk of extinction (McElhany et al. 2007). Contributors to risks the population faces include:

- habitat degradation in the lower Clackamas subbasin and passage conditions [which are being improved] at PGE's hydroelectric dams on the mainstem Clackamas (WRI 2004)

- potential genetic introgression from a non-local hatchery stock of winter steelhead that is now excluded from the upper subbasin but may still stray into natural spawning areas in the lower subbasin (McElhany et al. 2007);
- competitive displacement of native winter steelhead by introduced hatchery-origin summer steelhead that are now excluded from the upper subbasin but still present in the lower subbasin (Kostow et al. 2003)
- potential legacy effects on population productivity and diversity of a 22+ year period when the native run was excluded from habitats in the upper Clackamas subbasin (Beamesderfer et al. 2001); and
- potentially catastrophic events with a moderate probability of occurrence, such as landslides, disease outbreaks from hatchery operations, and pollutant spills (WLCTRT 2003).

4.2.4.2 Abundance & Productivity

The Clackamas' native winter steelhead population has a long-term geometric mean abundance of about 1,800 natural origin spawners (McElhany et al. 2007), and has recently rebounded from low abundances recorded during the 1990s (Chilcote 2007) (Figure 4-5). The population's abundance is high enough to suggest a low extinction risk, but there is moderate uncertainty in this assessment because of difficulties in evaluating the effects of stray hatchery fish and other factors on population productivity (McElhany et al. 2007). Historical records, although incomplete, indicate that steelhead runs in the Clackamas River were much larger than under current conditions. Clackamas River winter steelhead returns to North Fork Dam between 1963 and 2000 averaged 1,745 fish. Maximum returns of 4,353 fish occurred in 1971, and a low of 365 occurred in 1999. Returns have diminished in this decade and remain far below ODFW's annual escapement goal of 3,000 fish for the habitat above the North Fork Dam.

4.2.4.3 Spatial Structure

The spatial structure of Clackamas winter steelhead suggests a low risk of extinction, with moderate uncertainty (McElhany et al. 2007). Virtually all habitat historically accessible to winter steelhead in the Clackamas subbasin remains accessible to them (ODFW 2005), but the population's spatial structure has been affected by substantial habitat degradation in lower portions of the subbasin. Steelhead historically occupied more of the Clackamas River basin than either Chinook or coho salmon, because of their tolerance of higher gradient habitat. Winter steelhead spawn throughout most of the Clackamas River basin. Downstream of the Project, winter steelhead spawn in the lower mainstem Clackamas River and in major tributaries, including Clear, Deep, Eagle Creeks. Upstream of the North Fork Complex dams, winter steelhead spawn in the upper mainstem Clackamas River, the North and Oak Grove Forks of the Clackamas River, Roaring River, Collawash River, the Hot Springs Fork, and Fish Creek (ODFW 1992). The contribution to juvenile production resulting from spawning in the upper watershed, relative to juvenile production downstream of the dam, has not been determined. Chilcote (1998) determined that the Oregon component of the Lower Columbia River ESU has an unacceptably low capacity to survive future periods of environmental stress. The status of winter steelhead in the Clackamas River, which comprises a significant portion of the DPS, is a special concern.

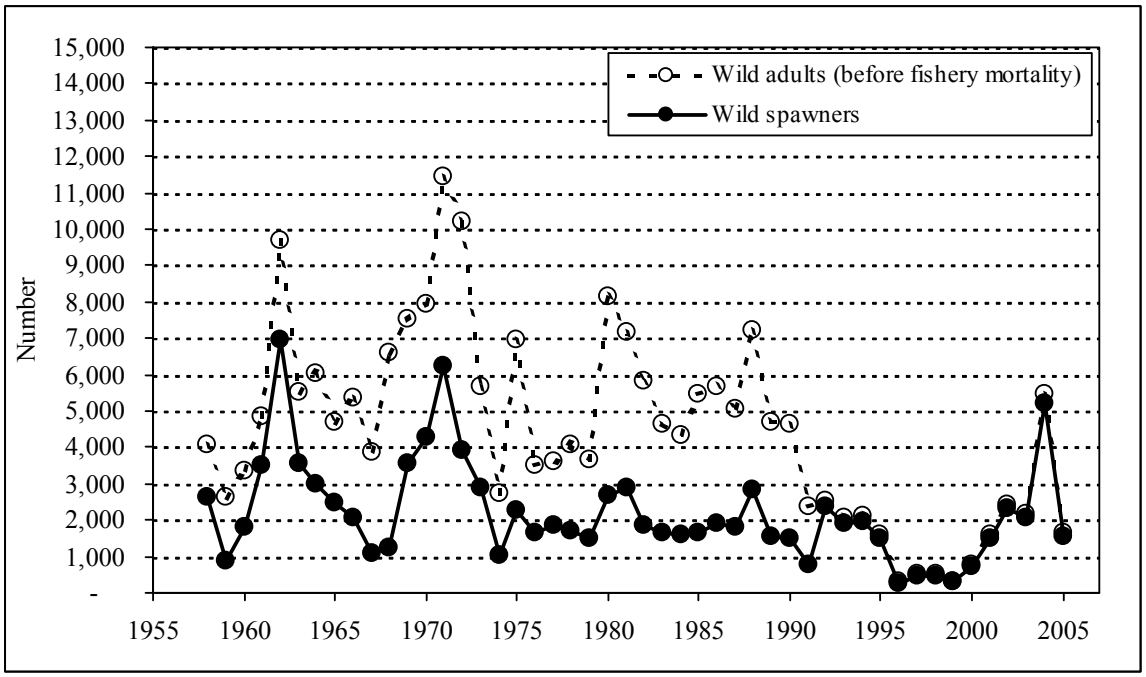


Figure 4-5 Estimated abundance of natural-origin ("wild") Clackamas late-run winter steelhead, 1958-2005 (data source: Chilcote 2007)

4.2.4.4 Diversity

McElhany et al. (2007) rated the diversity of the Clackamas' native population of winter steelhead as reflecting a low to moderate risk of extinction, based on an examination of life history traits, effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity. Their key concerns included the presence of non-native hatchery stocks of winter and summer-run steelhead in the lower subbasin, potential lingering effects of the 20+-year period of exclusion from the upper subbasin during the early 1900s, and diminished habitat quality in the lower subbasin.

4.2.4.3 Spatial Structure

The spatial structure of Clackamas winter steelhead suggests a low risk of extinction, with moderate uncertainty (McElhany et al. 2007). Virtually all habitat historically accessible to winter steelhead in the Clackamas subbasin remains accessible to them (ODFW 2005), but the population's spatial structure has been affected by substantial habitat degradation in lower portions of the subbasin. Steelhead historically occupied more of the Clackamas River basin than either Chinook or coho salmon, because of their tolerance of higher gradient habitat. Winter steelhead spawn throughout most of the Clackamas River basin. Downstream of the Project, winter steelhead spawn in the lower mainstem Clackamas River and in major tributaries, including Clear, Deep, Eagle Creeks. Upstream of the North Fork Complex dams, winter steelhead spawn in the upper mainstem Clackamas River, the North and Oak Grove Forks of the Clackamas River, Roaring River, Collawash River, the Hot Springs Fork, and Fish Creek

(ODFW 1992). The contribution to juvenile production resulting from spawning in the upper watershed, relative to juvenile production downstream of the dam, has not been determined. Chilcote (1998) determined that the Oregon component of the Lower Columbia River ESU has an unacceptably low capacity to survive future periods of environmental stress. The status of winter steelhead in the Clackamas River, which comprises a significant portion of the DPS, is a special concern.

4.3 Limiting Factors and Threats to Recovery

Factors unfavorably affecting the status of the Clackamas population of UWR Chinook and the Clackamas subbasin's other ESA-listed populations of anadromous salmonids include a variety of within-basin dam effects, including imperfect fish passage, large hatchery programs, and the cumulative effects of multiple land and water use practices on aquatic habitat. Habitat degradation is a particular concern in the lower Clackamas subbasin, below the dams, where the historic capacity to produce anadromous salmonids has been substantially diminished (WRI 2004).

4.4 Environmental Conditions

4.4.1 Habitat Access

Anadromous salmonid passage to and from their habitats within the Clackamas subbasin is affected by PGE's Clackamas River Hydroelectric Project and by migration impediments at road crossings of small streams (WRI 2004). Fish passage conditions at the hydroelectric project are an important factor limiting anadromous fish production in the upper portion of the Clackamas subbasin (WRI 2004). Deficient conditions at road crossings are remedied as opportunities are identified.

4.4.1.1 Upstream Passage of Anadromous Fish at the Clackamas River Hydroelectric Project

Facilities for the passage of upstream migrating salmonids are currently provided at all 3 of PGE's hydroelectric dams on the mainstem Clackamas River (Figure 4-6). Upstream passage is provided by two fish ladders: (1) the River Mill fish ladder, which provides passage over River Mill Dam into Estacada Lake; and (2) the Faraday-North Fork fish ladder, which spans 1.7 mi (2.7 km), allows sorting of fish at a trap near its entrance, and provides passage over both Faraday Diversion Dam and North Fork Dam. At the sorting trap, natural origin fish are returned to the ladder to resume their upstream migration, and hatchery fish are removed so they do not continue up the ladder. As part of the Biological Opinion on the Interim Operation of PGE Projects (NMFS 2003a), the River Mill ladder was rebuilt by PGE to bring its design and performance up to current NMFS' standards (the new ladder was put into service December 2006). Operational measures, such as a pulsed-flow regime down the Faraday Bypass reach, are being evaluated for their effectiveness at encouraging adult spring Chinook salmon to avoid potential migration delays at the Faraday Powerhouse and below the entrance to the Faraday-North Fork fish ladder.

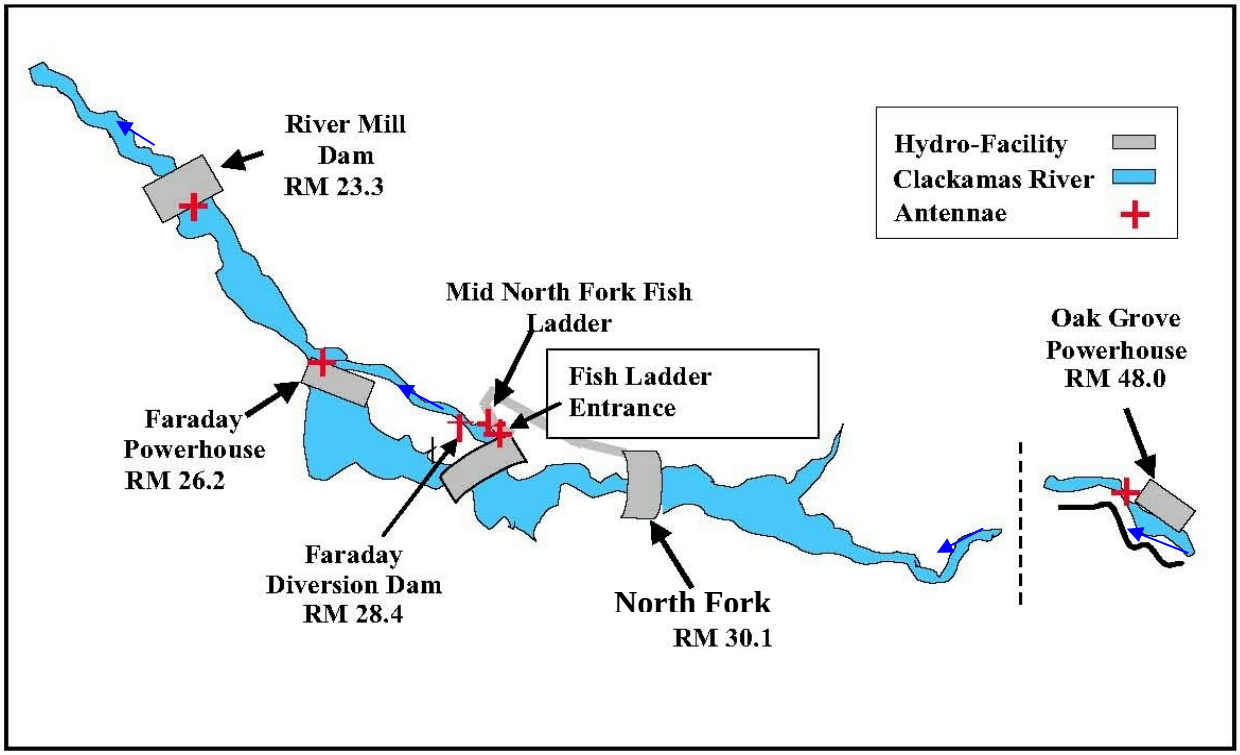


Figure 4-6 PGE hydroelectric dams on the mainstem Clackamas River (source: Shibahara et al. 2001)

4.4.1.2 Downstream Passage of Anadromous Fish at the Hydroelectric Project

PGE operates downstream fish passage facilities at the North Fork and River Mill dams, but not at Faraday Dam or the Faraday Powerhouse. The juvenile bypass facility at North Fork Dam, considered only partly effective (FERC 2006), consists of a surface collection system, the Faraday-North Fork fish ladder, a separator, an evaluation station, and a bypass pipeline. A portion of the juvenile salmonids migrating downstream from the upper Clackamas subbasin are attracted to a surface collection facility in North Fork Reservoir and are passed into the Faraday-North Fork fish ladder. Near the lower end of the 1.7-mi (2.7 km) long fish ladder, the downstream migrants pass through a "separator," where they are screened out, passed through a PIT-tag detector, and then diverted into a pipeline that conveys them 5 mi (8 km) to the tailrace of River Mill Dam. The separator also collects a sample of fish into a holding box where they are counted, passed through a PIT-tag detector, and measured before being released into the downstream migrant pipeline. The outlet of the pipeline was just renovated to provide added protection of juvenile downstream migrants. Spilled flows up to 500 cfs pass through a screen that diverts juveniles to the juvenile bypass facility. Spilled flows exceeding 500 cfs are not screened and attract fish to a spillway shown to cause elevated levels of injury and mortality (Heisey et al. 2002).

PGE follows spill management protocols at Faraday Dam that encourage fish to pass into the Faraday Bypass reach, rather than toward the Faraday Powerhouse via its diversion canal, whenever spills over North Fork Dam pass juveniles downriver. These protocols compensate for

the lack of fish passage structures at Faraday and will remain in effect until the partial forebay net to be constructed at North Fork is proven effective.

River Mill Dam, originally constructed in 1910–1911, is an 85 foot high spillway dam and power-house between rock abutments. Since its initial construction there have been multiple modifications to address safety concerns and to improve fish passage, but recent evaluations identified additional passage improvements that would be helpful. As part of the Biological Opinion on the Interim Operation of the Project (NMFS 2003a), PGE has modified the dam's spillway to limit injury and mortality of juvenile salmonids passing downstream via that route.

4.4.1.3 Other Passage Impediments

Fish passage is impeded or blocked at multiple road crossings of small tributary streams in both the upper and lower portions of the Clackamas subbasin, and affects fish access to historical coho and steelhead habitat within both areas (WRI 2004). Such barriers are likely more frequent along tributary streams in the lower subbasin due to higher road density than in the upper subbasin. Within the Deep and Goose Creek watersheds, for example, WPN (2005) identified 39 partial or total migration barriers on fish-bearing streams. Artificial structures such as the dams (WPN 2002, 2005), may also affect fish access to some areas.

4.4.2 Water Quantity/Hydrograph

Natural streamflows in the Clackamas subbasin, those to which the native salmonids are adapted, are similar to those described for other eastside tributaries to the Willamette River elsewhere in this document. Flows from the upper subbasin are greatest during major winter storms, remain relatively high during spring snowmelt, and decline during the summer dry season. Streams lower in the subbasin drain watersheds that receive little snowfall, are dominated by rainfall runoff, and experience earlier declines in flow than are seen at higher elevations in the upper subbasin. Natural streamflows in tributaries to the lower Clackamas tend to be very low during summer and early fall.

Flows within many of the subbasin's streams have been influenced by land use, but such changes are generally subtle in comparison to the effects of direct diversions of water for hydroelectric power generation, irrigation, residential use, or municipal and industrial use. PGE's hydroelectric project has substantial local effects on flows in sections of the lower Oak Grove Fork and the mainstem Clackamas River that are important to anadromous salmonids. Consumptive uses of water have altered seasonal flow patterns within lower portions of the subbasin, exacerbating low flow conditions and contributing to elevated water temperatures in many stream channels used by these fish.

4.4.2.1 Flow Reductions

4.4.2.1.1 Reductions for Hydropower Production

Flow patterns in the 4.4 mile section of the Oak Grove Fork naturally accessible to anadromous fish, and in the 4.9 miles of the Clackamas River from the mouth of this tributary to PGE's Oak Grove Powerhouse, are affected by large diversions of water (up to 585 cfs) from the tributary

and to the powerhouse at RM 48 on the mainstem Clackamas. Flows in the Oak Grove Fork below the diversion point were historically quite stable due to strong groundwater influences within its watershed, but have for decades been severely diminished by hydropower operations that greatly reduce flows year-round and cut summer-fall minimums within the reach from perhaps 250-300 cfs to 0-10 cfs (McBain and Trush 2004a).

Flows in the mainstem Clackamas between the Oak Grove Fork and Oak Grove Powerhouse are altered by hydropower operations during periods of low flow, when the tributary would naturally contribute about 40-50 percent of the flow found below its mouth (McBain and Trush 2004a).

Between the Oak Grove Powerhouse and North Fork Reservoir, daily average flows in the Clackamas River are relatively unaffected by PGE's hydroelectric operations, but daily and weekly fluctuations downstream of the powerhouse are modified by power peaking (Gomez and Sullivan 2001). The peaking generally occurs on weekdays, in the morning and evening.

PGE also reduces flow substantially in the mainstem Clackamas River below Faraday Dam. Unless river flows exceed a diversion capacity of more than 5,000 cfs, a minimum flow of approximately 120 cfs has been maintained in the Faraday Bypass reach to provide upstream passage and rearing habitat for anadromous salmonids. This minimum constituted less than a quarter of the lowest flows reaching the dam each year. The sufficiency of the 120 cfs minimum flow, particularly for effective fish passage, has long been debated.

Below River Mill Dam, flows in the Clackamas River follow a natural seasonal pattern and cause localized flooding during many winters.

4.4.2.1.2 Consumptive Uses of Water

Valid rights for consumptive diversions of water from streams in the lower elevation watersheds tributary to Clackamas River below River Mill can approach or exceed natural summer low flows in some of these streams. Such situations have been documented in assessments of the Clear, Foster, Deep, and Goose Creek watersheds (WPN 2002, 2005). Although not all water rights are exercised concurrently when flows are at their lowest, water diversions within the lower subbasin do tend to reduce streamflows, diminish rearing space, and increase water temperatures in many of the smaller streams used by ESA-listed anadromous salmonid. For example, low summer flow conditions that appear barely adequate to unsuitable for salmonids have been reported in both the Rock and Richardson Creek watersheds (Ecotrust 2000).

Streamflow conditions within the lower Clackamas River's tributary watersheds differ from those in the mainstem, because flows in the lower mainstem benefit from sustained late-season water yields from the upper subbasin. However, relatively abundant high-quality water has made the lower Clackamas a key source area for long-range plans to continue expanding the region's municipal and industrial water supply. The river now provides municipal water to over 200,000 residents in the Portland metropolitan region, and an increased demand for water is anticipated (EES 2004). At present, water providers, including the City of Lake Oswego, Clackamas River Water, the South Fork Water Board, and the North Clackamas County Commission, have Clackamas River water rights totaling nearly 300 cfs, about half of which are being exercised using existing diversion facilities. Expansions of diversion and treatment facilities by the water providers are anticipated (EES 2004), and may at some point conflict with

salmon conservation objectives. Consultants to the providers (Annear and Wells 2006) have developed a model to address mainstem water availability questions and examined the potential for supplementing lower Clackamas River flows with water stored in the upper subbasin.

4.4.2.2 Flow Fluctuations, Entrapment & Stranding

Unnaturally, rapid declines in flow can causes losses of small juvenile salmonids. Such changes in flow and river stage have occurred in the past along the mainstem Clackamas as a result of PGE's operation of the Clackamas River Hydroelectric Project.

Potential losses of juvenile salmonids caused by rapid water-level fluctuations in the mainstem Clackamas downstream from power peaking operations at Oak Grove Powerhouse (RM 48) have been considered during field reconnaissance and hydraulic simulations of channel cross-sections measured at sensitive locations. Daily maximum down-ramp rates during summer and early fall (a period when salmonid fry are present and ramp rates are relatively high) were estimated to have averaged 0.17 ft/hr at the sensitive locations in 1998 and 0.16 ft/hr in 1999, and exhibited absolute peaks at 0.66 ft/hr each year (Doughty 2004). Studies summarized by Hunter (1992) suggest that the average rates estimated by Doughty should have been reasonably safe for small salmonids but not the annual peak rates.

Peaking operations at the Faraday Powerhouse are anticipated to pose lesser risks, because the powerhouse discharges almost directly into the upper end of the reservoir created by River Mill Dam (Estacada Lake).

4.4.3 Water Quality

4.4.3.1 Water Temperature

Salmonids are sensitive to changes in water temperature and can be affected by shifts in thermal regimes during the summer rearing or spawning/incubation period. Unfavorable shifts in temperature have occurred in some streams used by anadromous salmonids in the upper Clackamas subbasin and a greater number of streams in the lower subbasin. For example, the ODEQ 2004/2006 Integrated Report (ODEQ 2006a) database identifies 68.7 stream miles as exceeding temperature criteria for core salmonid rearing habitat (16°C), including segments of Collawash River and Fish Creek in the upper subbasin, plus Eagle Creek, North Fork Eagle Creek and Bear Creek in the lower subbasin. A combined 25.5 miles of the lower Clackamas River and Cow Creek have been identified as exceeding temperature criteria for general salmonid rearing (18°C), and an additional 25.1 miles of Eagle Creek, Nohorn Creek, and Collawash River exceed temperature criteria for salmon and steelhead spawning habitat (13°C).

Elevated temperatures in Clackamas River tributaries are attributable to altered riparian vegetation and, in the lower subbasin, diminished streamflows. However, water quality modeling identifies PGE's mainstem reservoirs as a significant source of heating and thermal alteration of the lower mainstem Clackamas (ODEQ 2006b) (Figure 4-7). Heating that occurs in the reservoirs warms stored water and has caused a shift in temperature patterns downstream of River Mill Dam.

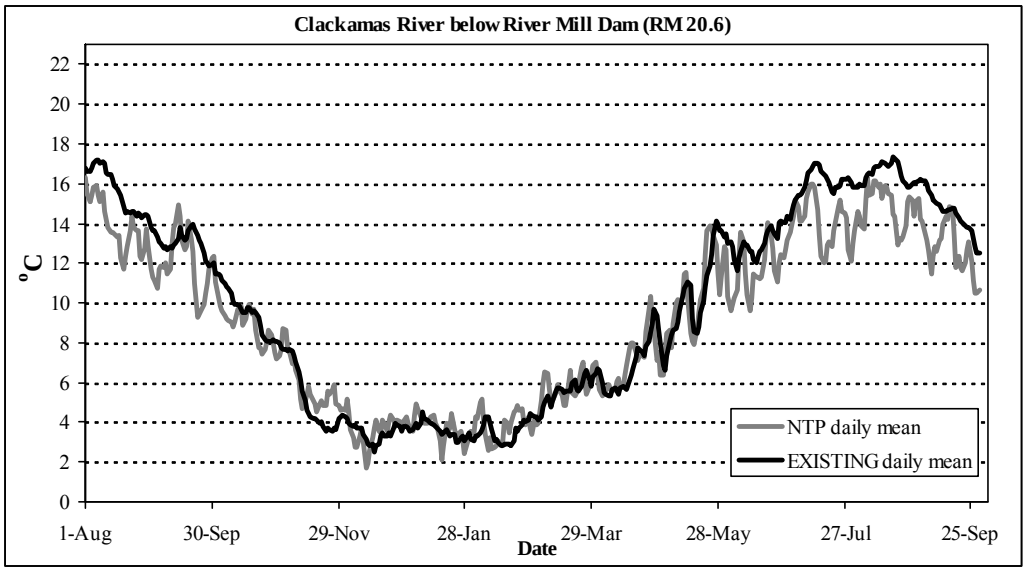


Figure 4-7 Simulated daily mean water temperatures in the Clackamas River below River Mill Dam for existing ("EXISTING") and no-dam (NTP) scenarios, August 2000 – September 2001 (data source: Arendt et al. 2008).

4.4.3.2 Dissolved Oxygen

Although Ecotrust (2000) suggests that low concentrations of dissolved oxygen occur in some small streams within the lower Clackamas subbasin, there is little data because monitoring of this water quality constituent in most of these streams has generally been limited. However, the ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as being water quality impaired due to low concentrations of dissolved oxygen.

4.4.3.3 Total Dissolved Gas

The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to excessive Total Dissolved Gas (TDG) levels.

4.3.3.4 Turbidity

Suspended sediment and turbidity levels have been elevated in some streams within the lower Clackamas subbasin (WPN 2002). However, the ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as being water quality impaired due to turbidity.

4.3.3.5 Nutrients/Contaminants

Nutrient levels are elevated in some streams within the lower subbasin but none of these streams are identified by the ODEQ 2004/2006 Integrated Report database as being water quality

impaired for this reason. The database does, however, identify a combined 52 miles of 8 streams in the lower subbasin as water quality impaired by intermittently high concentrations of *E. coli* bacteria. These include the lower 15 miles of the mainstem Clackamas, as well as Deep Creek, North. Fork, Deep Creek, Tickle Cree., Cow Creek, Barfield Creek, Rock Creek, and Sieben Creek. There are a number of potential sources of the bacterial contamination, including livestock and poorly functioning septic systems in rural-residential areas. The Clackamas River itself receives effluent from Estacada and Clackamas waste treatment plants, and picks up contaminants from tributaries and non-point sources along its route.

4.4.4 Physical Habitat Characteristics

Unfavorable human influences on the physical characteristics of habitat for ESA-listed anadromous salmonids are greater in lower portions of the Clackamas subbasin, below River Mill, than they are above that dam. A key reason for this is the pattern of land ownership with most of the lower subbasin in private ownership and the upper subbasin publicly owned. Most of the upper subbasin is managed by the Mt. Hood National Forest, which emphasizes aquatic conservation in its habitat management policies (USDA and USDI 1994).

Physical habitat quality is generally poorer in the lower subbasin due to reduced habitat diversity and increased levels of fine sediment (WRI 2004). The reductions in habitat diversity in the lower subbasin have been a function of a decline in LWD and channel simplifications that have resulted from active manipulation and changes in riparian conditions. In many cases, changes in stream conditions within the lower subbasin have been dramatic (Beamesderfer et al. 2001). Habitat in the upper basin is in considerably better shape than that in the lower subbasin, but has also lost diversity in many areas due to reductions in LWD. These reductions have been due to changes in riparian forests and stream-cleaning efforts that occurred before the importance of wood in the creation and maintenance of high-quality salmonid habitats was fully understood.

4.4.4.1 Substrate

The effects of varied land-use activities have influenced substrate conditions within streams used by the Clackamas subbasin's ESA-listed salmonid populations. These effects tend to be more pronounced in the lower subbasin, where WRI (2004) has identified elevated levels of fine sediments as a frequent limiting factor. Along the mainstem Clackamas, trapping of coarse sediments in PGE reservoirs prevents delivery of an average of more than 66,000 yd^3/yr of this material to the river channel below River Mill Dam (Wampler and Grant 2003). Over time this has caused dramatic riverbed coarsening, down-cutting, and channel simplification for 2 miles below the dam and contributed to changes in channel processes and features for as much as 9 miles below the dam (Wampler and Grant 2003). In combination with aggregate mining and isolation of the floodplain by bank protection structures, elimination of sediment delivery from the upper subbasin has helped create a less dynamic lower river with fewer active side channels and less salmon spawning habitat.

4.4.4.2 Large Woody Debris

Streams within portions of the upper Clackamas subbasin retain substantial quantities of in-channel wood, but a combination of natural disturbances, timber harvest, road construction, and stream-cleaning have diminished the abundance of LWD and the condition of fish habitat in other parts of the drainage network above River Mill Dam (Everest et al. 1987; USFS 1988, 1995; Cramer et al. 1997). Past losses of LWD have been offset in some streams on the Mt. Hood National Forest by direct placements into channels where its abundance was low.

All LWD transported from watersheds above River Mill Dam is trapped within PGE reservoirs and cannot influence channel processes and habitat quality in the lower Clackamas River without active intervention. This lost LWD delivery has likely contributed to reductions in the complexity and quality of anadromous salmonid habitat in the river. Similar losses of habitat function and quality due to reduced quantities of LWD have been common elsewhere in the lower subbasin. Past uses of channels and riparian vegetation have left instream abundances of LWD as well as wood recruitment potential low across much of the drainage network (Beamesderfer et al. 2001; WPN 2002, 2005).

4.4.4.3 Channel complexity, Off-channel Habitat & Floodplain Connectivity

Stream channel complexity, off-channel habitats, and floodplain connectivity are important elements of high-quality salmonid habitat that have been reduced in the Clackamas subbasin, frequently as a result of low LWD abundance or direct channel manipulations. The reductions appear to have been acute in areas of relatively gentle topography within watersheds below River Mill, where agricultural development and urbanization often influence stream conditions. For example, WPN (2005) identified 21.5 miles of ditched channels in these types of areas within the Deep and Goose Creek watersheds. Off-channel habitat and floodplain connectivity along the lower Clackamas River have been affected by bank stabilization and diking (WRI 2004). The USACE maintains 1.6 miles of revetments it has constructed along the lower river between RM 1.5 and RM 20.1.

4.4.4.4 Riparian Reserves & Disturbance History

Riparian vegetation along streams within lower portions of the Clackamas subbasin is often recently disturbed or in early to mid-successional stages as a consequence of man-caused disturbances, while that along streams within the upper subbasin more frequently includes older aged conifers (ODEQ 2006b). Conditions in the upper subbasin are improving, due to an increased focus on aquatic conservation by the USFS. However, the lower subbasin has predominantly private forestlands managed with less emphasis on aquatic conservation and is dominated by more intrusive agricultural, rural-residential, municipal, or industrial land uses in lowland areas or where the topography is gentle. Riparian vegetation provides variable but frequently good shading along streams in the lower subbasin, though along these streams it often consists of narrow bands of trees or shrubs and includes invasive species when bordered by non-forest land uses (Ecotrust 2000; WPN 2002, 2005). Along the lower Clackamas, bank protection structures such as the USACE revetments described in the last paragraph have removed riparian vegetation and contribute to deficiencies in LWD recruitment potential and shade. As indicated earlier, the near-term potential for riparian recruitment of LWD to streams is low across most of the lower subbasin.

4.5 Hatchery Programs

Hatchery programs for anadromous salmonids began operating in the Clackamas subbasin more than 100 years ago and have had a substantial influence on the subbasin's wild runs of fish. Descriptions of the earliest programs, which focused on spring and then fall Chinook salmon (Beamesderfer et al. 2001), raised substantial questions about the harm done to these runs. Recent programs within the subbasin are believed to be far more effective at returning adult fish, because of improvements in hatchery practices that began in the 1950s and 1960s. Hatchery programs within the subbasin have expanded to propagate Chinook salmon, coho salmon, and steelhead.

Hatchery produced spring Chinook and early-run coho smolts are released into the lower Clackamas subbasin each year. These programs have in the past focused almost exclusively on fishery augmentation, but are being modified to improve their consistency with ESA mandates for the conservation of natural-origin fish runs. All hatchery-origin salmon released into the subbasin are fin-clipped, allowing managers to screen any hatchery fish, other than a fraction with imperfect or regenerated fin clips, out of the upper basin run at North Fork adult ladder (near Faraday Diversion Dam). This fraction for spring Chinook has been as high as 26 percent at times as described above in 4.2.1.2.

There are also three hatchery stocks of steelhead that are currently released into the Clackamas River, early-winter (introduced), late-winter (native), and summer run (introduced). Since 1999, only unmarked steelhead (those presumed to be natural-origin) have been allowed to pass above North Fork Dam. The ODFW Clackamas Hatchery currently rears a late-winter run broodstock developed from unmarked winter steelhead at North Fork Dam. The Big Creek Hatchery stock of winter steelhead returns to the Clackamas River from October to early March, earlier than the February to June run timing of the native winter steelhead (Murtagh et al. 1992). Furthermore, the peak spawning period for Big Creek derived fish is January to early March compared with May and June for native Clackamas River winter steelhead

Hatchery summer steelhead that are released into the Clackamas River basin are fin-clipped and have been excluded from passage at North Fork since 1999. Prior to that time, these fish strayed to and spawned in streams within the upper subbasin that were used by wild winter steelhead (McElhany et al. 2007). The consequence for the wild late-winter fish was a reduction in productivity attributed to competition with the juvenile offspring of the summer steelhead (Kostow et al. 2003). The potential for hatchery summer steelhead to spawn and compete in streams with wild late-winter steelhead is still present in the lower subbasin and has not been studied.

4.6 Harvest

Recent harvest rates on the wild runs of ESA-listed anadromous salmonids in the Clackamas subbasin vary by species. Recently instituted marks-only regulations for the sport fishery and precautionary management of Columbia River commercial fisheries have lowered harvest mortality rates on the Clackamas subbasin's wild population of UWR (spring) Chinook from an average of about 55 percent prior to its listing under the ESA to approximately 20 percent today

(Chilcote 2007). The freshwater sport and commercial fisheries are causing about half of this mortality, with the remainder reflecting an assumption of harvest rates in ocean fisheries. Harvest rates on wild fall-run LCR Chinook, such as are found at very low abundance in the lower Clackamas at present are managed to stay below a maximum combined Rebuilding Exploitation Rate (RER) of 38 percent in all ocean and freshwater fisheries. Harvest-related mortality rates for the Clackamas' wild, late-run populations of coho salmon and winter steelhead are now below 30 percent and 5 percent, respectively (Chilcote 2007).

There is a very popular steelhead sport fishery on the Clackamas River. However, all hatchery steelhead are now fin-clipped and it is illegal to retain wild steelhead. Other than hooking mortality during catch-and-release, there appears to be little negative effect from harvest on wild LCR steelhead populations in the Clackamas.

4.7 Status of PCEs of Designated Critical Habitat in the Clackamas Subbasin

NMFS has determined that the following occupied areas of the Clackamas subbasin contain Critical Habitat for UWR Chinook, LCR Chinook, LCR Coho, and LCR Steelhead (NMFS 2005e; NMFS 2005b):

UWR Chinook (spring-run)

- Habitat of high conservation value for these fish, and thus important to their recovery, is present within five of the six watersheds within the Clackamas subbasin. This habitat includes 110.4 miles of PCEs for spawning/rearing, 18.7 miles of PCEs for rearing/migration, and 0.0 miles for migration/presence (NMFS 2005e). All five of the watersheds containing habitat of high conservation value were designated as Critical Habitat (NMFS 2005b), as listed below:
  - The Collawash River watershed contains 16.9 miles of spawning/rearing habitat and 0.2 miles of rearing/migration habitat (NMFS 2005e).
  - The Upper Clackamas watershed contains 23.7 miles of spawning/rearing habitat and 1.8 miles of rearing/migration habitat (NMFS 2005e).
  - The Oak Grove Fork watershed contains 4.0 miles of spawning/rearing habitat (NMFS 2005e).
  - The Middle Clackamas watershed contains 33.9 miles of spawning/rearing habitat and 3.3 miles of rearing/migration habitat (NMFS 2005e).
  - The Lower Clackamas watershed contains 22.9 miles of spawning/rearing habitat and 13.4 miles of rearing/migration habitat (NMFS 2005e).
- Habitat of low conservation value to UWR Chinook was not designated as Critical Habitat (NMFS 2005b). The Eagle Creek watershed was given a low conservation value to UWR Chinook and contains 13.8 miles of spawning/rearing habitat and 3.2 miles of rearing/migration habitat (NMFS 2005e).

LCR Chinook (fall-run)

- These fish are found in two watersheds within the Clackamas subbasin, Lower Clackamas River and Eagle Creek (NMFS 2005e).
- The Lower Clackamas River watershed contains habitat of high conservation value for LCR Chinook that was designated as Critical Habitat (NMFS 2005b). This watershed segment contains 34.8 miles of spawning/rearing habitat and 2.7 miles of rearing/migration habitat (NMFS 2005e).
- Habitat of low conservation value to LCR Chinook was not designated as Critical Habitat (NMFS 2005b). The Eagle Creek watershed was given a low conservation value to LCR Chinook and contains 13.8 miles of spawning/rearing and 3.2 miles of rearing/migration habitat (NMFS 2005e)

LCR Coho Salmon

- NMFS has not yet designated Critical Habitat for this evolutionary group of anadromous salmonids, although these fish are found throughout much of the lower Clackamas subbasin and in portions of the upper subbasin.

LCR Steelhead

- Habitat of high conservation value for these fish, and thus important to their recovery, is present within all six watersheds within the Clackamas subbasin. This habitat includes 263.3 miles of PCEs for spawning/rearing, 12.4 miles of PCEs for rearing/migration, and 2.8 miles for migration/presence (NMFS 2005e). The habitat in all of these watersheds, listed below, was designated as Critical Habitat for LCR Steelhead (NMFS 2005b).
  - The Collawash River watershed contains 34.0 miles of spawning/rearing habitat (NMFS 2005e).
  - The Upper Clackamas watershed contains 53.0 miles of spawning/rearing habitat (NMFS 2005e).
  - The Oak Grove Fork watershed contains 4.2 miles of spawning/rearing habitat (NMFS 2005e).
  - The Middle Clackamas watershed contains 45.6 miles of spawning/rearing habitat, 2.5 miles of rearing/migration habitat, and 0.4 miles of migration/presence habitat (NMFS 2005e).
  - The Lower Clackamas watershed contains 89.8 miles of spawning/rearing habitat and 9.9 miles of rearing/migration habitat, and 2.4 miles of migration/presence habitat (NMFS 2005e).
  - The Eagle Creek watershed contains 36.7 miles of spawning/rearing habitat (NMFS 2005e).

Table 4-8 summarizes the condition of PCEs within the Clackamas subbasin. All of the habitat indicators reflect sub-optimal conditions for salmon and steelhead.

Table 4-1 Critical habitat PCEs and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the Clackamas subbasin under the environmental baseline.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater migration corridors	Habitat Access	Physical Barriers	Up- and downstream fish passage conditions at the Clackamas River Hydroelectric Project are a key limiting factor for upper basin fish runs.	Hydroelectric dams and reservoirs
Freshwater migration corridors	Habitat Access	Physical Barriers	Culverts beneath road crossings of streams impair anadromous fish access to some historical habitats within the upper subbasin. Culverts beneath road crossings and other physical structures on streams in the lower subbasin impede or block anadromous fish movements into some historical habitats within the lower subbasin.	Forest roads Roads or other structures associated with forestry, agriculture, rural-residential land use, and urbanization
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/Hydrology)	Change in Peak/Base Flow	Naturally low summer flows are exacerbated in the lower subbasin by water withdrawals	Agricultural, rural-residential, municipal, and industrial development.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	The ODEQ 2004/2006 Integrated Report database identifies 68.7 stream miles as exceeding temperature criteria for core salmonid rearing (16°C), including segments of Bear Cr., Eagle Cr., and N.Fk. Eagle Cr. in the lower subbasin, and Collawash R. and Fish Cr. in the upper subbasin. The database also identifies a combined 25.5 miles of the lower Clackamas R. and Cow Cr. as exceeding criteria for general salmonids rearing (18°C). The ODEQ 2004/2006 Integrated Report database identifies 25.1 miles of Eagle Cr., Nohorn Cr., and Collawash R. as exceeding criteria for salmon and steelhead spawning (13°C)	Forest practices, agriculture, rural-residential development, and PGE hydroelectric reservoirs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as water quality impaired due to turbidity.	NA
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Contaminants/Nutrients	The ODEQ 2004/2006 Integrated Report database identifies a combined 52.0 miles of 8 streams in the lower subbasin as water quality impaired by high concentrations of E. coli bacteria. These include the lower mainstem Clackamas, Deep Cr., N. Fk. Deep Cr., Tickle Cr., Cow Cr., Barfield Cr., Rock Cr., and Sieben Cr. Nutrient levels are elevated in some streams within the lower subbasin but none are identified by the ODEQ database as being water quality impaired for this reason.	Livestock, agricultural, rural-residential, and municipal development.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to low dissolved oxygen.	NA
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to excessive TDG levels.	NA
Freshwater spawning sites	Habitat Elements	Substrate	Channel substrate conditions within the Clackamas subbasin reflect the cumulative effects of past watershed development and current land use. Elevated levels of fine sediments have the potential to limit salmonid production in the lower subbasin. Reservoirs above dams on the mainstem Clackamas River trap coarse sediment and block its delivery from the upper subbasin to the lower river. This has affected channel complexity and the availability of spawning gravels below River Mill Dam	Forest practices, road construction, and riparian alteration due to near-stream agricultural, rural-residential, and municipal development PGE hydroelectric dams and reservoirs

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Large woody debris (LWD) abundance and recruitment potential have been reduced along many streams, particularly in the lower subbasin where private lands predominate. Reservoirs above dams on the mainstem Clackamas River trap LWD and block its delivery from the upper subbasin to lower river. This has affected the complexity and quality of salmonid habitat in the lower Clackamas.	Forest practices, riparian alteration due to near-stream development, active wood removal PGE hydroelectric dams and reservoirs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Channel complexity, Off-channel Habitat, and Floodplain Connectivity.	Channel complexity and the availability of off-channel habitats important to juvenile salmonids has been reduced by reductions in LWD, direct channel alterations that have included USACE construction of revetments along the lower Clackamas River, reduced coarse sediment supply in the Clackamas River below River Mille Dam, and floodplain development.	Historic logging and use of streams for log transport Direct channel modifications Forestry, agriculture, rural-residential, and other development. USACE revetments PGE hydroelectric dams and reservoirs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Road density and location	Road densities are moderate to high across large portions of the Clackamas subbasin, and are generally highest in the lower subbasin.	Forestry, agriculture, rural-residential and other development.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves/Disturbance History	Forests in both the upper and lower portions of the subbasin have an abundance of early- to mid-successional stages, with many forestlands in the lower subbasin having been harvested at least two or three times. The lower subbasin is partially forested but is generally dominated by agricultural, rural-residential, municipal, or industrial land uses in lowland areas or where the topography is gentle.	Timber harvest Other land uses
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves /Disturbance	Riparian vegetation in both the upper and lower portions of the Clackamas subbasin is frequently in early- to mid-successional stages as a consequence of past human-caused disturbances. Conditions in the upper subbasin are improving, due to an increased focus on aquatic conservation by the U.S. Forest Service. Riparian conditions in the lower subbasin, particularly in areas of low topographic relief where agricultural, rural-residential, or municipal land uses predominate near streams are often poor. Opportunities for improvement may be limited in urbanizing areas.	Forest practices, agricultural practices, rural-residential development, and urbanization.

5. EFFECTS OF THE ACTION

"Effects of the action" refers to 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. Direct effects are considered immediate effects of the project on the species or its habitat. Indirect effects are those caused by the proposed action and are later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consultation. For the purposes of this BA, we do not differentiate effects to salmon and steelhead caused directly from individual bull trout translocated from the Metolius River from effects that occur from naturally produced bull trout either during project implementation or following.

If we are successful with this native fish restoration project and bull trout reestablish in the Clackamas River, there will be adverse effects to salmon and steelhead individuals (eggs, fry, juveniles) due to predation and interspecific competition in areas the species overlap. Although there is high likelihood bull trout will prey on salmon and steelhead juveniles, there is uncertainty regarding the overall population level effect predation and competition may have on the status and trend of anadromous salmonids in the Clackamas River, and their respective ESUs.

In addition to predation on, and competition with, anadromous salmonid juveniles, reintroducing bull trout to the Clackamas River will generate a response by other members of the aquatic community, namely from predation and competition for habitat and food resources. Predicting the likely response from a foodweb perspective is difficult due to the number of variables that contribute to foodweb dynamics. For example, bull trout will eat other predators that currently consume juvenile anadromous fish and eggs such as rainbow and cutthroat trout, mountain whitefish, and sculpin. In addition, foodweb dynamics are influenced by terrestrial organisms such as mammals and avian predators. Finally, there are additional uncertainties that will contribute to a foodweb response such as the carrying capacity (i.e., future population size) of the Clackamas River for bull trout, which is unknown and difficult to predict with precision, and locations in the watershed that will be utilized by bull trout for spawning, rearing, overwintering and foraging. Given the complexity of these relationships, and the dynamic nature of ecosystems, there is uncertainty whether the overall impact to salmon and steelhead at the population scale will be negative, positive or neutral.

It is important to assess the uncertainty regarding the effects of this action by using appropriate tools and methods, and then take steps necessary to reduce the uncertainty to an acceptable level while recognizing it cannot be eliminated entirely. In spite of the inherent challenges, there are multiple pathways by which we can assess the likelihood of negative impacts to salmon and steelhead from a reintroduction of bull trout in the Clackamas River. Our effects analysis relies on information on bull trout diet and feeding behavior, information from other watersheds where bull trout and anadromous salmonids coexist, an assessment of potential areas of vulnerability to salmon and steelhead from bull trout predation in the Clackamas River, and information and results from an expert science panel workshop that investigated potential effects to salmon and steelhead in the Clackamas River from a bull trout reintroduction. Lastly, our effects analysis also considers the management flexibility provided by the 10(j) non-essential experimental designation for reintroduced bull trout in the Clackamas and lower Willamette rivers.

5.1 Species Interactions

Current understanding of predator/prey relationships among bull trout and other species is limited, as is information on general interactions between bull trout and anadromous fish. Underwood et al. (1995) examined interactions among Chinook, steelhead, and bull trout. However, the life history strategy utilized by the bull trout population studied was resident (smaller sized fish at maturity) where piscivory was not the primary feeding strategy and no predator/prey relationships were noted. Instead the study focused on examining and confirming habitat partitioning among the three species, a trait common among species that evolve together. Habitat partitioning among sympatric species allows the utilization of different resources thereby reducing direct competition. This strategy was documented in several studies investigating interactions between bull trout and cutthroat trout (Marnell 1985; Nakano et al. 1992) and bull trout and rainbow trout (McPhail and Baxter 1996).

Although few studies have attempted to quantify bull trout predation impacts on sympatric fish species, the reputation of bull trout as an apex predator is not undeserved as there is an abundance of literature noting the aggressive piscivorous (i.e., fish eating) nature of this species. This reputation led to fish management actions that for many years included bounties, rotenone treatments, and trap and removal that ultimately extirpated many populations and in part led to the federal ESA listing of the species as threatened (Shively et al. 2007, Ratliff and Howell 1992). Despite these actions there were no attempts that the Service is aware of to quantify impacts of bull trout predation on anadromous or resident fish populations, relative to the array of other variables that determine population viability such as predation by other piscivorous fish, mammals or birds, sport and commercial angling, habitat conditions, migratory conditions, water quality and ocean conditions to name a few.

Bull trout are opportunistic feeders and prey on whatever fish species or aquatic organisms (e.g., crayfish, aquatic macroinvertebrates, etc.) are present and in the most abundance. In many rivers within the native range of bull trout, anadromous salmonids (including eggs, carcasses, juveniles) historically, and in many cases currently, constitute the most significant forage base for bull trout. Over the last century however, the decline in abundance and distribution of anadromous salmonids in many rivers in the western United States has likely led to a forage base shift by bull trout to other fish species. The reduction, and in many cases complete loss of anadromous salmonids within portions of the range of bull trout, has had unknown consequences. In some areas other species may have filled the niche previously occupied by anadromous fish and bull trout may not have been negatively affected. Conversely, the forage base in other areas may not have been replaced by other species and bull trout populations may have responded accordingly by reductions in abundance and distribution.

Within the native range of bull trout, many populations historically and currently overlap with the distribution of anadromous salmon and steelhead. In Oregon, bull trout, Chinook salmon and steelhead trout co-occur in a number of rivers including the McKenzie (Willamette River Basin), Hood, John Day, Deschutes rivers, the Wenaha, Minam, Lostine and other tributaries of the Grande Ronde River in northeast Oregon, and in the Walla Walla and Umatilla rivers. The status of salmon, steelhead, and bull trout in each of these river systems ranges from healthy to depressed. Although we are not aware of any studies assessing interactions between bull trout

and anadromous fish in these watersheds, we are also unaware of any studies that identify bull trout as a limiting factor in the status of salmon and steelhead populations these rivers.

Reintroducing bull trout would add to the already highly diverse assemblage of fish species, native and nonnative, found in the Clackamas River subbasin. The Clackamas River supports naturally reproducing populations of early and late-run stocks of coho salmon (*O. kisutch*), spring Chinook salmon (*O. tshawytscha*), and winter steelhead (*O. mykiss*), all of which are federally listed as threatened under the ESA. A small, remnant run of federally listed fall Chinook salmon utilize the lower Clackamas River and a small population of sea-run coastal cutthroat trout also persists in this part of the subbasin. The upper subbasin, above PGE's North Fork Dam, is managed as a wild fish sanctuary and all anadromous salmonids identified as hatchery origin (i.e., those that are adipose fin clipped), are captured at the North Fork Dam fish trap and prevented from migrating past the dam. Pacific lamprey (*Lampetra tridentata*) also occur upstream of North Fork Dam. Downstream of North Fork Dam, hatchery produced spring Chinook, coho, and winter and summer steelhead juveniles are released each year at a number of locations.

Other fish species present throughout the subbasin include resident and fluvial coastal cutthroat trout (*O. clarki clarki*), rainbow trout (*O. mykiss*), non-native brook trout (*Salvelinus fontinalus)*, non-native brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), Pacific lamprey, sculpin (*Cottus sp.*), mountain sucker (*C. platyrhynchus*), longnose dace (*Rhinichthys cataractae*), western brook lamprey (*L. richardsoni*), northern pikeminnow (*Pytchocheilus oregonensis*), chisel mouth (*Acrocheilus alutaceus*), redside shiner (*Richardsonius balteatus*), threespine stickleback (*Gasterosteus aculeatus*), and peamouth (*Mylocheilus caurinus*). Introduced exotic fish species, such as bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), brown bullhead (*Ameiurus nebulosus*), American shad (*Alosa sapidissima*), smallmouth bass (*Micropterus dolomieu*) and other species are encountered in some habitats in the lower watershed below Rivermill Dam (Murtagh et al. 1992).

Historically, juvenile anadromous fish (salmon and steelhead), along with eggs and carcasses of anadromous fish, likely comprised a significant component of the forage base for bull trout in the Clackamas River, as did other native fish such as sculpin, dace, whitefish, suckers and resident rainbow and cutthroat trout. Due to the significant reduction in the abundance of salmon and steelhead in the Clackamas River, reintroduced bull trout would be expected to rely heavily on the resident native fish community. While specific information on the relative abundance and distribution of resident native fish is generally lacking, we presume these populations to be relatively healthy based on watershed conditions in the upper Clackamas River (Shively et al. 2007).

Potential predation and competition impacts to the three species of threatened salmon and steelhead in the upper Clackamas River were identified as a concern during project scoping. In anticipation of this concern, the Service, in July 2008, sponsored an expert science panel workshop to assess potential impacts of a proposed bull trout reintroduction on ESA-listed salmon and steelhead in the Clackamas River. The panel consisted of five experts on bull trout and salmonid biology and ecology, food web dynamics, and population viability modeling. The workshop also solicited expert opinion on critical monitoring and management actions to reduce

uncertainty and risk to salmon and steelhead from a reintroduction of bull trout. The results from this workshop are summarized in Section 5.5 below.

5.2 Bull Trout Diet and Feeding Behavior

Large bull trout are widely recognized as predators of fish but because of their diverse life history forms (resident, anadromous, fluvial, and adfluvial) and habitats that range from small mountain lakes to large turbid, northern Canadian rivers, it is difficult to generalize about food preferences of these char (Budy et al. 2004; Goetz et al. 2004; Johnston 2005; McPhail and Baxter 1996; Post and Johnston 2002; Wilhelm et al. 1999). Bull trout appear to be opportunistic in their feeding behavior, and prey items range from midges to small mammals. Another element in bull trout feeding behavior is their increased activity during periods of low light (Goetz et al. 2004, Muhlfeld et al. 2003). For example, hydro-acoustic surveys of Lake Chester Morse by the Seattle Water Department indicated peak activity on dark, moonless nights and little activity by bull trout during the day (McPhail and Baxter 1996). Bull trout generally appear to be most visible at night during snorkeling surveys and during day time far fewer bull trout are typically visible (Spangler and Scarnecchia 2001; Peterson et al. 2002).

5.2.1 Juvenile Diet and Feeding Behavior

During night snorkeling in Idaho, Spangler and Scarnecchia (2001) found age-0 bull trout rearing in shallow, low velocity stream margin habitats in the summer. A possible advantage listed for summer shallow water feeding by small juvenile bull trout (less than 66 mm) was avoiding encounters with larger piscivorous bull trout and other aquatic predators. Fraley and Shepard (1989) also found young-of-the-year bull trout distributed more often along stream margins and in side channel locations in the Flathead River Basin, feeding on *Diptera* and *Ephemeroptera* aquatic invertebrates. Another Idaho study reported juvenile bull trout (70-170 mm) using pools more frequently than riffle habitat.

Juvenile bull trout are generally consumers of aquatic insects (Goetz et al. 2004; Budy et al. 2004; Fraley and Shepard 1989). Fraley and Shepard (1989) found that bull trout greater than 110 mm in the upper Flathead River consumed small trout and sculpin. Underwood et al. (1995) found bull trout (less than 200 mm) from three southeast Washington streams feeding on a wide range of food sources including mayfly nymphs, midge larva, rainbow trout, and frogs.

5.2.2 Sub-adult Diet and Feeding Behavior

In general, juvenile and sub-adult fluvial and adfluvial bull trout start to migrate to larger river or lake habitats after age-2 or 3 and begin feeding on larger prey with fish becoming an increasing part of their diets (Pratt 1992; Ratliff and Howell 1992). Ratliff et al. (1996) found most Metolius River bull trout spawned for the first time at age 5 and were at least 450 mm long. Some Metolius River bull trout did not become adfluvial but reared in the river system in a fluvial life history pattern and spawned earlier at age-4. Some of the age-2 and older bull trout in

the Metolius River system did not continue to disperse downstream from early juvenile rearing habitats but instead moved into adjacent warmer tributaries not utilized by bull trout for spawning. Ratliff et al. (1996) suggests that bull trout movement into these warmer tributaries is apparently for feeding opportunities on abundant sculpin.

In the upper Flathead River in winter, sub-adult bull trout (less than 400 mm) were observed concealed in deep pools and runs during daylight. At night these same fish were observed leaving the former habitats and utilizing shallow, low-velocity stream margin habitats during full darkness. The observers believed that these sub-adult bull trout were feeding on juvenile mountain whitefish or other small fish found in the shallow margin habitat (Muhlfeld et al. 2003). In the Flathead River, areas with concentrations of yearling whitefish often were the same locations where sub-adult bull trout were captured (Pratt 1992).

The opportunistic feeding behavior of sub-adult bull trout also apparently includes cannibalism of bull trout fry and juveniles (Goetz 1989, Post and Johnson 2002). Observations by Horner in 1978 of bull trout actually digging into the stream substrate to prey on juvenile bull trout and cutthroat was cited in Spangler and Scarnecchia (2001). In the South Fork Walla Walla and North Fork Umatilla rivers, the rate of bull trout cannibalism was found to be relatively high (Budy et al. 2004) despite information suggesting that bull trout in both systems feed on a high proportion of aquatic insects. In Lake Billy Chinook, as much as 10 percent of identifiable prey in sub-adult bull trout stomachs, were cannibalized smaller bull trout (Beauchamp and Van Tassel 2001).

5.2.3 Adult Diet and Feeding Behavior

Goetz et al. (2004) stated that large adult, migratory bull trout are “apex predators” that feed opportunistically based on what food items are most available at any one time or location. This may include cannibalism of other bull trout by larger adults (Beauchamp and Van Tassel 2001, Spangler and Scarnecchia 2001). In northern Canada, large adult bull trout are found in big turbid rivers such as the mainstem Peace and Laird rivers, feeding as wandering fluvial migrants. McPhail and Baxter (1996) presumed that the small numbers of widely scattered, large bull trout (some exceeding 900 mm) in these northern mainstem rivers was attributable to their position as top predators in these riverine habitats, where their diet includes suckers, grayling, red backed voles and mice.

Adult bull trout diets can differ greatly depending on the ecosystems and locations they are found in. In Alberta’s Harrison Lake, where bull trout are the only fish present, their diet was primarily small insects and zooplankton, even for adults (Wilhelm et al. 1999). Other evidence suggests that adult bull trout change their diet as prey abundance varies. The large adfluvial bull trout of Lake Billy Chinook in Oregon, have a diet largely of fish, with kokanee salmon and other salmonids (including whitefish) showing the highest percentages as prey items. Longnose dace, sculpins, and suckers were also prey species regularly selected. In autumn, bull trout in Lake Billy Chinook prey heavily on age-2 and age-3 kokanee salmon, while in summer adult bull trout primarily consume mountain whitefish (Beauchamp and Van Tassell 2001). Goetz et al. (2004) in studies of anadromous bull trout in Puget Sound reported, “…anadromous bull trout opportunistically utilize forage fish species (surf smelt, Pacific herring, and Pacific sand lance)

almost exclusively when they are present in the nearshore marine environments." Goetz et al. (2004) further concluded that bull trout feeding habits vary according to prey abundance, season, size, and competition, and that bull trout will adjust to utilize the prey sources that are available.

5.2.4 Skagit River Bull Trout Study

Lowery (2009) investigated trophic relationships and seasonal effects of predation on Pacific salmon by fluvial bull trout in a riverine food web. The objective of the study, which combined two years of field sampling of bull trout diet, distribution and growth along with stable isotope analysis and bioenergetics modeling, was to determine the annual and seasonal energy budgets of bull trout and to estimate their potential predation impacts on juvenile salmon and steelhead. The study occurred on the Skagit River, home to one of the region's largest bull trout and Chinook salmon populations, as well as populations of steelhead trout, sockeye, coho, pink, and chum salmon. Pink salmon and chum salmon populations in the Skagit River are among the largest in the lower 48 states. The study reach extended 40km downstream from the lowest-most dam associated with Seattle City Light's hydroelectric project on the Skagit River roughly to its confluence with the Sauk River, and included two tributaries utilized by bull trout for spawning. During the 2007/2008 study period, Lowery estimated approximately 1,600 bull trout greater than 300mm existed within the study reach.

Lowery found that age 1 and 2 bull trout present in tributaries of the Skagit River consumed primarily aquatic invertebrates. After shifting to the mainstem Skagit River at age 3 and 4, bull trout derived a large portion of their energy budget from salmon eggs and carcasses although juvenile salmon, resident fishes and aquatic insects were also important components of their annual energy budget. The top five contributors to annual bull trout diets for fish > 300mm were: 1) Pacific salmon carcass flesh; 2) fish eggs, primarily Pacific salmon; 3) resident fishes, primarily sculpin and dace; 4) aquatic invertebrates; and, 5) Pacific salmon fry/alevins. The impact of predation was found to be relatively low for all Pacific salmon with the exception of steelhead trout. Predation levels on steelhead trout juveniles were found to be significant enough to likely be impacting adult returns to this reach of the Skagit River.

The Skagit study provides information on the diversity and seasonality of diet and energy consumption for a fluvial bull trout population. The study also provides evidence that under certain scenarios, bull trout predation may cause population level impacts on certain species of Pacific salmon. However, there are significant differences between the Skagit River and the Clackamas River in terms of the diversity and abundance of Pacific salmon that warrants caution in making direct correlations regarding likely effects to salmon and steelhead from a bull trout reintroduction. The Skagit River, while harboring several stocks of threatened salmon, also contains other healthy stocks that number in the hundreds of thousands in adult returns. As a result, the forage base for bull trout in the Skagit River, while still showing considerable contributions by resident fishes and aquatic insects, is significantly weighted towards Pacific salmon eggs, carcasses and juvenile fish. In contrast, while steelhead and salmon populations in the Clackamas River are among the healthiest in their respective ESUs, current abundance is much reduced from historic and likely comprises a much lower percentage of the available forage base as compared to the anadromous forage base in the Skagit River. As a result, we

expect the annual energy budget of bull trout reintroduced to the Clackamas River will be skewed towards more readily available aquatic insects and resident fishes.

5.2.5 Piscivory by Other Native Fish Species

Bull trout consume other fish that are capable themselves of being piscivorous predators. Sculpin, rainbow trout, cutthroat trout and other anadromous salmonid species of the Clackamas River are also piscivorous and are known to consume other fish, including anadromous salmon fry and juveniles. During USFS smolt trapping in the Clackamas in 2007, wild coho and steelhead smolts were documented preying on coho salmon fry (Tom Horning, biologist, USFS, personal comm., 2007). In California, Chinook salmon fry have been known to be eaten in large numbers by yearling coho outmigrants. In some locations coho less than 30 mm were heavily preyed upon by torrent sculpins (Groot and Margolis 1991). Mobrand et al. (2005) in a review of hatchery effects on natural fish populations, determined that yearling hatchery coho, stream-type Chinook, and steelhead smolts are the most likely predators on wild salmonid fry because of their larger size when released.

Lowery and Beauchamp (2010) investigated the current food web of the upper Clackamas River in order to establish a baseline ahead of the bull trout reintroduction and to specifically aid future monitoring of impacts to anadromous salmonids. They reported low levels of piscivory by juvenile coho salmon, hatchery and native rainbow trout, coastal cutthroat trout, brown trout, and sculpin. Sculpin, mountain whitefish, juvenile Chinook salmon, and largescale suckers represented the most common fish prey. Additional information on this study is presented in section 2.9.3.1 of this BA.

5.3 Clackamas River Forage Base and Importance of Anadromous Prey Base

Bull trout are opportunistic feeders and when reintroduced to the Clackamas River would likely prey on a variety of native and nonnative fish species. In many locations, mountain whitefish are a preferred bull trout prey species and in the Clackamas River watershed, adult mountain whitefish are common in large pool habitats of the Clackamas and Collawash rivers (Murtagh et al. 1992, Ratliff 2003, Beauchamp and Van Tassel 2001, Pratt 1992, Bergamini 2005). Largescale suckers are also common in larger pool habitats in this watershed (Bergamini 2005). Large numbers of anadromous salmonids rear as pre-smolts in the upper Clackamas River. The five year average for smolt outmigrants annually passing North Fork Dam (all anadromous species 2001-2005) was 139,152 smolts (PGE 2001, 2002, 2003, 2004, 2005). Older juvenile, subadult, and adult bull trout would be expected to prey upon rearing juvenile anadromous salmonids. Coastal cutthroat trout, rainbow trout, sculpin, and a diverse assemblage of aquatic macroinvertebrates are found in abundance in many of the smaller tributary streams within the Clackamas River subbasin and would likely be preyed upon by bull trout. North Fork Reservoir is stocked annually with approximately 70,000 non-native hatchery rainbow trout, representing an additional forage base for older life stages of bull trout if they utilize this habitat.

Lowery and Beauchamp (2010) reported that sculpins represented the greatest fraction of fish biomass in all lotic habitats sampled in the upper Clackamas River subbasin in 2009 and 2010, suggesting that current conditions are more favorable for cottids than salmonids. The other most

abundant species that would be available for prey in lotic habitats included juvenile salmon, cutthroat trout, and rainbow trout. These species, along with mountain whitefish and largescale suckers, would represent the forage base in the upper mainstem Clackamas River and North Fork Reservoir. Additional information on this study is presented in section 2.9.3.1 of this BA.

Bull trout coexisted with many other native fish species in the Clackamas River for thousands of years, likely feeding on a variety of different species. Historically, anadromous Pacific salmon were likely the most abundant fish in the subbasin and they probably comprised a significant portion of the bull trout diet. However, current abundance and distribution of anadromous salmon in the subbasin is reduced from historic levels. In the Clackamas, bull trout may be more dependent upon other native species as a prey base, such as mountain whitefish and largescale sucker, both of which are present and abundant, along with other potential prey such as dace, sculpin, cutthroat and rainbow trout. Information on bull trout populations from other areas in the lower Columbia River Basin suggests that, while likely important, bull trout persistence is not dependent upon the presence of anadromous salmon.

5.4 Geographic Areas of Vulnerability for Salmon and Steelhead

As described in the Environmental Baseline, PGE owns and operates the Clackamas Hydroelectric Project, a system of three dams beginning with Rivermill Dam at river mile 23 extending upstream to North Fork Dam at river mile 30. Fish passage facilities that PGE has constructed and maintained at their dams on the mainstem Clackamas River provide anadromous fish access to all historically occupied streams above River Mill Dam. PGE's fish passage facilities are currently, or will soon be, upgraded per the terms of the Clackamas Settlement Agreement and PGE's new license, expected to be issued by FERC in 2010. These upgrades, along with changes in flow management and habitat improvements also associated with the new FERC license, are expected to significantly improve conditions for anadromous salmonids over baseline conditions.

Upstream passage is accomplished via fish ladders at Rivermill and Faraday dams and downstream passage is accommodated via multiple routes including fish ladders, bypass pipes, spill, and entrainment through the project's turbines. All of these passage mechanisms concentrate fish unnaturally and thus increase their susceptibility to terrestrial, aquatic and avian predators. In addition, project reservoirs, particularly North Fork Reservoir, create unnatural habitats that are significantly utilized for rearing and overwintering by anadromous juvenile salmonids. Reservoir environments, while often providing good growth environments for juvenile salmonids, also unnaturally expose rearing and migrating juvenile salmonids to predators.

Although we cannot predict with certainty the dispersal and behavior of reintroduced bull trout in the Clackamas River, given the migratory nature of the species, a large fraction of the older life stages may seasonally utilize North Fork Reservoir and possibly other locations within or below PGE's Clackamas Hydroelectric Project. If that occurs, anadromous juvenile salmonids that are rearing within, or migrating through, PGE's project, may be impacted by bull trout in the following ways: 1) by predation within hydro project reservoirs, bypass facilities, fish ladders,

and tailraces; and, 2) failure to emigrate due to avoidance of fish bypass or collection facilities due to presence of bull trout (i.e., predator avoidance).

The areas of highest predation vulnerability for juvenile salmon and steelhead are the areas they are most concentrated, namely the forebay of North Fork Reservoir (specifically the fish bypass and fish ladder entrance at North Fork Dam) and possibly the outflow of the fish bypass pipe below Rivermill Dam (Figure 5-1). In 2015, a surface collector will be constructed at North Fork Dam, largely replacing the existing fish bypass facility. The new surface collector is expected to increase downstream passage efficiencies for juvenile salmon and steelhead, particularly for Chinook salmon which, during relicensing studies, were noted as having greater difficulty finding the downstream fish bypass than coho or steelhead. Salmon and steelhead juveniles in other areas of PGE's project, such as North Fork Reservoir, are expected to be less vulnerable to predation impacts due to reduced concentrations of individuals, and in the case of the area between North Fork Dam and River Mill Dam, reduced numbers of rearing and migrating juvenile salmonids since the majority are bypassed around the entire project and deposited below Rivermill Dam via the North Fork Collector Pipe. As noted above, the completion of the new surface collector at North Fork Dam in 2015 is expected to increase the passage efficiency for juvenile salmon and steelhead.

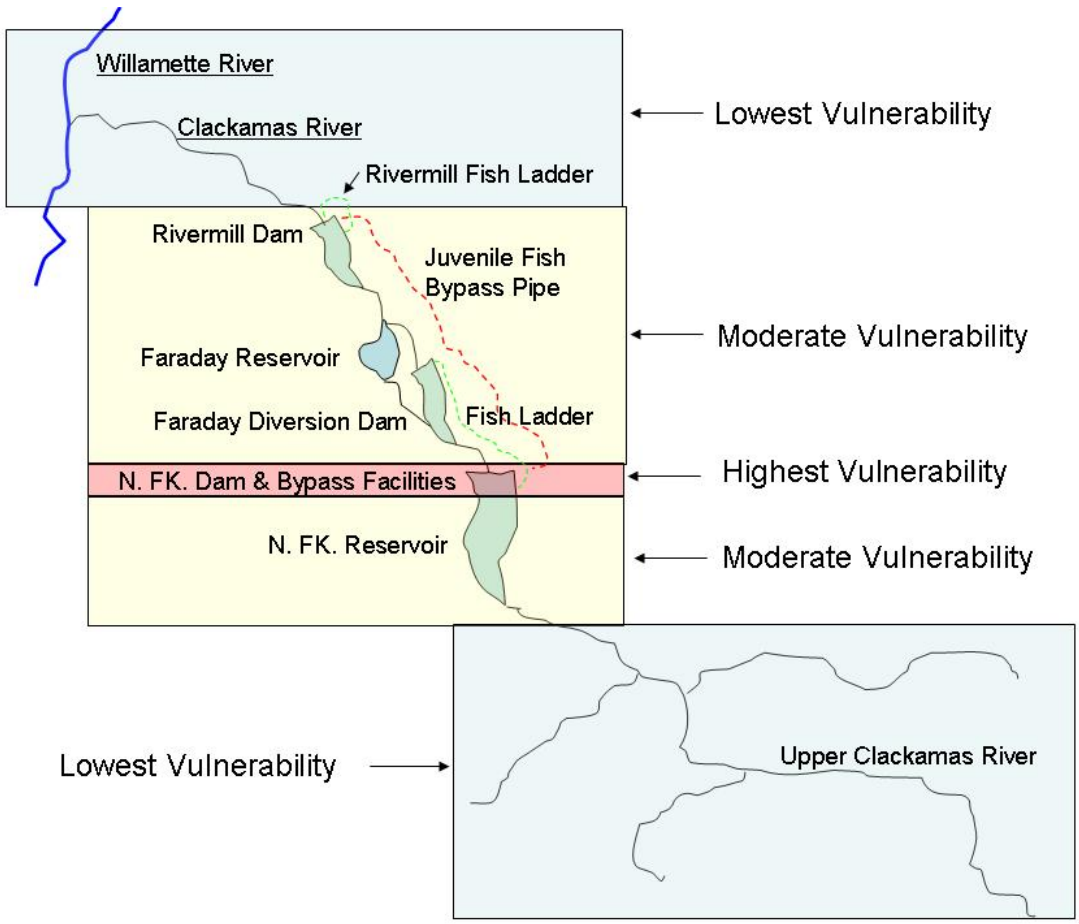


Figure 5-1 Areas of potential vulnerability to salmon and steelhead juveniles from bull trout predation in the Clackamas River

Although bull trout in the upper Clackamas River above North Fork Reservoir are anticipated to prey on juvenile salmon and steelhead as part of their forage base, vulnerability of anadromous juveniles, when compared to vulnerability in areas within PGE's project area, is likely to be lower due to greater prey diversity, greater habitat availability, and habitat partitioning in which sympatric species utilize different resources thereby reducing direct competition. This strategy was documented in several studies investigating interactions between bull trout and cutthroat trout (Marnell 1985; Nakano et al. 1992) and bull trout and rainbow trout (McPhail and Baxter 1996). Vulnerability to juvenile anadromous salmonids in areas below Rivermill Dam are also expected to be low when compared to areas within PGE's Project area, due to the limited suitability of habitat for bull trout, greater diversity of prey, and lower expected probability of occupation based on bull trout behavior in other populations in the lower Columbia River.

5.5 Expert Science Panel Workshop

Potential predation and competition impacts to four ESA listed salmon and steelhead populations in the Clackamas River were identified as a concern during project scoping. In anticipation of this concern, the Service, in July 2008, sponsored an expert science panel workshop to assess potential impacts of a proposed bull trout reintroduction on ESA-listed salmon and steelhead in the Clackamas River. The panel consisted of five experts on bull trout and salmonid biology and ecology, food web dynamics, and population viability modeling. The workshop also solicited expert opinion on critical monitoring and management actions to reduce uncertainty and risk to salmon and steelhead from a reintroduction of bull trout. The results from this workshop are fully presented in Appendix A of this BA, and are summarized below.

Expert judgment is often used as a source of information in the absence of, or to supplement, empirical research and statistically-sound studies. In ecology, expert judgment has always been sought for interpreting difficult or otherwise intractable problems in modeling, management, planning, and scientific understanding. Some examples include using expert opinion to evaluate an elk habitat model (Holthausen et al. 1994), to develop general faunal distribution models (Pearce et al. 2001), modeling rare species (Marcot 2006), evaluating adaptive management options (Failing et al. 2004), and many other applications.

Reaching consensus is typically the objective of expert panels convened by the National Research Council's programs for developing criteria for contract requests for proposals. Weisberg et al. (2008) found that consensus was possible for evaluating the condition of communities of benthic substrates. However, a consensus outcome of an expert panel does not provide information on the variation in expert judgment among the individual expert panelists. Nor does it provide for "outlier" opinions from experts that might not concur with the majority views.

For the Expert Panel Workshop, it was decided by the planning team that individual expertise, not consensus, was the objective of the paneling process, in large part because (1) the expert panel was to provide technical and scientific information to be later considered by decision-makers, and not specific consensus recommendations for management or a management decision per se, and (2) it was deemed of interest to determine the type and degree of variation *among* selected experts for the difficult questions posed.

Opening presentations.--The workshop was structured with an opening series of presentations to ensure that all expert panelists were equally informed on the following topics:

- the bull trout reintroduction program feasibility assessment and draft proposed action;
- the status and distribution of ESA-listed anadromous fish species in the Clackamas River and current recovery planning efforts;
- Portland General Electric's (PGE) hydro projects, reservoirs, and fish bypass systems in the Clackamas River system; and
- bull trout trophic interactions and food webs.

Model and discussion on trophic interactions and food web dynamics.--Also presented was a preliminary Bayesian network model depicting potential food web and species interaction dynamics relevant to relationships between bull trout, anadromous salmonids, and other predators and prey species in the river system. The model was presented to help prompt panel discussion on trophic and food web dynamics, including identifying key areas of uncertainty related to bull trout-salmonid interactions. The Bayesian network model was not used *per se* further in the workshop although the resulting discussions of trophic structure and food web dynamics were recounted and continued throughout the rest of the workshop.

Panel scoring of degree of impact of bull trout on salmonids.--On day two of the workshop, the expert panelists were engaged in a structured scoring of potential effects of bull trout on the extinction probability of each of the four ESA-listed salmon and steelhead populations of interest in the Clackamas River system: spring Chinook, fall Chinook, Coho, and winter steelhead. The instructions given to the panelists included that they were to (1) assume that bull trout reintroduction objectives would be met, that is, with at least 200-500 adult bull trout sustainable in the Clackamas River system by 2030, and (2) score the relative influence of bull trout on whatever absolute extinction probability might pertain to each salmon and steelhead population.

The scoring was conducted by using a modified Delphi paneling procedure. In brief, this procedure involved the panelists scoring how a bull trout reintroduction might influence each salmonid species, by each panelist spreading 100 points (thought of as probabilities) among one or more outcome categories of potential impacts. Spreading points would be an expression of uncertainty of outcomes and a means of displaying potential differences in outcomes among the salmonid species.

The Delphi paneling process entailed the panelists first individually and anonymously recording an initial set of outcome scores; then the panelists individually disclosing and explaining their scores to each other in a structured discussion, including an opportunity to engage with other observers and experts in the room; and then individually and silently rescoring outcomes based on new knowledge or insights gained from the shared disclosure and open discussion. The disclosure and discussion portion of the panel ensured that each panelist had equal time to present their ideas, seek clarification, and ask questions. The scores and discussion comments were recorded anonymously using letter codes (A-E) for each panelist. The scoring session encouraged the panelists to synthesize their own expert experience, the pre-workshop readings, the workshop presentations, and their shared interpretations and rationale.

The panelists were prompted to score the *degree of impact that bull trout would have on the extinction probability of each salmonid species over 100 years from the start of the reintroduction project*. The panel discussed an initially-presented 5 class system, did a first round of scoring, and then refined the classes and collectively agreed to use the following 7 categories and definitions for scoring potential bull trout impacts:

- **Very High** = bull trout influence contributes to 100% of the extinction probability
- **High** = bull trout influence contributes to about 95% of the extinction probability
- **Moderately High** = bull trout influence contributes to about 75% of the extinction probability
- **Moderate** = bull trout influence contributes to about 50% of the extinction probability
- **Moderately Low** = bull trout influence contributes to about 25% of the extinction probability
- **Very Low** = bull trout influence contributes to about 5% of the extinction probability
- **None** = bull trout influence has no contribution to the extinction probability

It was clarified to the panelists that they were to score only that portion of salmon and steelhead population extinction probabilities that would be caused by bull trout; they were not asked to score overall extinction probabilities. In this way, the relative impact contributed specifically by bull trout would be represented.

The results of the panelists' scoring of possible degree of impact of bull trout on salmonid probability of extinction ranged from moderately high impact to no impact at all. The mode of overall score values suggested that impact was viewed by the panelists in general to be very low or moderately low for spring Chinook, coho, and winter steelhead; and mostly none to very low for fall Chinook. However, some possible outcomes ranged into higher categories of impact but with far lower score levels.

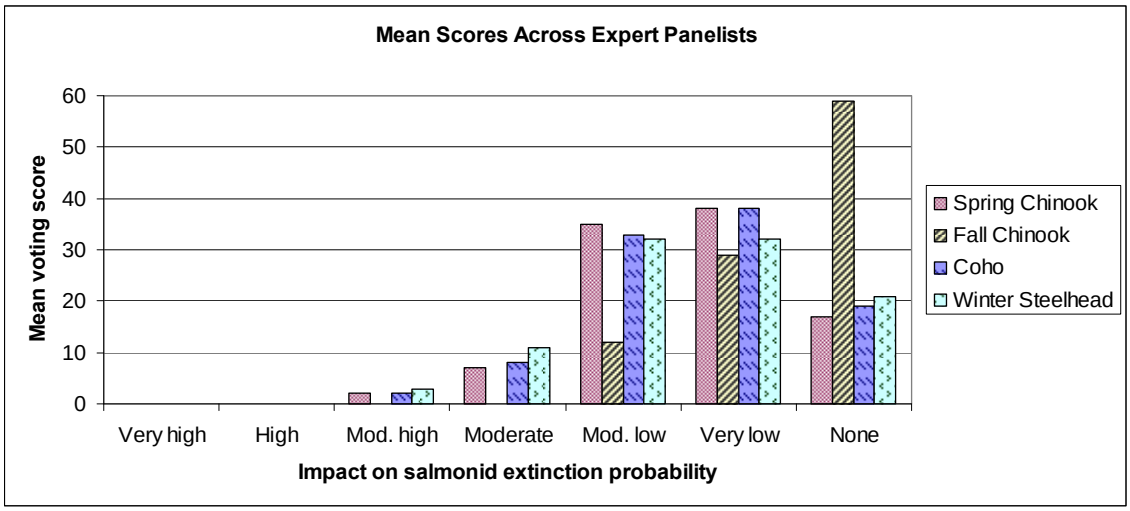


Figure 5-2 Mean scores of the potential impact of bull trout on salmon and steelhead population extinction probability.

These distributions of composite scores across the outcome categories for each species can be interpreted as expected probability distributions. Outcomes that scored with few points are still possible, according to at least some of the panelists, even if the probability of those outcomes is low. Figure 5-2 suggests that the panelists generally rated bull trout impacts on extinction probabilities of salmon and steelhead populations as "moderately low," "very low," or even "none." Also, the mean scores suggested that the panelists in general considered bull trout impacts on salmon and steelhead extinction probability to be lower for fall Chinook than for the other three populations. A different way to visualize these patterns is by summing the panelists' scores by species (Fig. 5-3 below):

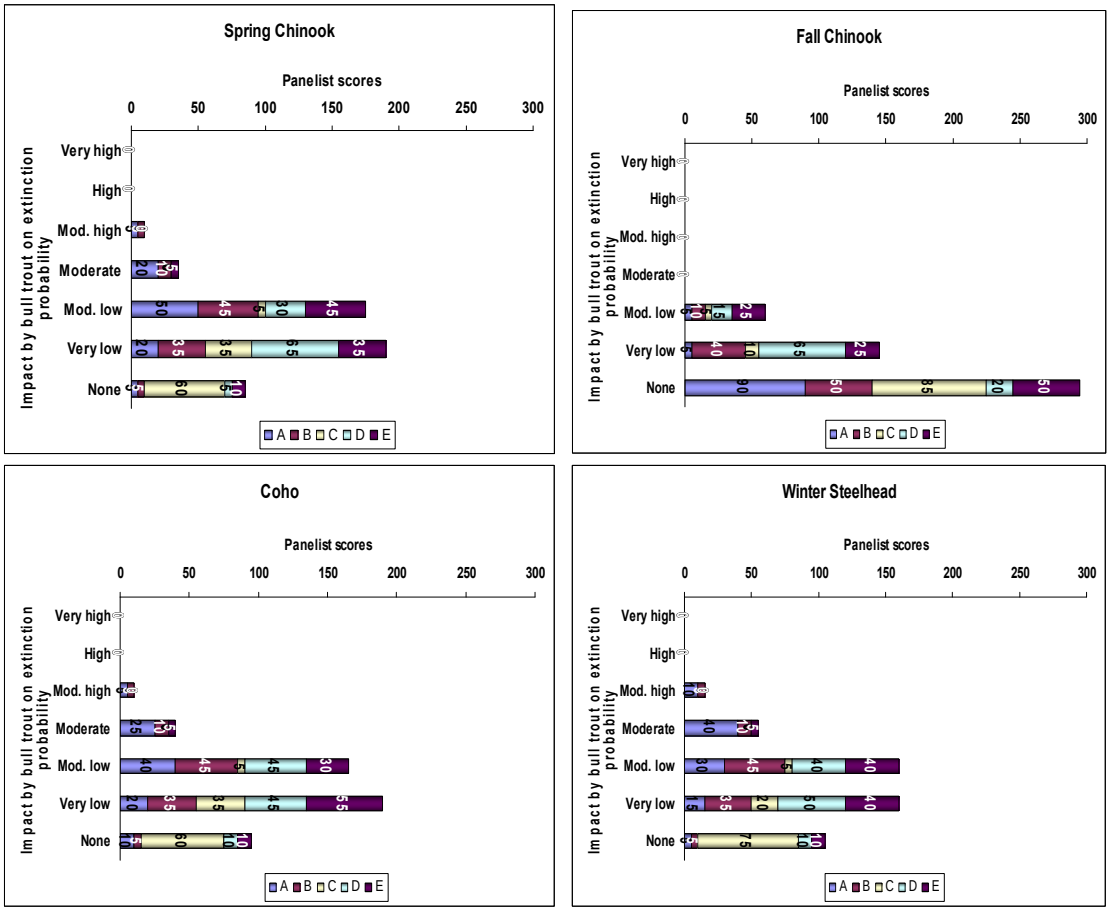


Figure 5-3 Sum of scores of the potential impact of bull trout on salmon and steelhead population extinction probability, across the 5 panelists (A-E) and by salmonid species.

Summarized in this way, it is more apparent that the panel generally expected lesser impacts from bull trout on fall Chinook than on the other three salmon and steelhead populations. The panel as a whole allocated most of their scores to "None" and "Very low" outcomes for fall Chinook, and most of their scores to "Very Low" and "Moderately Low" for the other three salmon and steelhead populations, with lower score levels allocated to "None," "Moderate," and "Moderately high." These distributions of composite scores across the outcome categories for each species can also be interpreted as expected probability distributions. Outcomes that scored with few points are still possible, according to at least some of the panelists, even if the

probability is low (e.g., panelists generally predicted a less than one in ten chance that bull trout would have a moderate to moderately high impact on salmonid extinction probability for spring Chinook, coho, and steelhead).

It should be reiterated that we did not ask the panelists to reach consensus on their scoring. Thus, it is also instructive to view the individual panelists' degrees of uncertainty and variation among the salmon and steelhead populations considered, across the various outcome categories, and among the individual panelists, as shown in Figure 5-4 below.

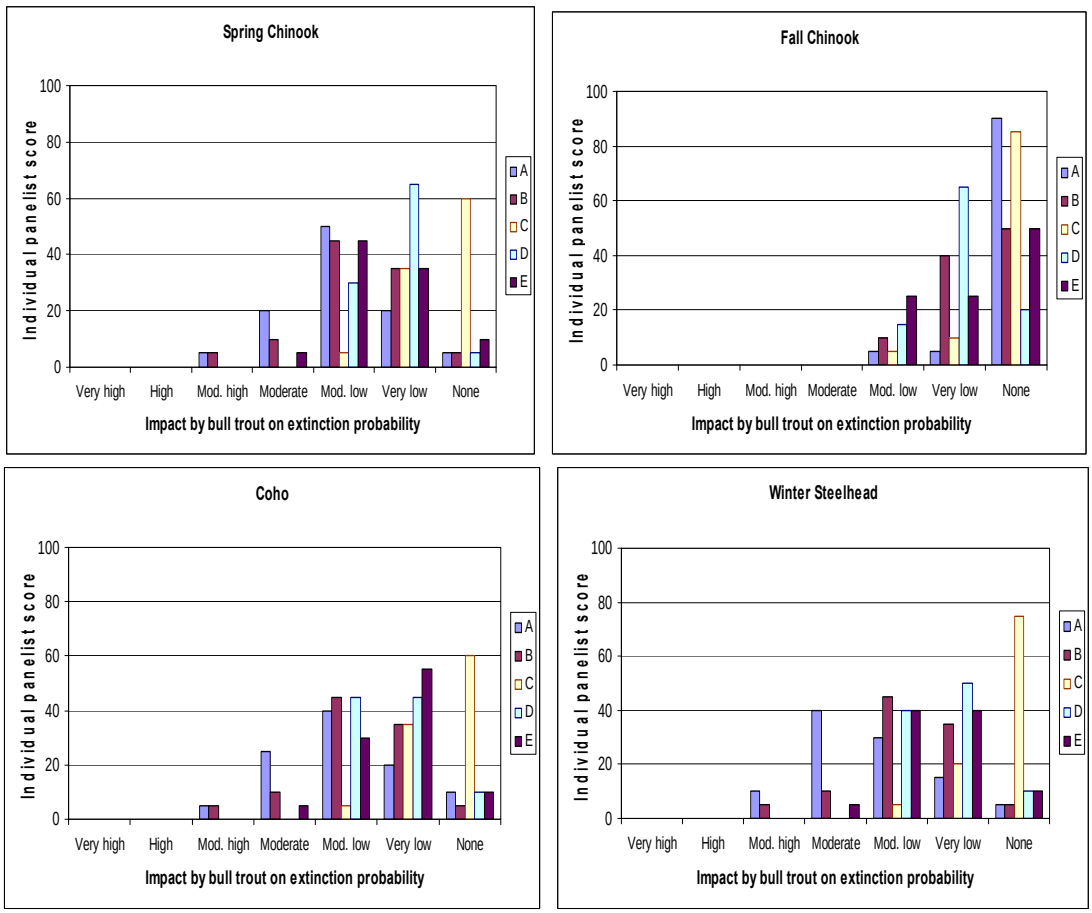


Figure 5-4 Individual panelist scores of bull trout impact on salmon and steelhead populations after 100 years of bull trout reintroduction. Legend: A-E represents the individual panelists.

Figure 5-4 suggest that (1) each panelist expressed some degree of uncertainty over the possible impact of bull trout on extinction probability of each salmon and steelhead population, suggested by the spread of scores across multiple outcomes; and (2) although the panelists differed in their specific score values, they concurred by not scoring bull trout impact on any population as "very high" or "high," with modes mostly in the categories of "moderately low" to "none."

5.6 Monitoring, Adaptive Management, and Flexibility under 10(j) Designation

Our proposed action (Chapter two) contains three critical components that will limit adverse effects to threatened salmon and steelhead from the bull trout reintroduction project. First, we have developed, and are committed to, a robust monitoring and evaluation program (Section 2.9) to determine whether we are meeting the project's goals and objectives, including limiting impacts to salmon and steelhead. Second, the information gained through our monitoring and evaluation program will feed into the adaptive management framework outlined for the project (Section 2.10), furthering our effectiveness with project implementation and ensuring if negative impacts to salmon and steelhead are identified, appropriate management actions are taken. Lastly, the 10(j) designation, under which the reintroduction will be implemented, will allow significant flexibility to manage the reintroduced bull trout population, and the ability to carry out management actions to address project-related impacts to salmon and steelhead (Section 2.7). For example, and as noted previously in the proposed action, individual bull trout identified as staging and foraging in areas of high vulnerability for salmon and steelhead (e.g., entrance to, within or immediately below fish bypass facilities) will be removed under the guidance provided in the decision framework presented in Figures 2.5 through 2.8, in Section 2.10.1. If over time, significant population level impacts to salmon and steelhead are identified, and attributed with a high level of certainty to bull trout (worst-case scenario), the reintroduction project will be terminated, and if supported by the management committee, action taken to actively remove all bull trout from the Clackamas River subbasin.

5.7 Scientific Take Associated with Monitoring

As noted in the proposed action, the effectiveness monitoring associated with the bull trout reintroduction project is expected to result in the limited take of juvenile salmon and steelhead. This take is expected to be generally non-lethal in nature, caused by surveys for bull trout in areas bull trout and anadromous salmonids overlap. Monitoring methodologies may include: minnow trapping, backpack electroshocking, snorkeling, dip-netting, seining, redd surveys, and trapping via a rotary screw trap. Methodologies for monitoring older life stages will include snorkeling, radio telemetry, mobile and stationary PIT tag antennas. Given that bull trout surveys will likely be concentrated in headwater areas of the Clackamas subbasin, upstream from most anadromous juvenile rearing areas, we expect impacts from this take to be extremely limited with lethal take anticipated to be less than one percent of fish handled.

5.8 Summary of Effects to Listed Salmon and Steelhead and Critical Habitat

In our assessment of direct and indirect effects from the proposed action, we identified the likelihood of predation of eggs, fry, and juvenile salmon and steelhead by bull trout, and competition between bull trout and anadromous salmonids for food resources and habitat. Avoidance of downstream fish passage facilities may constitute additional effects to juvenile salmon and steelhead if bull trout stage or forage near these facilities or other PGE hydro project features that concentrate migrating juveniles (smolts).

While adverse effects to salmon and steelhead individuals (eggs, fry, juveniles) are expected due to bull trout predation and competition, direct population level effects (often measured by adult returns), and by extension ESU/DPS effects, are not expected for the following reasons:

Low extinction risk: While the ESU's and DPS to which the Clackamas River salmon and steelhead populations belong are at high risk of extinction, the Clackamas specific populations (with the exception of the LCR fall Chinook) are ranked at low risk of extinction, reflecting the relative health of these populations compared to others in the ESU/DPS (Table 5-1 below). The low risk of extinction for these populations suggests the Clackamas River may be one of the best places, in terms of risk, to pursue a reintroduction of bull trout to historic habitat within the LCR and UWR ESU/DPS region. In addition, the multitude of actions to be carried out under the new FERC license that was issued in 2010 to PGE (e.g., fish passage, flow, water quality, habitat restoration) are expected to significantly benefit the recovery of listed populations of salmon and steelhead in the Clackamas River (NMFS 2010).

Complexity of foodweb: Food web dynamics are complex and difficult to predict. Populations of salmon and steelhead in the Clackamas River are currently impacted by an array of aquatic, terrestrial and avian predators, and the impact of another predator in the foodweb (bull trout) does not necessarily translate to an "additive" impact to salmon and steelhead individuals (eggs, fry, juveniles). As noted in section 5.1 above, reintroduced bull trout will likely rely heavily on the native resident fish component in the Clackamas River and will prey on current aquatic predators of salmon and steelhead individuals (i.e., coastal cutthroat trout, rainbow trout, brown trout, sculpin).

Very-low to moderately-low extinction probably from a bull trout reintroduction: As detailed in section 5.5 above, the expert science panel workshop to assess impacts of a bull trout reintroduction on salmon and steelhead extinction probabilities in the Clackamas River determined there was none to very-low extinction risk to LCR fall Chinook in the Clackamas River, and very-low to moderately-low extinction risk for the remaining three species of listed salmonids in the Clackamas River (Table 5-1 below). In general, the expert panelists predicted a less than one in ten chance that bull trout would have a moderate impact and a one in fifty chance of a moderately high impact on extinction probability for spring Chinook, coho and steelhead.

Monitoring and evaluation program to assess impacts: As noted in Section 2.9 of the proposed action, we propose to closely monitor and evaluate the reintroduction project, including a monitoring component developed specifically to assess impacts to salmon and steelhead populations. We have developed this monitoring component with the intent of reducing uncertainty and informing future management decisions associated with the bull trout reintroduction program. As decribed in Section 2.9, to assess impacts to listed anadromous salmonids we propose to: 1) determine if adult and subadult bull trout occupy areas within the PGE hydro project during periods in which they could consume particularly high numbers of rearing or migrating juvenile salmon and steelhead; 2) if so, determine if survival rates of listed anadromous salmonid juveniles rearing in, or moving through the PGE hydro-project area change; and, 3) if survival rates of listed anadromous salmonids juveniles decline, determine the degree to which bull trout are responsible for the decline by utilizing field data, bioenergetics and life-cycle monitoring.

As outlined in 2.10, adaptive management will guide how the reintroduction project is implemented on an annual basis. The primary tool to accomplish adaptive management is monitoring. The monitoring of impacts to salmon and steelhead will provide valuable information that will inform how the project is implemented in future years, including numbers, life stages, and release locations of bull trout, as well as the disposition of individual fish should they be documented or observed staging near, within or immediately below juvenile salmonid bypass systems.

Adaptive Management and the 10(j) non-essential experimental designation: The 10(j) designation will allow for significant management flexibility for the reintroduced bull trout population. If bull trout are documented staging at the entrance of fish collection facilities, within fish bypass systems, or at the outflow of a fish bypass, we will attempt to remove those individuals. If the monitoring and evaluation program suggests bull trout are having a population level impact on salmon and steelhead, management actions allowable under the 10(j) nonessential experimental designation, and under the adaptive management guidance and decision framework (Figures 2.5 through 2.8, Section 2.10.1), will be implemented to reduce or eliminate the impact. We fully anticipate the adaptive management of the project, implemented under the flexibility afforded by the 10(j) designation, will allow for the appropriate management action to reduce unanticipated impacts if they occur. As noted above in Section 5.6, if over time, significant population level impacts to salmon and steelhead are identified, and attributed with a high level of certainty to bull trout (worst-case scenario), the reintroduction project will be terminated, and further, if supported by the project's Manager's Committee, action taken to actively remove all bull trout from the Clackamas River subbasin.

5.8.1 Upper Willamette Spring Chinook Salmon

Although the UWR spring Chinook ESU is in poor condition and is at high risk of extinction, the Clackamas River population (1 of 7 independent populations within the ESU) was categorized as "low risk" of extinction over a 100-year time frame based on current abundance, productivity, spatial structure, and diversity characteristics (McElhaney et al. 2007). While this ranking suggests the Clackamas River population is the healthiest population within the ESU, it also underscores the value of this population to the future recovery of the ESU.

Spring Chinook juveniles in the Clackamas River exhibit a greater reliance on North Fork Reservoir for rearing as compared to steehead or coho salmon (Lowery and Beauchamp 2010). While North Fork Reservoir provides good rearing habitat for Chinook, it also exposes them to aquatic and avian predation to a greater degree than riverine habitats under which they evolved in the Clackamas River. As noted previously in this BA, if we are successful with the reintroduction we expect bull trout may utilize North Fork Reservoir for overwintering and foraging. As such, and considering the reliance on North Fork Reservoir by rearing Chinook salmon, these fish may be more vulnerable to predation impacts as compared to steelhead and coho, which rely much less on the reservoir for rearing (Lowery and Beauchamp 2010).

That said, the Clackamas River subbasin is large and there is an abundance of mainstem river habitat (~50 river miles) between North Fork Reservoir and suitable spawning habitats in the upper watershed. As a result, adult and subadult bull trout may find more food resources in the

mainstem Clackamas River than in North Fork Reservoir and thus may be prone to exhibit a fluvial rather than adfluvial life history. In that case, predation on spring Chinook juveniles in North Fork Reservoir may be limited. The monitoring and evaluation component of our proposed action that centers on assessing impacts to salmon and steelhead from bull trout will focus on areas of highest and moderate vulnerability including North Fork Reservoir and forebay, and PGE hydro project areas below North Fork Dam.

Spring Chinook were also documented during relicensing studies having longer migration delay and lower passage efficiency through the current fish bypass facility as compared to steelhead and coho, thus increasing their susceptibility to predation by bull trout and other predators. As noted previously in this BA, PGE's new license and associated Fish Passage and Protection Plan, calls for the completion by 2015, of a new 1,000 cfs surface collector at North Fork Dam, the addition of guidance nets for the collector, and a exclusion net in front of the spillway, all of which should greatly improve migration conditions over current conditions (NMFS 2010).

Listed ESU/DPS	ESU/DPS Extinction Risk (McElhaney et al. 2007)	Clackamas River Population Extinction Risk (McElhaney et al. 2007)	Impact of Bull Trout on Clackamas River Salmon & Steelhead Extinction Probabilities (Marcot et al. 2008)	Effects of Proposed Action on Listed Salmon and Steelhead Populations in the Clackamas River
UWR Chinook (Spring)	High Risk	Low Risk (only independent population among 7 in the ESU that was characterized as low risk)	Very Low to Moderately Low Extinction Risk over 100 years	Adverse effects are anticipated due to predation by bull trout and competition for food and habitat. Likely the most vulnerable of the 4 species of salmon and steelhead due to the potential spatial and temporal overlap in North Fork Reservoir (high prevalence of rearing Chinook juveniles). Although Clackamas specific population level impacts are not anticipated, the M&E program, management flexibility under 10(j) NEP status, and adaptive management of the project are expected to provide assurance against unanticipated population level effects.
LCR Chinook (Fall)	High Risk	Very High (extirpated or nearly so based on McElhaney et al. 2007)	None to Very Low Extinction Risk over 100 years	Limited to no impact expected from bull trout due to the extremely low numbers of LCR Chinook present in the Clackamas River, their limited distribution below Rivermill Dam, and the low likelihood of bull trout occupying the lower Clackamas River due to lack of suitable habitat.
LCR Coho	High Risk	Low Risk (only independent population among 24 in the ESU that was characterized as low risk)	Very Low to Moderately Low Extinction Risk over 100 years	Adverse effects are anticipated due to predation by bull trout and competition for food and habitat. Although Clackamas specific population level impacts are not anticipated, the M&E program, management flexibility under 10(j) NEP status, and adaptive management of the project are expected to provide assurance against unanticipated population level effects.
LCR Steelhead	High Risk	Low Risk (only independent population among 23 in the DPS that was characterized as low risk)	Very Low to Moderately Low Extinction Risk over 100 years	Adverse effects are anticipated due to predation by bull trout and competition for food and habitat. Although Clackamas specific population level impacts are not anticipated, the M&E program, management flexibility under 10(j) NEP status, and adaptive management of the project are expected to provide assurance against unanticipated population level effects.

Table 5-1 Summary table of extinction risk and effects of proposed action on 4 species of salmon and steelhead (table generated in part from: McElhaney et al. 2007, NMFS 2010, Marcot et al. 2008).

Given the low extinction risk for the Clackamas River population of UWR Chinook, as determined by McElhaney et al. (2007), and the predicted low to moderately low impacts on extinction probability by the proposed action as reported by Marcot (2008), we anticipate population and ESU level effects to be unlikely. Despite the low likelihood of population level effects, the Service, along with our co-sponsor ODFW, is committed to the adaptive management of the bull trout reintroduction project consistent with the recovery of listed salmon and steelhead populations in the Clackamas River (section 2.10.1 above). In development of the proposed action we considered input from project stakeholders, including NOAA and PGE, concerning potential impacts to salmon and steelhead, and as a result, made modifications to the proposed action. These modifications include: reduced numbers of older life stages for transfer; reduced timeframe for transfer of older life stages (decision point after two years as to continuation of older life stage transfers); PIT tagging of all bull trout transferred; and, radio-tagging all subadults and adults for the first two years. In addition, we committed to the development of a monitoring and evaluation component to assess potential impacts during and following the reintroduction. If our monitoring and evaluation program (section 2.9 above) suggests population level impacts are likely occurring, the decision framework outlined in section 2.10.1 of this BA will provide the necessary pathway for a management response.

5.8.2 Lower Columbia Winter Steelhead

Although the LCR winter steelhead ESU is in relatively poor condition and is at high risk of extinction, the Clackamas River population (1 of 23 independent populations within the ESU) was categorized as "low risk" of extinction over a 100-year time frame based on current abundance, productivity, spatial structure, and diversity characteristics (McElhaney et al. 2007) . While this ranking suggests that the Clackamas River population is the healthiest population within the ESU, it also underscores the value of this population to the future recovery of the ESU.

Given the low extinction risk for the Clackamas River population of UWR Chinook, as determined by McElhaney et al. (2007), and the predicted low to moderately low impacts on extinction probability by the proposed action as reported by Marcot (2008), we anticipate population and ESU level effects to be unlikely. Despite the low likelihood of population level effects, the Service, along with our co-sponsor ODFW, is committed to the adaptive management of the bull trout reintroduction project consistent with the recovery of listed salmon and steelhead populations in the Clackamas River (section 2.10.1 above). In development of the proposed action we considered input from project stakeholders, including NOAA and PGE, concerning potential impacts to salmon and steelhead, and as a result, made modifications to the proposed action. These modifications include: reduced numbers of older life stages for transfer; reduced timeframe for transfer of older life stages (decision point after two years as to continuation of older life stage transfers); PIT tagging of all bull trout transferred; and, radio-tagging all subadults and adults for the first two years. In addition, we committed

to the development of a monitoring and evaluation component to assess potential impacts during and following the reintroduction. If our monitoring and evaluation program (section 2.9 above) suggests population level impacts are likely occurring, the decision framework outlined in section 2.10.1 of this BA will provide the pathway for a management response.

5.8.3 Lower Columbia Coho Salmon

Although the LCR coho salmon ESU is in relatively poor condition and is at high risk of extinction, the Clackamas River population (1 of 24 independent populations within the ESU) was categorized as "low risk" of extinction over a 100-year time frame based on current abundance, productivity, spatial structure, and diversity characteristics (McElhaney et al. 2007). While this ranking suggests that the Clackamas River population is the healthiest population within the ESU, it also underscores the value of this population to the future recovery of the ESU.

Given the low extinction risk for the Clackamas River population of UWR Chinook, as determined by McElhaney et al. (2007), and the predicted low to moderately low impacts on extinction probability by the proposed action as reported by Marcot (2008), we anticipate population and ESU level effects to be unlikely. Despite the low likelihood of population level effects, the Service, along with our co-sponsor ODFW, is committed to the adaptive management of the bull trout reintroduction project consistent with the recovery of listed salmon and steelhead populations in the Clackamas River (section 2.10.1 above). In development of the proposed action we considered input from project stakeholders, including NOAA and PGE, concerning potential impacts to salmon and steelhead, and as a result, made modifications to the proposed action. These modifications include: reduced numbers of older life stages for transfer; reduced timeframe for transfer of older life stages (decision point after two years as to continuation of older life stage transfers); PIT tagging of all bull trout transferred; and, radio-tagging all subadults and adults for the first two years. In addition, we committed to the development of a monitoring and evaluation component to assess potential impacts during and following the reintroduction. If our monitoring and evaluation program (section 2.9 above) suggests population level impacts are likely occurring, the decision framework outlined in section 2.10.1 of this BA will provide the necessary pathway for a management response.

5.8.4 Lower Columbia Fall Chinook Salmon

The Clackamas River historically supported a large run of fall Chinook salmon. The population has declined, is quite small, and is present only in the lower Clackamas River below Rivermill Dam (NMFS 2010). The Hatchery Scientific Review Group (HSRG 2008) estimated that average annual returns of natural-origin LCR (fall) Chinook to the Clackamas subbasin (~ 50 adults) are exceeded by the average number of stray hatchery-

origin fish entering the subbasin from other programs elsewhere in the Lower Columbia region (~70 adults). McElhaney et al. (2007) reported LCR fall Chinook in the Clackamas River to be "extirpated or nearly so".

Given the extremely low numbers of LCR Chinook present in the Clackamas River, their limited distribution below Rivermill Dam, and the low likelihood of bull trout occupancy in the lower Clackamas River due to lack of suitable habitat, impacts from the proposed action on fall Chinook in the Clackamas River, and to the ESU in general, are expected to be insignificant and discountable.

5.8.5 Effects to Critical Habitat

NMFS has designated critical habitat for three of the four salmon and steelhead species that may be affected by the proposed action (there is no designated critical habitat for LCR coho salmon). Critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. Within these areas, the PCEs essential for the conservation of the species are those sites and habitat components that support one or more life stages, including:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.

- 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.

- 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.

- Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and salt water; 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.

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

We have reviewed the PCEs essential for the conservation of the species and determined that the bull trout reintroduction may affect, but will not likely adversely affect, any of the PCEs identified above, which are focused on physical aspects of the habitat. Only two PCEs appear to be potentially impacted by bull trout; freshwater rearing and migration corridors. We anticipate effects to these two PCEs to be insignificant and discountable as neither of these two PCEs identifies predation or competition with other native fish as a negative impact on the PCE. As a result, we have determined that the reintroduction of bull trout to the Clackamas River may affect, but will not likely adversely affect, designated critical habitat for LCR and UWR Chinook, and LCR steelhead.

6. CUMULATIVE EFFECTS

'Cumulative effects' are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Cumulative effects that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of a designated critical habitat.

As part of the FCRPS Biological Opinion remand collaboration process, the states of Oregon, Washington, and Idaho provided information on various ongoing and future or expected projects that NMFS determined are reasonably certain to occur and will affect recovery efforts in the lower Columbia basin. These include tributary habitat actions that will benefit specific populations of LCR Chinook, steelhead, and coho, as well as actions that should be generally beneficial throughout each ESU/DPS. Generally, these actions are completed, ongoing, or reasonably certain to occur. They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights and sensitive areas, instream flow rules, stormwater and discharge regulation, Total Maximum Daily Load (TMDL) implementation, and hydraulic project permitting. Responsible entities include cities, counties, and various state agencies. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of salmon and steelhead populations and the functioning of PCEs in critical habitat designated for LCR Chinook, steelhead, and UWR Chinook. Therefore, these activities are likely to have cumulative effects that will significantly improve conditions for the three species that occur within the action area.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can also be considered reasonably certain to occur in the future because they are currently ongoing or occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the action area, non-Federal actions are likely to include urban development and other land use practices. Based on trends in U.S. census data, Crossett et al. (2004) predicted that the area of the Pacific Northwest that includes Clackamas County would grow another 10 to 15 percent between 2003 and 2008. Although state, tribal, and private actions that provide infrastructure and services for population growth, including water supply and runoff from impermeable surfaces, are likely to continue within the action area, past effects on listed salmonids and their habitat are not a guarantee of a continuing level of effect. That depends on whether there are economic, administrative, and legal impediments (or in the case of contaminants,

safeguards), as described above. The Service finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities.

In summary, the cumulative effects are both positive and negative. Human population increases will continue to have a negative effect while recovery efforts in the LCR will have a positive effect. Following is a discussion of a number of activities that could potentially affect listed species in the Clackamas River basin. The Service is not aware of any additional State or private action in the Project area that is reasonably certain to occur or that would affect the listed species or their proposed critical habitat.

6.1 Hatchery Operations

The Clackamas River Hatchery is a State-run facility. Operation of the Clackamas River Hatchery and release of hatchery spring Chinook salmon into the Clackamas River will continue to occur during the new license period. Resource managers and the public are placing increasing value on natural production of salmon and steelhead populations and there is evidence that hatchery programs result in both short- and long-term negative impacts on wild salmonid populations. Hatchery introductions may negatively impact upper Willamette River Chinook salmon Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, and Lower Columbia River steelhead ESUs by increasing competition between hatchery and wild fish, and by reducing the genetic integrity of wild runs. Conversely, there are some beneficial uses of hatchery fish including harvest and that hatchery fish can be used as a reserve for restarting lost populations e.g., lost due to a catastrophic event. The proposed actions include measures to continue separating hatchery origin spring Chinook salmon, coho salmon, and steelhead at the Faraday-North Fork fish ladder, and to continue transporting and releasing marked hatchery salmon downstream of River Mill Dam. This conservation measure will reduce the number of hatchery Chinook salmon reaching the watershed upstream of North Fork Dam, and will reduce competition and other interactions between wild and hatchery Chinook salmon, thus providing a beneficial aspect to the species. PGE also proposes to provide limited funding to support marking all hatchery production and to monitor the interactions between wild and hatchery spring Chinook salmon.

The Eagle Creek National Fish Hatchery water source is upstream of a barrier waterfall on Eagle Creek that blocks anadromous fish access. The Clackamas River Hatchery's water source is well water and pumped Clackamas River water. Both hatcheries use modern, sanitary techniques to minimize disease. In addition, both hatcheries monitor their water quality and no adverse effects are anticipated from hatchery management on water quality.

6.2 Non-Federal Timber Harvest

The U.S. Forest Service manages the upper 70 percent of the watershed, situated within Mt. Hood National Forest. The U.S. Bureau of Land Management (2 percent) and the

State of Oregon (< 0.1 percent) manage smaller portions of the watershed. The Confederated Tribes of the Warm Springs Indian Reservation also own forest lands in the upper watershed (about 2 percent). Only 5 percent of forestland in the watershed is held in private ownership. Although the majority of harvestable forestland in the watershed is in Federal ownership, timber harvest on private lands during the period of the new license may affect listed species and their habitat. Future non-Federal timber harvest may affect the salmonid ESUs and their habitat by increasing stream temperatures, turbidity, eutrophication (increase of nutrients beyond normal processes), and decreasing large woody debris recruitment, particularly in tributaries to the Clackamas River.

6.3 Recreation

A variety of recreational opportunities are available in the watershed, including boating, fishing, camping, hiking, and others. Regulated fisheries for salmon, steelhead, and trout occur in the Clackamas River basin. The State of Oregon regulates salmon and steelhead harvest in the basin as outlined in the annual Fishing Regulations (ODFW 2010). Because of the proximity to Portland, recreational use is significant in the Clackamas River basin and is likely to continue to increase. Potential recreational impacts include but are not limited to incidental catch of listed salmonids (when targeting stocked fish such as rainbow trout), increased risk of toxic materials entering watercourses and harassment of spawning salmonids.

6.4 Urban and rural development

Urban and rural development can contribute to riparian habitat fragmentation, water quality degradation (especially from non-point sources), and other impacts to salmonids and salmonid habitat. Much of the Clackamas River watershed downstream of the Project is used for agriculture. The effects of agricultural and other rural development on salmonids and salmonid habitat in the Clackamas River basin will likely continue at current levels under existing comprehensive land use planning (Metro Regional Services 1997).

The Portland Metro region is the largest urban area in Oregon, with smaller towns such as Estacada closer to the Project vicinity. Other urban areas in the watershed are the town of Sandy, located near the watershed's northern margin in the Deep Creek drainage, and the Gladstone/Oregon City area, located near the mouth of the Clackamas River. These towns are within 30 miles of Portland and are vulnerable to rapid development as Portland's population increases. The Metro Council is responsible for managing the Portland metropolitan region's urban growth boundary, and is required by state law to have a 20-year supply of land for future residential development inside the boundary. Every five years, the Metro Council is required to conduct a review of the land supply and, if necessary, expand the boundary to meet that requirement. The Metro Council last expanded the urban growth boundary in 2005. In the foreseeable future, it is likely that urban development within the watershed will impact listed salmonids.

6.5 Water supply

In October 1996, water providers in the Portland metropolitan region issued the final report of the Regional Water Supply Plan. This plan is the result of a multi-year study that examined strategies and actions to meet the water supply needs of the Portland metropolitan area, into the year 2050.

The Clackamas River currently provides municipal water to over 200,000 residents in the Portland metropolitan region. Water providers drawing from the Clackamas River, including the City of Lake Oswego, Clackamas River Water, the South Fork Water Board, and the North Clackamas County Commission, has developed intake and treatment capacity for 116 million gallons per day (mgd) on the lower 5 miles of the river. The town of Estacada also has an intake serving approximately 2,600 residents. Several new or expanded water supply facilities, providing a total of 22.5 mgd, are planned on the Clackamas River through 2011 (PGE 2005).

Clackamas River Water and other suppliers are evaluating their current capacities to meet the increasing regional needs for high quality drinking water. Increased diversions from the river may further modify hydrologic conditions and may, among other impacts, increase risk of entrapment of downstream migrants.

7. CONCLUSIONS

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 C.F.R. Part 402 (the consultation regulations). Procedures for conducting consultation under section 7 of the ESA are further described in the Services' Consultation Handbook (USFWS and NMFS 1998). Jeopardy is defined as to engage in an action that reasonably 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. Therefore it must determined, (a) whether the species can be expected to survive with an adequate potential for recovery under the effects of the action, the effects of the environmental baseline, and any cumulative effects, and (b) whether affected designated critical habitat is likely to remain functional (or retain the ability to become functional) to serve the intended conservation role for the species in the near and long term under the effects of the action, environmental baseline and any cumulative effects.

The analysis in the preceding sections of this BA forms the basis for conclusions as to whether the proposed action, the reintroduction of bull trout to the Clackamas river, satisfies the standards of ESA Section 7(a)(2). To satisfy those standards, the proposed action must not be likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Chapter 2 of this BA describes the proposed reintroduction of bull trout to the Clackamas River. Chapter 3 defines the current status of each of the four listed salmonid species present in the action area and the status of critical habitat designated for three of the salmonid species. Chapter 4 evaluates the condition of the environmental baseline. Chapter 5 describes the likely effects of the proposed action on the four listed salmonid species present in the action area, and designated critical habitat for three of the populations in the action area. Chapter 6 considers the cumulative effects of relevant non-Federal actions reasonably certain to occur within the action area. Chapter 7 synthesizes all of the relevant information in the baseline, effects, and cumulative effects chapters to assess effects of the proposed action on the listed species as a whole across its range and life cycle, and effects on designated critical habitat. On the basis of this information and analysis, the Service draws its conclusions about the effects of the proposed action on the likelihood of survival and recovery of the 4 listed salmonid species that occupy the action area, and the likelihood that the proposed action will destroy or adversely modify designated critical habitat.

After reviewing 1) the rangewide status of UWR Chinook salmon, LCR Chinook salmon, LCR steelhead, and LCR coho salmon; 2) the rangewide status of critical habitat designated for the first three species listed above; 3) the status of the environmental baseline within the action area; 4) the effects of the proposed action; and, 5) any cumulative effects, we reach the conclusion that the proposed action does not appreciably diminish the likelihood of survival and recovery of the four listed anadromous species under the jurisdiction of NMFS, nor will the proposed action destroy or adversely modify designated critical habitat.

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9. APPENDICES

9.1 Appendix A: Assessing Potential Impacts of a Proposed Reintroduction of Bull Trout on ESA-Listed Salmon and Steelhead in the Clackamas River

Report on a Bull Trout Expert Panel Workshop Held July 2008 on "Assessing Potential Impacts of a Proposed Reintroduction of Bull Trout on ESA-Listed Salmon and Steelhead in the Clackamas River"

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Chris Allen, USDI Fish and Wildlife Service, Oregon Fish & Wildlife Office
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Final version: September 23, 2008

EXECUTIVE SUMMARY OF FINDINGS

On July 21-23, 2008, an expert panel workshop was held in Vancouver, Washington, to help determine the potential impact of reintroducing bull trout into the Clackamas River system, on four existing ESA-listed salmonids: spring Chinook, fall Chinook, Coho, and winter steelhead. The panel consisted of five experts on bull trout and salmonid biology and ecology.

The workshop was rigorously structured using a modified Delphi process so that panelists could learn from other presenters and from each other, yet offer their knowledge individually. The panelists were asked to (1) score possible outcomes of the degree of impact of bull trout on salmonids' probabilities of extinction, among 7 categories ranging from very high impact to no impact; (2) suggest and prioritize possible topics for monitoring, should the proposed project be enacted, and (3) suggest possible management actions, should bull trout be found to have unacceptable adverse effects on salmonids. The panel also discussed related topics, such as the degree of reversibility of a bull trout reintroduction, and lessons learned from other river systems with and without bull trout and other desired fish species. The workshop was also attended by two facilitators and a note-taker, several selected biologists who presented summaries of topics pertinent to bull trout and salmonid biology and habitat ecology, and up to 10 observers consisting of other managers and biologists from a variety of agencies. All workshop participants, including the expert panelists, were specifically not asked to make or recommend policy decisions, as the purpose of the workshop was to provide technical, scientific information for later consideration by managers and decision-makers.

The results of the panelists' scoring of possible degree of impact of bull trout on salmonid probability of extinction ranged from moderately high impact to no impact. The variation in scores expressed the panelists' individual uncertainty, variability among the panelists, and expected differences among the salmonid species. The mode of overall score values suggested that impact was viewed by the panelists in general to be very low or moderately low for spring Chinook, Coho, and winter steelhead; and mostly none to very low for fall Chinook. However, again, some possible outcomes ranged into higher categories of impact but with far lower score levels.

The panelists identified 19 possible monitoring activities under four main objectives (environment, predator status, prey status, and trophic interactions). The highest priority monitoring categories pertained to determining predator (bull trout) abundance and reproduction, establishing baseline and periodic consumption rates, periodically determining size structure in bull trout populations, annually determining prey abundance and productivity, and determining baseline and periodic rates of trophic interactions. Other monitoring activities pertained to determining bull trout demography, habitat selection, abundance of salmonids, variation in fish distribution, and other topics.

The panelists identified 21 possible management activities that could be used to reduce adverse impacts of bull trout on salmonids, should any be discovered after reintroduction. The management activities fell under six main objectives (monitoring, offsetting impacts of bull trout, direct predator control, prey enhancement and management, public perception, and reservoir management) and pertained to a variety of types and degrees of possible impact.

Discussions by the panelists and observers of each of these scoring and listing tasks, and other topics pertinent to bull trout and salmonid biology and ecology, were recorded by the note taker and presented here in an appendix.

WORKSHOP PURPOSE AND OBJECTIVES

The following problem statement, overall goal, specific objectives, expected products, and agency roles were provided to the attendees (expert panelists, managers, and other observers) prior to the workshop, and again presented during the opening day of the workshop.

Workshop problem statement.--Based on findings from the *Clackamas River Bull Trout Reintroduction Feasibility Assessment* (2007), a proposal to reintroduce bull trout to the Clackamas River, Oregon, is being developed by the Fish and Wildlife Service (FWS) and Oregon Department of Fish and Wildlife (ODFW). Whereas a successful reintroduction of bull trout into the Clackamas would represent a major success for the species' recovery, there are concerns about the impacts of this effort on other ESA-listed species (Chinook and Coho salmon, steelhead trout). In particular, predation on salmon and steelhead by bull trout has been identified as an area of uncertainty.

Overall workshop goal.--Provide a scientific assessment of potential impacts to salmon and steelhead from a reintroduction of bull trout to the Clackamas River and outline monitoring and management strategies that could be implemented to reduce uncertainty and risk following a possible reintroduction.

Specific workshop objectives.--

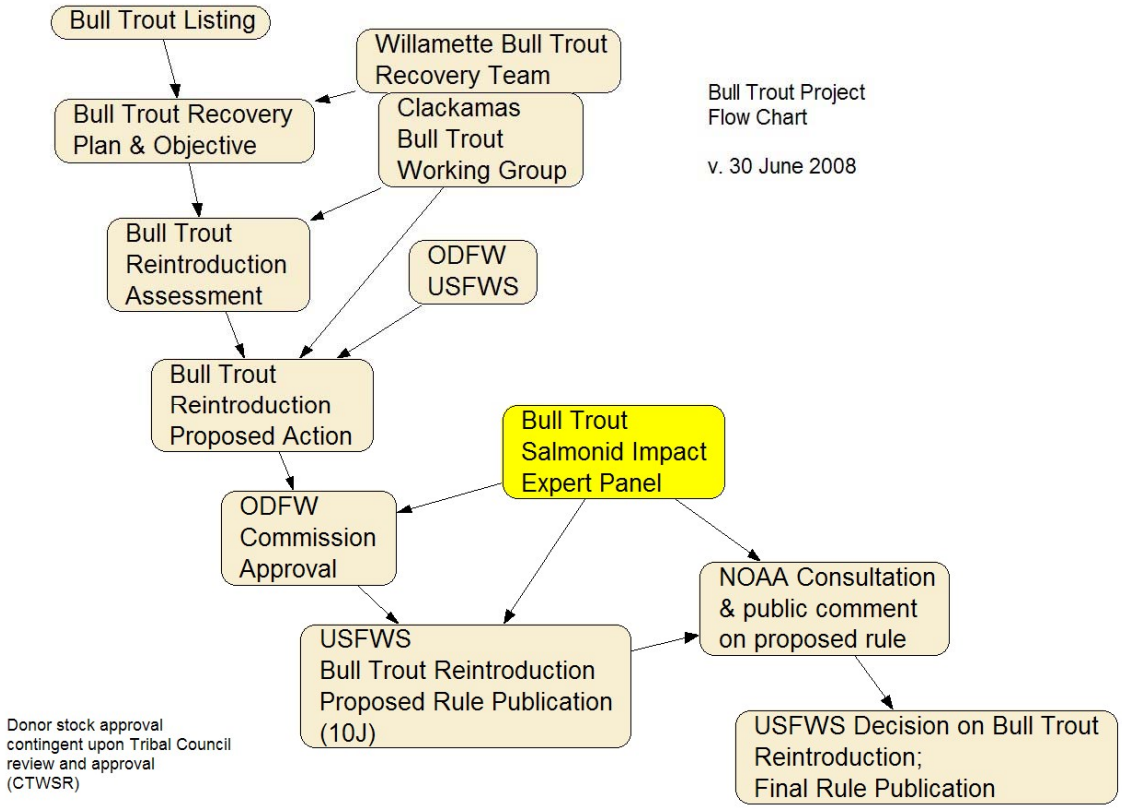
- An evaluation of potential interaction effects between reintroduced bull trout and existing anadromous salmonids in the Clackamas River system
- Suggestions for priority monitoring activities
- Suggestions for possible ameliorative management activities that could reduce undesirable species interactions.

Products derived from the workshop.--

- Provide a scientific assessment of potential risks and uncertainties under the proposed management scenario (i.e., a self-sustaining population of 200 to 500 adult bull trout by 2030 or sooner) and associated actions for bull trout reintroduction.
- Evaluate alternative activities for minimizing risk and uncertainty around the issue of impacts by bull trout on ESA-listed salmon and steelhead trout in the Clackamas River.
- Produce a summary report (this report) that describes the results of the assessment with reference to a potential reintroduction of bull trout into the Clackamas River

Agency roles.--FWS and ODFW are the lead agencies in the development of a reintroduction proposal. The U.S. Forest Service - Mt. Hood National Forest (USFS), National Marine Fisheries Service (NMFS), and the Confederated Tribes of the Warm Springs Reservation (CTWSR) are cooperating agencies. U.S. Geological Survey (USGS) is providing scientific support.

Also presented during the opening section of the workshop was the following flowchart for the Bull Trout Reintroduction Project, specifically to illustrate the context, role, and expected use of the workshop results.



WORKSHOP AGENDA, ATTENDEES, AND METHODS

The agenda for the workshop is presented in Appendix 1.

Pre-workshop materials.--Prior to the workshop, each expert panelist was sent a letter of invitation that explained the purpose, methods, and expected outcome of the workshop (Appendix 2) along with a set of pre-workshop reading materials (Appendix 3) and a list of questions and answers further explaining the overall project (Appendix 4).

Workshop attendees.—The workshop was attended by 5 expert panelists: Dave Beauchamp (University of Washington and USGS), Jason Dunham (USGS), Kathryn Kostow (ODFW), Paul McElhany (NMFS), and Michael Meeuwig (Montana State University). Workshop facilitators, planning team members, and other observers are listed in Appendix 5. The 5 expert panelists were chosen based on their individual expertise in bull trout and salmonid biology and ecology.

Opening presentations.--The workshop was structured with an opening series of presentations (see Appendix 1) to ensure that all expert panelists were equally informed on the following topics:

- the bull trout reintroduction program feasibility assessment and draft proposed action;
- the status and distribution of ESA-listed anadromous fish species in the Clackamas River and current recovery planning efforts;
- Portland General Electric's (PGE) hydro projects, reservoirs, and fish bypass systems in the Clackamas River system; and
- bull trout trophic interactions and food webs.

Model and discussion on trophic interactions and food web dynamics.--Also presented was a preliminary Bayesian network model depicting potential food web and species interaction dynamics relevant to relationships between bull trout, anadromous salmonids, and other predators and prey species in the river system. The model (Appendix 6) was presented to help prompt panel discussion on trophic and food web dynamics, including identifying key areas of uncertainty related to bull trout-salmonid interactions. The Bayesian network model was not used *per se* further in the workshop although the resulting discussions of trophic structure and food web dynamics were recounted and continued throughout the rest of the workshop.

Panel scoring of degree of impact of bull trout on salmonids.--On day 2 of the workshop, the expert panelists were engaged in a structured scoring of potential effects of bull trout on the extinction probability of each of the 4 ESA-listed salmon and steelhead populations of interest in the Clackamas River system: spring Chinook, fall Chinook, Coho, and winter steelhead. The instructions given to the panelists included that they were to (1) assume that bull trout reintroduction objectives would be met, that is, with at least 200-500 adult bull trout sustainable in the Clackamas River system by 2030, and (2) score the relative influence of bull trout on whatever absolute extinction probability might pertain to each salmon and steelhead population. Selection of this particular scoring approach is described in Appendix 7.

The scoring was conducted by using a modified Delphi paneling procedure (Appendix 7). In brief, this procedure involved the panelists scoring how a bull trout reintroduction might influence each salmonid species, by each panelist spreading 100 points (thought of as probabilities) among one or more outcome categories of potential impacts (see Appendix 8 for worksheet used). Spreading points would be an expression of uncertainty of outcomes and a means of displaying potential differences in outcomes among the salmonid species.

The Delphi paneling process entailed the panelists first individually and silently recording an initial set of outcome scores; then the panelists individually disclosing and explaining their scores to each other in a structured discussion, including an opportunity to engage with other observers and experts in the room; and then individually and silently rescoring outcomes based on new knowledge or insights gained from the shared disclosure and open discussion. The disclosure and discussion portion of the panel

ensured that each panelist had equal time to present their ideas, seek clarification, and ask questions. The scores and discussion comments were recorded anonymously using letter codes (A-E) for each panelist. The scoring session encouraged the panelists to synthesize their own expert experience, the pre-workshop readings (Appendix 3), the workshop presentations (Appendix 1, 6), and their shared interpretations and rationale.

The panelists were prompted to score the *degree of impact that bull trout would have on the extinction probability of each salmonid species over 100 years from the start of the reintroduction project*. The panel discussed an initially-presented 5 class system, did a first round of scoring, and then refined the classes and collectively agreed to use the following 7 categories and definitions for scoring potential bull trout impacts:

- **Very High** = bull trout influence contributes to 100% of the extinction probability
- **High** = bull trout influence contributes to about 95% of the extinction probability
- **Moderately High** = bull trout influence contributes to about 75% of the extinction probability
- **Moderate** = bull trout influence contributes to about 50% of the extinction probability
- **Moderately Low** = bull trout influence contributes to about 25% of the extinction probability
- **Very Low** = bull trout influence contributes to about 5% of the extinction probability
- **None** = bull trout influence has no contribution to the extinction probability

It was clarified to the panelists that they were to score only that portion of salmon and steelhead population extinction probabilities that would be caused by bull trout; they were not asked to score overall extinction probabilities. In this way, the relative impact contributed specifically by bull trout would be represented.

The panelists were also asked to provide written documentation of the basis for their scores. After their second (and final) round of scoring, the meeting facilitators displayed the score results on screen, summarizing mean and ranges of score values among the panelists. The panel provided further explanation and discussion of their scores, which was captured in meeting notes.

Identification of possible monitoring and management activities.--After scoring potential degree of impact of bull trout on salmonids, the panelists were then led through two structured brainstorming sessions (see Appendix 7 for further details of methods) in which they were prompted to list possible monitoring and management objectives and specific activities, without regard to the likely cost of each effort, and under the presumption that the bull trout reintroduction project would be enacted.

The list of possible monitoring activities was displayed on screen. After discussing and refining the list, the panelists were given hard copies of the list and asked to individually rank each monitoring activity by three priority levels: (1) essential to conduct, (2) important but not necessarily essential, and (3) worthwhile but of lower importance. The

individual panelists' priority scores were recorded and the monitoring activities were sorted by mean and range of the priority scores, and by overall monitoring objectives. Discussion within the panel and observers ensued and caveats and ideas were recorded in the written meeting notes.

In the final panel task, also in a structured brainstorming procedure, the panelists listed possible management activities to reduce or eliminate effects of bull trout on the four ESA-listed salmon and steelhead populations, assuming that the bull trout reintroduction project would be enacted and that it might be found that bull trout have an unacceptably high adverse impact on the salmonid species. The list of possible management activities, along with type and degree of impact and overall management themes, were displayed on screen. The expert panel and observers then engaged in open discussions as to the feasibility or expected result of the various management activities; discussions were recorded in the written meeting notes.

RESULTS AND DISCUSSION

Opening presentations.--The opening day talks (see Appendix 1) were made with PowerPoint presentations.[5]

Scoring of impacts of bull trout on salmonids.—The individual panelist scores are presented in Appendix 9 along with score sums, means, and ranges. The means of all 5 panelist scores were distributed among the species in Figure 1:

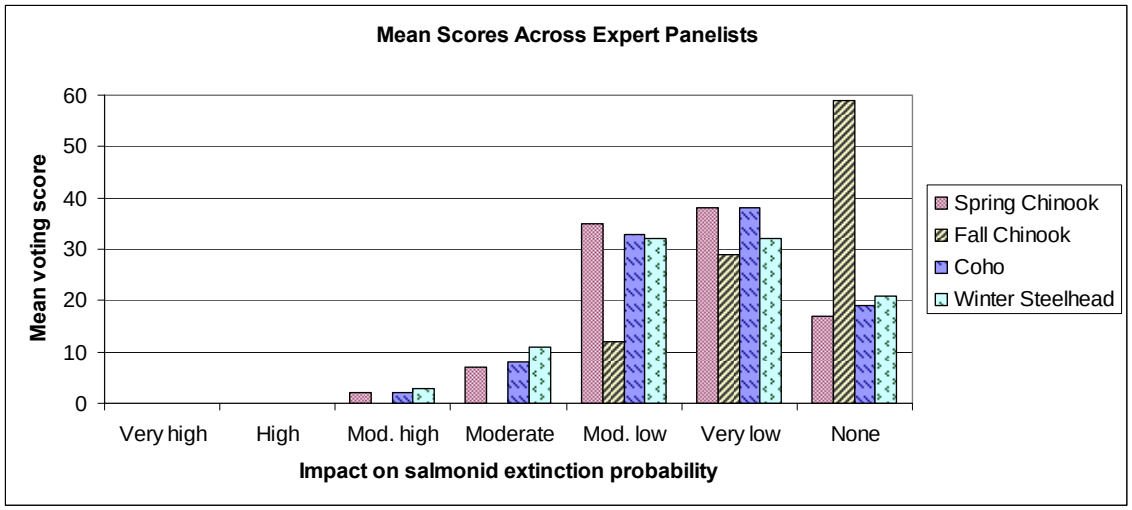


Figure 1. Mean scores of the potential impact of bull trout on salmon and steelhead population extinction probability.

Figure 1 suggests that the panelists generally rated bull trout impacts on extinction probabilities of salmon and steelhead populations as "moderately low," "very low," or

[5] The PowerPoint files are available from the U.S. Fish and Wildlife Service, upon request (Chris Allen, 503.231.6179, chris_allen@fws.gov).

even "none." Also, the mean scores suggested that the panelists in general considered bull trout impacts on salmon and steelhead extinction probability to be lower for fall Chinook than for the other three populations. However, there were non-zero scores suggested even at the "moderately high" and "moderate" degrees of impact for three of the populations; these ratings should not be ignored.

A different way to visualize these patterns is by summing the panelists' scores by salmonid species (Fig. 2):

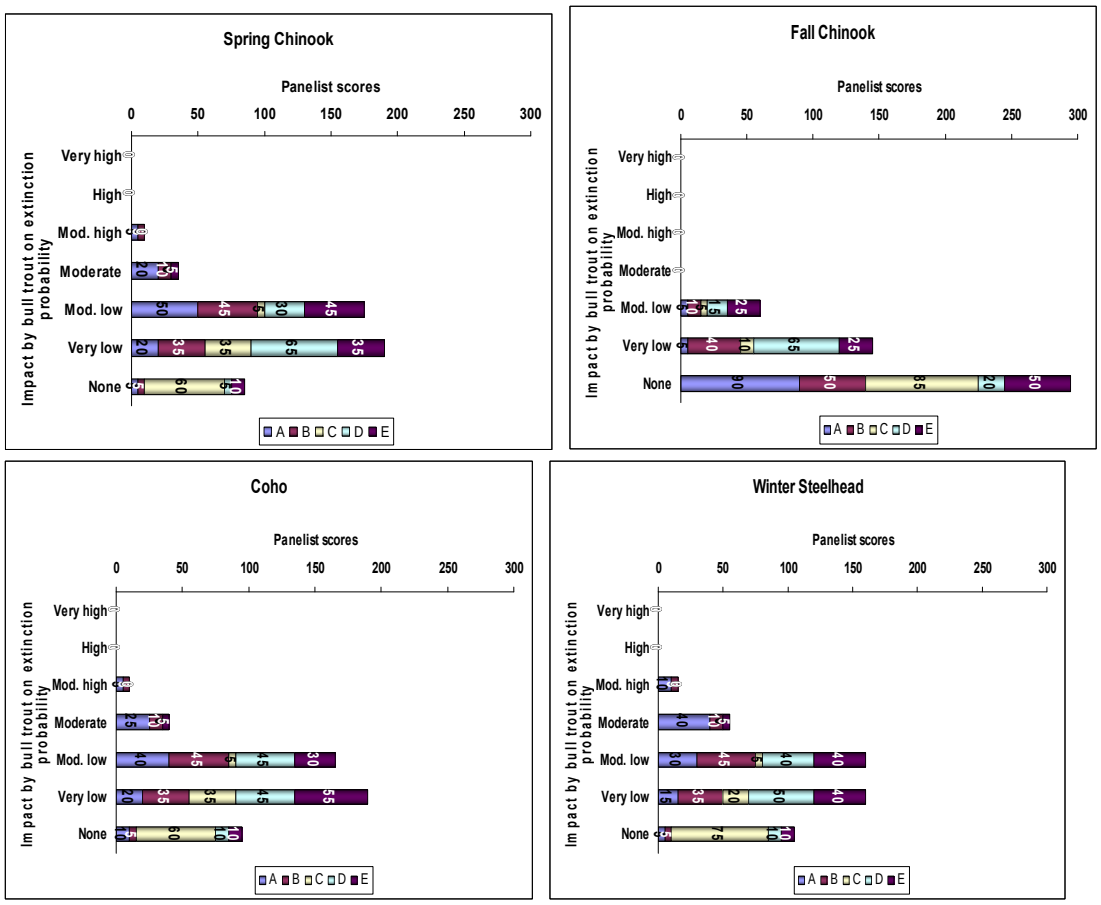


Figure 2. Sum of scores of the potential impact of bull trout on salmon and steelhead population extinction probability, across the 5 panelists (A-E) and by salmonid species.

Summarized in this way (Fig. 2), it is more apparent that the panel generally expected lesser impacts from Bull Trout on Fall Chinook than on the other 3 salmon and steelhead populations. The panel as a whole allocated most of their scores to "None" and "Very low" outcomes for Fall Chinook, and most of their scores to "Very Low" and "Moderately Low" for the other 3 salmon and steelhead populations, with lower score levels allocated to "None," "Moderate," and "Moderately high."

These distributions of composite scores across the outcome categories for each species can be interpreted as expected probability distributions. Outcomes that scored with few points are still possible, according to at least some of the panelists, even if the probability

is low. Whether such expected outcomes as "Moderately high" that scored with few outcome points still trigger concern for the species will be the purview of the decision-makers.

It should be clarified that we did not ask the panelists to reach consensus on their scoring. Thus, it is also instructive to view the individual panelists' degrees of uncertainty and variation among the salmon and steelhead populations considered, across the various outcome categories, and among the individual panelists, as shown in Figure 3.

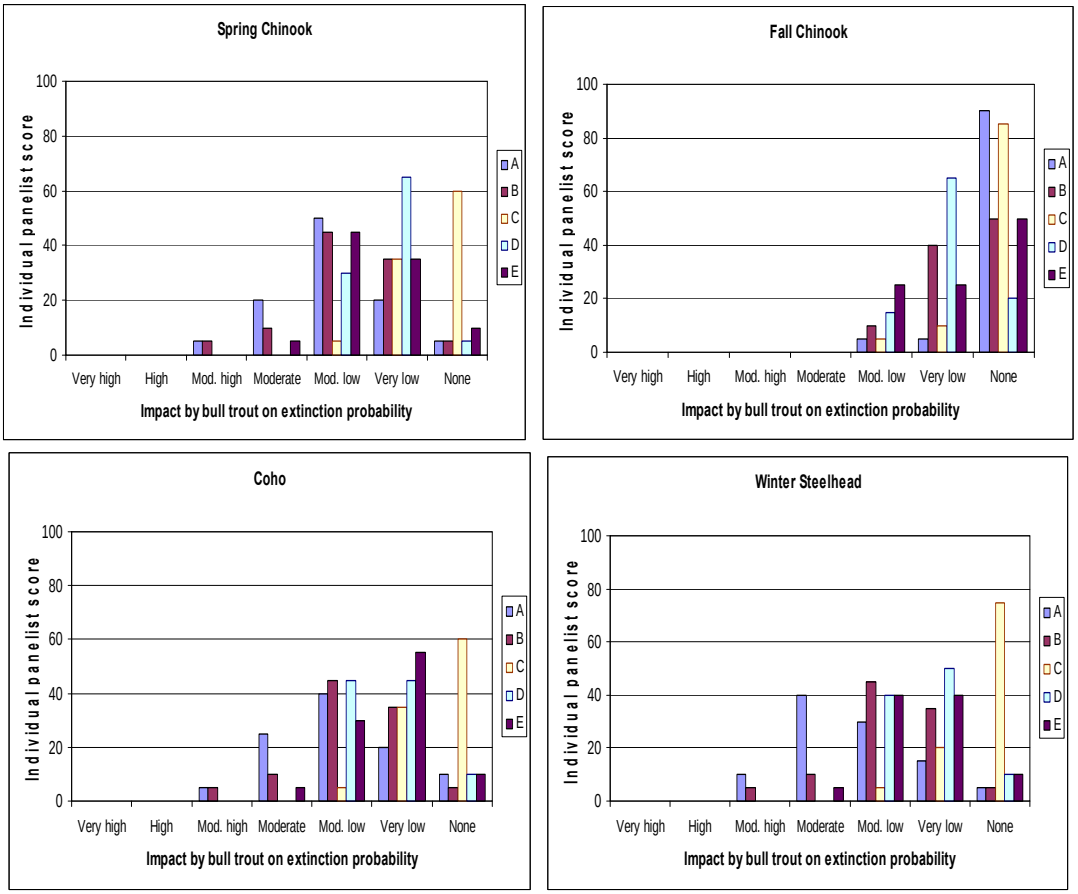


Figure 3. Individual panelist scores of bull trout impact on salmon and steelhead populations after 100 years of bull trout reintroduction. Legend: A-E represents the individual panelists.

Figure 3 suggest that (1) each panelist expressed some degree of uncertainty over the possible impact of bull trout on extinction probability of each salmon and steelhead population, suggested by the spread of scores across multiple outcomes; and (2) although the panelists differed in their specific score values, they concurred by not scoring bull trout impact on any population as "very high" or "high," with modes mostly in the categories of "moderately low" to "none."

Identification of possible monitoring activities.—The expert panel identified a collective set of 19 possible monitoring activities that could follow bull trout reintroduction, without regard to cost. The activities variously pertain to general

objectives for monitoring the overall aquatic environment, predator (bull trout) status, prey (salmon and steelhead population) status, and trophic interactions; and would address various aspects of predator age and growth, angler catch of bull trout, bull trout movement, bull trout size structure, food web and predator consumption dynamics, predator and prey demography, predator and prey habitat selection and reservoir use by prey, predator and prey abundance and productivity, reservoir limnology, and other topics.

The full list of all 19 monitoring activities is presented in Appendix 10. The top activities ranked as essential to conduct by at least 4 of the 5 panelists pertained to monitoring of:

- bull trout reproduction and recruitment, e.g., spawning surveys, age, and size (annual)
- rates of consumption of food by bull trout (baseline and periodic)
- size structure of bull trout in reservoir and river environments (periodic)
- smolt and adult abundance, size, and age of the 3 listed salmon and steelhead species at North Fork Dam (annual)
- juvenile and adult abundance and size structure of the 3 listed salmon and steelhead species above North Fork Reservoir (annual)
- diet and stable isotopes of fish and key invertebrates to identify major predators (fish & others) of salmonids and other fishes (that is, to determine the food web) (baseline and periodic)

Much discussion was held regarding interpretation and qualification of the impact scores and the monitoring activities (Appendix 11).

Identification of possible management activities.—The expert panelists collectively identified some 21 possible management activities that could be pursued, should bull trout be found to have unacceptable impacts on the 4 ESA-listed salmon and steelhead populations if a reintroduction were occur (Appendix 12). The management activities were not prioritized because the type and degree of bull trout impact might vary considerably. Thus, the management activities were categorized by type and degree of impact and by overall management theme, as noted above.

As examples, if the type and degree of impact was found to be high to very high impact from bull trout on the other listed salmonids, one possible management activity pertaining to predator (bull trout) control was identified as complete removal of the bull trout population or maintenance of the bull trout population at a specified lower level. If the type and degree of impact was predation by bull trout on juvenile salmonids in tributaries, one possible management activity pertaining to prey (salmonid) management was identified as adding refuge cover in tributary habitat and other habitat enhancements to reduce predation levels.

Additional comments and discussions.—During the workshop, we recorded a great deal of the discussions and comments made by the expert panelists and observers.[6]

ACKNOWLEDGMENTS

Success of the workshop was largely due to the contributions and participation of the five expert panelists -- Dave Beauchamp, Jason Dunham, Kathryn Kostow, Paul McElhany, and Michael Meeuwig – and from the management support by Chris Wheaton of ODFW, Paul Henson and Miel Corbett of USFWS, and Gary Larson of USFS.

Agencies and institutions that sponsored and contributed to the success of this workshop included USDI Fish and Wildlife Service, USDA Forest Service, Oregon Department of Fish and Wildlife, Portland General Electric, NOAA Fisheries, Confederated Tribes of the Warm Springs Reservation (CTWSRO), and USDI Geological Survey.

We also extend our thanks to the following invited speakers for their presentations: Chris Allen, Todd Alsbury, Doug Cramer, Dave Beauchamp, and Jason Dunham.

[6] These notes are available from the U.S. Fish and Wildlife Service, upon request (Chris Allen, 503.231.6179, chris_allen@fws.gov).

APPENDICES

1. Workshop agenda.

2. Letter of invitation sent to each invited expert panelist.

3. List of pre-workshop reading materials sent to each expert panelist.

4. Project question and answer sheet, sent to each expert panelist prior to the workshop.

5. List of workshop attendees: invited expert panelists, meeting facilitators, workshop planning team, and observers.

6. Bull trout food web model presented at the workshop by Jason Dunham and Bruce Marcot.

7. Detail of expert panel methods used during the workshop.

8. Worksheet used by the expert panelists to score potential impacts from bull trout on each of the 4 ESA-listed salmonids in the Clackamas River system.

9. Results of the expert panel scoring of degree of impact of bull trout on ESA-listed salmon and steelhead populations.

10. Potential monitoring activities identified by the expert panel.

11. Written explanatory notes and discussion comments from the five expert panel participants, recorded from their scoring of bull trout impacts and listing of potential monitoring activities.

12. Potential management activities identified by the expert panel, for reducing or eliminating unacceptable impacts of bull trout on salmon and steelhead populations, sorted by management theme.

APPENDIX 1 - Agenda - Bull Trout Expert Panel Meeting June 21-23, 2008: "Assessing Potential Impacts of a Proposed Reintroduction of Bull Trout on ESA-Listed Salmon and Steelhead in the Clackamas River"

Location: City of Vancouver's Water Resources Education Center
Vancouver, Washington

Prework for Bull Trout Expert Panel:

- Review items sent out in advance – Binder with feasibility study, selected publications

DAY 1 - MONDAY, July 21, 2008

Time	Topic	Main messages	Lead	Objective
1:00-1:20p	**WELCOME** • Roster Check In, introductions (BT Expert Panel; Workshop Facilitators & Advisors; BT Biologist Observers; Manager Observers; Note-taker) • Overall workshop goal • What you should have received/brought • Agenda review • WELCOME by ODFW and USFWS Managers	Introductions to the workshop. No decisions to be made. No major changes to the agenda.	Dan Shively Chris Wheaton with Paul Henson or Rollie White	*Expectations for the workshop:* To provide objective technical information on potential effects of bull trout on salmonids in the Clackamas River system, for informing ODFW, USFWS, NOAA, and other stakeholders.
1:20-1:30p	**OVERVIEW OF METHODS** • Roles of bull trout expert panel, facilitators, and observers – clarify how workshop fits overall project proposed action • Summarize specific workshop objectives • Grounding in terminology: define key terms and concepts to be addressed	Information sharing. Scoring and written info will be anonymous.	Dan Shively, Bruce Marcot	*Present flow chart diagram* of overall project, and how this workshop fits in *Specific workshop objectives*: • Evaluate potential interaction effects between reintroduced Bull Trout and existing salmonids in the Clackamas River system. • Suggest priority monitoring activities. • Suggest possible ameliorative management activities that could reduce undesirable species interactions.

Time	Topic	Main messages	Lead	Objective
1:30-2:00p 2:00-2:40p	**BACKGROUND PRESENTATIONS** (each 20 min, with 10 min Q&A) • Brief Synopsis of Feasibility Assessment Conclusions and Draft Proposed Action • Overview of Status and Distribution of ESA-Listed Anadromous Species in the Clackamas River & Current Recovery Planning Efforts	Presentation Presentation	Chris Allen Todd Alsbury	The purpose of all presentations is to ensure that all panelists are equally up to speed on each presented topic and have a chance to ask questions of each speaker (i.e., leveling and elevating playing field).
2:40-3:00p	**BREAK**			
3:00-3:30 3:30-4:00p	• Overview of PGE's Hydro Projects, Reservoirs, and Fish Bypass Systems • Review of Bull Trout Trophic Interactions	Presentation Presentation	Doug Cramer Dave Beauchamp	Sharing of information (continued)
3:50-4:10p 4:10-4:25p 4:25-4:55p	**PANEL DISCUSSION OF FOOD WEB DIAGRAM AND MODEL** • Review of Bull Trout Food Web • Introduction to Food Web Bayesian Network Model Guided discussion on bull trout/anadromous salmonid interactions (results will provided as a handout tomorrow) • Structural uncertainty • Dynamic uncertainty	Presentation Presentation, model demonstration Expert panel discussion (Note-taker will capture panel's key discussion points)	Jason Dunham Bruce Marcot Dan Shively with Bruce Marcot	Present current thinking on how bull trout fit into the river ecosystem food web. Present working hypothesis model that depicts the dynamics of how food web dynamics interact. Engage expert panel in discussion of food web model. Engage the expert panel in a discussion of how the food web system may be functioning
4:55-5:00	**WRAP-UP OF DAY 1** Briefly review work done today, mention tomorrow's expert panel exercises coming up; address any logistics needs for the evening • Optional Social @ McMenamin's 5:30p	Summary	Dan Shively	Summary, wrap-up, preparation for tomorrow

DAY 2 - TUESDAY, July 22, 2008

Time	Topic	Main messages	Lead	Objective
8:00-8:10a	**WELCOME** • Today's objectives, agenda, and expected products • Any logistics needs	Housekeeping	Dan Shively	Welcome, orientation to the day's upcoming work
8:10-8:20a	**BRIEF REVIEW OF PREVIOUS DAY** • Quick reminder of workshop objectives • Quick reminder of the themes of yesterday's presentations • Handout or display results of yesterday afternoon's revision of the food web diagram and/or model	Review, reminders, and handout on interactions list	Dan Shively Bruce Marcot	Recap and address any new ideas or thoughts on food web since Day 1
8:20-10:00a	**TASK 1: EXPERT PANEL EVALUATION OF SPECIES INTERACTIONS** **INTRODUCTION** • Objectives, expected products • Review methods - modified Delphi paneling process entailing individual scoring; structured disclosure, discussion, and Q&A; individual rescoring • Ground rules for conduct **FIRST SCORING SESSION** • Individual silent scoring of questions (handout to be provided) **STRUCTURED DISCLOSURE, DISCUSSION, Q&A** **SECOND SCORING SESSION**		Bruce Marcot Bruce Marcot Bruce Marcot	The expert paneling is intended to meet the first of the workshop objectives, that is, to provide an evaluation of potential interaction effects between reintroduced Bull Trout and existing salmonids in the Clackamas River system.
10:00-10:30a	**BREAK**	Entry of scores into spreadsheet by Marcot et al.	(Marcot, Allen)	

Time	Topic	Main messages	Lead	Objective
10:30-11:30a	**BRIEF PRESENTATION OF SCORING RESULTS** **GUIDED PANEL DISCUSSION ON OVERALL EXTINCTION RISK AND CONTRIBUTION BY BULL TROUT** **OPEN FLOOR FOR MANAGERS AND OTHER OBSERVERS TO ASK CLARIFYING QUESTIONS OF PANELISTS**	Presentation Facilitated discussion	Bruce Marcot Dan Shively	Ensure panel has opportunity to see the distribution of their scores, and at least to briefly discuss meaning and implications; and for the note-taker to capture key points.
11:30a-12:30p	**LUNCH**			
12:30-2:30p	**TASK 2: SUGGESTIONS FOR MONITORING ACTIVITIES** • Guided panel brainstorming exercise to identify monitoring themes and activities	Facilitated discussion	Dan Shively & Bruce Marcot	Develop a list of potential monitoring themes, objectives, and activities presuming that the proposed action will take place.
2:30-2:50p	**BREAK**			
2:50-4:50p	**SUGGESTIONS FOR MONITORING ACTIVITIES (CONTINUED)** • Guided panel brainstorming exercise • Summary of results **OPEN FLOOR FOR MANAGERS AND OTHER OBSERVERS TO ASK CLARIFYING QUESTIONS OF PANELISTS**	Facilitated discussion	Dan Shively & Bruce Marcot	(as above)
4:50-5:00p	**WRAP-UP OF DAY 2** Briefly review work done today, mention tomorrow's activities; address any logistics needs for the evening	Summary	Dan Shively	Summary, wrap-up, preparation for tomorrow

DAY 3 - WEDNESDAY, July 23, 2008

Time	Topic	Main messages	Lead	Objective
8:00-8:10a	**WELCOME** • Today's objectives, agenda, and expected products • Any logistics needs	Housekeeping	Dan Shively	Welcome, orientation to the day's upcoming work
8:10-10:00a	**TASK 3: SUGGESTIONS FOR POTENTIAL AMELIORATIVE MANAGEMENT ACTIVITIES TO REDUCE ADVERSE SPECIES INTERACTIONS** • Guided panel brainstorming exercise to identify potential management actions, pertinent not only to food web interactions but also to other factors. • Is the assumption valid that bull trout introduction is reversible? • Could the bull trout population be managed at a particular size(s)?	Facilitated discussion	Dan Shively & Bruce Marcot	Develop a list of potential mitigating or ameliorative management activities to address potential adverse effects on anadromous salmonids, presuming that the proposed action will take place.
10:00-10:20a	**BREAK**			
10:20-11:00a	**SUGGESTIONS FOR POTENTIAL AMELIORATIVE MANAGEMENT ACTIVITIES (CONTINUED)** • Guided panel brainstorming exercise • Summary of results **OPEN FLOOR FOR MANAGERS AND OTHER OBSERVERS TO ASK CLARIFYING QUESTIONS OF PANELISTS**	Facilitated discussion	Dan Shively & Bruce Marcot	(as above)
11:00-11:30a	**WORKSHOP WRAP-UP AND CONCLUSION**	Wrap-up	Dan Shively, Rollie White	Summary of workshop accomplishments; return to overall flowchart of project; next steps in process

Appendix 2. Letter of invitation sent to each invited expert panelist.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Oregon Fish and Wildlife Office
2600 SE 98th Avenue, Suite 100
Portland, Oregon 97266
Phone: (503) 231-6179 FAX: (503) 231-6195

Reply To: 8183.5304A
File Name: Workshop Invite D Beauchamp.doc
TS Number: 08-865

[name, address of invited expert panelist]

Subject: Clackamas River Bull Trout Reintroduction Expert Panel Meeting

Dear _____:

Thank you for agreeing to participate in the July 21-23, 2008, expert panel workshop to assess impacts of a proposed reintroduction of bull trout on federally listed salmon and steelhead in the Clackamas River, Oregon. The results of this workshop will support various decision making processes associated with a reintroduction of bull trout to the Clackamas River. The workshop will be held in Vancouver, Washington, at the Water Resources Education Center (map and directions enclosed) beginning at 1 pm July 21, ending at 12 pm July 23.

We will follow this letter with a packet of background materials that will include a draft workshop agenda, relevant sections from the Clackamas River Bull Trout Reintroduction Feasibility Assessment, a USGS publication on the Feasibility Assessment, Q&A for the project, and relevant literature. Although we intend to cover some of these items in presentations at the front end of the workshop we ask that you familiarize yourself with these materials ahead of time.

Dan Shively, Fisheries Program Leader for the Mt. Hood National Forest, will facilitate the workshop, and Dr. Bruce Marcot, research wildlife ecologist with Region 1, U.S. Forest Service will serve as a technical facilitator for all exercises involving quantitative scores or estimates. Dr. Jason Dunham, U.S. Geological Survey, who previously contacted you about the workshop, will participate on the panel and continue to serve as one of the workshop contacts for panel members.

The general format for the workshop will be as follows: Day 1 will begin with an overview of workshop goals, objectives, and methods, followed by a series of short

background presentations for the panel, and end with a discussion of ecological interactions. Day 2 will focus on expert panel evaluations of species interactions using a modified Delphi paneling process entailing individual scoring, structured disclosure, discussion, Q&A and individual rescoring. The end of day 2 and most of day 3 will focus on a structured brainstorming session and panel discussion of potential monitoring activities to address uncertainty and risk associated with a reintroduction of bull trout, and suggestions for potential ameliorative activities to reduce adverse species interactions.

Per diem (food, lodging, travel) for the workshop is available from the FWS to panel members that require funding assistance. If you are not from the Portland/Vancouver area and will need accommodations, the closest hotel to the Education Center is Homewood Suites, 701 SE Columbia Shores Boulevard, Vancouver, 1-360-750-1100. In order to provide per diem we will need participants to complete several forms prior to the workshop. If you plan to seek per diem please contact our administrative assistant Diana Acosta as soon as possible at 503.231.6179. Please note that in order to accommodate air travel cost, our office will need to process your reservations.

Thank you again for agreeing to participate in the expert panel workshop. If we can be of any assistance or if you wish to discuss any aspect of the panel process, please feel free to call me at (503) 231-6179 or contact Chris Allen of my staff at the same number.

Sincerely,

Miel Corbett
Acting State Supervisor

Appendix 3. List of pre-workshop reading materials sent to each expert panelist.

A. Workshop Statement of Work (see text)

B. Draft Workshop Agenda (see Appendix 1)

C. Directions to Workshop

D. Project Question and Answer Sheet (see Appendix 4)

E. Publications

1. Shively et al. 2007. Clackamas River Bull Trout Reintroduction Feasibility Assessment (select sections most pertinent to workshop goals and objectives)
2. Dunham & Gallo, 2008. Assessing the Feasibility of Native Fish Reintroductions: A Framework and Example Applied to Bull Trout in the Clackamas River, Oregon
3. Beauchamp & Van Tassell, 2001. Modeling Seasonal Trophic Interactions of Adfluvial Bull Trout in Lake Billy Chinook, Oregon.
4. Seddon et al. 2007. Developing the Science of Reintroduction Biology

Appendix 4. Project question and answer sheet, sent to each expert panelist prior to the workshop.

Commonly Asked Questions and Answers

Possible Proposal to Reintroduce Bull Trout to the Clackamas River

Q. What action is being considered?

A. Agencies are considering whether to propose reintroducing a "nonessential experimental population" of bull trout into the Clackamas River, where they were once abundant and widely distributed.

Q. Who is working on this proposal?

A. The U.S. Fish and Wildlife Service and the Oregon Department of Fish and Wildlife in cooperation with the U.S. Forest Service. The U.S. Geological Survey is providing scientific support. Coordination on the proposal is occurring with the Confederated Tribes of the Warm Springs Reservation of Oregon.

Q. Why would this reintroduction be proposed?

A. Bull trout are a species listed as "threatened" under the federal Endangered Species Act, and the goal of that law is to recover species from being threatened or endangered to the point that they no longer need its protection. Their reintroduction into the Clackamas River is under consideration because it would meet objectives of the current Fish and Wildlife Service recovery strategy for the species in the Willamette Basin, as well as other agencies' goals to restore native fish communities.

Q. Why choose the Clackamas River for this proposal?

A. The Clackamas was considered for reintroduction even before the bull trout was listed as threatened, in years of discussion between the Forest Service and Oregon Department of Fish and Wildlife. With these two key partners already exploring the possibility, and the need expressed in the bull trout recovery plan, it was logical to continue exploring the idea. There are other appropriate locations for bull trout reintroduction, and examination of this possible reintroduction will gain knowledge and experience that can be applied elsewhere. From the bull trout's perspective, the Clackamas is a good candidate because bull trout haven't been documented there since about 1963; the factors which caused them to disappear have been remedied, and about 70 miles of the upper river and tributaries contain suitable habitat for bull trout spawning and rearing.

Q. How can a "nonessential" population contribute to recovery?

A. A nonessential experimental population would contribute to the recovery of the bull trout in the Willamette Basin, but it is not essential to the survival of the species in the wild. The designation allows for greater flexibility in managing other land uses and human activities, without the usual level of protections being given to individuals of the reintroduced species. The designation of nonessential experimental

populations [through Section 10(j)] was added to the Endangered Species Act in 1982 by Congress in order to increase the public's tolerance for putting a protected species back into an area where it had been previously.

Q. Would the agencies later want to change the nonessential population to an "essential" designation?

A. It is not likely that the Fish and Wildlife Service would propose to change the nonessential experimental population classification. Any changes that might become necessary would occur in cooperation with the State of Oregon and other affected parties and would require another federal rule-making process. The only likely change would be if the species recovers and is removed from the list of threatened and endangered species, in which case the "nonessential experimental population" designation would be eliminated as part of the delisting.

Q. What will bull trout do to salmon and steelhead in the Clackamas River?

A. Like many other native fish in the Clackamas River, bull trout will eat juvenile salmon and steelhead. They also will eat other fish which would have eaten juvenile salmon and steelhead. These predator/prey dynamics are complex, and despite the fact that these species evolved together, it is uncertain whether bull trout would have a negative, positive, or neutral effect on today's salmon and steelhead populations. Because of this, the agencies are seeking to understand the potential impacts before making the decision to propose the reintroduction. A panel of expert scientists will meet in July 2008 to answer the questions about potential bull trout effects on salmon and steelhead in the Clackamas River.

Q. How is this proposed reintroduction affected by the recent completion of the 5-year status review of bull trout?

A. The U.S. Fish and Wildlife Service completed its 5-year status review of the bull trout with two recommendations: retain threatened status for the species as currently listed throughout its range, and evaluate whether distinct population segments (DPSs) exist and merit protection under the Endangered Species Act. The first recommendation validates the science and decisions underlying this proposal. Any change resulting from the second recommendation will be well in the future, and meanwhile the reasons to continue studying this proposal remain.

Q. Would the presence of a protected species in the Clackamas River affect land management activities, like timber harvest?

A. The proposal under consideration would be to designate a "nonessential experimental population," under the authority of Section 10(j) of the Endangered Species Act, specifically to avoid restricting land management and recreational activities. Throughout the entire nonessential experimental population area, no federal agency or its contractors would be in violation of the Endangered Species Act for harming or killing bull trout as a result of any authorized agency action.

Q. What about impacts of this protected species on recreational river uses?

A. The reintroduction will not conflict with recreational uses of the river. For example, since it would be within a nonessential experimental population area, a person

fishing in accordance with Oregon angling regulations would not be in trouble for inadvertently harming a bull trout.

Q. What activities will be prohibited because of this nonessential experimental population area?

A. It remains illegal to deliberately "take" (harm or kill) bull trout, which generally would occur if they are taken or possessed in violation of state fish and wildlife laws or regulations. In other words: fishing in violation of state regulations which results in catching these fish, or polluting the waters in violation of state or federal law, could result in additional penalties for harming the fish. Fishing and other activities conducted legally will not result in penalties if they happen to result in catching or otherwise harming the fish.

Q. Is it even biologically possible to reintroduce this threatened species here?

A. A report published in 2007 by the agencies concluded that the proposal would be feasible, given what was found on habitat quality and availability, suitable donor stocks, nonnative species interactions, available prey species and threats.

Q. Where in the Clackamas River would the fish be reintroduced?

A. They would be released into historical bull trout habitat in the upper Clackamas River above the confluence with the Collawash River. This reach contains the most suitable habitat for reintroductions.

Q. When might these fish be put into the Clackamas?

A. The reintroduction could begin in the spring of 2009 and continue through the fall depending on whether the fish being moved are juvenile, subadult or adult fish. Transfer would continue annually for ten years in the first phase of the reintroduction. Transfer of fish in phase two (years 11 through 20) would be contingent on the success of phase one.

Q. How would this reintroduced population contribute to recovery of the species?

A. The reestablishment of bull trout in the Clackamas River would reduce the risk of elimination of bull trout from the greater Willamette Basin, and contribute to stabilizing bull trout populations in the lower Columbia River. The specific recovery objectives that would be supported by this action are:

- Maintain current distribution of bull trout and restore distribution where recommended in recovery unit chapters.
- Maintain stable or increasing trend in abundance of bull trout.
- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.
- Conserve genetic diversity and provide opportunity for genetic exchange.

Q. Where would the fish come from?

A. The most appropriate donor stock for the reintroduction has been determined to be from the Metolius River, in the Deschutes River Basin, a tributary of the lower Columbia River in north central Oregon.

Q. How many bull trout would be moved?

A. The potential proposed action includes the direct transfer of adult, subadult and juvenile bull trout from the Metolius River to the Clackamas River. For the first few years we anticipate transferring annually approximately 100 adults, 100 subadults, and several thousand juveniles and fry. The numbers and life stages of fish transferred annually will be linked strongly to the annual population size of the donor stock, as well as to information derived from monitoring and evaluating the success of the various life stages over the initial few years of the project.

Q. What happens after the bull trout are released in the river?

A. The Fish and Wildlife Service and partner agencies will monitor them to document survival, movement, spawning and natural recruitment. Reports will document the stocking rates and monitoring activities that took place during the previous year. Periodic progress reports will be released, and the agency will fully evaluate this reintroduction effort after phase one (ten years) is complete to determine whether to continue the project.

Q. Will the bull trout leave the area where they are released?

A. Bull trout do tend to migrate within large river systems, and some of the reintroduced fish are expected to move out of the release area on the upper Clackamas. To ensure that any reintroduced bull trout that may move are covered by the nonessential experimental population designations, the area's boundaries will extend downstream from the release areas the entire length of the Clackamas River, and include the Willamette river downstream to where it meets the Columbia River (including Multnomah Channel) and upstream to Willamette Falls. It is expected that the majority of reintroduced fish and future offspring of these fish will remain within the area boundaries. If bull trout move outside the boundaries, the Fish and Wildlife Service could propose to extend the boundaries to include the entire range of the expanded population.

Appendix 5. List of workshop attendees: invited expert panelists, meeting facilitators, workshop planning team, and observers.

Expert Panel Participants: Dave Beauchamp (UofW/USGS BRD), Jason Dunham (USGS FRESC), Kathryn Kostow (ODFW), Paul McElhany (NMFS Science Center), and Michael Meeuwig (Montana State University).

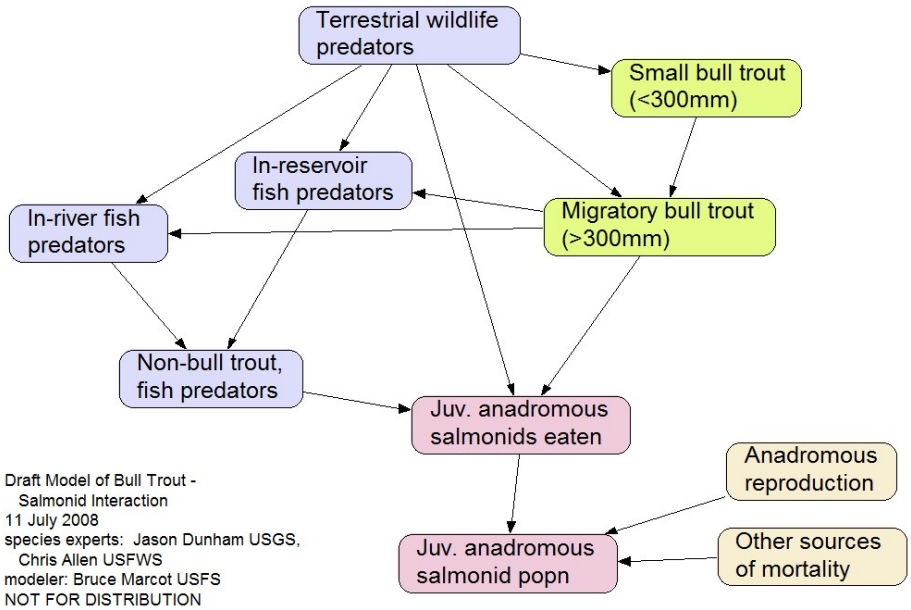
Facilitator: Dan Shively (USFS) with assistance by Bruce Marcot (USFS)

Workshop Planning Team: Dan Shively and Bruce Marcot (USFS); Rollie White, Chris Allen, and Steve Morey (USFWS); Jason Dunham (USGS)

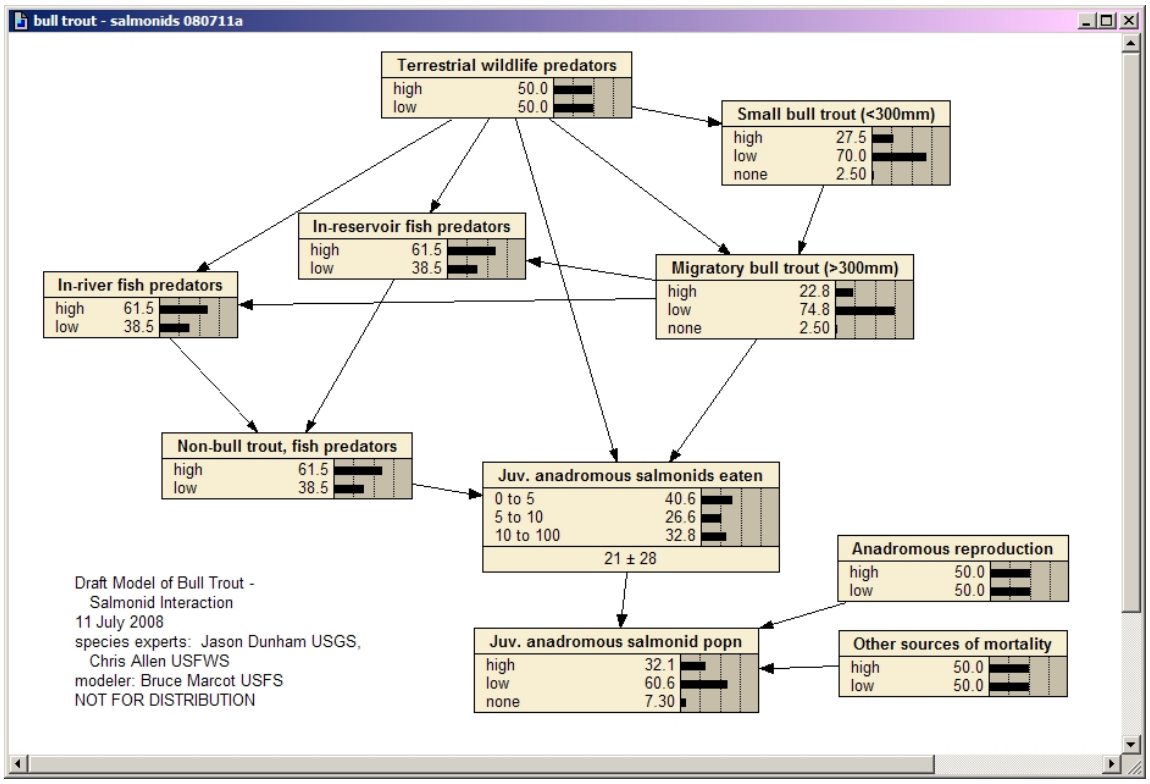
Manager Observers:
Paul Henson (FWS, State Supervisor, Oregon Fish and Wildlife Office), Miel Corbett (FWS OFWO), John Esler (PGE), Gary Larson (USFS, Mt. Hood Forest Supervisor), Chris Wheaten (ODFW, NW Regional Supervisor)

Additional Observers:
Nick Ackerman (PGE), Chris Allen (FWS OFWO), Todd Alsbury (ODFW), Jeff Boechler (ODFW), Doug Cramer (PGE), Brad Goerhring (FWS OFWO), Jen Graham (CTWSRO), Erin Lowery (UW), Rick Swart (ODFW), Rebecca Toland (FWS OFWO), Richard Turner (NOAA Fisheries), Garth Wyett (PGE), Bob Progulske (FWS OFWO).

Appendix 6. Bull trout food web model presented at the workshop by Jason Dunham and Bruce Marcot.



Influence diagram.



Bayesian network model developed from the influence diagram.

Appendix 7. Detail of expert panel methods used during the workshop.

Author: Bruce G. Marcot

This appendix provides a brief overview of concepts of expert paneling and the specific paneling methods used in the Bull Trout Expert Panel Meeting of July 2008.

On Expert Paneling

Expert judgment is often used as a source of information in the absence of, or to supplement, empirical research and statistically-sound studies. In ecology, expert judgment has always been sought for interpreting difficult or otherwise intractable problems in modeling, management, planning, and scientific understanding. Some examples include using expert opinion to evaluate an elk habitat model (Holthausen et al. 1994), to develop general faunal distribution models (Pearce et al. 2001), modeling rare species (Marcot 2006), evaluating adaptive management options (Failing et al. 2004), and many applications.

For many years, experts in particular fields of study have provided knowledge and experience that have been represented in computer expert systems. For example, Cheung et al. (2005) incorporated expert knowledge in an expert system to predict extinction probabilities of marine fishes, Crist et al. (2000) used an expert systems tool to evaluate effects of land use on biodiversity, and O'Keefe et al. (1987) developed an expert system approach to evaluating the conservation status of rivers. Many other examples are found in the literature.

One critical step in all of these examples is the soliciting and representing of expert knowledge in a reliable, repeatable, and unbiased fashion, especially from more than one expert for a particular problem. One major method for this is the conducting of panels of multiple experts in such as way as to ensure that individual and collective expertise is appropriately solicited and summarized.

Expert panels have been used extensively by natural resource and land management agencies for a wide variety of problems. Some examples include evaluating potential effects on species viability from an array of forest and land management planning options (FEMAT 1993, Lehmkuhl et al. 1997), determining the appropriate conservation status for a wide variety of potentially at-risk species under the Northwest Forest Plan (Marcot et al. 2006), developing a management plan for a national forest in Alaska (Shaw 1999), and other programs and projects.

An important consideration in seeking expert judgment from an expert panel is to clarify if consensus among all panelists is desired, or if individual judgment among the panelists is desired. Each of these objectives entails different paneling methods, results, and cautions. For example, to reach consensus among a group of individuals with disparate opinions and preferences, Hajkowicz (2008) and Bojórquez-Tapia et al. (2005) tested and

suggested use of multiple criteria analysis. To provide individual expert judgments, I have used a modified Delphi technique (Marcot 2006, Marcot et al. 2006), described in more detail below. Consensus might entail potential bias from group-think and excluding outlier opinions. Providing individual judgments might entail bias from different, individual motivations.

Reaching consensus is typically the objective of expert panels convened by the National Research Council's programs for developing criteria for contract requests for proposals. Weisberg et al. (2008) found that consensus was possible for evaluating the condition of communities of benthic substrates. However, a consensus outcome of an expert panel does not provide information on the variation in expert judgment among the individual expert panelists. Nor does it provide for "outlier" opinions from experts that might not concur with the majority views.

For the project objectives at hand, it was decided by the workshop planning team that individual expertise, not consensus, was sought as the objective of the paneling process, in large part because (1) the expert panel was to provide technical and scientific information to be later considered by decision-makers, and not specific consensus recommendations for management or a management decision per se, and (2) it was deemed of interest to determine the type and degree of variation *among* selected experts for the difficult questions posed.

Bull Trout Expert Panel Methods

Overall paneling approach

The Bull Trout Expert Panel procedure was structured as a modified Delphi paneling process. The Delphi paneling process entails a structured querying, disclosure, discussion, and revisiting of expert judgment on some focused problem of interest (e.g., see MacMillan and Marshall 2006). In addition to some of the above-cited expert paneling projects, the Delphi process has been used to assess status of wildlife species (Clark et al. 2006), to prioritize urban improvement strategies in India (Gokhale 2001), to develop habitat suitability index curves (Crance 1987), and for other ecological projects.

The standard Delphi process entails eventually reaching consensus among a panel of experts, but the modification used here (and in many previous expert panels) omits the consensus step because it was desired to obtain individual experts' input, in part to discover the range of judgment and interpretation among the experts on the panel. A consensus approach would not provide this.

Scoring of potential bull trout impacts

The specific Delphi method we used in the Bull Trout Expert Panel for scoring of potential impacts of bull trout on ESA-listed salmonids was as follows (also see Appendix 1):

1. Prior to the workshop, each expert panelist was sent a letter of explanation (Appendix 2) along with pre-meeting reading material (see Appendix 3 for list).

The purpose was to ensure that the panelists understood the nature of the questions and the general paneling methods to be used in the meeting, and would all come prepared with having studied the same background material.

2. At the workshop, a series of focused presentations was provided by various experts (some of the presentations by some of the panelists) on various key topics of the Clackamas River system, its dam management structure, and biology and ecology of salmonids (see Appendix 1 for presentation topics).

The purpose of these presentations, as with the pre-meeting reading material, was to ensure that all expert panelists were brought up to the same, common level of understanding of these key topics, that is, bring them to parity, so when they score outcomes they have all been equally informed on the major background information.

3. In preparation for the panel scoring exercise, during the workshop the scoring worksheet format and key terms and definitions were reviewed so that all panelists would understand and interpret the intent and terminology in the same ways.

The overall purpose of steps 1-3 is to reduce or eliminate bias from variation in their understanding of the ecological and environmental context and terminology, and of scoring methodology. The aim is to ensure that whatever variation may result among the panelists' scores and contributions would be principally from their individual ecological interpretations and expertise.

4. The panelists were then asked to provide initial scores of the potential degree of impact of bull trout on the 4 ESA-listed salmonids in the Clackamas River system. See Appendix 8 for the score sheet used.

The scoring was explicitly to be made on the assumption that bull trout reintroduction objectives are met (that is, at least 200-500 adult bull trout would be sustainably present in the Clackamas River system by 2030). The scoring was done by having each panelist spreading 100 points among one or more possible impact outcome categories (ranging None to Very High), for each of the four salmonids (Spring Chinook, Fall Chinook, Coho, and Winter Steelhead). This first round of scoring was done individually, in silence, without interaction and discussion.

5. Next, the panelists engaged in structured disclosure and discussion.

One by one, each panelist was asked to disclose their scoring for each salmonid and explain why they scored as they did. After this structured disclosure, they engaged in more open discussion on their rationale, including how they considered and weighed various factors in their scores. The discussion was followed by then allowing the panelists to ask questions of the observers and other experts in the room. The overall purpose of structured disclosure and discussion was to allow each panelist to learn from reach other, to bring out their best efforts and broadest judgments of all information and considerations.

6. The panelists then engaged in a second, final round of silent scoring, which constituted their final expert contribution on degree of impact. The panelists were also asked to describe, in words on their score sheet, their rationale for why they scored as they did, that is, to denote and describe which main environmental, biological, or ecological factors they considered and weighed in their scoring decisions.

Note that, between steps 4 and 6, the panelists suggested expanding the initial 5-category classification of impact to a 7-category classification, as follows:

Very High = bull trout influence contributes to 100% of the extinction probability
High = bull trout influence contributes to about 95% of the extinction probability
Moderately High = bull trout influence contributes to about 75% of the extinction probability
Moderate = bull trout influence contributes to about 50% of the extinction probability
Moderately Low = bull trout influence contributes to about 25% of the extinction probability
Very Low = bull trout influence contributes to about 5% of the extinction probability
None = bull trout influence has no contribution to the extinction probability

The panelists wanted to be able to more precisely denote possible impacts in the range between None and Moderate; this modification permitted this, and all panelists concurred with this change and felt more comfortable using it for their second round of scoring.

7. Results of the final scores were then presented back to the panelists (Appendix 9) for their information and interpretation (using Excel on a laptop computer projected to a screen).

Potential monitoring activities

The panelists were then quizzed, using a structured brainstorming paneling method, to provide ideas on potential monitoring activities and metrics, again presuming that the bull trout reintroduction program would go forward. The structured brainstorming approach took the form of individually asking each panelist in turn to suggest their "top two" monitoring topics and metrics, without repeating or critiquing what a previous panelist might have suggested; and going around the panel as many times as they felt necessary to provide ideas. Panelists were allowed to "pass" after the first round if they felt that their main ideas had already been suggested and added to the list, which was presented on screen.

The panelists then engaged in an open discussion to refine their list of potential monitoring activities, that is, to exclude, combine, or split out some suggestions. They also provided information on each monitoring activity's overall objective, theme, and duration or frequency (see Appendix 10).

The panelists were then given printouts of the final list of monitoring activities, and asked to score each activity on a 3-class priority scale: 1 = essential to conduct, 2 = important

but not necessarily essential, and 3 = worthwhile but of lower importance. They provided these scores individually in silence (just as they had done the scoring of potential bull trout impact on each salmonid, in the previous exercise).

Their scores were then entered into the spreadsheet; sums, means, and ranges of their scores were calculated; and the monitoring activities were then sorted by on increasing sum scores and then increasing mean scores. This resulted in a final list of suggested monitoring activities sorted by decreasing priority (Appendix 10).

Potential management activities

The expert panelists were then asked to provide ideas on potential management activities that could be considered, should the bull trout reintroduction program go forward *and* it be found that there was unacceptably adverse effects on the salmon and steelhead populations. The panelists provided ideas on such potential management activities again in a structured brainstorming process as described above. The panelists also specified the type and degree of adverse impact and the overall management theme to which potential management activity pertained.

The panel then was asked to engage in an open discussion to revise and refine their list of potential management activities, that is, to exclude, combine, or split out some suggestions. The final list was then sorted by management theme (Appendix 12).

Additional panel activities

The workshop agenda also provided, at the end of the sessions, each panelist to offer any comments of interpretation, caution, recommendation, or any other statement, and to interact more freely with all observers and managers in the room.

The expert panelists were also given an opportunity to review the content of the note taker's summary of each of their main comments (see Appendix 11) to ensure that what is presented in this report correctly captured their statements during the workshop.

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Appendix 8. Worksheet used by the expert panelists to score potential impacts from bull trout on each of the 4 ESA-listed salmonids in the Clackamas River system.

Panelist code: _____
Date: _____

TASK 1: DEGREE OF IMPACT

Assume that bull trout reintroduction objectives are met (that is, at least 200-500 adult bull trout sustainable by 2030). Now, **what are the impacts from bull trout on ESA-listed salmon and steelhead populations?**

Spread 100 points among one or more cells in each column (the spread of points represents your degree of predictability for each species); score each species independently.

Key: Round 1 / Round 2

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very High	/	/	/	/
High	/	/	/	/
Moderately High	/	/	/	/
Moderate	/	/	/	/
Moderately Low	/	/	/	/
Very Low	/	/	/	/
None	/	/	/	/
Total	100 / 100	100 / 100	100 / 100	100 / 100

Very High = bull trout influence contributes to 100% of the extinction probability
High = bull trout influence contributes to about 95% of the extinction probability
Moderately High = bull trout influence contributes to about 75% of the extinction probability
Moderate = bull trout influence contributes to about 50% of the extinction probability
Moderately Low = bull trout influence contributes to about 25% of the extinction probability
Very Low = bull trout influence contributes to about 5% of the extinction probability
None = bull trout influence has no contribution to the extinction probability

Overall rationale for your scoring across all species – *denote only for Round 2*
Check all that apply to your scoring:

- Refer to food web diagram
- Role of reservoirs in juvenile rearing of salmonids
- Migratory timing of salmonids
- Spatial and temporal habitat use by predatory bull trout
- Predator aggregations caused by in-stream structures
- Current abundance and recent trend of each salmonid species
- Other: _____

Appendix 9. Results of the expert panel scoring of degree of impact of bull trout on extinction probabilities of ESA-listed salmon and steelhead populations. See Appendix 8 for worksheet used.

Panelist A

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	5	0	5	10
Moderate	20	0	25	40
Mod. low	50	5	40	30
Very low	20	5	20	15
None	5	90	10	5

Panelist B

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	5	0	5	5
Moderate	10	0	10	10
Mod. low	45	10	45	45
Very low	35	40	35	35
None	5	50	5	5

Panelist C

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	0	0	0	0
Moderate	0	0	0	0
Mod. low	5	5	5	5
Very low	35	10	35	20
None	60	85	60	75

Panelist D

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	0	0	0	0
Moderate	0	0	0	0
Mod. low	30	15	45	40
Very low	65	65	45	50
None	5	20	10	10

Panelist E

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	0	0	0	0
Moderate	5	0	5	5
Mod. low	45	25	30	40
Very low	35	25	55	40
None	10	50	10	10

SUM OF ALL PANELIST SCORES

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	10	0	10	15
Moderate	35	0	40	55
Mod. low	175	60	165	160
Very low	190	145	190	160
None	85	295	95	105
	No. of panelists:	5		

MEAN SCORES

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	2	0	2	3
Moderate	7	0	8	11
Mod. low	35	12	33	32
Very low	38	29	38	32
None	17	59	19	21

RANGE OF SCORES (MAX-MIN)

Degree of impact	Spring Chinook	Fall Chinook	Coho	Winter Steelhead
Very high	0	0	0	0
High	0	0	0	0
Mod. high	5	0	5	10
Moderate	20	0	25	40
Mod. low	45	20	40	40
Very low	45	60	35	35
None	55	70	55	70

Appendix 10. Potential monitoring activities identified by the expert panel, listed in decreasing order of mean priority. \1

	Objective	Monitoring theme	When	Brief description, metric	Panelist A	Panelist B	Panelist C	Panelist D	Panelist E	Sum	Mean	Range	Comment
1	predator status	predator abundance & reproduction	annual	bull trout reproduction and recruitment, e.g., spawning surveys, age, and size	1	1	1	1	1	5	1	0	
2	trophic interactions	consumption	baseline & periodic	estimate rates of consumption of food by bull trout	1	1	1	1	1	5	1	0	tied with item 6
3	predator status	bull trout size structure	periodic	monitor size structure of bull trout in reservoir and river environments	1	1	1	2	1	6	1.2	1	
4	prey status	prey abundance & productivity	annual	smolt and adult abundance, size, and age of the 3 listed species at North Fork Dam	1	1	2	1	1	6	1.2	1	some redundancy re: adults w/ 5
5	prey status	prey abundance & productivity	annual	juvenile and adult abundance & size structure of the 3 listed species above the North Fork Reservoir	1	1	1	1	2	6	1.2	1	some redundancy re: adults w/ 4
6	trophic interactions	trophic interactions	baseline & periodic	monitor diet & stable isotopes of fish and key invertebrates to identify major predators (fish & others) of salmonines and other fishes (determine food web)	1	1	1	1	2	6	1.2	1	tied with item 2
7	predator status	demography	baseline & periodic	life stage and habitat-specific survival estimation of bull trout	1	1	2	2	2	8	1.6	1	
8	predator status	fish habitat selection	baseline & periodic	habitat selection by predator, probability of habitat use	2	2	1	2	1	8	1.6	1	
9	prey status	species abundance	baseline & annual	monitor Coho, Chinook, & winter steelhead abundance in nearby, adjacent basins, for reference both marine and other common freshwater effects	2	2	2	1	1	8	1.6	1	

	Objective	Monitoring theme	When	Brief description, metric	Panelist A	B	C	D	E	Sum	Mean	Range	Comment
10	trophic interactions	spatial and temporal variation in distribution of species	baseline & periodic	general surveys; over time for temporal variation; seasonally; all aquatic species	1	2	2	1	2	8	1.6	1	"all aquatic species" includes inverts & other taxa; contributes to 6
11	environment	reservoir limnology	~monthly	monitor temp & zooplankton	1	2	3	1	2	9	1.8	2	
12	predator status	age and growth	baseline & periodic	age and growth of all predators	1	1	2	2	3	9	1.8	2	
13	prey status	demography	baseline & periodic	life stage and habitat-specific survival estimation of all prey species	1	2	2	2	2	9	1.8	1	
14	prey status	fish habitat selection	baseline & periodic	habitat selection by prey, probability of habitat use	3	2	2	2	1	10	2	2	
15	prey status	fish use of reservoir	annual or periodic	hydroacoustic survey in reservoir to determine fish species abundance and distribution	2	2	2	3	1	10	2	2	this item is a subset of 10
16	trophic interactions	bull trout movement	periodic	tracking of bull trout movement through the basin, esp. if below the dam, to better understand interaction with prey species	2	2	2	3	1	10	2	2	
17	environment	habitat	baseline & periodic	monitor habitat to determine environmental correlates to better understand potential species interaction	3	2	3	2	3	13	2.6	1	
18	prey status	prey behavior	periodic	monitor of behavior of prey species, microhabitat selection diel activity	3	2	3	2	3	13	2.6	1	
19	predator status	angler catch of bull trout	annual or periodic	monitor angler catch of bull trout	3	3	3	3	3	15	3	0	

\1 Priority scoring: 1 = essential to conduct; 2 = important but not necessarily essential; 3 = worthwhile but of lower importance.

Appendix 11. Written explanatory notes and discussion comments from the five expert panel participants, recorded from their scoring of bull trout impacts and listing of potential monitoring activities.

These notes include any hand written notations, clarifications, comments, justifications etc.. made by individual panelists on their scoring forms.

Task #1 refers to the panelists scoring the potential effect of reintroduced bull trout on the four existing ESA-listed salmonid species in the Clackamas River system. Task #2 refers to potential monitoring activities. (See Appendix 7 for explanation of how these panel tasks were conducted.)

Panel Member A

Task #1 Notes:

Panelist A noted that for this exercise he/she assumed a population of 500 adult bull trout in the Clackamas River (this is the top end of our 200 to 500 fish goal as stated in background presentations from day 1 of the workshop).

Overall Rationale: Panelist A circled all bullets on score sheet and included additional information in italics below:

Refer to food web diagram: *all species*
Role of reservoirs in juvenile rearing of salmonids: *zooplankton during fall and late spring, insects during winter & early spring. Spring Chinook & Coho reportedly immigrate into the reservoir in fall and remain until outmigration in late spring*
Migratory timing of salmonids: *Spring Chinook & Coho vulnerable during migration into reservoir & chronic exposure in reservoir.*
Spatial and temporal habitat use by predatory bull trout: *fraction of subadult and adult bull trout use reservoir during fall through spring, adults move into river in summer, subadults stay in reservoir or go upstream.*
Predator aggregations caused by in-stream structures:
Current abundance and recent trend of each salmonids species:
Other: *Temporal patterns in thermal regime in both stream and reservoir (include vertical profile) will determine the degree of spatial-temporal overlap between predatory bull trout and juvenile salmonids. A cooler and less stratified reservoir will increase predation due to increased spatial-temporal overlap of predators and prey.*
Other: *Relative availability of juvenile salmon and steelhead compared to other forage fish among seasons & between river & reservoir habitat. If juvenile salmonids are the predominant fishes in the reservoir, they will absorb nearly all of the predatory impact by bull trout.*

Task #2 Notes:

In the 3rd row of the scoring sheet, under the column header "Brief description, metric", Panelist A crossed out "…all predators" and replaced with "bull trout".

The same thing was done 3 cells below the previous edit. The panelist crossed out "all predator species" and replaced with "bull trout".

Panel Member B

Task #1 Notes:

Panelist B provided the following rationale for his/her scoring:

- Spring Chinook, Coho & winter steelhead all scored the same because all share time and space with bull trout. No compelling data to conclude one species more vulnerable than another.
- Fall Chinook most likely no impact on risk, little likelihood of significant overlap in time and space.
- For spring Chinook, Coho & steelhead, most likely moderate-low, or low. Bull trout likely to prey on salmon and have some impact but not high relative to other threats. Bull trout part of historical ecosystem; should be able to coexist.
- A few points allocated to moderate & moderate-high risk category because there is possibility of worst case scenario of large artificially high bull trout population in reservoir that eat lots of salmon (analogous to terns in the Columbia). Species translocations have a history of going awry.

Task #2 Notes:

Panelist B noted the following:

- All his/her priority 1 tasks are needed for crisis monitoring
- All his/her priority 2 tasks are needed to understand and manage interactions (e.g. if you want to try to change the environment to reduce interactions). Also priority 2 tasks are generally needed to estimate food webs.
- Circled items are needed to estimate consumption rates (panelist circled 6 rows associated with monitoring activities – rows 3, 5, 6, 13, 17& 19).

Panel Member C

Task #1 Notes:

On the scoring sheet where the "Degree of impact" definitions were provided, Panelist C suggested inserting "biologically significant" into the definition of "None" so that it reads "bull trout influence has no *biologically significant* contribution to the extinction probability.

Panelist C also inserted 2 footnotes in the "Very High" definition. One footnote read: "Relative not absolute extinction probability, threats." The other footnote read: "Consider entire life cycle"

Panelist C provided the following rationale for his/her scoring: "I considered bull trout in the context of 1) the entire Clackamas River and threats therein, and 2) in the context of threats to salmon throughout their life cycle from freshwater to marine habitats and back. In this view I see "moderate" (50% of the risk) to represent a huge fraction of the risk that is not likely to be accounted for by any single variable. The category of "None" was not interpreted as zero, but rather, not biologically significant. Overall given the wide array of known problems with anadromous species & existing threats, the latter seem to loom much larger than I could easily imagine coming from bull trout alone. I erred on the side of caution in according more of the extinction risk to bull trout. Furthermore, I did not consider potential positive effects of bull trout on salmon (e.g. consumption of other predators) that are possible."
Task #2 Notes:

Panelist C provided only one note on the Task #2 scoring sheet and that was to cross out "all predators" and replace with "bull trout" in row 17 under the column header "brief description, metric".

Panel Member D

Task #1 Notes:

Under the "Rationale" portion of the scoring sheet, Panelist D circled the following categories (from the task #1 scoring sheet) that applied to his/her scoring:

Refer to food web diagram:
Role of reservoirs in juvenile rearing of salmonids:
Migratory timing of salmonids:
Spatial and temporal habitat use by predatory bull trout:
Current abundance and recent trend of each salmonids species:

Panelist D provided the following additional rationale:

"Ocean conditions, as well as other factors including passage and non-bull trout predators, likely contribute to population abundance of the anadromous salmonids in question. These topics were

outlined in the feasibility assessment. The reintroduction of bull trout would likely result in some added mortality to anadromous salmon, specifically small size-class individuals; however, the variety of other factors influencing population extinction probability of these anadromous salmonids outweigh the influence of an introduced bull trout population, in my opinion. Data suggest that bull trout are opportunistic predators; therefore bull trout may key-in on a certain salmonid prey species when abundant, but may favor other prey sources in the system (e.g. sucker species) in years of low salmon abundance. That is, bull trout will likely not select for anadromous salmonids in years that they are of low abundance (they will likely switch to other prey species)."

Panelist D provided additional rationale for scoring across species:

- Food web diagram: Abundant linkages, prey items, and predators other than bull trout should spread predation risk across many components of the food web, especially for an opportunistic predator.
- Role of reservoir: Bull trout will likely use the reservoir and prey on anadromous salmon but other species (e.g. sucker) may provide a forage base for bull trout.
- Migratory timing: The spatial and temporal overlap of piscivorous bull trout and potential anadromous salmonid prey is a very important question that should be addressed, variability in this overlap added to a large degree in the uncertainty of my scoring.
- Recent trends of salmonids species: Trends in anadromous salmonids are often tied to ocean conditions. This is likely a large contributor to the extinction probability of the species in question and in my opinion outweigh the potential influence of an introduced predator with a shared evolutionary history.

Task #2 Notes:

Panelist D stated that "tracking of bull trout movement through the basin, especially if below the dam, to better understand interaction with prey species" was ranked low (he/she ranked it a 1) because this activity was redundant, although at a finer resolution, with the activity "general surveys; over time for temporal variation; seasonally; all aquatic species" (he/she ranked this a 3). The two activities referred to in Panelist D's notes are from rows 16 and 18 from the Task #2 scoring sheet.

Panel Member E

Task #1 Notes:

Panelist E provided the following scoring rationale that they termed "Contributing Factors" by species on the back of Task #1 score sheet. He/she also provided scoring by percentages by species on the back of the sheet but these numbers correspond to the scoring in the table on the front of the score sheet.

- Spring Chinook: smaller size; higher spatial overlap; yearling/sub yearling duration of vulnerability; relatively abundant now
- Fall Chinook: very small; lower river, no spatial overlap unless bull trout move down river; subyearling short duration of vulnerability; very low abundance now.
- Coho: moderately small; may be preferred; modest spatial overlap; yearlings, but maybe some 2-year olds?; relatively abundant now.
- Winter Steelhead: small to large; modest spatial overlap, but may increase as fish rear; long period of vulnerability (2-3 years); modest abundance now.

Task #2 Notes:

Panelist E provided the following statement at the bottom of the score sheet: "Having problems with "all predators" versus "bull trout". "Some of these are higher priority for bull trout then for all predators or all aquatic species". "Agree with changes to bull trout – use those scores".

For several rows (6 & 17), it appeared Panelist E provided two scores; one score if considering just bull trout, and another if considering all predator species.

Panelist E scored row 18 as a 2 but penciled in the following comment in the margin: "might be higher for some species".

Appendix 12. Potential management activities identified by the expert panel, for reducing or eliminating unacceptable impacts of bull trout on salmon and steelhead populations, sorted by management theme.

Type, degree of impact	Management theme	Brief description of activity
High to very high impact from bull trout on other listed salmonids	Monitoring	Confirm type and degree of impact by collecting better data; improved or more intensive monitoring; to determine if indeed there is an impact so stated
Other threats	Offset impacts of bull trout	Deal with the lower river; mitigate threats to anadromous salmonids in Lower Clack River
All impact levels of bull trout predation on salmonids	Offset impacts of bull trout	Put more management emphasis to address other H and non-native fish species impacts on listed salmon on the Clack. River to offset possible bull trout predation effects
High to very high impact from bull trout on other listed salmonids	Predator control	Bull trout removal in toto, or maintain bull trout population at lower specified level
Moderate to high bull trout predation on salmonids	Predator control	Targeted eradication of bull trout on particular size classes; through public angling or fisheries managers
Moderate to high bull trout predation on salmonids	Predator control	Targeted eradication of bull trout redds to reduce the population
Predation on fall Chinook and chum on lower river	Predator control	Control downstream movement of bull trout at North Fork Dam
Moderate to high bull trout predation on salmonids	Predator control	Stop introducing bull trout; observe effects (passive)
All impact levels of bull trout predation on salmonids	Prey enhancement	Enhance 3 listed prey populations by increasing habitat capacity throughout the range of the populations (including areas below North Fork Dam), and increasing survival of prey populations
All impact levels of bull trout predation on salmonids	Prey enhancement	Ensure healthy mountain whitefish populations and other native resident fish species by increasing habitat capacity throughout the range of the populations and increasing their survival; the purpose is to provide a stable alternative prey base for bull trout
Predation by bull trout on juvenile salmonids in tributary habitats	Prey management	Add refuge cover in tributary habitat; habitat enhancements to reduce predation
Predation in reservoir	Prey management	Trap outmigrating smolts and physically move them below the reservoir
All impact levels of bull trout predation on salmonids	Prey management	Reservoir management to increase populations of other non-salmonid prey items

All impact levels of bull trout predation on salmonids	Prey management	Hatchery rainbow trout management in North Fork Reservoir: increase or decrease stocking levels or sizes of fish dependent on results of the baseline food web monitoring
All impact levels of bull trout predation on salmonids	Prey management	Focused supplementation of salmon carcasses in areas known to be forage hot spots if determined
All impact levels of bull trout predation on salmonids	Prey management	Facilitate upstream lamprey passage at North Fork Dam
All impact levels of bull trout predation on salmonids	Prey management	Add wood or structure to the reservoir and inlet channel as refuge habitat for prey species
Noncompliance with fishing regulations	Public management	Enhance law enforcement controls on enforcing fishing regulations in upper basin
Social impact	Public perception	Public conservation education about bull trout reintroduction objectives
Time and area of acute predation	Reservoir management	Adjust flow regime, or engineering to guide smolts to bypass system more quickly
Thermal impacts on trophic interactions	Reservoir management	Water management to adjust the thermal structure/productivity of reservoirs

9.2 Appendix B: Baseline Food Web Assessment of the Upper Clackamas River Basin Prior to Reintroduction of Bull Trout

August 2010

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Introduction

The introduction or re-introduction of an aquatic predator can influence potential prey populations through both direct and indirect effects that reverberate through the host community (Stein 1979, Miller et al. 1988, He and Kitchell 1990, Vigliano et al. 2009). Predation will directly reduce prey abundance, but may only become important if the predation rate measurably increases the mortality rate of prey above some acceptable level. The magnitude of direct predation effects are influenced by the degree of spatial-temporal overlap of predators and prey, size-structured predator-prey interactions, diet composition and consumption rates of predators, and the abundance of predators and prey (Sih et al. 2010). Indirect effects of predators can also be important influences on the growth and survival of prey species (Peckarsky et al. 2008, Schmitz et al. 2008). Predators might also differentially feed on a particular species, thus benefitting other species by competitive release or predation buffering. Predation risk can alter behavior, habitat use, foraging success, time budgets (i.e., foraging versus refuging), or temporal-spatial distribution and movement patterns of potential prey (He and Kitchell 1990, Okuyama 2009). These anti-predator behaviors can result in reduced growth rates during vulnerable life stages. Size-selective mortality can be a strong force regulating juvenile salmonid populations during freshwater (Biro et al. 2003a,b, 2005) and early marine life stages (Parker 1971; Ward et al. 1989; Henderson and Cass 1991; Sogard 1997; Beamish et al. 2004; Moss et al. 2005; Cross et al. 2009; Duffy 2009; Ruggerone et al. 2009). Therefore, factors that reduce growth during juvenile life stages can ultimately lead to significantly lower survival in subsequent life stages, particularly for anadromous fishes (Beauchamp et al. 2007; Duffy 2009).

Bull trout (*Salvelinus confluentus*) were listed as threatened in 1998 under the Endangered Species Act (ESA) and are native to coldwater habitats in western North America ranging from northern Nevada to the southern Northwest territories, and from the Pacific Coast to the Rocky Mountains (Cavender 1978, Haas and McPhail 1991, Reist et al. 2002). They were extirpated from the Clackamas River basin in northwestern Oregon approximately fifty years ago with the last verified observation in 1963 (Goetz 1989). In compliance with the ESA, the United States Fish and Wildlife Service (USFWS) proposed to reintroduce bull trout into the Upper Clackamas River above North Fork Reservoir as a nonessential experimental population. The Upper Clackamas River is an important producer of Lower Columbia River anadromous fishes,

containing populations of ESA-listed Lower Columbia River spring Chinook salmon, Lower Columbia River coho salmon, Lower Columbia River steelhead, and non-listed coastal cutthroat trout, all of which exhibit primarily stream-type life history patterns prior to seaward migration.

The productivity of freshwater habitats is an important component of the Pacific salmon *Onchorhynchus* spp. life cycle. Habitat complexity is often cited as beneficial to juvenile stream-type Pacific salmon, because it can buffer the river system from extreme environmental events such as flooding and mass wasting (Bell et al. 2001). Temporal and spatial use of rearing and foraging habitats by juvenile salmonids can reflect the complexity of the habitat available, with individuals using a variety of habitats or regions of a river system on a seasonal or ontogenetic basis (Quinn and Peterson 1996). In-stream trapping conducted by the Clackamas River Fisheries Working Group (CRFWG) (CRFWG 1995-2006) consistently reported migrations by juvenile salmonids within and emigration from the Upper Clackamas River throughout the year, indicating complex use patterns throughout the river system. Annual monitoring by the CRFWG also indicated that freshwater productivity for juvenile Pacific Salmon has declined, but mechanisms driving this decline have not been identified.

Feasibility assessments and risk management evaluations of the proposed reintroduction of bull trout concluded that the establishment of a bull trout population in the Clackamas River was likely and would have minimal to negligible negative impacts on native fish populations (Shively et al. 2007, Marcot et al. 2008). Current and future food web studies can address some uncertainties identified by Marcot et al. (2008) including, prey and predator abundance and size structure, prey and predator productivity, trophic structure, and seasonal predation vulnerability by species of conservation concern. Even minimal risk of extirpation is a concern for managers tasked with the conservation and recovery of listed anadromous salmonids. Consequently, monitoring the ecological effects of the reintroduced bull trout population, as it assimilates into the Upper Clackamas River food web, was identified as a top priority for the monitoring and evaluation of the reintroduced population.

Bull trout are generally top predators in aquatic habitats. Bull trout commonly consume prey with higher energy content such as fish eggs or fish but also consume aquatic insect larvae

and salmon carcasses when seasonally available. In the Skagit River, WA, bull trout became piscivorous around FL = 100 mm where fish comprised 56% of the estimated biomass consumed annually by a size structured unit population of 1000 individuals > 300mm. In addition to fish prey, bull trout in the Skagit River consumed marine derived food sources with high energy density such as Pacific salmon eggs as well as lower energy content foods like adult Pacific salmon carcasses and aquatic insect larvae (Lowery 2009). In Lake Billy Chinook, OR, bull trout were both major predators on kokanee and cannibalistic (Beauchamp and Van Tassell 2001). Bull trout in coastal Washington and Puget Sound migrate to marine waters and consume high quality prey such as surf smelt (S. Brenkman NPS unpublished data). Consumption of both high and low quality prey highlights the behavioral plasticity in feeding by bull trout in response to seasonal variation in food quality and quantity. Bull trout appear capable of adopting migratory life history strategies to exploit seasonally-predictable sources of abundant or high-quality food. The fluvial and anadromous life history of bull trout in the Skagit River, the shift from historically fluvial to adfluvial forms after formation of Lake Billy Chinook, and the anadromous life histories in coastal Washington rivers are examples of this plasticity.

In the Upper Clackamas Basin, the reintroduced bull trout population would initially be small, so the ability to detect ecologically-relevant responses by the host assemblage will require a focus on sensitive indicators of response. While bull trout abundance is low, evidence and effects of direct predation will likely be harder to detect and quantify than changes in growth rates, size-age distribution, and temporal-spatial distribution patterns by juvenile salmonids and other fishes, as a result of indirect, non-consumptive effects of predation risk. Changes in behavior or habitat use by juvenile salmonids in response to increased predation risk would likely result in reduced feeding and growth rates, thus potentially reducing survival during the remainder of freshwater rearing and subsequent marine life stages. This study will establish quantitative baseline data on seasonal distribution, size structure, growth and feeding patterns of juvenile anadromous salmonids and other key fishes within specific habitats of the Upper Clackamas Basin and will enable subsequent comparison of these response indicators through different phases of the bull trout reintroduction and establishment.

The objectives of this study were to determine how the Upper Clackamas River food web currently functions by: 1) identifying temporal distribution patterns with an emphasis on important seasonal growth habitats for protected salmonids; 2) quantifying their feeding and growth performance within those habitats; 3) quantifying the consumption demand of other species within the food web that potentially share common prey with anadromous salmonids; and 4) identifying the current predation risk to salmonids by predatory fish.

Study Area

The Clackamas River is located in northwest Oregon in Clackamas County (**Figure 1**). This investigation took place within the Upper Clackamas River, defined as all portions of the river and tributaries upstream of and including the North Fork (NF) reservoir at RM 30. The primary sampling locations were the tributary habitats of Big Bottom, Oak Grove Fork and Pinhead Creek (**Figure 1**), and NF Reservoir (**Figure 2**). The free flowing sections of the mainstem Clackamas River above NF Reservoir could not be sampled effectively within the logistical limitations of this study, but methodical seasonal sampling for biological data (diet, size structure, growth) was conducted in the river-reservoir transition zone (**Figure 2**). The North Fork Reservoir is an impoundment of approximately 122 hectares created by the North Fork Dam operated by Portland General Electric. The Reservoir is approximately 8.5 km long with a mean depth of 16 m and a 37-m maximum depth. The surface elevation of the reservoir did not fluctuate appreciably during [or among?] sampling periods. Surface temperatures were measured seasonally and ranged from 5.5˚C in winter to 18.1˚C in summer. Weak thermal stratification occurred in late summer where the surface temperature is 2.6-3.4˚C warmer than the deepest portion of the water column. The upstream portion of the reservoir is relatively shallow and the downstream portion of the reservoir near the forebay of the NF Dam is steep sided with little littoral habitat. The river-reservoir transition zone is characterized by moderate flow during periods of spill in spring and negligible to moderate flow other times of the year. This created seasonal stream- then lake-like conditions which influenced the physical conditions related to the production or availability of insects and zooplankton in this habitat.

Big Bottom is a large complex of permanent and ephemeral braided channels connected to the mainstem Clackamas River and is considered an important area for Pacific salmon production. We sampled three sites in the Big Bottom region (BB1, BB2, BB3): BB1 and BB2 were ground

water fed and contained adequate flow for fish year round. The mouth of BB1 was located approximately 300 m from the mainstem Clackamas River, BB2 was located approximately 50m from the confluence of the channel and mainstem. BB3 was a small side channel off of the mainstem and only contained water during the spring runoff period.

The Oak Grove Fork is a major tributary and an important source of all three listed anadromous fishes within the study area, particularly steelhead. Pinhead Creek is a stable spring fed stream that is expected to be a likely bull trout spawning location once the population becomes established. Only wild-produced fishes are permitted to pass the NF dam; therefore, the Upper Clackamas River is considered a wild fish only system with one exception. Hatchery rainbow trout *O. mykiss* are planted in the NF reservoir for a put and take fishery during spring, summer, and early fall. This is the only non-wild produced fish within the study area. There are three other nonnative fish species in the upper Clackamas river watershed including brown trout *Salmo trutta* in NF Reservoir, brown trout and kokanee *O. nerka* in reservoirs located on Oak Grove Fork, and brook trout *S. fontanalis* in some of the alpine lakes and short sections of the lake outlet streams in the headwaters of the Clackamas River. The remaining fishes in these habitats are: dace *Rhinichthys* spp., largescale sucker *Catostomus macrocheilus*, Pacific lamprey *Lampetra tridentata*, shorthead sculpin *Cottus confusus*, mountain whitefish *Prosopium williamsoni*, Pacific salmon and trout: Chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, cutthroat trout *O. clarki*, rainbow trout, and anadromous steelhead *O. mykiss*.

Chapter 2 Methods

We documented seasonal distribution, diet, size structure, growth, and abundance in the primary tributary habitats, and NF Reservoir. Only seasonal distribution, diet, growth, and size structure data were collected in the mainstem transition zone into the reservoir. These data were used as inputs for bioenergetics model simulations to quantify seasonal feeding and growth performance by juvenile salmonids within these habitats in response to ambient thermal regime and food supply. The model simulations also calculated seasonal consumption rates on all prey categories to determine the current feeding rates and consumption demand for key prey eaten by each age class and species. These simulations were also applied to the other abundant species in the Clackamas River tributary habitats and North Fork Reservoir in order to assess the relative importance of competitive or predation-prey interactions within the existing fish community.

We used backpack electrofishing in the tributary streams and river-reservoir transition zone and a combination of hydroacoustics, gillnetting, snorkeling, and limnology in the NF Reservoir to collect data and samples.

Tributary Sampling

Population data (density, abundance, biomass) and biological samples (e.g., diet, size, scales, stable isotopes, etc.) were collected seasonally in tributary habitats. Sampling for abundance and standing stock biomass of fishes was conducted within tributary habitats using three pass electrofishing (Temple and Pearsons 2007) during May, August, and November 2009, and January 2010. Numerical abundance and standing stock biomass were estimated using MicroFish Software (Van Deventner and Platts 1989). We sampled one sampling unit in Oak Grove Fork and Pinhead Creek and three sampling units in Big Bottom. A sampling unit was defined as a section of stream where length was approximately six times the wetted width. We selected this length due to the logistical constraints of sampling these habitats and to ensure we sampled a majority of fishes present in these locations. Stream sampling units were enclosed with block nets to prevent immigration and emigration. We attempted to sample each unit once per season depending on environmental conditions. Oak Grove Fork was effectively sampled for population data and biological samples during summer, autumn, and winter. High flow rates prevented sampling during spring. In BB1 and BB2, population data and biological samples were collected in spring, summer, and autumn, but during winter, only biological samples could be collected at just BB1. BB3 was only sampled in spring, because it was dewatered in other seasons. Pinhead Creek was sampled all four seasons.

The river-reservoir transition zone was defined as the upstream portion of the NF Reservoir inundation zone extending approximately 3 river kilometers upstream of Promontory Point. Width varied from 300-600 meters with depths ranging from 2-5 meters depending on season. Flow varied within the reach and was dependent on upstream flow and spill at NF Dam. In general flow was highest in spring and autumn and lowest in summer and winter. Only biological samples were collected in this site via electrofishing during spring, summer, and autumn.

Length, weight, scales, otoliths, white muscle, fin, and diet samples were collected from most fishes in all locations. Length and weight were used to characterize the biomass and size structure of individual populations. Scales and otoliths are used to estimate age and annual growth. White muscle, fin clips, or whole fish were used in stable isotope analysis. In compliance with scientific collection and handling permits (UW IACUC permit #3286-18, NOAA permit #s 14490 & 15016), a subset of protected Pacific salmon juveniles were anesthetized in buffered tricane methanosulfonate (MS-222), then length, weight, scales, and fin tissue were collected. Stomach contents were obtained by gastric lavage (n=26 coho salmon released, n=125 kept, n=49 *O. mykiss* released, n=98 kept). The fish were allowed to recover before release back into the sample reach. The other species of fish captured (cutthroat trout and shorthead sculpin) were euthanized with an overdose of buffered MS-222, then species, length, weight, stomach contents, scales, and a tissue sample of muscle or fin were collected from each fish captured. Coastal cutthroat trout were caught in low numbers (n=58), so we did not achieve our target sample size for this species. Due to the wide range of sizes of shorthead sculpin all individuals were kept to ensure accurate length/weight relationships and biomass estimates from the smallest (18.3mm) to the largest (107.9mm) individual. All samples were placed on ice in the field and frozen within three hours of collection.

Reservoir Sampling

Reservoir sampling consisted of seasonal vertical temperature profiles, depth-stratified zooplankton collections, vertical light profiles, turbidity measurements, shoreline snorkel surveys, hydroacoustics, and gill netting during May, August, December 2009 and January 2010. Temperature and zooplankton were collected at two fixed sites within the reservoir: one near the confluence of the North Fork Clackamas Arm in the main body of the NF Reservoir and one near the forebay of the NF Dam along the log boom. Temperature profiles were collected using a (YSI model here) at 1m intervals. When thermally stratified, the epilimnion was represented by the 0-5 m depth interval. Zooplankton were collected in 0-5 m and 0-15 m vertical hauls using a conical 30-cm-diameter, 363-µm-mesh net. The NF Reservoir was effectively sampled all four seasons. A total of 49 seasonal gill net sets were deployed (spring n=10, summer n=13, autumn n=14, and winter n=12) with horizontal sinking gill nets consisting of paired small mesh (2.5, 3.2, 3.8, 5.1, 6.4, and 7.6 cm stretched mesh) and large mesh (8.9, 10.2, 11.4, 12.7, and 15.2 cm stretched

mesh) nets. Gill nets were set perpendicular to the northern shore of the NF reservoir to avoid capturing migrating Pacific salmon smolts which generally oriented along the southern shore during outmigration (D. Cramer personal communication). The paired small- and large mesh nets were set perpendicular to shore with the shallow end at bottom depths of approximately 4m and 10 m to maximize vertical coverage in the shallow reservoir. Due to the shallow depth of the reservoir and presence of recreational watercraft, a minimum bottom depth of 4 m was selected for the 2-m high gill nets during this study. This ensured the safety of boaters and sampling gear by keeping the top of the nets at least 2 m below the surface. Soak time was varied (6-12 hours) in order to reduce mortality on juvenile Pacific salmon. Varied soak time did not appear to affect CPUE; however, longer soak times resulted in predation by signal crayfish *Pacifasticus leniusculus* on captured fish during summer.

Hydroacoustic surveys were used to quantify the seasonal, size-specific abundance and diel distribution patterns of fishes in the pelagic habitat of the reservoir. Hydroacoustic surveys were conducted during May, August, and December 2009 and January 2010, using a zigzag pattern from shore to shore. These transects were repeated during daylight, crepuscular, and night surveys each season. We towed tow multiplexed split-beam 200 kHz transducers configured in downlooking (6.8^{o} full beam angle) and side-looking (12.8^{o} full beam angle) orientations, linked to a Biosonics DE-6000 scientific echosounder (Noise threshold -60 dB bottom threshold 60m, ping rate 3pps, pulse width 0.3ms, and target acceptance criteria using minimum and maximum normalized pulse length of 0.30-1.50 at -6dB from peak amplitude. Hydroacoustic data were analyzed using standard echo counting techniques (Beauchamp et al. 1997, 2009) with EchoView 4.8 software (Myriax Pty. Ltd.) to estimate depth-specific densities of fish within different size classes. Fish schools were not encountered; therefore, single target counts were used exclusively to analyze hydroacoustic data. Extensive groundwater input created numerous columns of bubbles; these false targets had to be identified and manually excluded during post-processing, before analysis could proceed. Dorsal-aspect target strengths from the vertical transducer were converted to fish lengths using Love's (1971) equation. Once converted, fish were combined into size classes (15-95mm, 96-300mm, and 301-500mm) and compared to seasonal size-structured proportional catch composition from gillnetting to estimate the species specific standing stock biomass of fishes in the NF Reservoir. Target strengths from the horizontal transducer were used to estimate fish density within the upper 4.6-18.2 m of the water column over a range of 10-40 m from the boat. Horizontal hydroacoustic

data cannot reliably estimate target size, but can be used to estimate the density of all targets with TS > -60 dB to enumerate the numbers of fish in the upper water column. These shallow water targets were presumably rainbow trout, mountain whitefish, or juvenile Chinook salmon.

Hydroacoustic estimates of large (FL > 300 mm) limnetic fish (adult brown trout and mountain whitefish) or benthically oriented (sucker spp.) fishes are generally too variable to use for opportunistic population assessment and can misappropriate species abundance estimates in multi-species communities (Beauchamp et al. 2009, but see Yule 2000, and Gangl and Whaley 2004); therefore, the hydroacoustic results and analysis focused on smaller fishes. We calculated population estimates for these larger fishes to structure consumption estimates, but these estimates should be considered very coarse due to the high variability and potential biases discussed above.

To assess fishes that were too small to be sampled by gill nets and too close to shore to be detected in the hydroacoustic transects, we used a strip transect snorkel survey along the perimeter of the NF reservoir to determine seasonal fish (30-150 mm FL) use of the littoral zone. The survey consisted of single or paired swimmers following 2-m wide strip transects originating from shore. The 2-m width was chosen to allow total detection of all fishes within the transect. Few fish 30-150 mm were observed outside the 2-m strip, but only those fish observed within the 2-m wide strip were included in the counts. All fish observed within a transect were identified to species and grouped into either 30-50 mm FL or 50-150 mm FL size classes. A subsample of juvenile salmonids were collected and measured to verify size classes. We only quantified juvenile salmonids, other fish observed are reported in the results section. To estimate the number of fishes we used a ratio estimator (eq. 6.1 in Cochran 1977):

$$\hat{N} = \frac{A}{w}\left(\frac{\sum_{j=1}^{n} f_j}{\sum_{j=1}^{n} l_j}\right)$$

Where: $\hat{N}$ is the estimated number of fish in the littoral zone of the NF Reservoir, A is the total area of the littoral zone, w is the constant width of the transect, j is the jth transect, f_j is the number of fish counted in the j_{th} transect, and l_j is the length of the jth transect.

Variance of the population total is estimated using (eq 2.46 in Cochran 1977):

$$Var\left(\hat{N}\right) = \left(\frac{A}{w}\right)^2 \left[\frac{\left(1-F\right)^2}{n\left(\bar{l}\right)^2} \frac{\sum_{j=1}^{n}\left(f_j - \hat{R}\, l_j\right)^2}{\left(n-1\right)}\right]$$

Where $\bar{l}$ is the mean transect length, F is the fraction of the total area sampled in this survey and is defined as:

$$F = \frac{w\sum l_j}{A}$$

and $\hat{R}$ is the ratio estimator:

$$\hat{R} = \left(\frac{\sum_{j=1}^{n} f_j}{\sum_{j=1}^{n} l_j}\right)$$

Juvenile Chinook salmon were counted in the 30-50 mm and 50-100 mm size classes. Juvenile coho salmon and unidentified salmonids were observed in 30-50 mm and 50-150mm size ranges.

Zooplankton Biomass and Production Estimates

Standing stock biomass of primary crustacean zooplankton species was estimated from empirical data, and production was estimated using a production/biomass regression model (Stockwell and Johannsson 1997). Zooplankton were identified to genus, counted, and body length (from the base of the helmet to the base of the tail spine or setae) was measured for the first 15 individuals of each taxon using a dissecting microscope with a digital camera and Image Pro image analysis software. Body mass was estimated using taxon-specific length-wet weight relationships (Dumont et al. 1975). Zooplankton biomass density (g/L), at 0-5m and 5-15m, was expanded to the whole reservoir based on bathymetric information provided by PGE (JB Hoy and J Daniels PGE unpublished data) resulting in a whole reservoir estimate of zooplankton standing stock biomass.

Age and Growth

Age, size structure, and growth were examined among sites and habitats for Chinook and coho salmon, rainbow, cutthroat, brown trout, mountain whitefish, and sucker using scales collected from the preferred area (Scarnecchia 1979). All scales were read three times by two independent readers and only those scales that could be read consistently were used in this study. Ages of sculpin were estimated by size modes in length frequency distributions. Length/weight relationships were applied to length-at-age data (**Table 1**) to estimate weight-at-age at each sampling location for each species. The annual growth increments in terms of weight were used as inputs for bioenergetics model simulations (**Table 2**).

Diet Analysis

Diet composition for each species was analyzed with respect to changes in the proportional weight contribution, MW_i from Chipps and Garvey (2007), of each prey category to the diet by season, habitat type, and size class of consumer (Beauchamp et al. 2007). Prey items were identified under a dissecting microscope. Fish prey were identified to species, and standard lengths (SL mm) were measured whenever possible. Prey items were classified into groups based on energetic content and similarities in ecological function or by the foraging modes used by fish to obtain them (i.e., benthic, drift, surface, and piscivory) rather than their taxonomic status. For example, the energy density of immature aquatic invertebrates is lower than adult aquatic or terrestrial invertebrates, so the latter two were grouped for more accurate determination of energy densities. Vertebrate prey items were more variable in energy density, and were identified to species whenever possible. All stomach contents were blotted dry and weighed to the nearest 0.001g wet weight. After all diet items were identified, the contents were preserved in a solution of 95% ethanol and archived.

Stable Isotope Analysis

Stable isotope analysis was used to provide a time-integrated signal for the food web relationships of key species in tributary and reservoir habitats. The stable isotope data provided a useful method for corroborating diet data and for identifying changes in trophic interactions related to ontogenetic or habitat shifts. For juvenile Pacific salmon, analysis occurred at the start and end of the growing season (Spring and Autumn/Winter). Resident fishes were analyzed at various times of the year. Stable isotope ratios of carbon and nitrogen in the tissues of fish and

invertebrates can describe the trophic position of key species (herbivores, invertebrate predators, fish predators, etc) and the primary energy pathways of the food web (e.g., benthic, pelagic, detritus-based; Peterson and Fry 1987; Vander Zanden and Rasmussen 1999). In general, $\delta^{13}C$ isotope values are similar between prey and consumer and can be used to identify the flow of energy through the ecosystem after a correction of ≈1‰ per trophic level (DeNiro and Epstein 1976; Vander Zanden and Rasmussen 2001). Stable isotopes of nitrogen concentrate in tissues and are good indicators of trophic level. Trophic levels in the ecosystem are generally indicated by an increase of approximately 3.4‰ for $\delta^{15}N$ between prey and their consumers (Minagawa and Wada 1984; Vander Zanden and Rasmussen 2001). These stable isotope ratios allow researchers to determine the trophic position and energy pathways available to different members of a food web (Johnson et al. 2002; Post 2002, McIntyre et al. 2006).

Stable isotopes were measured using a continuous flow Carlo Erba 2100 elemental analyzer interfaced with a Thermo-Finnigan Deltaplus isotope ratio mass spectrometer (Mark Haught, University of Washington, School of Oceanography Stable Isotope Laboratory, Seattle, WA). Stable isotope ratios, in δ notation, were reported as a ratio (*R*) of the heavy isotope to the light isotope ($^{13}C/^{12}C$ or $^{15}N/^{14}N$) normalized by internationally recognized reference standards:

$$\delta = \left[\left(R_{sample}/R_{standard} - 1\right)\right] \cdot 100$$

The reference material was Vienna Pee Dee belemnite limestone for carbon and atmospheric N_2 for nitrogen.

Bioenergetics Modeling

Consumption was estimated using the Wisconsin bioenergetics model (Hansen et al. 1997). Species-specific physiological parameter sets were used for Chinook and coho salmon (Stewart and Ibarra 1991), steelhead-rainbow trout (Rand et al. 1993), cutthroat trout (Beauchamp et al. 1995), brown trout (Dieterrman et al. 2004), sculpin spp. (Moss 2001), and whitefish spp. (Rudstam et al. 1994). The most common application of the model estimates consumption by an average representative from each age class based on growth achieved over some specified time interval (e.g., season or year), given the observed changes in diet composition and thermal regime. We used the model to estimate daily consumption by the

average individual from each age/size class of key fish species within tributary and reservoir habitats of the Upper Clackamas River food web. Simulations fit daily consumption estimates to annual growth increments, based on seasonal changes in size-specific diet composition, and monthly changes in the thermal experience of the consumer. Bioenergetics simulations were run to estimate the baseline feeding rate and growth performance associated with each age class of each life history strategy observed or reported for anadromous salmonid populations in the study area. The bioenergetics model expressed feeding rate as a percentage of the theoretical maximum consumption (% Cmax) possible for a consumer of a given size under the thermal regime experienced. Because the bioenergetics model accounts for the otherwise confounding effects of variable temperatures and body sizes when estimating growth or consumption, the simulated feeding rates can be useful indicators of food supply or accessibility for different species and life stages within distinct habitats. These baseline feeding rates and growth performance metrics can then be compared to analogous metrics among years, during and after the bull trout introduction to determine whether feeding rate or growth performance changed.

Life histories of juvenile Pacific salmon were modeled based on observed habitat use from tributary and reservoir sampling in this study, historic stream trapping by the CRFWG, and juvenile Pacific salmon monitoring by PGE. Seasonal migrations within the Upper Clackamas River system have been monitored by the CRFWG for approximately 10 years (CRFWG 1995-2006) primarily through the use of in-stream screw traps at: 1) the mouth of Oak Grove Fork, 2) the mouth of Fish Creek, 3) in the mainstem Clackamas in Big Bottom (near Switch Creek), and 4) near the mouth of the South Fork Clackamas. In addition, a trap was operated in NF Reservoir on the juvenile bypass facility operated by PGE at the NF Dam. Different life history strategies were inferred from modal seasonal movement and distribution patterns and were simulated to reflect the most common stage-specific habitat use patterns by juvenile salmonids in order to estimate their growth performance and seasonal consumption demand for key prey resources under current conditions.

Temperatures used in model simulations originated from various sources. Reservoir temperatures were a combination of reported vertical temperature profiles (PGE 2000, 2001) and seasonal vertical temperature profiles from this study. Thermal stratification within the reservoir

was generally weak or lacking and the depth distribution of acoustic targets did not exhibit behaviors consistent with thermal stratification, so the average temperatures across all depths were used for thermal experience in the reservoir simulations. Temperatures for Big Bottom (D. Shively, USFS, personal communication) and Pinhead Creek (T. Shibihara, PGE personal communication) were provided by local biologists. Temperatures for Oak Grove Fork were accessed from the Clackamas River Water Providers long term dataset consisting of monthly grab samples averaged over ten years.

Bioenergetics simulations were used in two ways: 1) to evaluate the seasonal feeding and grow performance resulting from each of the major life history strategies observed for juvenile Chinook, coho, and steelhead within the Upper Clackamas River Basin; and 2) to estimate the annual population-level consumption demand by the major fish species in each habitat.

In the first application, seasonal feeding rate and growth performance was estimated for the average individual fish employing each of the common life history strategies observed in the basin. Simulations estimated the amount of consumption required to satisfy the seasonal growth observed for different species and age classes within and between habitats through the year. For each species, distinct size modes were tracked within or between habitats (e.g., see Figures 3-5 below) to obtain the initial and final body mass used as inputs to the model for fitting consumption to seasonal growth increments. These simulations calculated the feeding rate and growth efficiency of the average fish for each major life history combination of species-age class-habitat. Simulations for Chinook and coho salmon started May 1st and ended in mid-January, which corresponded to the last sampling date when discrete size modes could still be identified with reasonable certainty. Age-0 *O. mykiss* emerged and began exogenous feeding at some unknown time between the May and August sampling periods. Consequently, there was too much uncertainty in reconstructing their growth trajectories from emergence until body mass was first measured in August. Therefore, the simulations for age-0 steelhead started in August and extended through November, January, and then May, August, and November of the following year. The estimated feeding rates were obtained from model outputs (estimated proportion of maximum consumption or % Cmax), growth efficiencies (food consumed/observed growth), and the energetic quality of common prey were used to compare feeding and growth

performance of key fish species in all habitats. Growth performance is affected by four major factors: body size, temperature, feeding rate, and the energy density of prey, and the bioenergetics model can account for all of these factors explicitly (Beauchamp 2009). Feeding rates and growth efficiencies are commonly used to evaluate quality of foraging habitats while accounting for the effects of temperature and prey quality. The energetic quality of prey (energy density, J/g wet weight) consumed provides context for evaluating feeding rate and growth efficiencies. For example consumers would require a higher feeding rate of low-energy density prey to achieve an observed growth rate than would be needed if prey with higher energy density were eaten (Hanson et al. 1997).

In the second application, the annual population-level consumption demand for prey was estimated for each the major fish species within each habitat. Seasonal bioenergetic simulations were performed on age-specific growth cohorts representing the most commonly observed life history strategies for Chinook and coho salmon and *O. mykiss*. The simulations estimated the feeding rate and biomass of each prey category consumed on a daily basis (g/d) over the duration of the simulation. Simulations for each cohort started on May 1 (simulation day 1) and ended April 30 the following year (simulation day 365).

Model inputs for the energy densities (J/g wet weight) of consumers and prey were obtained from literature values (**Table 3**). Annual energy budgets were calculated to determine the importance of different food sources during different seasons and life stages for key fish species in the food web. The estimated biomass of each prey consumed during each season and life stage in the model simulations was multiplied by the corresponding energy density of prey to calculate the total energy contributed by each prey category during different seasons and life stages.

Individual consumption estimates were expanded to the population level based on observed life histories, gill netting, direct population estimates from electrofishing and hydroacoustics, and population modeling. For migrant fishes, we only estimated consumption for individuals since accurate accounting of their residency in various habitats was uncertain. In tributary streams we estimated consumption based on observed size structure from electrofishing

and population estimates from the depletion survey. Population estimates varied seasonally, but a regular pattern of recruitment and mortality was not observed; therefore, we treated tributary habitats as open populations where fishes immigrate and emigrate at will. As such, annual population level consumption estimates in tributary streams were calculated based on the single point estimate of standing stock biomass and population size for that species in that season/location. Any missing data (seasonal population estimate or missed size class) was derived by averaging between the adjacent sampling intervals. Consumption estimates in the NF Reservoir were calculated in a similar way (based on hydroacoustics rather than electrofishing) except for mountain whitefish.

Since Chinook salmon were a major consumer in North Fork Reservoir throughout the year, we had to construct their seasonal population dynamics in order to simulate their consumption demand on major prey resources. We assumed that recruitment of age-0 fry to the reservoir was only just beginning during sampling in May. Combined hydroacoustic and gill netting surveys estimated that 176,000 age-0 Chinook salmon were in the reservoir during August, 24,600 in early December, and 3,700 in January. We further assumed that fry immigration into the reservoir peaked on July 1st at an arbitrarily-selected abundance of 300,000, then abundance declined due to natural mortality to the estimated 176,000 in August. Abundance was then allowed to decline daily, using an instantaneous daily mortality value fitted to the estimated abundances of 24,600 on December 1st and 3,700 in mid-January.

The mountain whitefish population was assumed to reside in the NF Reservoir year round, except during spawning, based on high levels of parasites observed in the peritoneal cavities of all size classes captured. We used the population estimate of mountain whitefish 96-300 mm from the autumn evening hydroacoustics survey to model their population structure. Mountain whitefish are late fall/early winter spawners, and we hypothesized that staging adfluvial mountain whitefish would be accurately represented during this period. We then iteratively fit an annual survival rate, resulting with S = 52%, to structure the reservoir population for individuals 96-300mm. Once fit, we assumed a fry to age 1 survival rate of 10% to characterize the population structure (following Beauchamp and Shepard 2008). We then

converted these survival rates to instantaneous daily mortality rates to model annual daily population level consumption (**Table 4**).

Results

Seasonal habitat use patterns

General life history patterns expressed by juvenile Pacific salmon were identified as tributary resident, fluvial, and adfluvial prior to seaward migration. Tributary residents reared in tributary streams or braided channels in Big Bottom for 1-2 years. Fluvial fishes migrated to mainstem habitats within 3 months of emergence and may also use other habitats seasonally within the riverscape. Adfluvial fishes occupied the NF reservoir for 1-3 years. A fourth migrant life history type was assumed to exist in the Upper Clackamas River and was characterized by using multiple habitats over unknown time scales. We did not focus on this life history type due to lack of adequate samples. However, stream trapping conducted by the CRFWG has identified cohorts of fish immigrating and emigrating from some habitats that are not always size structured as expected. This suggests that there are within-system migrations to foraging/rearing habitats that are characteristic of a migrant life history. In the following section, note the units used for density estimates. In-stream densities are reported as biomass (g/m^2), but the reservoir values are reported as numerical density by volume ($\#/m^3$).

Chinook salmon—Spring Chinook salmon exhibited a predominantly lacustrine rearing strategy in the Upper Clackamas Basin. Age-0 Chinook salmon initially observed in riverine (Big Bottom and Pinhead Creek), transition zone, and reservoir habitats during spring, but were primarily found in NF Reservoir for the remainder of the year (**Figure 3**). During spring, densities of age-0 Chinook were highest in Pinhead Creek (0.006 g/m^2; **Table 5**) and in shallow littoral regions of NF reservoir (0.301 $fish/m^2$). During the remainder of the year, densities of age-0 Chinook salmon were highest in NF Reservoir in both nearshore and offshore habitats during summer ($0.026/m^3$), autumn ($0.005/m^3$), and winter ($0.001/m^3$; **Table 6**). Age-0 Chinook

salmon grew quickly in the reservoir from spring through summer and autumn. After spring, Chinook were extremely rare in non-reservoir habitats, and were significantly smaller than those found concurrently in the reservoir (**Figure 3**). During winter, the reduced numbers and more disjunct size distribution suggested that little or no growth occurred between autumn and winter, and immigration-emigration of fish from or to other locations might have occurred. The older age 2 and 3 Chinook salmon were only encountered in the NF Reservoir.

The differences in habitat-specific density, size structure, and growth suggest at least two patterns of habitat use by juvenile Chinook salmon. First, an adfluvial life history where age-0 Chinook salmon migrated to the NF reservoir soon after emergence in spring to rear in NF reservoir for 1-3 years, as evidenced by length at age (**Table 1**; **Figure 3**). Second, a fluvial life history where juvenile Chinook used tributaries, Big Bottom, or the mainstem during the first growth year, then likely rearing in the mainstem during subsequent growth periods. Evidence of mainstem rearing by juvenile Chinook salmon was supported by observations of a bimodal out migration by smolts from the Upper Clackamas River, with one pulse in spring and the second pulse in autumn (CRFWRG 1995-2006). The hydroacoustic and gill net surveys from this investigation identified a marked reduction in use of the NF Reservoir by Chinook salmon from autumn to winter which corresponds to the outmigration and rearing patterns reported by the CRFWRG (1995-2006).

***Coho Salmon*—**In contrast to spring Chinook salmon, age-0 and age-1 coho salmon primarily utilized tributary habitats and the transition zone during the growing season; measurable numbers of juvenile coho were only found in NF Reservoir during winter and the following spring as age-1 smolts (**Figure 4**). The highest juvenile coho densities in terms of both biomass and numbers were found in Big Bottom, followed by Oak Grove and Pinhead Creek, with maximum biomass and numerical densities during summer then declining through autumn and winter in these lotic habitats (**Table 5**). The size and growth of juvenile coho salmon varied among habitats. Bimodal size distributions of age-0 coho were evident in Big Bottom during spring through fall. The secondary mode of larger juveniles was consistently larger than the modal sizes from other habitats except the few age-0 coho found in NF Reservoir during summer (**Figure 4**). During summer-autumn, the primary mode of smaller coho in Big Bottom was smaller than the modal sizes in Oak Grove and the transition zone. Age-0 coho were consistently smallest in Pinhead

Creek during summer-winter. Juvenile coho salmon were captured in the river-reservoir transition zone in spring, summer, and autumn, but densities could not be quantified; the transition zone was not sampled in winter. Use of the NF reservoir by coho salmon was generally low and varied seasonally with the highest densities observed in spring (0.008/m^3) and winter (0.001/m^3), but very low densities in summer and autumn (>0.001/m^3; **Table 6**).

The patterns in seasonal CPUE combined with differences in habitat-specific growth rates (**Figure 4**) suggest that coho salmon expressed at least two life history strategies within the basin. First, coho salmon generally reared in tributary habitats for over a year and were present in most habitats. Our sampling indicates this might be their primary strategy in the Upper Clackamas River. A second life history type characterized by more transient behavior is illustrated by the following observations. Coho salmon reared in tributaries during spring, occupied Big Bottom during summer and autumn, then moved to NF Reservoir during winter. Rearing was also observed in the river-reservoir transition zone suggesting a fluvial component of the coho salmon population. Lake-rearing coho were also observed, but their catch rates, especially during the peak summer-autumn growing season, were very low in comparison to Chinook salmon (**Figures 3-4; Table 6**). Juvenile coho were not observed in the littoral zone except in spring, thus suggesting that lake rearing by coho salmon was not as common as rearing in the streams or mainstem-transition zone.

Steelhead-Rainbow trout—Juvenile steelhead-rainbow trout were most heavily concentrated in Oak Grove throughout the year, whereas their use of other lotic habitats and NF Reservoir appeared minimal (**Figure 5**). *O. mykiss* densities were highest in Oak Grove Fork in summer (1.278 g/m^2) and lowest in winter (0.741 g/m^2). *O. mykiss* were captured consistently but in low densities in Pinhead Creek during summer (0.023 g/m^2), autumn (0.002 g/m^2), and winter (0.052 g/m^2), in Big Bottom 2 only in Autumn (0.043 g/m^2), and in the river-reservoir transition zone in summer. Densities of *O. mykiss* in the NF Reservoir were highest in autumn and winter and lower during spring and summer. In general, *O. mykiss* were found in the highest densities and exhibited the most complex size structure in Oak Grove Fork. Other habitats such as Pinhead Creek and Big Bottom contained *O. mykiss* but in much lower densities and less complex size structures (**Figure 5**). The NF Reservoir *O. mykiss* population varied seasonally and individuals did not show evidence of year round use of the reservoir. This suggests that *O. mykiss* were

primarily tributary residents, and likely mainstem residents as well, with a smaller adfluvial component to the population. The observed size structure and size at age of *O. mykiss* in tributary streams differed from the size structure and size at age in the NF Reservoir. Notably, the length at age of *O. mykiss* in tributaries differed from previous observations of length at age for steelhead smolts reported by Hansen et al. (2000; in CRFWG 2000). This suggests that steelhead likely rear in habitats distinct from resident rainbow trout. The length at age for *O. mykiss* observed in the NF reservoir is similar to those for steelhead reported by Hansen et al. (2000) but this observation cannot distinguish the mechanism(s) responsible for this increased growth (i.e. better growth conditions in the NF Reservoir vs. increased feeding rate in lotic habitats).

Resident Fishes--Of the resident fishes sampled in tributary streams, shorthead sculpin represented the highest densities in all habitats and seasons in terms of biomass (0.148-4.989 g/m^2) and numbers (0.002-1.14/m^2) except for cutthroat trout in Big Bottom 1 during autumn (1.116 g/ m^2) (**Table 5**). Other resident fishes, mountain whitefish and longnose dace, were observed in the diets of piscivorous fishes, but were not collected in specific sampling sites. In addition to fish we collected, giant salamander larvae *Dicamptodon* spp. were found seasonally at all tributary sites and signal crayfish *Pacifastacus leniusculus* at both Big Bottom site 2 and NF Reservoir. Length at age by habitat for shorthead sculpin and coastal cutthroat trout are given in the Appendix (Figures A 1 & 2).

Seasonal Abundance and Distribution of Fish and Zooplankton in North Fork Reservoir

Brown trout, juvenile coho salmon, rainbow trout, hatchery rainbow trout, largescale sucker, and mountain whitefish were captured every season in NF Reservoir. Juvenile Chinook salmon were too small for gill netting in spring (age-0 Chinook were assessed with littoral snorkeling surveys-see below), but were captured in gill nets during summer, autumn, and winter. Large scale sucker were caught at the highest rates all seasons at a rate of 5.43-25.75 fish per net, Chinook salmon were caught at 1.5-4.38 per net, and brown trout were caught in the lowest numbers at 0.07-0.38 fish per net (**Table 6**). Cutthroat trout were not captured in NF Reservoir but were collected in the fish bypass facilities operated by PGE (D. Cramer personal communication), suggesting that NF Reservoir was used more as a migratory corridor than as a

rearing habitat for cutthroat trout. No prespawning adult salmon were collected during netting but one steelhead kelt (spring) and one spawned-out female coho salmon (autumn) were captured during netting. Spawned out coho were observed during shoreline snorkeling in fall suggesting that some moved or were washed downstream to the NF reservoir prior to death. The steelhead kelt was released alive.

Shoreline snorkeling surveys indicated extensive use of the littoral zone, by juvenile Chinook and coho salmon during spring, dace and sculpin during summer, but no regular use of the littoral zone by any fish species in autumn and winter. We only quantified salmonids during spring, estimating no less than 10,987 (3025 SE) age-0 Chinook salmon and 795 (491 SE) age-0 coho salmon in the 30-50mm size class occupying the littoral zone of the NF Reservoir. Larger Chinook salmon (50-100mm) were less abundant (23; 15 SE). Coho salmon in the larger size class were more numerous than Chinook salmon but highly variable; 316 (180 SE) 50-150mm. Thirty five (22 SE) unidentified salmonids 120-150mm were also estimated in the littoral zone.

The hydroacoustic surveys recorded seasonal use of the NF reservoir, diel behavior, and the vertical and horizontal distributions of small fishes (15-300 mm FL; **Figure 6**). In spring, the smallest size class of fish (15-95 mm) was distributed throughout the water column with higher modal densities near the surface and the bottom during daylight. Crepuscular densities were evenly distributed throughout the water column, and nocturnal densities were highest near the surface, with a secondary density mode at approximately 25m. The intermediate size class (96-300 mm) was generally below 10 m depths during daylight and night, whereas some moved above 10 m during crepuscular periods. The side looking transducer indicated increased fish densities in the upper water column at dusk.

Summer diel distributions of fishes indicated a general two-fold increase in fish densities compared to spring (**Figure 6**). During daylight, fish were evenly distributed throughout the water column. During crepuscular periods, densities of the smaller fish increased in the upper 10 m. At night, densities of smaller fish increased further in the upper 10-m layer, whereas the modal density of fish in the 96-300mm size class shifted deeper to 20-24m. Side looking results indicated that densities of fish near the surface were generally similar throughout the diel

sequence and were considerably lower than the peak dusk and night densities detected at 5-10 m by the downlooking transducer.

In autumn fish densities declined markedly across all periods and size classes (**Figure 6**). Day and crepuscular periods indicated low densities throughout the water column. Densities increased at night with a high-density peak of 96-300 mm fish in the 15-20m depth range. During winter, fish were distributed throughout all depths. Relatively high densities of the largest fish (301-500 mm) were concentrated in the upper 10 m during all diel periods, but was highest at night. Density estimates from the side looking transducer were similar during all diel periods.

The gill net catch composition was applied to these density estimates to derive population estimates and diel behavior of small pelagic fish (<300mm) which were predominantly juvenile Pacific Salmon (**Table A1**). We estimated approximately 70,000 coho salmon and no pelagic Chinook salmon during spring (but see above in the snorkeling results), 259 coho salmon and 176,005 Chinook salmon in summer, no coho salmon and 24,648 Chinook salmon in autumn, and 2,455 coho salmon and 3,682 Chinook salmon in winter. These values correspond with the observed outmigration timing and count estimates for juvenile salmon outmigrants reported by PGE, where the majority of Chinook salmon left the system in two pulses: first in November-December and second during March-April prior to our May sampling. Yearling and older Chinook migrated out of the reservoir before May, whereas the age-0 Chinook in the lake were confined to shallow littoral regions during spring and were only accessible via snorkeling. The majority of coho salmon migration occurs in May-July, and most had likely not yet left the NF Reservoir during our spring sampling.

The estimates for large fish were too variable to allow reliable density or abundance estimates due to the presence of the abundant largescale suckers that sporadically ascended into the water column, potentially biasing population estimates for the other large fishes. Therefore hydoacoustics were used to inform assumptions about relative abundance and behavior of large fishes but could not be used to accurately estimate their abundance.

Zooplankton- *Daphnia* were the predominant zooplankter in the reservoir throughout the year, but exhibited a strong seasonal production cycle. The *Daphnia* bloom started sometime after sampling in mid-May. Densities were extremely low in spring (≤0.003 *Daphnia*/L), greatest in summer (3.2-9.8 *Daphnia*/L), undetectable during autumn, and very low during winter (0.007/L). When present, *Daphnia* densities were much higher in the 0-5 m depth interval than at 5-15 m depths. The biomass of crustacean zooplankton in the NF reservoir fluctuated seasonally, generally following the trend in seasonal densities (**Table 7**). During May, the standing stock biomass in the reservoir was very low for *Daphnia* (30 kg) and copepods (44 kg). By August, zooplankton biomasses increased approximately three orders of magnitude to 32 MT of *Daphnia*, 6MT of copepods, and 6 MT of *Leptodora*. No macro-zooplankton were detectable during November, and biomasses were very low in January with 24 kg of *Daphnia* and 4 kg of copepods.

Seasonal Diet Composition

Diets in Tributary and Transition Zone --Seasonal variability in diet composition was driven mostly by size-class and species (**Table 8**). All members of tributary food webs consumed primarily immature aquatic insects. Benthically-oriented sculpin consumed harpacticoid and cyclopoid copepods, amphipods, and gastropods. Juvenile Pacific salmon and resident trout fed predominantly on drift organisms, consuming adult aquatic and terrestrial insects. Piscivory was uncommon in tributary habitats, but did occur. Cutthroat trout 96-300mm were the only piscivores in Big Bottom 1 preying on mountain whitefish. In the Oak Grove Fork during summer coho salmon 15-95mm consumed sculpin, as did cutthroat trout and giant salamander larvae in the 96-300mm size class; during winter only rainbow trout in the 96-300mm size class consumed sculpin. In Pinhead creek during spring, cannibalism was observed in sculpin 15-95mm, and cutthroat trout 96-300mm consumed dace. During summer in Pinhead creek cutthroat trout 15-95mm consumed unidentified fish; and in winter, cutthroat trout 96-300mm consumed sculpin. In the river-reservoir transition zone during summer, rainbow trout 15-95mm consumed unidentified salmonids and sculpin.

Diets in the Reservoir--In the NF reservoir, aquatic insects and *Daphnia* spp. were important seasonal diet items for most fishes captured. For juvenile salmonids, Aquatic insects, followed by copepods were important during the spring. Daphnia were the predominant prey during summer, then insects were the primary prey during the remainder of the year (**Table 8**). Piscivory in the NF Reservoir was much more common than in the tributary habitats with the non-native fishes responsible for the majority of the piscivory observed. Brown trout consumed unidentified salmonids in the spring and juvenile Chinook salmon, sculpin, and mountain whitefish during summer and autumn. Hatchery rainbow trout consumed juvenile suckers in spring and juvenile suckers, sculpin, and mountain whitefish during autumn and winter. Wild rainbow trout consumed sculpin in autumn and dace in winter.

Stable Isotope Analysis

Chinook and coho salmon fry initially showed highly enriched maternal $\delta^{15}N$ values averaging 15.2‰ (SD= 1.5‰) in tributary, transition, and reservoir habitats; however, $\delta^{15}N$ declined rapidly in fry > 40 mm FL in all habitats as growth from exogenous feeding on invertebrates attenuated the maternal signal (**Figure 7 and 8**). Although $\delta^{15}N$ values for wild *O. mykiss* were similar to that of resident salmonids or the larger anadromous salmon parr (**Figure 9**), even the smallest specimens examined had grown enough to potentially mask a anadromous maternal signal. Therefore, the stable isotope data were equivocal when attempting to separate resident from anadromous forms of juvenile *O. mykiss*. In NF reservoir, the higher $\delta^{15}N$ values (11‰-14‰) for the smaller hatchery rainbow trout (FL < 280 mm) reflected the signal from hatchery food; values declined in larger hatchery rainbow as growth diluted the hatchery feeding signal, but were still highly enriched compared to other food web members.

In Big Bottom, after the maternal anadromous signals in Chinook and coho fry (**Figure 10a**) was diluted by growth into the parr stage (**Figure 10b**), the $\delta^{15}N$ values were most depleted for giant salamander larvae (4.8‰-5.2‰) and variable but most enriched in coastal cutthroat trout (6.1‰-9.8‰). Sculpins and salmonid parr of all species exhibited considerable overlap in $\delta^{15}N$ values 5.6‰-8.0‰, suggesting that all were feeding at the same trophic level, thus supporting the diet data. Average $\delta^{13}C$ values suggested moderate overlap among sculpin and

all species of juvenile salmonids, again supporting the overlap observed in the diet data where sculpin consumed primarily benthos and aquatic insects while salmonids consumed aquatic and terrestrial insects.

In Oak Grove Fork, sculpin occupied a slightly lower trophic level and were distinctly segregated by a more depleted $\delta^{13}C$ energy pathway than juvenile salmonids (**Figure 11**). This supports observations of alternate energetic pathways also found in the diet data, similar to Big Bottom but more pronounced. The stable isotope data suggested potentially greater diet overlap between Pacific giant salamander larvae and salmonids in Oak Grove than in Big Bottom.

In Pinhead Creek, the $\delta^{15}N$ values were generally higher for all species than in the other tributaries, as indicated by the relatively high $\delta^{15}N$ of gastropods, a basal herbivore (**Figure 12**). Sculpin exhibited an energy pathway (more depleted $\delta^{13}C$ values) that was segregated from salmonid parr, but occupied the same trophic level.

In the river-reservoir transition zone, $\delta^{13}C$ ranged from -26.5‰- -12.4‰ and $\delta^{15}N$ ranged from -1.1‰-12.4‰ (**Figures 13a-b**). This follows a similar pattern observed in the tributary habitats with some modest segregation via $\delta^{13}C$ energy pathways with somewhat similar trophic levels between sculpin and salmonid parr. In addition, dace and suckers occupy considerably lower trophic positions, but utilize a broad range of energy pathways as demonstrated by their highly variable $\delta^{13}C$ values. Average $\delta^{15}N$ values were lowest for lamprey ammocoetes (-1.1‰-0.5‰), representing a basal filter-feeding herbivore-detritivore.

The NF Reservoir contained the most fish species and greater isotopic variability than the other habitats sampled with $\delta^{13}C$ ranging from -40.3‰ to -17.1‰ and $\delta^{15}N$ ranging from 1.9‰-8.8‰ (**Figures 14a**). Although energy pathways overlapped considerably as indicated by the generally wide range of $\delta^{13}C$ values both within and among species, the relatively more depleted and narrower range of $\delta^{13}C$ values for Chinook salmon parr indicated a greater reliance on a pelagic energy pathway, feeding primarily on zooplankton prey, supplemented secondarily by benthic invertebrates (Figure 14b). Smaller brown trout (200-325 mm FL) fed at a lower trophic level with a greater proportion of benthically-derived prey than larger brown trout (325-450 mm FL; **Figure 14b, 15**). The elevated $\delta^{15}N$ and depleted $\delta^{13}C$ of larger brown trout agreed with diet

data, which indicated that Chinook salmon represented a significant fraction of their diet (**Figure 14b**). The rest of the fish community relied more heavily on benthic energy pathways with invertebrates and suckers occupying lower trophic levels, salmonid parr and mountain whitefish at intermediate trophic levels, and brown trout and hatchery rainbow trout at higher trophic levels.

Habitat-specific Seasonal Feeding and Growth of Anadromous Salmonids

Results in the following section will follow a similar format where observed individual growth (g/year) and estimated feeding rate, expressed as a percentage of the theoretical maximum consumption rate (%Cmax), growth efficiency (growth/consumption = GE), and the top contributors to the annual energy budget are reported for each species and cohort (**Table 2**).

***Chinook salmon*—**From the seasonal and length frequency distributions, we inferred that age-0 Chinook salmon predominantly used NF Reservoir as the primary rearing habitat from spring through emigration the following year. Bioenergetic model simulations indicated that reservoir-rearing age-0 Chinook exhibited high feeding rates (90% Cmax) from May through November, growing an average 25.9 g with high growth efficiency (GE = 12%). During December and January, feeding declined markedly to 39% Cmax and age-0 Chinook experienced 2% weight loss. Over the entire simulation period (May-mid January), *Daphnia* contributed 73% of the total biomass of food consumed, followed secondarily by aquatic insects. In contrast, age-0 Chinook salmon that reared in in Big Bottom during May-November only grew 2.9 g, feeding at at a low 31% Cmax primarily on aquatic insects. Growth efficiency was higher in Big Bottom (GE = 16%), because cooler temperatures remained closer to the optimum range for growth under conditions of limited food supply.

***Coho Salmon*--**Coho salmon primarily used tributary and transition habitats, but their feeding and growth rates were considerably lower than for lacustrine-rearing Chinook salmon. During May-July, feeding rates and growth performance for age-0 coho were highest (40-42% Cmax, 2.0-2.9 g incremental growth) in Big Bottom, Oak Grove, and the transition zone, but were much lower in Pinhead Creek (31% Cmax, 0.8 g incremental growth). During August-December,

feeding (21-31% Cmax) and growth rates were lower than earlier in the growing season in all habitats; however, feeding was somewhat higher during August-October in Pinhead Creek (31% Cmax) and the transition zone (29% Cmax) than in Big Bottom (21% Cmax) or Oak Grove (24% Cmax). For age-1 coho, Big Bottom was the only habitat containing measureable numbers of age-1 coho during May-December, but feeding rates were consistently low (23-30% Cmax).
Steelhead-Rainbow Trout--*O. mykiss* used Oak Grove Fork as their primary rearing habitat from emergence in late spring or early summer through December of the following year. Age-0 *O. mykiss* fed at a relatively low rate (18% Cmax) during summer, declining to 10% during autumn. Feeding and growth appeared to increase to 24% Cmax for age-1 from January through July; however, size selective overwinter mortality might have removed the smaller individuals of this cohort, thus artificially inflating apparent growth. Feeding rates increased to 27% Cmax for age-1 *O. mykiss* during summer and autumn. Pinhead Creek was also used secondarily, but low sample sizes only allowed tracking of age-0 growth cohorts from August through January of their first year. O. mykiss fed at a low rate during August-November (20% Cmax), and feeding rate declined to 14% Cmax during December-January. Some age 1-2 *O. mykiss* were encountered in NF Reservoir, but samples were too sporadic to track feeding and growth performance.

Population-Level Consumption Demand by Key Species in Lotic Habitats

Shorthead sculpin consumed 2-3 fold more prey biomass per unit area (g/m^2) than the combined consumption by other sympatric fishes in the lotic habitats examined (**Figures 16a-c**). Aquatic immature and adult aquatic insects represented the greatest biomass of prey consumed annually by all fishes in tributary habitats. Cutthroat trout and juvenile coho salmon were the second most-important consumers in Big Bottom and Pinhead Creek (**Figures 16a-b**), whereas *O. mykiss* followed by coho were the other significant consumers in Oak Grove (**Figures 16c**). Annual consumption demand by the fish community was much higher in Oak Grove (39 g/m^2) than Big Bottom (6.5-12.5 g/m^2) or Pinhead Creek (8 g/m^2). Chinook salmon consumed the lowest biomass of food in lotic habitats, which reflected the low densities and generally short occupation of the stream habitats.

Annual Population-Level Consumption Demand by Key Species in North Fork Reservoir

Aside from suckers which were not modeled, bioenergetic simulations indicated that juvenile Chinook salmon consumed the greatest biomass of invertebrate prey (21.7 metric tons/yr, MT/yr) in North Fork Reservoir, followed by mountain whitefish (6.9 MT/yr; **Figure 17**a). Chinook primarily consumed *Daphnia* (19.0 MT) from late spring through mid-autumn, followed by aquatic insects (2.5 MT) during spring autumn and winter. Approximately half of the total consumption demand by Chinook salmon came from the assumed immigration and mortality patterns assigned to the population between May and August. Nonetheless, even if consumption from the June-July population scenario was removed, Chinook salmon would still impose the highest consumption demand in North Fork Reservoir, especially on *Daphnia*. During August, Chinook salmon consumed an estimated 14% of the *Daphnia* biomass in the reservoir. In contrast, mountain whitefish primarily consumed aquatic insects (5.6 MT) followed secondarily by *Daphnia* (0.8 MT), and benthos (0.4 MT). Consumption demand by coho salmon was attributed to the pulse of 70,000 juveniles passing through the reservoir in spring, but their consumption was minor compared to Chinook salmon and mountain whitefish.

Of the potentially piscivorous salmonids in North Fork Reservoir, brown trout >300 mm FL were the most important predator on juvenile Chinook salmon (173 kg/yr plus another 26 kg of unidentified salmonids); brown trout also consumed substantial amounts of mountain whitefish (241 kg/yr) and sculpin (110 kg/yr; **Figure 17b**). Under the predation scenario that assumed 405 brown trout >300 mm FL in the reservoir during summer, 294 in autumn, 187 in winter, and 16 in spring, the seasonal consumption estimates translated into annual numerical predation losses of 26,700 juvenile Chinook and unidentified salmon (which were also presumed to be Chinook), and represented 15% of the estimated abundance of juvenile Chinook in the reservoir during August. This estimate accounted for the seasonal changes in both consumption by brown trout and prey body weight. Both small and large hatchery rainbow were significant piscivores on non-salmonid fishes like suckers (281 kg/yr), sculpin (81 kg/yr), and unidentified fish (9 kg/yr; **Figure 17b**). Wild *O. mykiss* < 300 mm FL exhibited minimal piscivory on benthic fishes (29 kg dace, 1 kg sculpin), feeding primarily on aquatic insects and secondarily on terrestrial insects and *Daphnia*.

Discussion

In the Upper Clackamas River Basin, the current life history patterns expressed by juvenile anadromous salmonids varied from a heavy reliance on the reservoir during first-year rearing by spring Chinook salmon, to lotic rearing by coho salmon in Big Bottom, Pinhead Creek, Oak Grove, and the transition zone, to heavy use of Oak Grove Fork by ages 0-1 *O. mykiss*. These interspecific differences in habitat use influenced feeding and growth performance in response to the specific trophic interactions and environmental conditions experienced within each habitat. Each habitat offered a different combination of environmental conditions, seasonal food supply, and community of potential competitors and predators.

In lotic habitats, feeding and growth were considerably lower for all three anadromous salmonids species than in North Fork Reservoir. Bioenergetic simulations determined that the slower observed growth was the result of low feeding rates (only 20-50% Cmax), suggesting food limitation rather than a thermal constraint. In fact, the cooler lotic temperatures compensated somewhat for the limited food supply by increasing growth efficiency via reduced metabolic demands. Food limitation could result from low overall productivity, intra-specific density dependence, or interspecific competition for common food resources. Aquatic insects represented the primary energy pathway supporting salmonids and sculpins in all of the lotic habitats, as indicated by both diets and stable isotope analysis.

Sculpins represented the greatest fraction of fish biomass in all lotic habitats examined, and imposed 2-4-fold higher consumption demand on the invertebrate food supply than did sympatric salmonids. Sculpin consumption rate in the Clackamas River (0.69 mean Cmax, range 0.29-1.40) was much higher than in the Trask River in Northwest Oregon (0.38 mean Cmax) (Raggon 2010) suggesting that current conditions are more favorable for cottids than salmonids. In the Trask River Raggon (2010) determined that cottid feeding performance was 4 times greater than sympatric cutthroat trout suggesting that resource partitioning (aquatic vs. terrestrial) was an important factor structuring the annual energy budgets of cutthroat trout in the Trask River drainage. In the Upper Clackamas River Basin, stable isotope analyses indicated varying degrees of diet segregation between sculpin and salmonids, particularly with respect to $\delta^{13}C$ pathways, ranging from relatively high overlap in Big Bottom to significant segregation in

Pinhead Creek and Oak Grove Fork, and moderate overlap in the transition zone. Subsidies from terrestrial insects were important for propping up the feeding and growth rates in the mainstem habitats of Big Bottom and the transition zone (representing 41-48% of the prey biomass consumed annually by coho, 21% for Chinook in Big Bottom), but contributed much less to annual consumption in Pinhead Creek (17% for coho, 24% for *O. mykiss*) and Oak Grove Fork (27% for coho, 7% for *O. mykiss*).

Piscivory was minimal in lotic habitats, but considerably higher in North Fork Reservoir. We detected a relatively low level of piscivory in the upper Clackamas River tributaries involving juvenile coho, *O. mykiss*, cutthroat trout, and sculpin as predators with mountain sculpin and mountain whitefish representing the most common fish prey. This suggests that the factors currently regulating the structure and function of the lotic fish communities were related to environmental conditions, food supply, and potentially competition rather than by predation.

North Fork Reservoir supported high feeding (90% Cmax) and growth by age-0 Chinook salmon during spring through autumn, then no apparent growth during winter. *Daphnia* was the primary contributor to the high feeding and growth period. Although the seasonal sampling program could not identify the timing or magnitude of the *Daphnia* bloom and subsequent decline in the reservoir, or the corresponding dietary shift by juvenile Chinook salmon, the highly depleted $\delta^{13}C$ signature of Chinook compared to other reservoir fishes supported their inferred heavy and prolonged reliance on *Daphnia* during the peak growth period. *Daphnia* are important prey for other lacustrine-rearing populations of both fall (Rondorf et al. 1990; Koehler et al. 1996) and spring-summer Chinook salmon (Muir and Coley 1995). Moreover, other juvenile salmon species exhibit a strong dietary selection for *Daphnia* that is triggered at very low ambient densities (Scheuerell et al. 2005). The low feeding and growth rates during December and January corresponded to the complete absence of macro-zooplankton in the reservoir by the end of November.

In North Fork Reservoir, brown trout > 300 mm FL were identified as the only significant predator on Chinook salmon, while also eating substantial amounts of mountain whitefish and sculpin. Hatchery rainbow trout were important predators on juvenile largescale suckers, and to a lesser degree on mountain whitefish and sculpin. The simulated reservoir

predation scenario suggested that annual losses from brown trout predation represented 15% of the juvenile Chinook population estimated to be in the reservoir during August.

These estimates of predation losses should be considered within the bounds of the sampling limitations and analyses that were possible in this study. The predation estimates were highly sensitive to assumptions regarding the seasonal abundance of brown trout in the reservoir (i.e., peak abundance of 405 predators in summer, declining seasonally to a minimum of 16 during spring); furthermore, converting these predation losses into mortality estimates would require accurate estimates of the number of juvenile Chinook salmon entering the reservoir. Peak immigration of juvenile Chinook salmon into the reservoir probably occurred in late spring, and attrition from predation and other sources of natural mortality or emigration likely reduced abundance significantly before the population assessment was performed in August. Thus, predation losses likely represented an annual mortality rate of less than 10% of the juvenile Chinook salmon population that entered the reservoir. Despite the uncertainties described above, this predation scenario reasonably accounted for seasonal variability in predator abundance and diet (supported by stable isotope analysis), and effects of the thermal regime on seasonal consumption rates. This scenario suggests that predation mortality for juvenile Chinook salmon and other salmonids appears to be relatively low in the reservoir under current conditions. However, a significant limitation to this study was the inability to sample for short-term, acute predation responses while pulses of juvenile salmonids were migrating into or out of the reservoir. Other studies have demonstrated that acute predation can be hard to detect without very-high sampling frequency during pulses of prey fish availability, but can result in severe mortality over very short periods (days or weeks; Cartwright et al. 1998; Baldwin et al. 2000; Beauchamp et al. 2007).

The source of brown trout in North Fork Reservoir was likely Timothy Lake or Harriet Lake, both reservoirs on the Oak Grove Fork. The vectors for transporting brown trout to the NF Reservoir are either spill from the upper dams on Timothy and Harriet lakes or through Frog Lake, the forebay of the Oak Grove powerhouse. Natural reproduction in other parts of the system is possible but has not been documented. Although brown trout were caught in low

numbers, they were captured consistently all four seasons, suggesting a persistent presence, regardless of the vector for transport.

Density dependent mortality can be a major factor influencing the abundance and size structure of salmon populations (Ward et al. 2008a-b). Kostow and Zhou (2006) determined that stocking hatchery summer steelhead in the Upper Clackamas River reduced the productivity of winter steelhead by increasing density dependent mortality for winter steelhead. Although current salmonid densities in the Upper Clackamas River are relatively low, the low feeding rates estimated for juvenile salmonids in lotic habitats suggest that food limitation already occurs and could potentially be exacerbated as densities of trophic competitors increase. In the Connecticut River, high sculpin densities were associated with low survival of juvenile Atlantic salmon, independent of other native species (Ward et al. 2008a-b). High sculpin density can also alter lower trophic level processes such as leaf shredding by invertebrates (Konishi et al. 2001); conversely, the growth rates and size structure of sculpin can be reduced by the presence of predatory fishes even if direct predation is rare (Zimmerman and Vondracek 2007).

The current spatial-temporal distribution patterns and associated feeding and growth performance of anadromous salmonids provide context for evaluating potential responses to the re-itroduction of bull trout into the Upper Clackamas River Basin. Bull trout exhibit a wide range of feeding behaviors, from seasonal specialization to generalist feeding patterns, but generally become piscivorous at a relatively small size in fluvial habitats (Fraley and Shepard 1989; Lowery 2009), and become highly piscivorous in lake and reservoir populations at intermediate to large sizes (Beauchamp and Van Tassell 2001; Clarke et al. 2005). Juvenile bull trout in tributaries to the Skagit River, WA consumed primarily aquatic insects until reaching a fork length of 100 mm when they began to prey on small fishes. Coho salmon and *O. mykiss* were the most common salmonid fishes present and consumed. No sculpin were found co-occurring with bull trout in the tributaries, but fluvial adult bull trout in the mainstem Skagit River fed heavily on sculpin (Lowery 2009). Juvenile bull trout >110mm in the Flathead River system in MT consumed sculpin and trout (Fraley and Shepard 1989).

In the Upper Clackamas River, juvenile salmon, sculpin, cutthroat trout, and *O mykiss* would be the most abundant fishes available as prey for piscivorous bull trout in the tributaries. Small sculpin would be available year round and juvenile coho salmon would be available in most lotic habitats during spring through fall, whereas age 0-1 *O. mykiss* would primarily be available in Oak Grove Fork. Newly-emerged Chinook salmon fry would be available briefly as prey in tributaries during spring, before and during their migration to North Fork Reservoir, with much lower densities of stream-rearing forms remaining Big Bottom and Oak Grove Fork through the first growing season. Since piscivorous bull trout routinely consume other salmonids up to 40-50% of their own body length (Beauchamp and Van Tassell 2001; Beauchamp et al. 2007), a 100-mm yearling bull trout would be capable of eating juvenile salmonids from the time of emergence through the 1-3 months needed to outgrow the gape-limitation threshold of the relatively abundant age-1 year class. The age-0 salmon and steelhead would likely remain vulnerable to predation by all older age classes of bull trout in the basin. Mountain whitefish are common prey of both fluvial and adfluvial bull trout, but were not found in the tributary habitats. A modest adfluvial population of mountain whitefish was found in North Fork Reservoir, but we speculate that many more will be found in the mainstem river habitats that we were unable to sample. Adult fluvial bull trout are primarily piscivorous, feeding on seasonally abundant resident or anadromous prey fishes, but can also consume significant amounts of salmon eggs, carcass flesh, and invertebrates (Lowery 2009). However, given the relatively low escapement levels for Chinook and coho salmon, and the absence of species that exhibit high spawner densities like pink, chum, or sockeye salmon, the contribution of salmon eggs and carcasses is expected to be a relatively minor portion of the diet for bull trout in the Clackamas Basin, unlike the very significant contribution of these marine energy subsidies to the annual energy budget of bull trout in the Skagit River. Therefore, predation demand by bull trout will have to be satisfied by primarily by resident and anadromous fishes in tributary, mainstem, and reservoir habitats, and secondarily by invertebrates when prey fish availability is low.

A seasonal examination of the relative abundance, size distribution, and trophic interactions of fishes in the mainstem Clackamas River will be necessary to determine whether the mainstem serves as important seasonal or year-round rearing habitat for juvenile salmon or steelhead, and to determine whether significant populations of resident fishes like mountain

whitefish or sculpin represent either important competitors with juvenile salmonids or alternative prey for bull trout.

There is a reasonable probability that some or all of the subadult and adult bull trout will adopt an adfluvial life history strategy as was observed for the donor population when the Deschutes River was impounded to form Lake Billy Chinook. The primary forage base for bull trout in North Fork Reservoir would be the short-duration pulses of juvenile salmon and steelhead migrating seasonally into or out of the reservoir, and a year-round supply of largescale suckers, juvenile Chinook salmon, mountain whitefish, hatchery rainbow trout, and sculpin. In addition, although sculpins were not sampled effectively in the reservoir, they were found in measurable amounts in the diets of brown trout and hatchery rainbow trout. Even during summer, thermal stratification in the reservoir is weak and is unlikely to offer an effective thermal refuge for juvenile Chinook salmon from predatory bull trout or brown trout. Since juvenile Chinook salmon in the basin rely heavily on the reservoir as a nearly year-round rearing habitat and currently achieve high feeding and growth rates, it will be important to monitor both direct predation impacts and indirect effects such as changes in diel distribution and feeding which would likely reduce growth and survival.

Predators can have wide ranging direct and indirect effects on their prey populations (Woodward et al. 2008). The direct effect of predation (mortality) on prey populations is often a main focus of population level predator-prey evaluations (Beauchamp 2007). Estimating direct predation effects is certainly important for quantifying mortality, but the indirect or non-consumptive effects could potentially be a stronger influence on the growth, distribution, and ultimate survival of prey (Lima 1998). Anti-predator strategies can include refuging behavior, spatial-temporal segregation, and ontogenetic shifts in growth and energy allocation (Biro et al. 2003).

Juvenile Pacific salmon exhibit complex habitat use patterns across their native and introduced range and often shift habitat use in response to a changing environment. Examples include juvenile coho salmon using beaver dams (Pollock et al. 2004), juvenile Chinook salmon rearing in lakes or reservoirs (Rondorf et al. 1990, Koehler et al 2006), and increased use of

intentionally placed large woody debris and engineered log jams (Whiteway 2010). The behavioral and ecological plasticity of juvenile Pacific salmon will provide managers, tasked with monitoring the Upper Clackamas River bull trout reintroduction, context for evaluating the ecological effects of an establishing predator population. Bull trout also exhibit complex migratory behavior within (Nelson et al. 2002, Mogen and Kaeding 2005) and among river systems (Brenkman and Corbett 2005). For example, the proposed donor stock from the Metolious River, OR, a tributary of the Deschutes River, was originally fluvial, but the installation of dams on the mainstem Deschutes River created the Lake Billy Chinook reservoir and bull trout have adopted fluvial and adfluvial life histories.

This analysis compiled seasonal trophic dynamics of fishes in tributary, river-reservoir transition zone, and reservoir habitats for key salmonid and non-salmonid members of the basin food web in order to characterize the current structure and function of the Upper Clackamas River food web; however, important uncertainties remain regarding the role of mainstem habitat and whether all major life history strategies were examined for juvenile Chinook, coho, and steelhead in this basin. This baseline food web analysis was based on the assumption that the selection of habitats sampled were representative of other reaches within the same tributaries and other tributaries. Other tributaries are also heavily utilized by rearing coho salmon and *O. mykiss* (e.g., Strobel 2006). Although our results suggest that North Fork Reservoir is the primary rearing habitat for juvenile spring Chinook salmon in the basin, it is possible that significant fluvial rearing cold be occurring in some of the un-sampled tributaries. Indirect evidence of significant fluvial-rearing forms might be detected in by multiple modes in length frequency distributions from trapping sites above the reservoir and at the smolt bypass or from back-calculated growth trajectories using scales. Funding constraints prevent effective sampling in mainstem habitats, so important gaps in knowledge remain regarding the role of the mainstem as seasonal or year-round rearing and migratory habitat for juvenile anadromous salmonids and resident fishes. Our analysis will aid managers and biologists tasked with monitoring and evaluating the performance of the reintroduced bull trout population as it becomes established in the Upper Clackamas River food web. Additional analysis of the mainstem Clackamas River is recommended to establish a more comprehensive representation of the trophic dynamics currently present in the Upper Clackamas River.

Recommendations for Monitoring and Evaluation

During the current investigation in the Upper Clackamas River Basin, no predation on juvenile Pacific salmon was detected in the tributaries, and brown trout were the only significant predator on juvenile salmon in the North Fork Reservoir. However, only a portion of the mainstem habitat was evaluated during this investigation, and was localized in the transition zone at the confluence with North Fork Reservoir. Therefore, a more comprehensive evaluation of predation interactions within the Upper Clackamas River mainstem (where large predatory-sized fishes like bull trout are likely to reside), from the headwaters to North Fork Reservoir is recommended to establish current use by trophic interactions of juvenile salmon and steelhead, and other resident fishes vulnerabilities and provide context for monitoring and evaluation of the bull trout reintroduction. Such activities can include snorkel surveys to visually sample mountain whitefish and large predatory-sized trout and estimate the size of the mainstem predator populations and angling to collect diets and other biological data from those potential predators. Without that evaluation it will be difficult to interpret the results of population level monitoring and only habitat specific changes within tributary sites and the NF Reservoir will be immediately quantifiable.

If juvenile Pacific salmon become vulnerable to predation by an introduced bull trout population we may see shifts in localized habitat use measured as changes in the relative abundance of juvenile Pacific salmon compared to resident fishes (tributary and reservoir). As bull trout populations expand in the reintroduction area, there may be shifts in the duration of residency in various habitats (tributary, reservoir, and mainstem). We hypothesize that the most sensitive indicators of ecological change due to the bull trout reintroduction will be changes in seasonal distribution and size structure of juvenile salmonids within and among habitats. With these considerations in mind, the following progression of monitoring activities will likely capture large scale behavioral and ecological shifts in juvenile salmon populations.

Future monitoring can take advantage of trapping sites and existing data to identify and isolate beneficial and detrimental processes related to life-stage and habitat-specific feeding, growth performance, and survival for juvenile salmon. Within-basin growth and movements can

be measured using existing in-stream trapping methods. Past trapping efforts using screw traps were able to evaluate migration timing and size structure of juvenile Pacific salmon and resident fishes. Weight was also collected from most individuals captured but not reported. These data currently exist, but were not made available for this project. An evaluation of the length/weight relationships of juvenile Pacific salmon among and within species and years will be necessary to determine if biomass production as well as numerical production is changing due to the presence of the introduced predator. The ecological effects of bull trout could manifest as shifts in numbers of fish moving as well as the mass and length of fish moving; therefore, trapping activities should include weight measurements in order to determine which processes are involved in production and migratory behavior.

Tributary indices can be used to evaluate relative change in abundance and residence times in habitats where trapping is not feasible. Protocols similar to the collection methods described in the *Tributary Sampling* section of this report, performed seasonally, will allow managers to evaluate localized behavior of prey populations and monitor recruitment patterns of bull trout as they begin to colonize various habitats within the Upper Clackamas River system. Data such as size structure and length/weight relationships can be collected continuously in order to evaluate short term changes in growth.

Stable isotope analysis can be used as a proxy for diets during monitoring and evaluation activities. Changes in trophic position and energy source for stream and reservoir fishes can be detected with stable isotopes and can provide information on the magnitude and direction of trophic shifts. Stable isotope analysis was completed during the current project and, combined with the diet analysis, will provide context for future analysis once bull trout become established. This will allow habitat specific monitoring of trophic shifts without conducting large scale diet analysis. The diets and stable isotope signatures of bull trout should be evaluated during the establishment phase to provide context for future analysis of trophic behavior. Tissues (frozen or dried fin clips) for stable isotope analysis should be collected from all bull trout used during reintroduction. The relatively high turnover rate by smaller, fast-growing bull trout (e.g., fish that undergo a two-fold or greater increase in body mass after release) will enable us to examine their trophic position and the major energy pathways used in their host environment within 6-12 months after reintroduction. Larger subadults and adults could potentially require 12 months

before their isotopic signatures could be evaluated if using conventional muscle or fin tissue. However, samples of epidermal slime can effectively reflect more recent trophic dynamics (e.g., over the past 1-2 months; Church et al. 2009).

All adult bull trout used for the reintroduction should have an identifiable external mark such as an external tag to aid in monitoring efforts. Mainstem sampling can use a combination of snorkeling and angling to determine the presence, abundance, size structure, and trophic behavior of fluvial bull trout. Similar methods used on the Skagit River, WA produced comprehensive diet, and size structure data for bull trout >300mm. These direct observations provide important information regarding the performance (production) of the establishing population as well as its feeding and migratory behavior.

Telemetry methods such as pit tagging and acoustic or radio tagging will provide information regarding seasonal use of the tributary-river-reservoir system. Each method has strengths and weaknesses as either stationary gate-keepers or for mobile searches. A key consideration is that if bull trout become adfluvial, radio telemetry might not detect signals within the reservoir. Spawning locations, foraging migrations, duration of habitat use, and common areas of aggregation can be identified with these techniques and will help direct bull trout field collection, but careful attention to designing an integrated telemetry program into the broader research and monitoring effort will be essential.

Monitoring and evaluation of the reintroduction will require an integration of various analytical techniques to provide the most comprehensive effort possible. It is important that the current populations of Pacific salmon and steelhead persist while the bull trout population becomes established. It is very likely that bull trout will consume juvenile Pacific salmon, at least seasonally; therefore, it is imperative that the trophic behavior of key food web members within the upper Clackamas River be monitored continuously to prevent unintended detrimental effects to the function of the ecosystem and persistence of current populations.

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Table 1. Mean fork lengths (FL) -at-age (N, SD) by location for fish caught in the Upper Clackamas River, OR. Fork lengths were measured during late autumn, winter, and spring to correspond the presumptive period of annulus formation prior to the main growing season. An asterisk (*) denotes FL-at-age during the growing season (summer-autumn) due to a lack of adequate samples collected during the time of annulus formation. Location abbreviations are defined as; BB 1 is Big Bottom 1, BB 2 is Big Bottom 2, OGF is the Oak Grove Fork, Pinhead is Pinhead Creek, Transition is the River-Reservoir Transition Zone, and Reservoir is the NF Reservoir. Species abbreviations are as follows; Coho is coho salmon, Cutt is Coastal cutthroat trout, *O. mykiss* is wild *O. mykiss*, Brown is brown trout, CHK is Chinook salmon, Hatch is hatchery rainbow trout, Sucker is largescale sucker, and Whitefish is mountain whitefish.

		Age							
		1	2	3	4	5	6	7	8
Location	Species	Length (mm)							
BB 1	Coho	69 (2,10)	95 (2,7)*						
BB 1	Cutt	84 (6,18)	129 (5,20)*	186 (2,70)*					
BB 2	CHK	66 (2,3)							
BB 2	Coho	64 (4,3)	92 (3,6)*						
BB 2	Cutt	66 (1,NA)							
BB 2	*O. mykiss*	63 (1,NA)							
OGF	Coho	70 (3,5)							
OGF	Cutt	93 (1,NA)*		180 (1,NA)*					
OGF	*O. mykiss*	60 (18,5)	114 (13,23)*	145 (3,19)*					
Pinhead	Coho	59 (11,9)							
Pinhead	Cutt	118 (5,18)	134 (2,22)						
Pinhead	*O. mykiss*	52 (1,NA)	120 (1,NA)						
Transition	Coho	89 (1,NA)	92 (1,NA)						
Reservoir	Brown			329 (3,77)*	375 (4,102)*				
Reservoir	CHK	110 (5,5)	137 (13,11)	176 (1,NA)*					
Reservoir	Coho	105 (6,4)	120 (16,5)						
Reservoir	*O. mykiss*		161 (2,16)	207 (3,32)	222 (1,NA)*				
Reservoir	Hatch			259 (4,31)	284 (4,20)	340 (1,NA)			
Reservoir	Sucker		108 (1,NA)	190 (4,30)	251 (6,38)	389 (3,9)	412 (10,33)	427 (5,44)	443 (1,NA)
Reservoir	Whitefish	135 (1,NA)*	166 (6,17)	215 (8,29)	234 (7,21)	286 (6,23)	308 (1,NA)		

Table 2. Bioenergetics growth inputs and annual simulation outputs by location for key food web members in the Upper Clackamas River, OR. Species abbreviations used are defined as Chinook salmon-CHK, coho salmon-COHO, coastal cutthroat trout-Cutt, *O. mykiss*-RBT, hatchery *O. mykiss*- RBT-H, shorthead sculpin-Sculpin, brown trout-Brown, mountain whitefish-Whitefish.

Species	Age	Location	Size Class	% Cmax	Initial day	Final day	Initial Weight (g)	Final Weight (g)	Growth (g)	Consum-ption (g)	GE
CHK	0	Big Bottom	30-95	31%	1	365	0.38	3.14	2.8	25.8	11%
CHK	0	NF Reservoir	30-95	90%	1	210	0.38	26.30	25.9	220.0	11.8%
CHK	0	NF Reservoir	96-300	39%	210	255	26.30	25.80	-0.5	17.5	-2.9%
Coho	0	Big Bottom	30-95	40%	1	90	0.66	3.68	3.0	8.1	37.3%
Coho	0	Big Bottom	30-95	21%	91	180	3.68	4.49	0.8	6.4	12.6%
Coho	0	Big Bottom	30-95	23%	181	220	4.49	4.49	0.0	15.4	0.0%
Coho	1	Big Bottom	30-95	23%	1	90	7.56	8.53	1.0	16.3	6.0%
Coho	1	Big Bottom	30-95	24%	91	180	8.53	9.20	0.7	14.3	4.7%
Coho	1	Big Bottom	30-95	30%	181	220	9.20	9.20	0.0	26.0	0.0%
Coho	0	Transition	30-95	42%	1	90	0.56	3.98	3.4	10.1	33.8%
Coho	0	Transition	30-95	24%	91	180	3.98	5.59	1.6	8.7	18.5%
Coho	0	Transition	30-95	29%	181	220	5.59	5.59	0.0	21.1	0.0%
Coho	0	Oak Grove Fork	30-95	31%	1	90	0.72	4.76	4.0	7.8	51.7%
Coho	0	Oak Grove Fork	30-95	31%	91	180	4.76	5.81	1.0	5.0	20.9%
Coho	0	Oak Grove Fork	30-95	23%	181	220	5.81	5.81	0.0	10.4	0.0%
Coho	0	Pinhead Creek	30-95	42%	1	90	1.44	2.59	1.2	11.7	9.8%
Coho	0	Pinhead Creek	30-95	29%	91	180	2.59	3.84	1.2	9.1	13.7%
Coho	0	Pinhead Creek	30-95	23%	181	220	3.84	3.84	0.0	23.2	0.0%
Coho	0	NF Reservoir	30-95	40%	1	365	0.52	12.99	12.5	95.6	13%
Coho	1	NF Reservoir	96-300	34%	1	365	12.99	20.43	7.4	197.9	4%
RBT	0	Oak Grove Fork	30-95	18%	1 [1]	90 [1]	1.46	2.82	1.4	11.1	12.2%
RBT	0	Oak Grove Fork	30-95	10%	91 [1]	180 [1]	2.82	2.25	-0.6	3.5	-16.3%
RBT	1	Oak Grove Fork	30-95	24%	1 [2]	210 [2]	2.25	9.19	6.9	49.1	14.1%
RBT	1	Oak Grove Fork	30-95	27%	211 [2]	340 [2]	9.19	22.39	13.2	98.5	13.4%
RBT	0	Pinhead Creek	30-95	20%	1 [1]	90 [1]	0.38	0.97	0.6	3.7	15.8%
RBT	0	Pinhead Creek	30-95	14%	91 [1]	180 [1]	0.97	1.20	0.2	3.7	6.2%
RBT	1	NF Reservoir	96-300	23%	1	365	34.72	48.60	13.9	430.7	3%
RBT	2	NF Reservoir	96-300	37%	1	365	48.60	193.08	144.5	1382.5	10%
Cutt	0	Big Bottom 1	30-95	29%	1	365	0.47	4.69	4.2	37.8	11%
Cutt	1	Big Bottom 2	30-95	29%	1	365	4.69	11.85	7.2	97.1	7%
Cutt	2	Big Bottom 2	96-300	32%	1	365	11.85	30.66	18.8	212.8	9%
Cutt	0	Pinhead Creek	30-95	31%	1	365	0.85	6.36	5.5	45.7	12%
Cutt	1	Pinhead Creek	96-300	30%	1	365	6.36	17.11	10.7	186.4	6%
Cutt	2	Pinhead Creek	96-300	31%	1	365	17.11	28.44	11.3	115.5	10%

[1] Day 1=8/1, Day 90=10/30, Day 91=11/1, Day 180=1/30

[2] Day 1=1/1, Day 210=7/30, Day 211=8/1, Day 340=12/10

Table 2-continued.

Species	Age	Location	Size Class	% Cmax	Initial day	Final day	Initial Weight (g)	Final Weight (g)	Growth (g)	Consum-ption (g)	GE
Sculpin	0	Big Bottom 1	15-95	33%	1	365	0.16	0.53	0.4	5.8	6%
Sculpin	1	Big Bottom 1	15-95	47%	1	365	0.53	1.24	0.7	12.1	6%
Sculpin	2	Big Bottom 1	15-95	63%	1	365	1.24	2.70	1.5	23.9	6%
Sculpin	3	Big Bottom 1	15-95	82%	1	365	2.70	5.43	2.7	43.0	6%
Sculpin	4	Big Bottom 1	15-95	92%	1	365	5.43	8.00	2.6	60.3	4%
Sculpin	5	Big Bottom 1	15-95	106 %	1	365	8.00	11.93	3.9	83.9	5%
Sculpin	0	Big Bottom 2	15-95	49%	1	365	0.51	1.17	0.7	12.3	5%
Sculpin	1	Big Bottom 2	15-95	57%	1	365	1.17	1.97	0.8	19.2	4%
Sculpin	2	Big Bottom 2	15-95	70%	1	365	1.97	3.28	1.3	29.2	4%
Sculpin	3	Big Bottom 2	15-95	85%	1	365	3.28	5.46	2.2	45.0	5%
Sculpin	0	Pinhead Creek	15-95	35%	1	365	0.10	0.33	0.2	2.3	10%
Sculpin	1	Pinhead Creek	15-95	52%	1	365	0.33	0.78	0.4	5.4	8%
Sculpin	2	Pinhead Creek	15-95	72%	1	365	0.78	1.76	1.0	11.3	9%
Sculpin	3	Pinhead Creek	15-95	83%	1	365	1.76	2.84	1.1	17.0	6%
Sculpin	4	Pinhead Creek	15-95	110 %	1	365	2.84	5.29	2.4	29.6	8%
Sculpin	5	Pinhead Creek	15-95	140 %	1	365	5.30	9.80	4.5	51.1	9%
Sculpin	0	Oak Grove Fork	15-95	29%	1	365	0.11	0.44	0.3	5.7	6%
Sculpin	1	Oak Grove Fork	15-95	40%	1	365	0.44	1.12	0.7	12.5	5%
Sculpin	2	Oak Grove Fork	15-95	47%	1	365	1.12	1.89	0.8	19.6	4%
Sculpin	3	Oak Grove Fork	15-95	57%	1	365	1.89	3.19	1.3	30.2	4%
Sculpin	4	Oak Grove Fork	15-95	68%	1	365	3.21	5.00	1.8	43.9	4%
Sculpin	5	Oak Grove Fork	15-95	75%	1	365	5.00	6.95	1.9	57.9	3%
Sculpin	6	Oak Grove Fork	15-95	87%	1	365	6.95	10.05	3.1	78.8	4%
RBT-H	2	NF Reservoir	301-500	29%	1	365	141.81	289.72	147.9	2582.5	6%
RBT-H	3	NF Reservoir	96-300	29%	1	365	289.72	472.45	182.7	1681.7	11%
Brown	3	NF Reservoir	301-500	32%	1	365	154.19	542.30	388.1	2494.8	16%
Brown	4	NF Reservoir	301-500	41%	1	365	542.30	896.72	354.4	1753.4	20%
Whitefish	0	NF Reservoir	15-95	7%	1	365	0.30	2.86	2.6	29.0	9%
Whitefish	1	NF Reservoir	301-500	17%	1	365	2.86	35.83	33.0	3109.4	1%
Whitefish	2	NF Reservoir	96-300	8%	1	365	35.83	51.30	15.5	348.1	4%
Whitefish	3	NF Reservoir	96-300	11%	1	365	51.30	138.60	87.3	1332.4	7%
Whitefish	4	NF Reservoir	96-300	14%	1	365	138.60	213.96	75.4	1047.6	7%
Whitefish	5	NF Reservoir	96-300	15%	1	365	213.96	457.22	243.3	319.7	76%

Table 3. Energy density values (J/g wet weight) of consumers and prey used for bioenergetics simulations.

Day	Chinook Salmon	Coho Salmon	*O. mykiss*	Cutthroat Trout	Sculpin spp.	Dace spp.	Mountain Whitefish	Brown Trout	Sucker spp.	Unid. Salmonid
1	5200	5200	5200	5200	5369	5369	5369	5200	5369	5200
365	5200	5200	5200	5200	5369	5369	5369	5200	5369	5200

Day	Unid. Fish	Unid. Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insect	Benthos	Zoo-plankton	Gastro-pod	Other
1	5200	8000	4000	4200	5000	2250	2250	4000	4200
365	5200	8000	4000	4200	5000	2250	2250	4000	4200

Table 4. Modeled mountain whitefish population structure based on the estimated standing stock biomass of individuals in the 96-300mm size class in the NF Reservoir during autumn.

Size Class	Age t	N_t
15-95	0	67440
96-300	1	6744
96-300	2	3499
93-300	3	1815
96-300	4	942
301-500	5	489
	Total age 1-4	13000

$S_{15\text{-}95mm}$ =	10%
$S_{96\text{-}500mm}$ =	52%
$Z_{15\text{-}95mm}$ =	-2.3026
$Z_{96\text{-}500mm}$ =	-0.6562

Table 5. Seasonal site-specific population estimates from three pass depletion electrofishing in tributary habitats during field sampling 2009-2010. Species abbreviations are defined as; COHO juvenile coho salmon, CHK juvenile Chinook salmon, CTT cutthroat trout, RBT rainbow trout, SCLP sculpin spp., and SAL salamander spp. Biomass (g) referred to the total mass of each species estimated within the area of each sampling unit. Area is the area sampled used to calculate density.

Species	Location	Season	$\hat{N}$	SE	Biomass (g)	Area (m^2)	Numerical Density (fish/m^2)	Biomass Density (fish g/m^2)
CHK	Big Bottom 2	Summer	1	1	1	200.75	0.005	0.005
CHK	Big Bottom 2	Autumn	2	2	6.4	200.75	0.010	0.032
CHK	Big Bottom 3	Spring	2	1	0.6	137.25	0.015	0.004
CHK	Oak Grove Fork	Summer	1	0	3.9	467.5	0.002	0.008
CHK	Pinhead Creek	Spring	6	0	2.8	442	0.014	0.006
COHO	Big Bottom 1	Summer	13	1	90.1	433.5	0.030	0.208
COHO	Big Bottom 1	Autumn	12	6	76.6	433.5	0.028	0.177
COHO	Big Bottom 2	Spring	6	1	7.4	200.75	0.030	0.037
COHO	Big Bottom 2	Summer	24	3	101.5	200.75	0.120	0.506
COHO	Big Bottom 2	Autumn	11	11	44.7	200.75	0.055	0.223
COHO	Big Bottom 3	Spring	5	10	1.5	137.25	0.036	0.011
COHO	Oak Grove Fork	Summer	19	6	90.5	467.5	0.041	0.194
COHO	Oak Grove Fork	Autumn	10	5	58.1	467.5	0.021	0.124
COHO	Oak Grove Fork	Winter	4	0	15.9	467.5	0.009	0.034
COHO	Pinhead Creek	Spring	15	0	21.6	442	0.034	0.049
COHO	Pinhead Creek	Summer	17	2	44.1	442	0.038	0.100
COHO	Pinhead Creek	Autumn	13	2	49.9	442	0.029	0.113
COHO	Pinhead Creek	Winter	4	0	10.5	442	0.009	0.024
CTT	Big Bottom 1	Spring	13	38	107.4	433.5	0.030	0.248
CTT	Big Bottom 1	Summer	11	1	112.1	433.5	0.025	0.259
CTT	Big Bottom 1	Autumn	25	21	483.6	433.5	0.058	1.116
CTT	Big Bottom 2	Spring	1	1	3.2	200.75	0.005	0.016
CTT	Big Bottom 2	Summer	1	2	1.8	200.75	0.005	0.009
CTT	Oak Grove Fork	Summer	2	1	74.9	467.5	0.004	0.160
CTT	Pinhead Creek	Spring	8	6	68.5	442	0.018	0.155
CTT	Pinhead Creek	Summer	8	0	53.7	442	0.018	0.121
CTT	Pinhead Creek	Autumn	5	1	18.2	442	0.011	0.041
CTT	Pinhead Creek	Winter	5	0	102.7	442	0.011	0.232
RBT	Big Bottom 2	Autumn	3	0	8.7	200.75	0.015	0.043
RBT	Oak Grove Fork	Summer	130	19	597.3	467.5	0.278	1.278
RBT	Oak Grove Fork	Autumn	38	3	208.5	467.5	0.081	0.446
RBT	Oak Grove Fork	Winter	18	5	346.5	467.5	0.039	0.741
RBT	Pinhead Creek	Summer	6	1	10.2	442	0.014	0.023
RBT	Pinhead Creek	Autumn	1	0	1	442	0.002	0.002

Table 5 Continued Species	Location	Season	$\hat{N}$	SE	Biomass (g)	Area (m^2)	Numerical Density (fish/m^2)	Biomass Density (fish g/m^2)
RBT	Pinhead Creek	Winter	3	0	23	442	0.007	0.052
SAL	Big Bottom 2	Autumn	3	1	15.8	200.75	0.015	0.079
SAL	Oak Grove Fork	Autumn	2	0	47.8	467.5	0.004	0.102
SAL	Oak Grove Fork	Winter	4	0	69.8	467.5	0.009	0.149
SCLP	Big Bottom 1	Spring	87	22	287.4	433.5	0.201	0.663
SCLP	Big Bottom 1	Summer	38	4	127.9	433.5	0.088	0.295
SCLP	Big Bottom 1	Autumn	32	13	154.9	433.5	0.074	0.357
SCLP	Big Bottom 2	Spring	21	6	29.7	200.75	0.105	0.148
SCLP	Big Bottom 2	Summer	66	29	167.3	200.75	0.329	0.833
SCLP	Big Bottom 2	Autumn	229	461	443.4	200.75	1.141	2.209
SCLP	Big Bottom 3	Spring	15	0	38.8	137.25	0.109	0.283
SCLP	Oak Grove Fork	Summer	531	510	2332.4	467.5	1.136	4.989
SCLP	Oak Grove Fork	Autumn	74	10	274.8	467.5	0.158	0.588
SCLP	Oak Grove Fork	Winter	36	4	123.1	467.5	0.077	0.263
SCLP	Pinhead Creek	Spring	114	37	203.3	442	0.258	0.460
SCLP	Pinhead Creek	Summer	181	8	398.2	442	0.410	0.901
SCLP	Pinhead Creek	Autumn	162	0	262.7	442	0.367	0.594
SCLP	Pinhead Creek	Winter	197	52	405.5	442	0.446	0.917

Table 6. Seasonal catch per unit effort (mean # fish/net set) in the North Fork Reservoir, OR.

Season	Size Class	Net Sets	Brown Trout	Juv. Chinook Salmon	Juv. Coho Salmon	Wild Rainbow Trout	Hatchery Rainbow Trout	Sculpin spp.	Adult Steelhead	Sucker spp.	Mountain Whitefish
Spring	15-95	10	0	0	0.100	0	0	0	0	0	0
Spring	96-300	10	0	0	1.000	0.100	0.300	0	0	2.300	0.400
Spring	301-500	10	0.100	0	0	0	0.200	0	0.100	6.500	0.200
Summer	15-95	13	0	0.231	0	0	0	0.077	0	0	0
Summer	96-300	13	0.077	4.000	0.154	0.154	0.308	0	0	11.08	1.692
Summer	301-500	13	0.308	0.154	0	0.077	0	0	0	3.923	0.231
Autumn	15-95	14	0	0	0	0	0	0	0	0	0
Autumn	96-300	14	0.071	3.000	0	0.500	0.786	0	0	2.000	1.571
Autumn	301-500	14	0	0	0.071	0.143	0	0	0	3.429	0.071
Winter	15-95	12	0	0	0	0	0	0	0	0	0
Winter	96-300	12	0	1.500	1.000	0.583	0.417	0	0	4.417	3.083
Winter	301-500	12	0.083	0	0	0	0	0	0	21.33	0.083

Table 7. Seasonal standing stock biomass estimates (kg) for crustacean zooplankton in the NF reservoir, OR. Samples were collected at two locations with vertical hauls at 5m and at15m details on the equipment and computations are described in the text. No zooplankton were encountered during sampling in Autumn (November).

Season	Depth (m)	*Daphnia*	*Bosmina*	Copepods	*Leptodora*	Total
Spring	0-5m	30.1	0.0	44.1	0.0	74.2
(May)	5-15m	0.0	0.0	0.0	0.0	0.0
Summer	0-5m	28,338.5	20.6	5,323.9	3,554.9	69,232.5
(August)	5-15m	3,554.3	0.0	653.0	2,387.0	28,077.3
Autumn	0-5m	0.0	0.0	0.0	0.0	0.0
(November)	5-15m	0.0	0.0	0.0	0.0	0.0
Winter	0-5m	24.1	0.0	4.4	0.0	28.5
(January)	5-15m	0.0	0.0	0.0	0.0	0.0

Table 8. Diet proportions (mean proportion by weight) calculated from observed diets collected seasonally in tributary, river-reservoir transition, and reservoir habitats in the upper Clackamas River Watershed.

Species	Habitat	Size Class	Season	n	Sucker	Dace	White-fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Unid Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
Chinook	Big Bottom 3	15-95	Spring	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.13	0.13	0.00
Chinook	Big Bottom 2	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Chinook	Big Bottom 2	15-95	Autumn	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.57	0.00	0.00	0.00
Chinook	Pinhead	15-95	Spring	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.10	0.03	0.00	0.00
Chinook	Oak Grove	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Coho	Big Bottom 2	15-95	Spring	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.12	0.00	0.02	0.00
Coho	Big Bottom 3	15-95	Spring	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.05	0.06	0.10	0.00	0.00
Coho	Big Bottom 1	15-95	Summer	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.02	0.48	0.01	0.00	0.08
Coho	Big Bottom 2	15-95	Summer	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.03	0.56	0.00	0.00	0.01
Coho	Big Bottom 1	15-95	Autumn	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.02	0.18	0.01	0.00	0.07
Coho	Big Bottom 2	15-95	Autumn	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.52	0.01	0.00	0.00
Coho	Big Bottom 1	96-300	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.56	0.00	0.00	0.00
Coho	Big Bottom 2	96-300	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.20	0.00	0.00	0.00
Coho	Pinhead	15-95	Spring	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.02	0.09	0.01	0.00	0.02
Coho	Pinhead	15-95	Summer	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.02	0.19	0.01	0.00	0.11
Coho	Pinhead	15-95	Autumn	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.18	0.01	0.00	0.03
Coho	Pinhead	15-95	Winter	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.05	0.00	0.00	0.16
Coho	Oak Grove	15-95	Summer	15	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.47	0.01	0.46	0.00	0.00	0.03
Coho	Oak Grove	15-95	Autumn	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.03	0.08	0.00	0.00	0.00
Coho	Oak Grove	15-95	Winter	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

Table 8-Diet in tributaries-continued

Species	Habitat	Size Class	Season	n	Sucker	Dace	White -fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Unid Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
O.mykiss	Big Bottom 2	15-95	Autumn	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.04	0.00	0.00	0.00
O.mykiss	Pinhead	15-95	Summer	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.03	0.15	0.02	0.00	0.00
O.mykiss	Pinhead	15-95	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.47	0.00	0.00	0.00
O.mykiss	Pinhead	15-95	Winter	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
O.mykiss	Pinhead	96-300	Winter	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.07
O.mykiss	Oak Grove	15-95	Summer	62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.05	0.17	0.00	0.00	0.00
O.mykiss	Oak Grove	15-95	Autumn	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.01	0.14	0.00	0.00	0.00
O.mykiss	Oak Grove	15-95	Winter	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.06	0.01	0.00	0.00
O.mykiss	Oak Grove	96-300	Summer	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.10	0.22	0.00	0.00	0.00
O.mykiss	Oak Grove	96-300	Autumn	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00
O.mykiss	Oak Grove	96-300	Winter	2	0.00	0.00	0.00	0.50	0.00	0.00	0.04	0.29	0.17	0.00	0.00	0.00	0.00	0.00
Cutt	Big Bottom1	15-95	Spring	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.01	0.00
Cutt	Big Bottom2	15-95	Spring	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Cutt	Big Bottom1	15-95	Summer	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.03	0.20	0.00	0.01	0.05
Cutt	Big Bottom2	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Cutt	Big Bottom1	15-95	Autumn	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.26	0.05	0.03	0.00
Cutt	Big Bottom1	15-95	Winter	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.15	0.00	0.02	0.00
Cutt	Big Bottom1	96-300	Spring	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.01	0.22	0.00	0.00	0.00
Cutt	Big Bottom1	96-300	Summer	3	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.21	0.00	0.00	0.36
Cutt	Big Bottom1	96-300	Autumn	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.13	0.00	0.00	0.60
Cutt	Oak Grove	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Cutt	Oak Grove	96-300	Summer	1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cutt	Pinhead	15-95	Spring	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.08	0.00	0.00	0.00
Cutt	Pinhead	15-95	Summer	4	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.48	0.13	0.18	0.05	0.05	0.06
Cutt	Pinhead	15-95	Autumn	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.01	0.11	0.04	0.00	0.02
Cutt	Pinhead	15-95	Winter	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.09	0.00	0.00
Cutt	Pinhead	96-300	Spring	2	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.15	0.00	0.00	0.00
Cutt	Pinhead	96-300	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.14	0.00	0.00	0.00
Cutt	Pinhead	96-300	Winter	4	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.02

Table 8-D iet composition in Tributaries--Continued

Species	Habitat	Size Class	Season	n	Sucker	Dace	White-fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Unid Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
Sculpin	Big Bottom 1	15-95	Spring	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.92	0.00	0.00	0.06	0.01	0.00
Sculpin	Big Bottom 1	96-300	Spring	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Sculpin	Big Bottom 1	15-95	Summer	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.04	0.01	0.06	0.01	0.03
Sculpin	Big Bottom 1	15-95	Autumn	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.04	0.01	0.05
Sculpin	Big Bottom 1	15-95	Winter	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.19	0.10	0.00
Sculpin	Big Bottom 2	15-95	Spring	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.02	0.24	0.05	0.00
Sculpin	Big Bottom 2	15-95	Summer	38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.04	0.09	0.00	0.01
Sculpin	Big Bottom 2	15-95	Autumn	46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.07	0.07	0.03
Sculpin	Big Bottom 3	15-95	Spring	9	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.92	0.01	0.01	0.02	0.00	0.00
Sculpin	Pinhead	15-95	Spring	42	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.78	0.01	0.04	0.10	0.00	0.05
Sculpin	Pinhead	15-95	Summer	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.02	0.03	0.00	0.10
Sculpin	Pinhead	15-95	Autumn	51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.04	0.06	0.00	0.05
Sculpin	Pinhead	15-95	Winter	65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.04	0.07	0.00	0.04
Sculpin	Oak Grove	15-95	Summer	45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.01	0.04	0.00	0.00
Sculpin	Oak Grove	96-300	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Sculpin	Oak Grove	15-95	Autumn	53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.02	0.00	0.00
Sculpin	Oak Grove	96-300	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Sculpin	Oak Grove	15-95	Winter	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.02	0.00	0.00
Sculpin	Oak Grove	96-300	Winter	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Salamander	Big Bottom 2	15-95	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.01	0.00	0.03
Salamander	Big Bottom 2	96-300	Autumn	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.35
Salamander	Oak Grove	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.03	0.00	0.00	0.00	0.00
Salamander	Oak Grove	96-300	Summer	9	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00
Salamander	Oak Grove	96-300	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Salamander	Oak Grove	15-95	Winter	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Salamander	Oak Grove	96-300	Winter	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

Table 8. Diet composition in the Transition Zone

Species	Habitat	Size Class	Season	n	Sucker	Dace	White-fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Unid Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
Chinook	Transition	15-95	Spring	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.04	0.09	0.01	0.01	0.00
Coho	Transition	15-95	Summer	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.10	0.43	0.00	0.00	0.00
Coho	Transition	15-95	Autumn	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.66	0.00	0.00	0.00
Coho	Transition	15-95	Spring	10	0.00	0.00	0.00	0.04	0.00	0.00	0.05	0.00	0.64	0.05	0.22	0.00	0.00	0.00
Cutt	Transition	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.06	0.44	0.00	0.00	0.00
Dace	Transition	15-95	Spring	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Dace	Transition	15-95	Summer	31	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.70	0.02	0.19	0.00	0.07	0.00
O.mykiss	Transition	15-95	Summer	4	0.00	0.00	0.00	0.04	0.00	0.03	0.00	0.00	0.28	0.09	0.52	0.00	0.03	0.00
Sucker	Transition	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.25	0.00	0.00	0.25	0.00
Sucker	Transition	15-95	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25	0.25	0.00
Sculpin	Transition	15-95	Spring	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.02	0.10	0.00
Sculpin	Transition	15-95	Summer	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.03	0.02	0.05	0.07	0.03
Sculpin	Transition	15-95	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

Table 8. –Continued. Diets in North Fork Reservoir

Species	Habitat	Size Class	Season	n	Sucker	Dace	White-fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Unid Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
Brown	Reservoir	>300	Spring	1	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown	Reservoir	>300	Summer	3	0.00	0.00	0.46	0.21	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown	Reservoir	96-300	Summer	1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown	Reservoir	>300	Winter	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Chinook	Reservoir	15-95	Spring	19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.10	0.14	0.11	0.18	0.00
Chinook	Reservoir	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.93	0.00
Chinook	Reservoir	96-300	Summer	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.93	0.00
Chinook	Reservoir	96-300	Autumn	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.18	0.00	0.00	0.00
Chinook	Reservoir	96-300	Winter	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Coho	Reservoir	15-95	Spring	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.21	0.00	0.00	0.00	0.00
Coho	Reservoir	96-300	Spring	10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.92	0.04	0.03	0.00	0.00	0.00
Coho	Reservoir	96-300	Winter	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.01	0.00	0.00
O.mykiss	Reservoir	96-300	Spring	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.05	0.00	0.00	0.00	0.00
O.mykiss	Reservoir	96-300	Summer	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00
O.mykiss	Reservoir	96-300	Autumn	7	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.62	0.00	0.18	0.00	0.00	0.00
O.mykiss	Reservoir	>300	Autumn	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
O.mykiss	Reservoir	96-300	Winter	7	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00
RBT-H	Reservoir	96-300	Spring	3	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.01	0.00	0.00	0.00	0.00
RBT-H	Reservoir	>300	Spring	2	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00
RBT-H	Reservoir	96-300	Summer	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.20	0.00	0.00	0.30	0.00
RBT-H	Reservoir	96-300	Autumn	10	0.20	0.00	0.28	0.10	0.00	0.00	0.15	0.04	0.12	0.00	0.00	0.00	0.00	0.00
RBT-H	Reservoir	96-300	Winter	5	0.20	0.00	0.43	0.18	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00

Table 8-Continued. Diets in reservoir.

Species	Habitat	Size Class	Season	n	Sucker	Dace	White-fish	Sculpin	Chinook	Unid. Salmonid	Unid Fish	Fish Egg	Aquatic Insect	Aquatic Pupae	Terr. Insects	Amphi-pod	Zoo-plankton	Gastro-pod
WF	Reservoir	96-300	Spring	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
WF	Reservoir	>300	Spring	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
WF	Reservoir	96-300	Summer	15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.15	0.00	0.00	0.53	0.00
WF	Reservoir	>300	Summer	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
WF	Reservoir	96-300	Autumn	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.05	0.01	0.00	0.05
WF	Reservoir	>300	Autumn	1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
WF	Reservoir	96-300	Winter	35	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
WF	Reservoir	>300	Winter	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Sculpin	Reservoir	15-95	Summer	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00

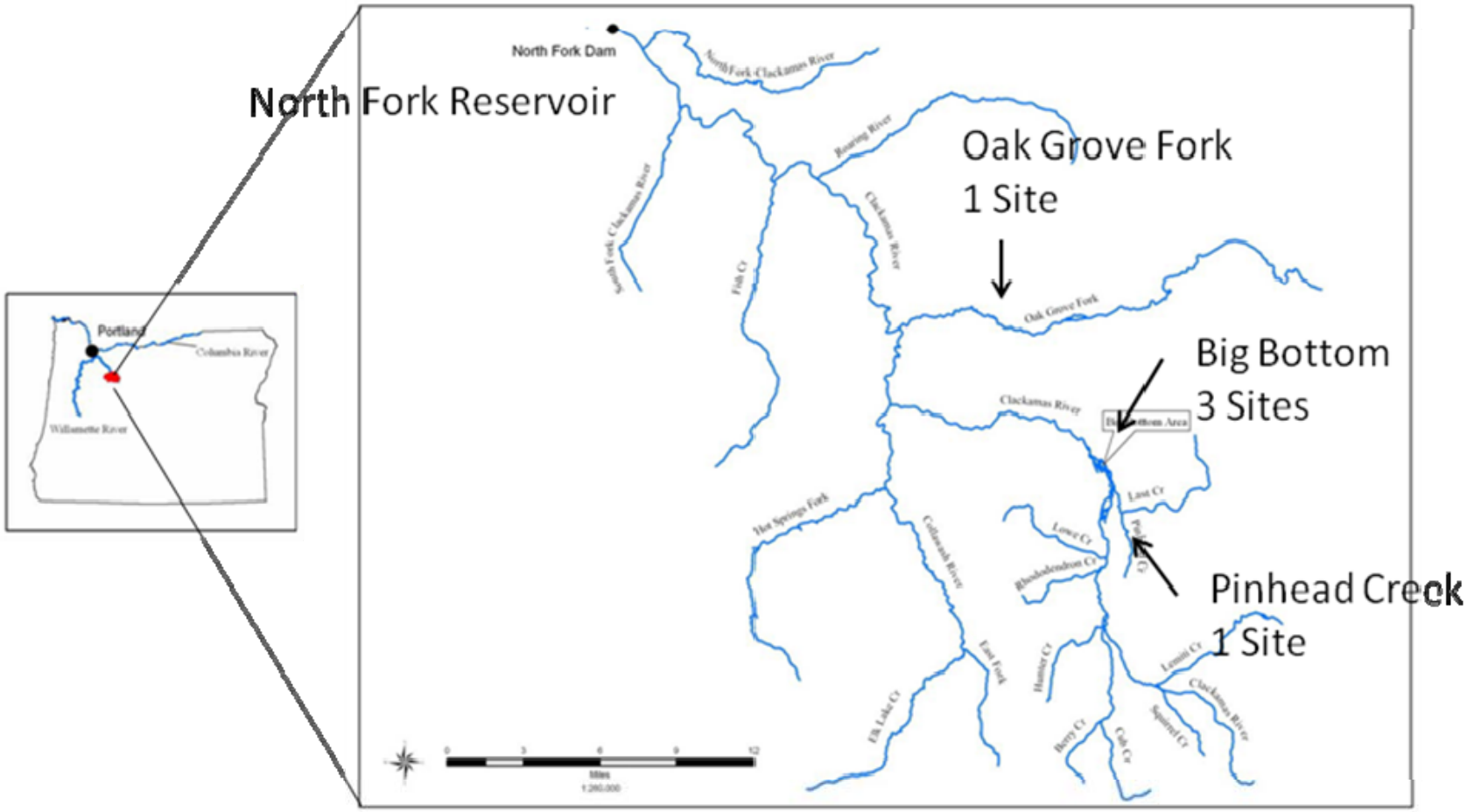

Figure 1. Map of the upper Clackamas river basin and sampling locations used in this study.

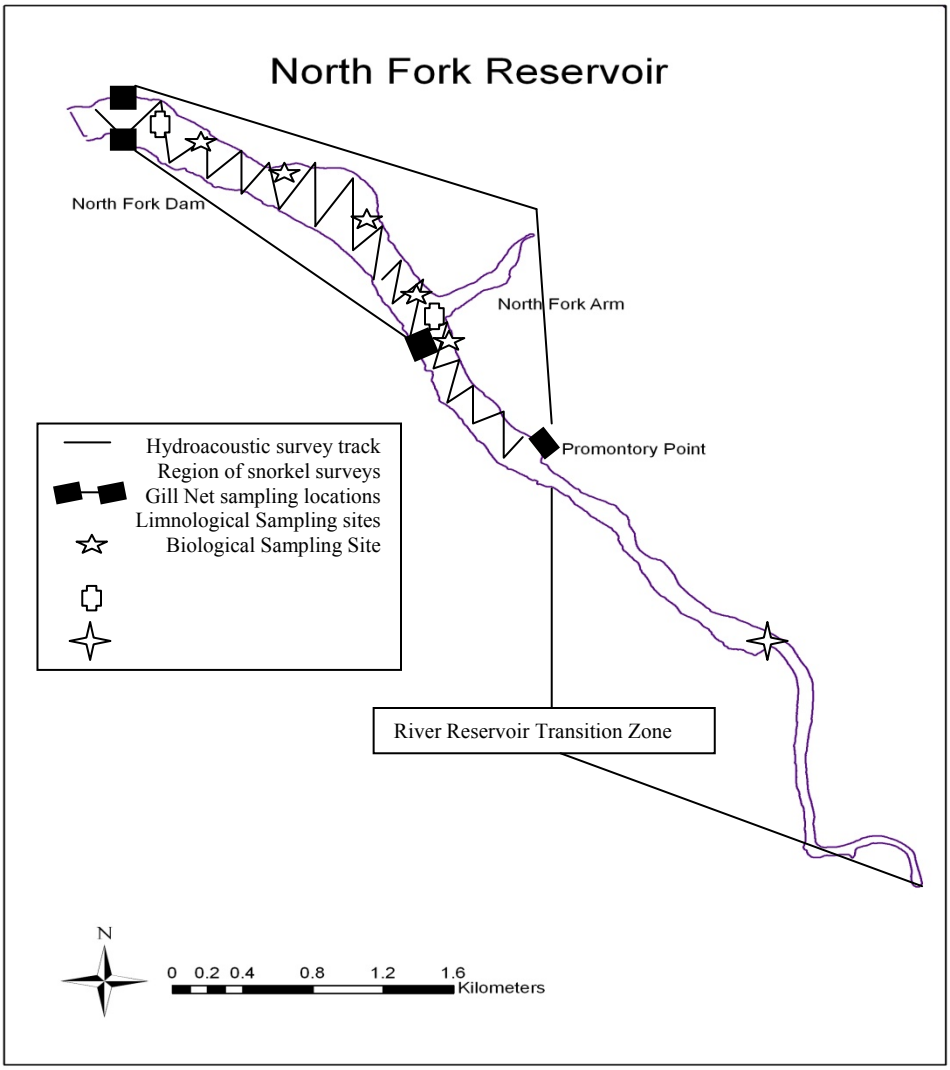

Figure 2. Map of the NF reservoir and sampling locations used during this investigation. Biological samples in the River-Reservoir Transition Zone were not used for distribution or density estimation but provided diet, size structure, and growth information for this habitat.

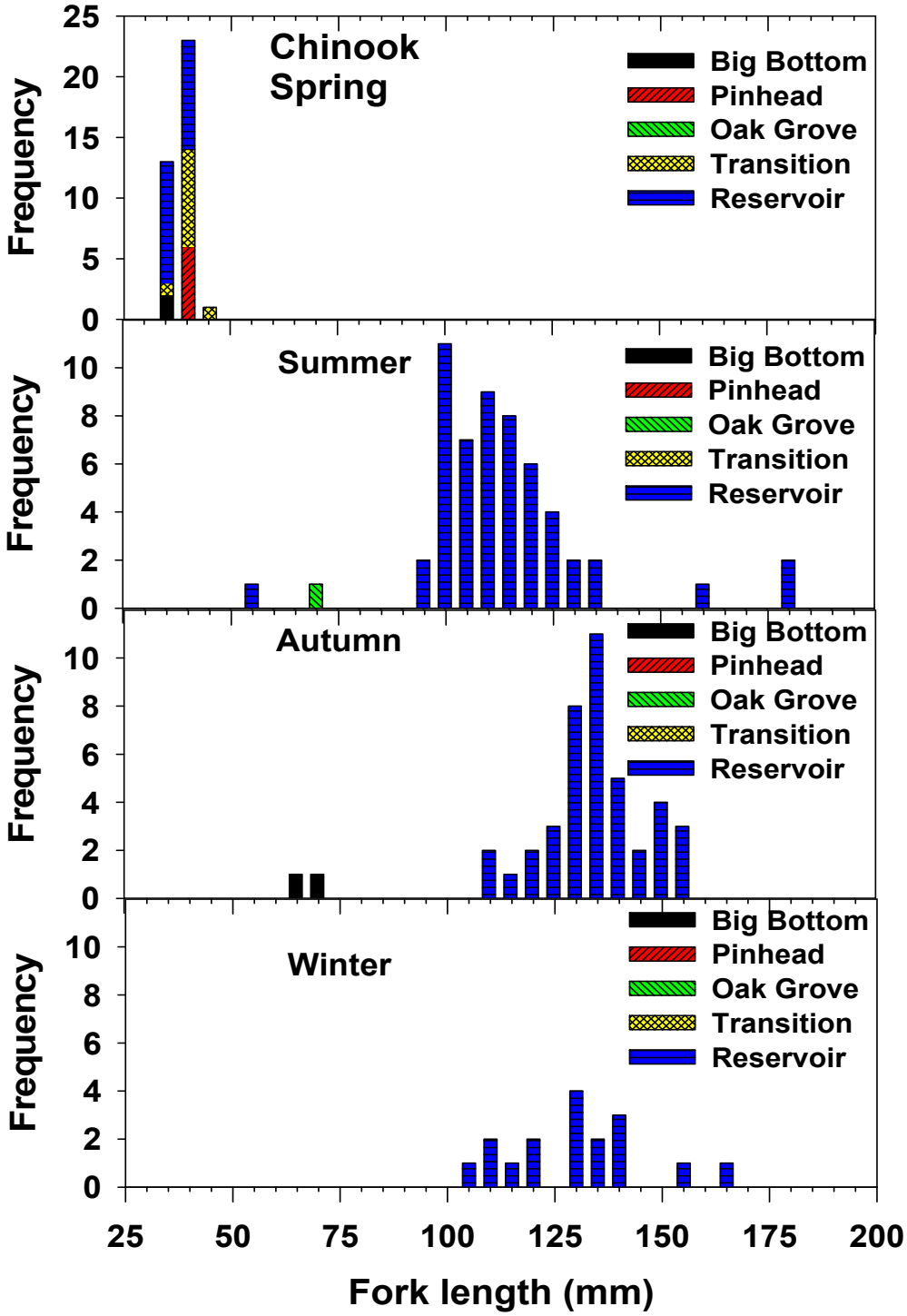

Figure 3. Length frequencies of juvenile Chinook salmon sampled in riverine, transition zone, and reservoir habitats in the Upper Clackamas Basin during different seasons from May 2009 to Janutary 2010. Oak Grove could not be sampled during spring due to high flows.

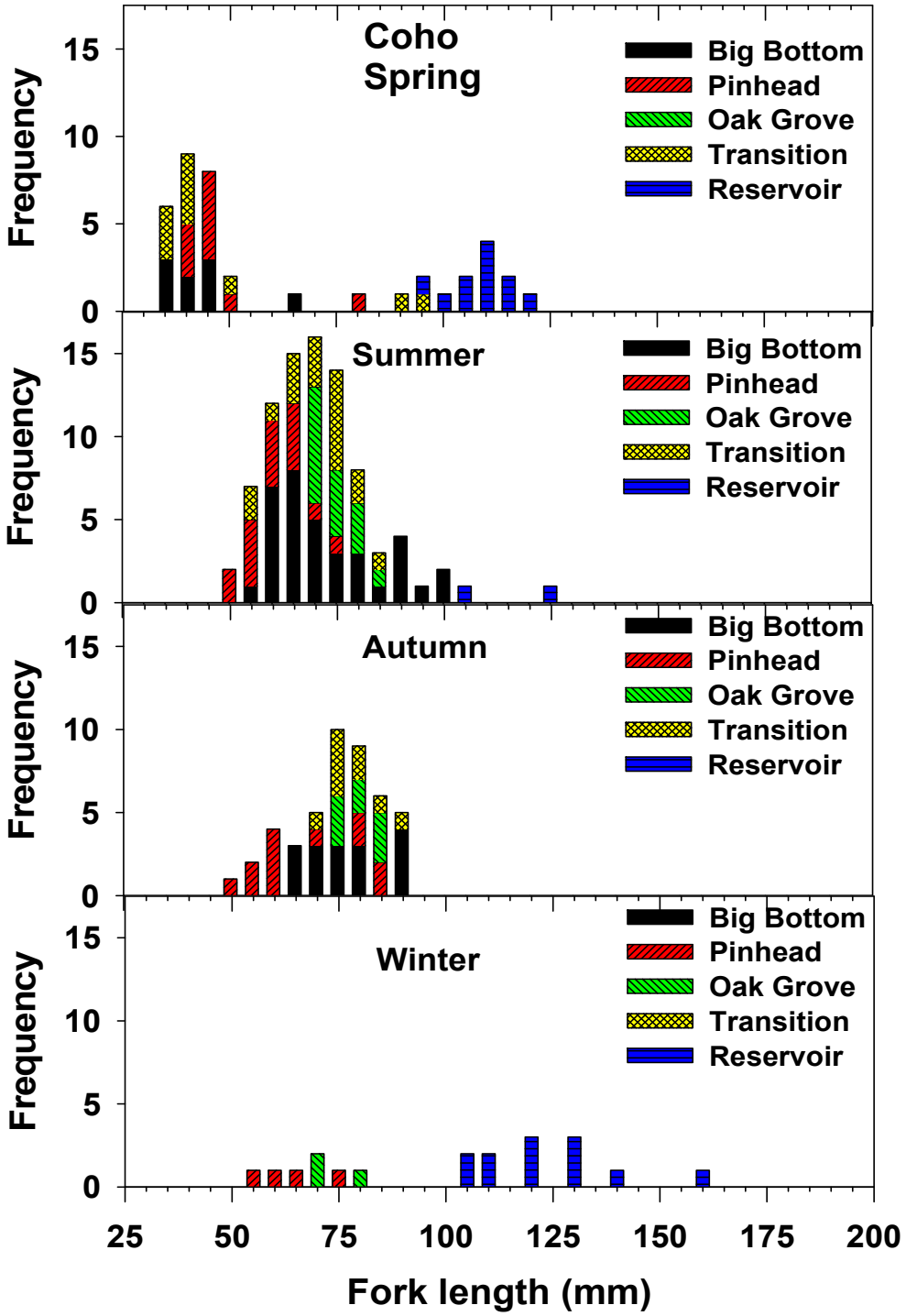

Figure 4. Length frequencies of juvenile coho salmon sampled in riverine, transition zone, and reservoir habitats in the Upper Clackamas Basin during different seasons from May 2009 to Janutary 2010. Oak Grove could not be sampled during spring due to high flows.

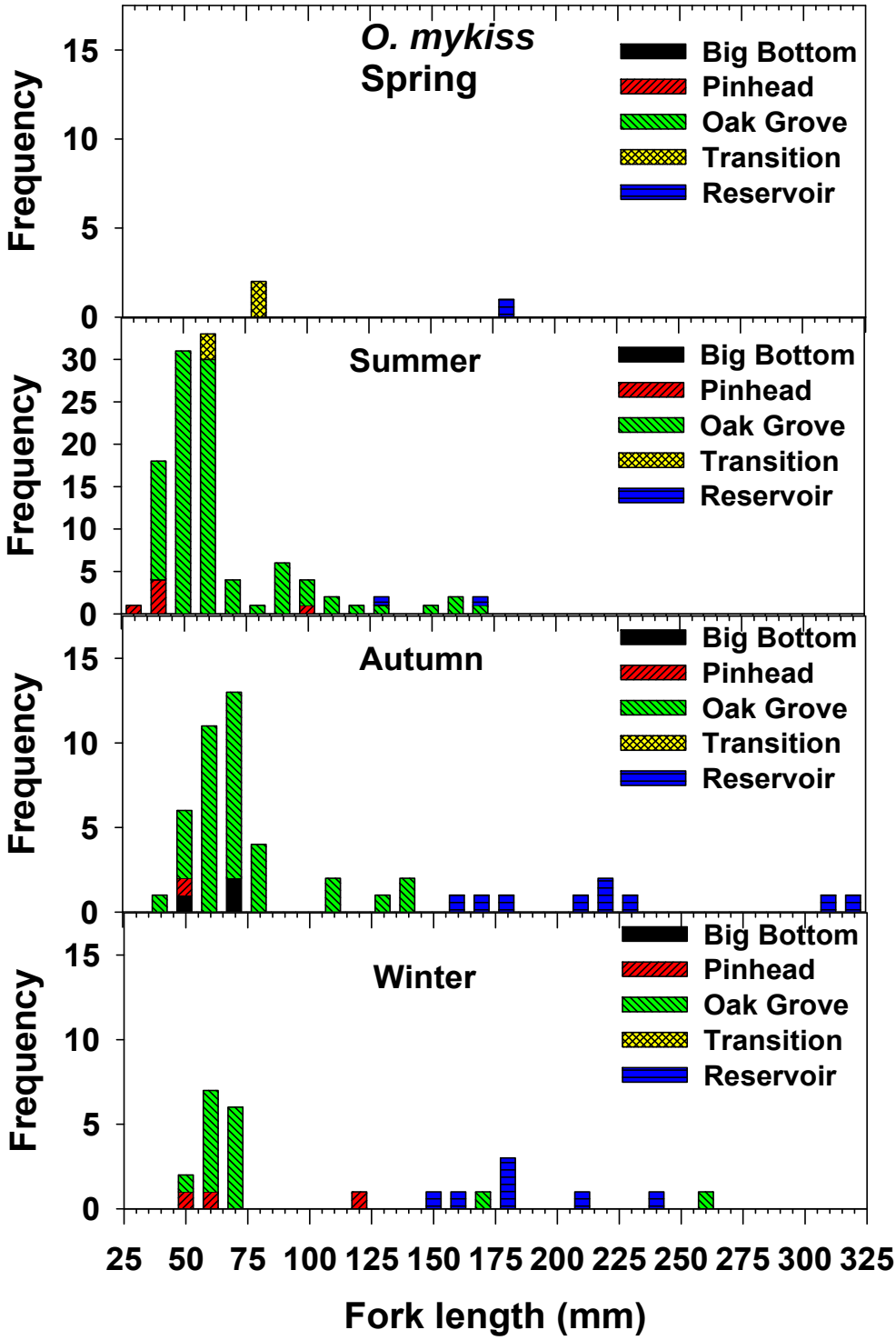

Figure 5. Length frequencies of juvenile *O. mykiss* sampled in riverine, transition zone, and reservoir habitats in the Upper Clackamas Basin during different seasons from May 2009 to Janutary 2010. Oak Grove could not be sampled during spring due to high flows.

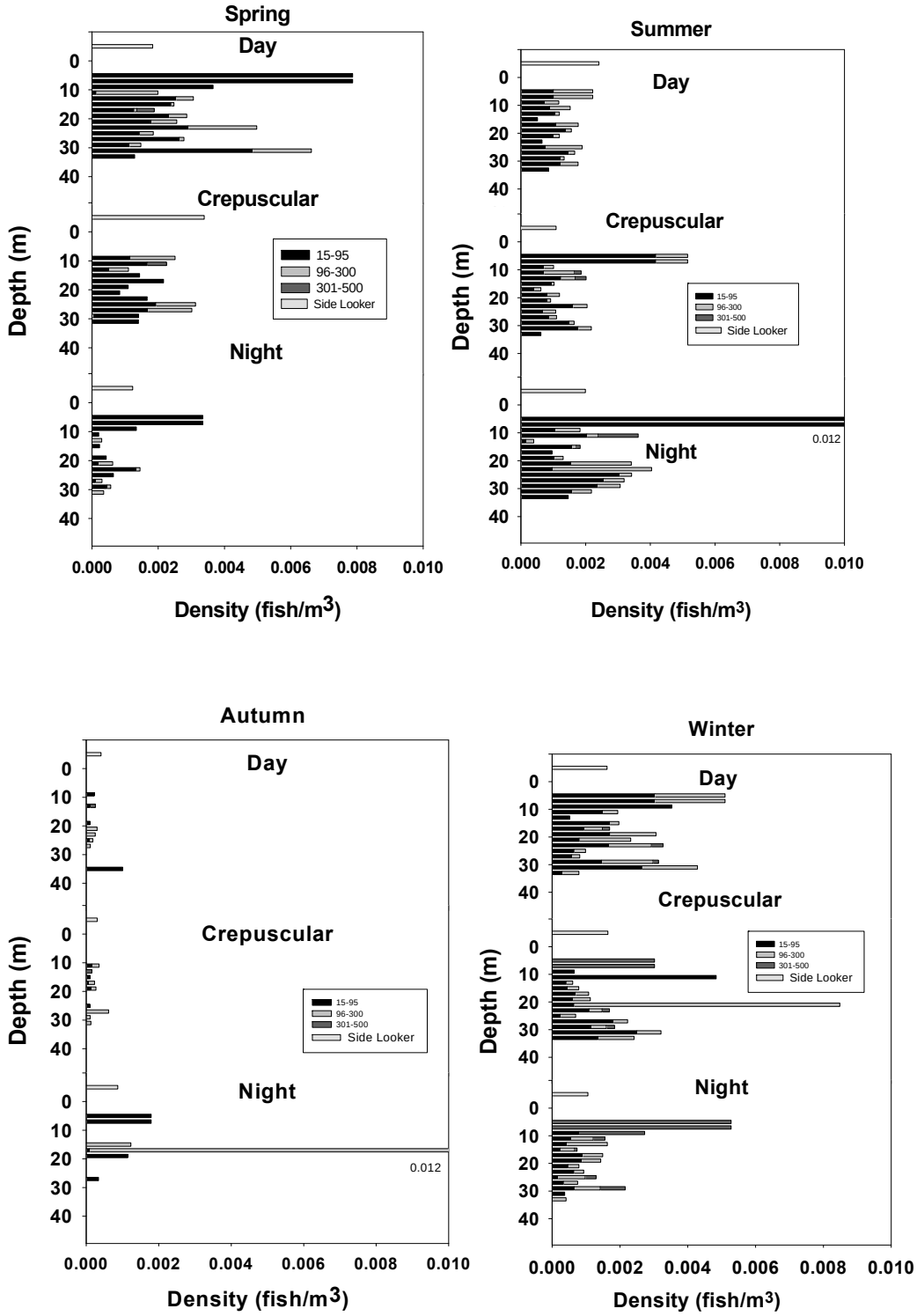

Figure 6. Seasonal size structured fish density estimates from hydroacoustic surveys in the North Fork Reservoir, OR. Densities in the 0-2m depth bin are estimated with the side looking transducer. Side looking data was only used to characterize densities of fishes. Numbers near the truncated bars in Summer and Autumn indicate fish densities.

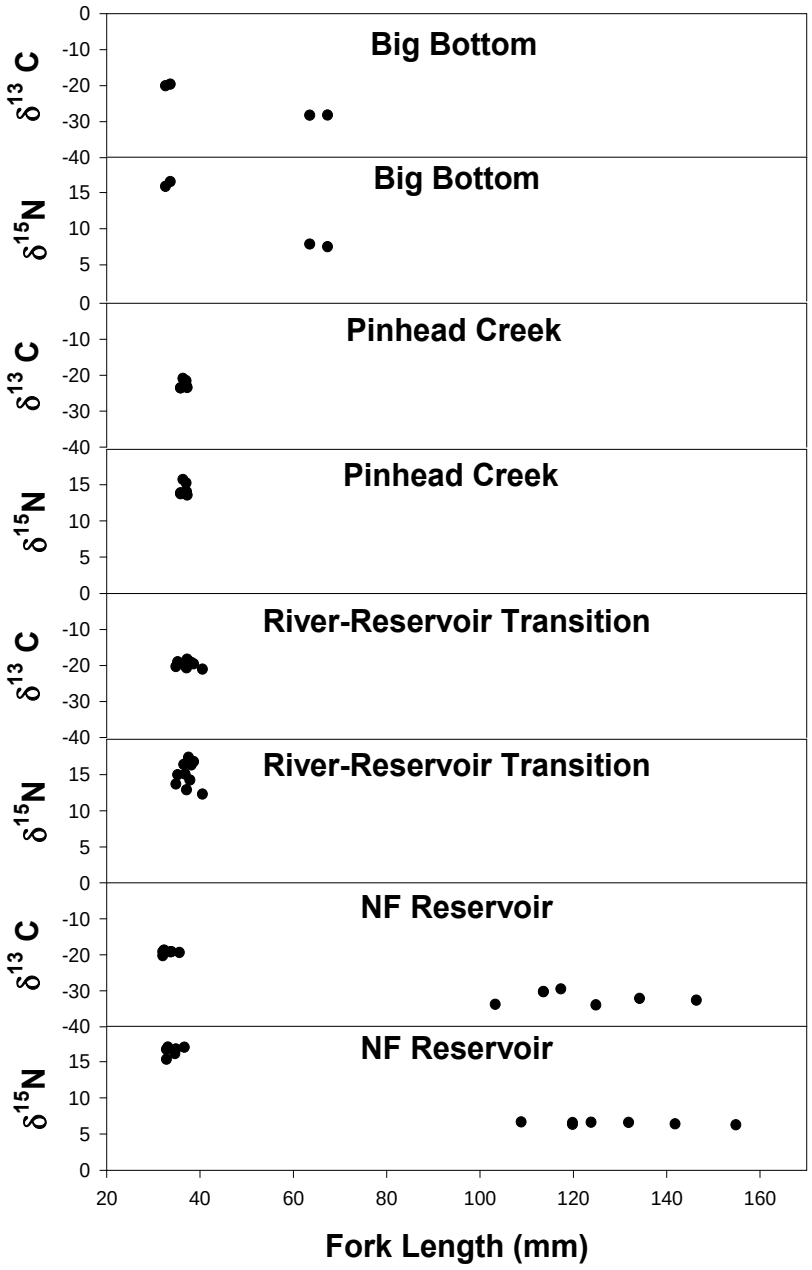

Figure 7. Plots of stable isotope values vs. fork length for Chinook salmon in tributary, river-reservoir transition, and reservoir habitats. Samples were collected in May, August, November 2009, and January 2010. Note the zero on the y-axis is shared between $\delta^{13}C$ and $\delta^{15}N$.

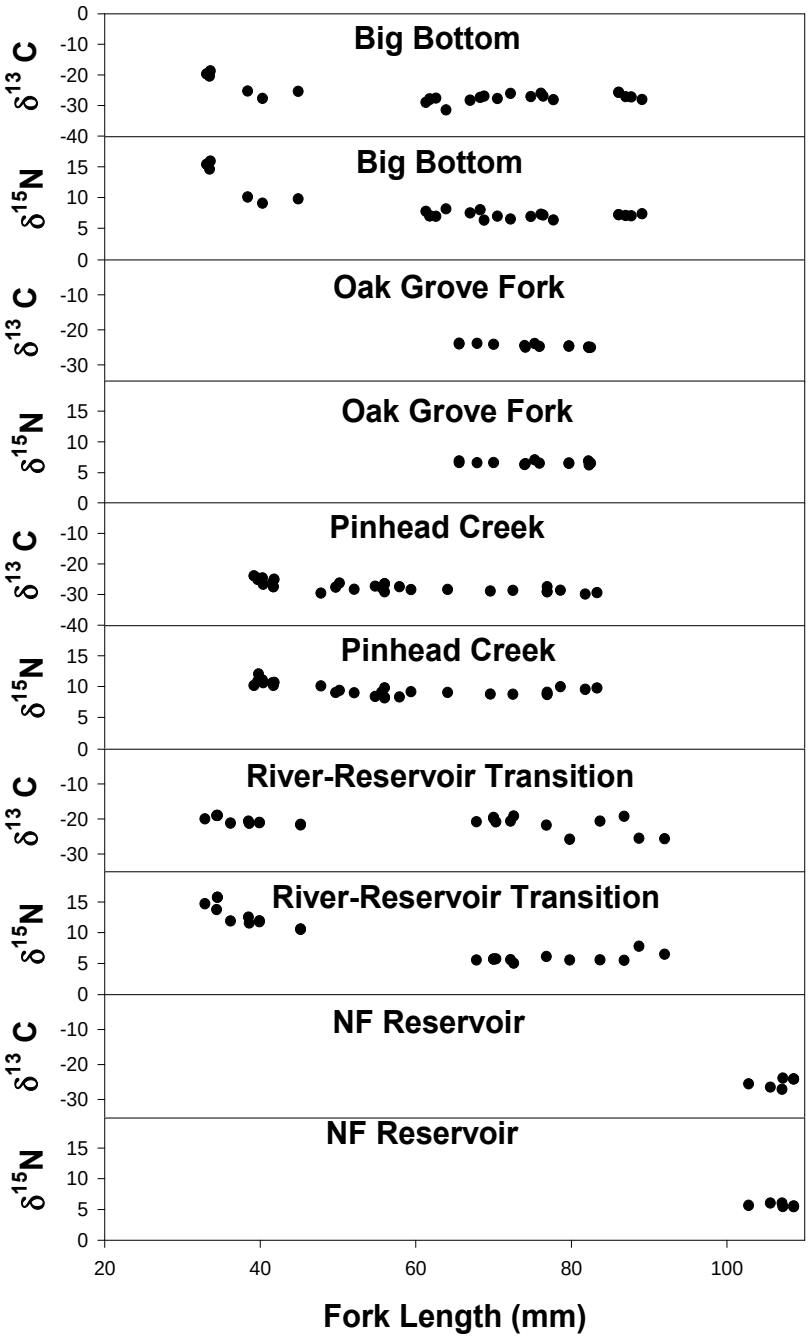

Figure 8. Plots of stable isotope values vs. fork length for coho salmon in tributary, river-reservoir transition, and reservoir habitats. Samples were collected in May, August, November 2009, and January 2010. Note the zero on the y-axis is shared between $\delta^{13}C$ and $\delta^{15}N$.

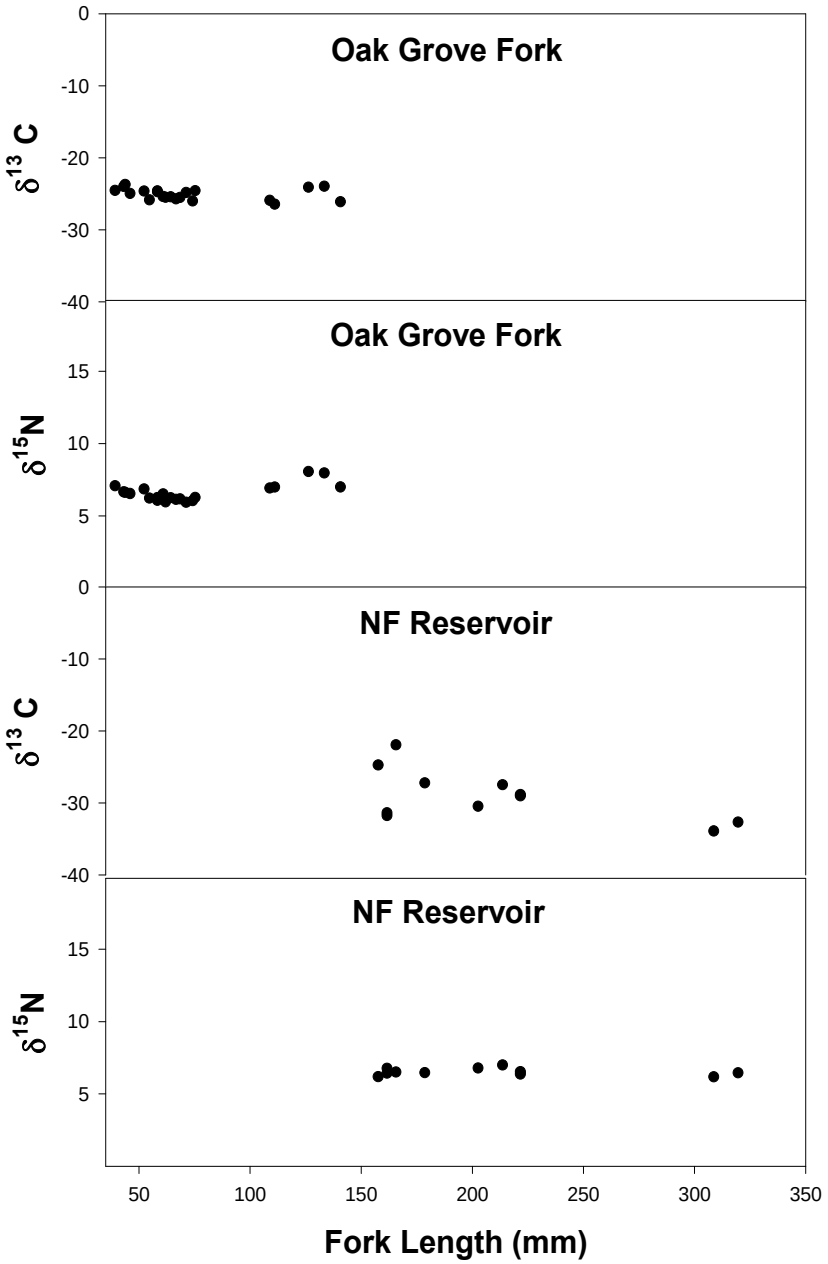

Figure 9. Plots of stable isotope values vs. fork length for wild *O. mykiss* in tributary and reservoir habitats. Samples were collected in May, August, November 2009, and January 2010. Although none of the fry or parr exhibited elevated $\delta^{15}N$ consistent with anadromous origin, the sampled specimens were already large enough to have diluted the maternal signal via exogenous feeding and a significant post-emergent increase in body mass.

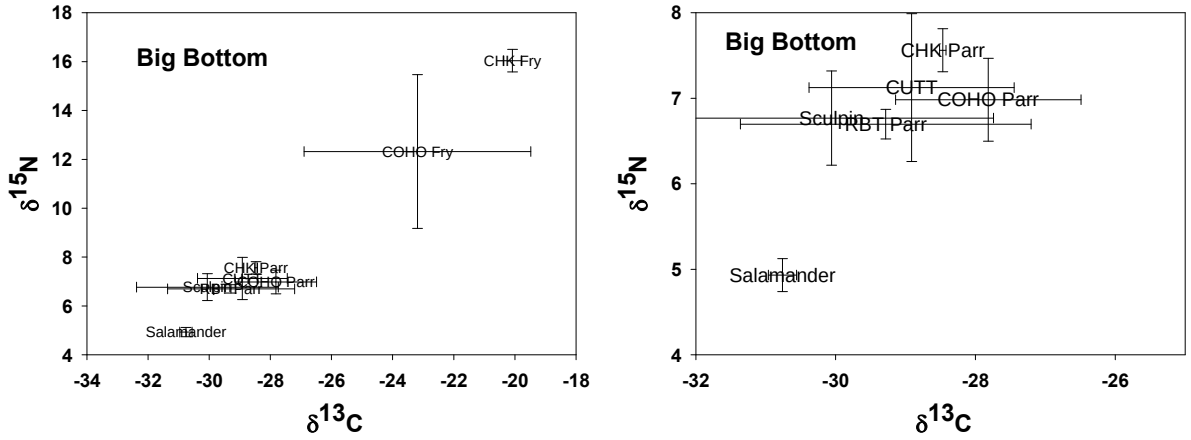

Figure 10. A) Plots of mean $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for key members of the Big Bottom food web (error bars represent one standard deviation). B) The panel on the left displays all of the fishes analyzed in this habitat the panel on the right is an enlarged view of the same data (note the scale of the x and y axes). The symbols are defined as; CHK Fry are Chinook salmon <50mm, CHK Parr are Chinook salmon >50mm, COHO Fry are coho salmon <50mm, COHO Parr are coho salmon >50mm, RBT Parr are *O. mykiss* >50mm, CUTT are coastal cutthroat trout, Sculpin are shorthead sculpin, and salamander are giant salamander larvae.

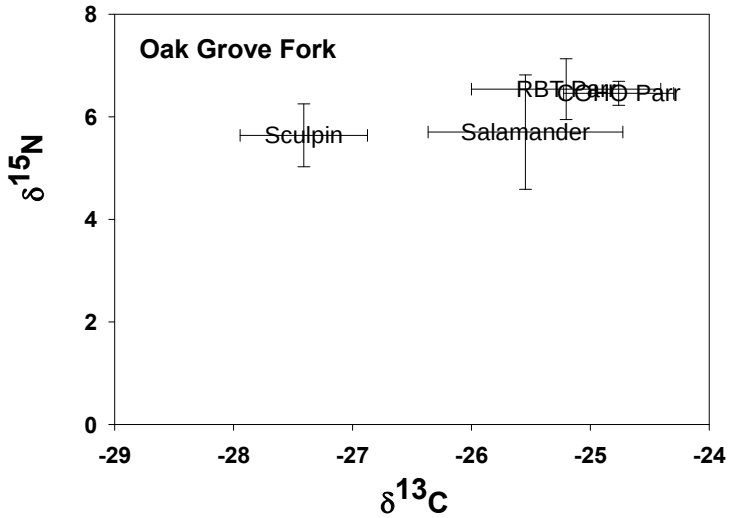

Figure 11. Plots of mean $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for key members of the Oak Grove Fork food web (error bars represent one standard deviation). The symbols are defined as; COHO Parr are coho salmon >50mm, RBT Parr are *O. mykiss* >50mm, Sculpin are shorthead sculpin, and salamander are giant salamander larvae.

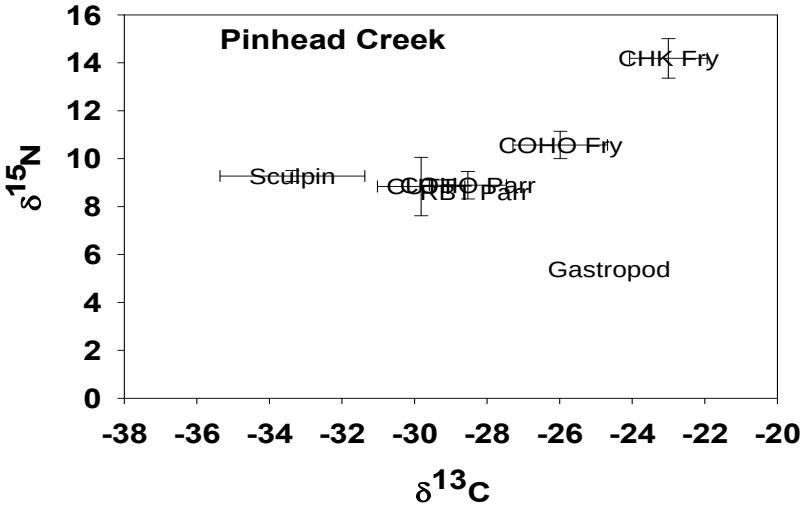

Figure 12. Plots of mean $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for key members of the Pinhead Creek food web (error bars represent one standard deviation). The symbols are defined as; CHK Fry are Chinook salmon <50mm, COHO Fry are coho salmon <50mm, COHO Parr are coho salmon >50mm, RBT Parr are *O. mykiss* >50mm, CUTT are coastal cutthroat trout, Sculpin are shorthead sculpin, and Gastropod are unidentified gastropod spp. Note: CUTT, RBT Parr, and COHO Parr have similar values and exhibit a large degree of overlap.

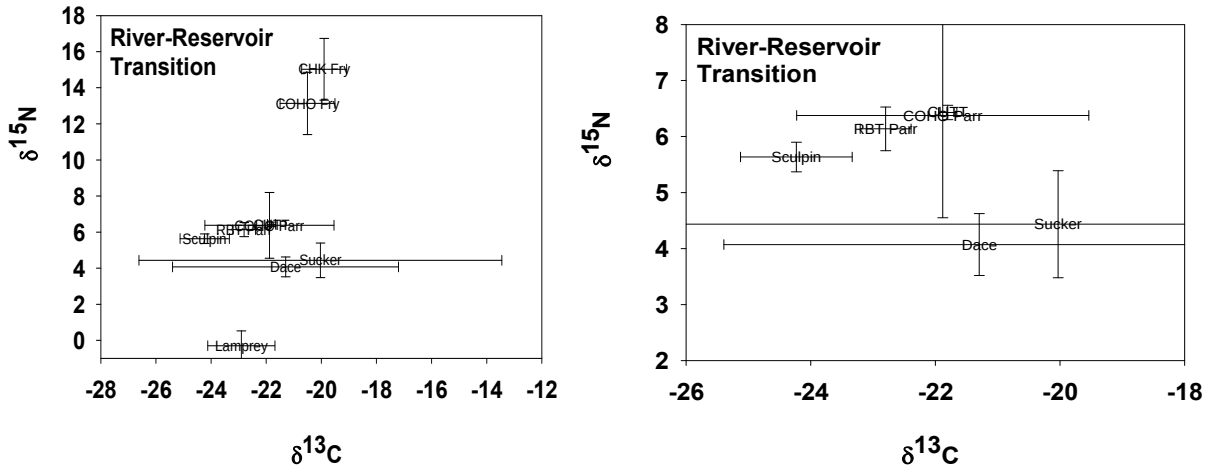

Figure 13. A) Plots of mean $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for key members of the River-Reservoir Transition zone food web (error bars represent one standard deviation). B) The panel on the left displays an enlarged view of the fishes analyzed in this habitat from the right panel (note the scale of the x and y axes). The symbols are defined as; CHK Fry are Chinook salmon <50mm, COHO Fry are coho salmon <50mm, COHO Parr are coho salmon >50mm, RBT Parr are *O. mykiss* >50mm, CUTT are coastal cutthroat trout, Sculpin are shorthead sculpin, juveniles, Lamprey are lamprey ammocoetes, and Sucker are juvenile largescale suckers.

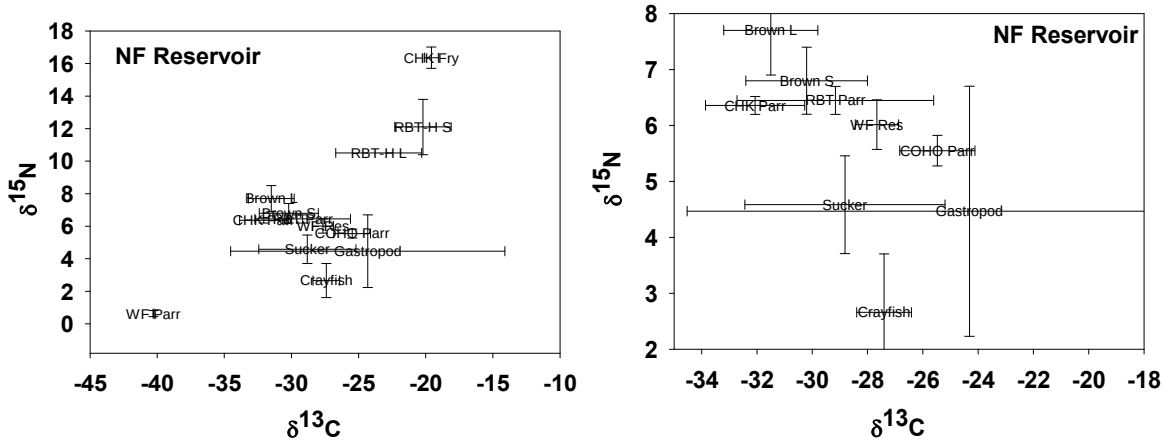

Figure 14. A) Plots of mean $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for key members of the NF Reservoir food web (error bars represent one standard deviation). B) The panel on the left is an enlarged view of the same data, but excluding the fish with elevated trophic position from anadromous maternal signals (Chinook and coho fry) or hatchery-fed rainbow trout, (note the scale of the x and y axes). The symbols are defined as; CHK Fry are Chinook salmon <50mm, CHK Parr are Chinook salmon >50mm, COHO Parr are coho salmon >50mm, RBT Parr are *O. mykiss* >50mm, RBT-H S are hatchery rainbow trout 200-300mm, RBT-H L are hatchery rainbow trout 300-500mm, Brown S are brown trout 200-325mm, Brown L are brown trout 325-450mm,, WF are mountain whitefish, Crayfish are signal crayfish, Gastropod are unidentified gastropod spp., and Sucker are largescale sucker juveniles.

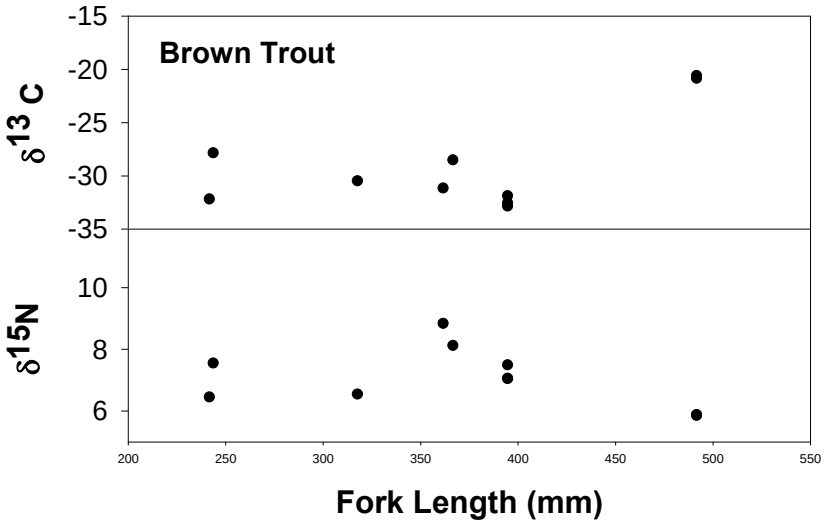

Figure 15. Plots of stable isotope values vs. fork length for brown trout in reservoir habitats. Samples were collected in May, August, November 2009, and January 2010.

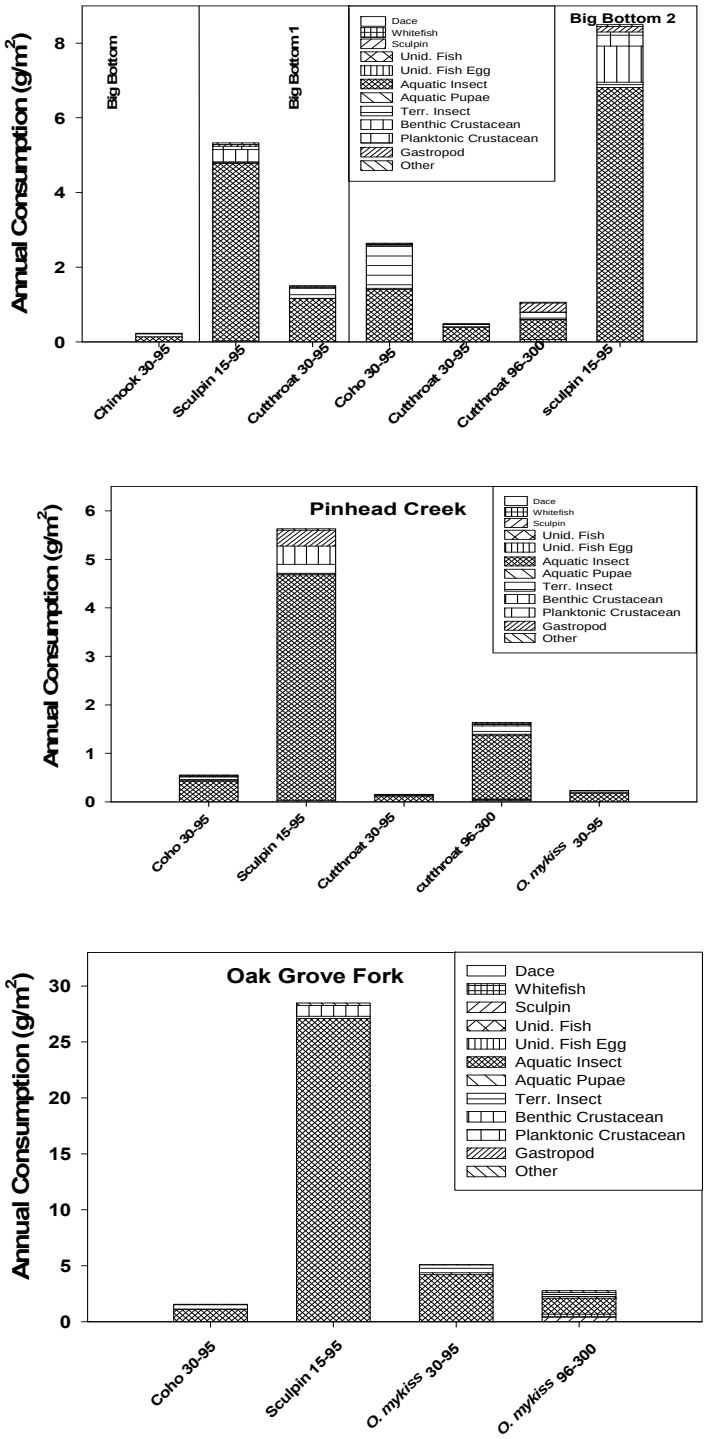

Figure 16. Annual estimates of prey biomass consumed (g/m^2)by the key species and size classes of fish in the Upper Clackamas River watershed in: A) Big Bottom 1-3; B) Pinhead Creek; and C) Oak Grove. Consumption was based on annual bioenergetics simulations (simulation day1= May 1, 2009, simulation day 365 = April 30, 2010) and population estimates within stream sampling units from 3-pass depletion electrofishing.

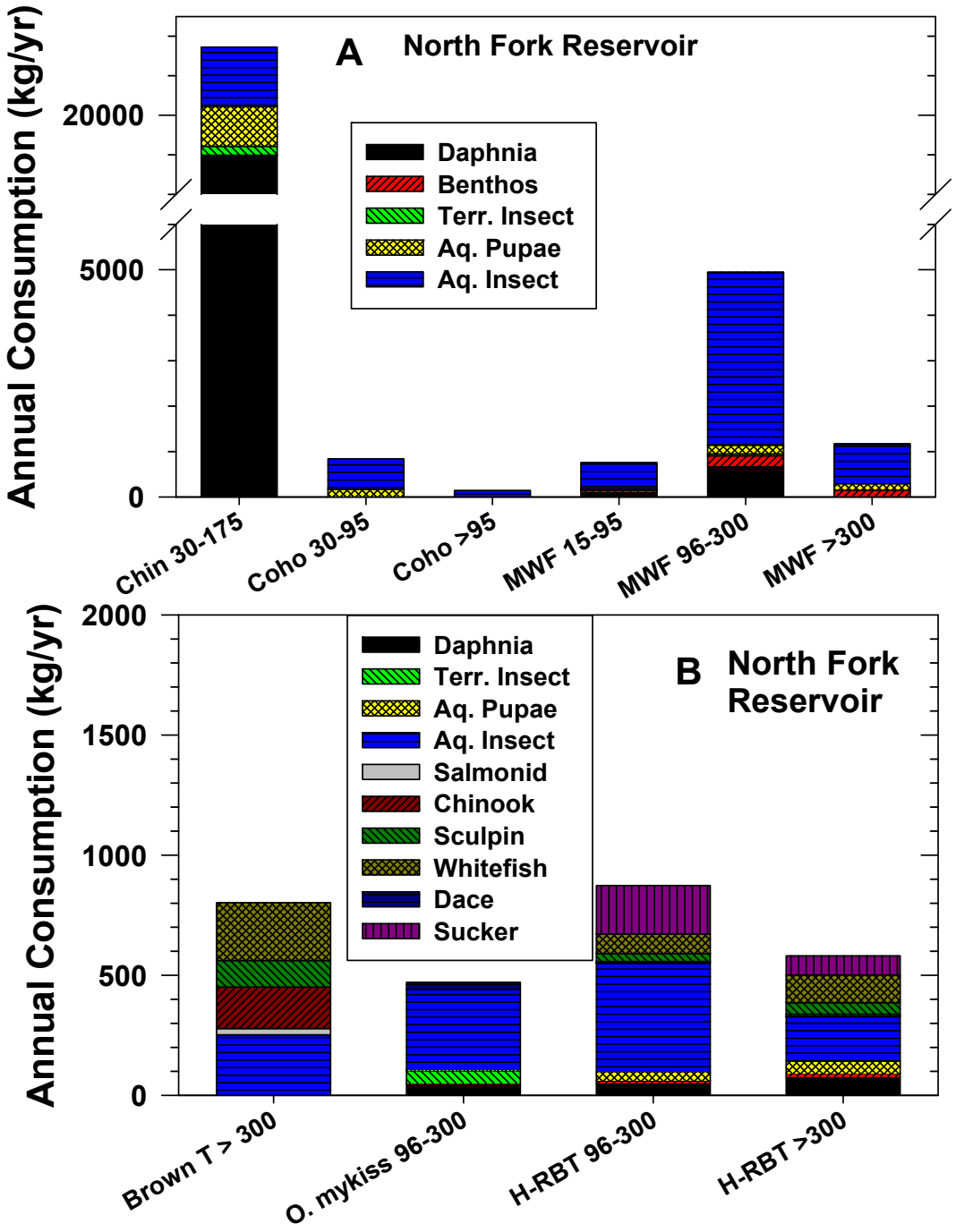

Figure 17. Estimates of annual population-level consumption in the NF Reservoir by A) juvenile salmon and mountain whitefish; and B) wild brown and rainbow trout, and two sizes of hatchery rainbow trout. Consumption was based on annual bioenergetics simulations (simulation day 1= May 1, 2009, day 365 = April 30, 2010) and population estimates from hydroacoustics, gill netting and spring littoral snorkeling. Note the 10x difference in Y-axes.

Appendix

Table A1. Population estimates of fish in the NF reservoir by species based on results from diel hydroacoustic surveys and proportional catches from gillnetting. A. Spring-Summer surveys

Season	Period	Size Class	Brown Trout	Chinook Salmon	Coho Salmon	Wild O.mykiss	Hatchery Rainbow Trout	Sucker spp,	Mtn White-fish
Spring	Day	15-95	-	-	85,879	-	-	-	-
Spring	Day	96-300	-	-	3,216	322	965	7,396	1,286
Spring	Day	301-500	14	-	-	-	29	935	29
Spring	Dusk	15-95	-	-	27,206	-	-	-	-
Spring	Dusk	96-300	-	-	2,258	226	677	5,193	903
Spring	Dusk	301-500	31	-	-	-	62	2,011	62
Spring	Night	15-95	-	-	69,117	-	-	-	-
Spring	Night	96-300	-	-	1,011	101	303	2,325	404
Spring	Night	301-500	-	-	-	-	-	-	-
Summer	Day	15-95	-	67,204	-	-	-	-	-
Summer	Day	96-300	232	12,045	463	463	927	33,355	5,096
Summer	Day	301-500	-	-	-	-	-	-	-
Summer	Dusk	15-95	-	112,045	-	-	-	-	-
Summer	Dusk	96-300	226	11,747	452	452	904	32,531	4,970
Summer	Dusk	301-500	444	222	-	111	-	5,655	333
Summer	Night	15-95	-	168,861	-	-	-	-	-
Summer	Night	96-300	130	6,739	259	259	518	18,662	2,851
Summer	Night	301-500	809	405	-	202	-	10,318	607

Table A1-continued-B. Autumn and Winter surveys.

Season	Period	Size Class	Brown Trout	Chinook Salmon	Coho Salmon	Wild O.mykiss	Hatchery Rainbow Trout	Sucker spp,	Mtn White-fish
Autumn	Day	15-95	-	-	-	-	-	-	-
Autumn	Day	96-300	23	945	-	158	248	630	495
Autumn	Day	301-500	-	-	34	67	-	1,612	34
Autumn	Dusk	15-95	-	-	-	-	-	-	-
Autumn	Dusk	96-300	54	2,263	-	377	593	1,508	1,185
Autumn	Dusk	301-500	-	-	35	71	-	1,700	35
Autumn	Night	15-95	-	-	-	-	-	-	-
Autumn	Night	96-300	587	24,648	-	4,108	6,455	16,432	12,911
Autumn	Night	301-500	-	-	-	-	-	-	-
Winter	Day	15-95	-	-	-	-	-	-	-
Winter	Day	96-300	-	4,139	2,759	1,610	1,150	12,187	8,508
Winter	Day	301-500	4	-	-	-	-	1,114	4
Winter	Dusk	15-95	-	-	-	-	-	-	-
Winter	Dusk	96-300	-	2,654	1,770	1,032	737	7,816	5,456
Winter	Dusk	301-500	94	-	-	-	-	24,131	94
Winter	Night	15-95	-	-	-	-	-	-	-
Winter	Night	96-300	-	3,682	2,455	1,432	1,023	10,842	7,569
Winter	Night	301-500	373	-	-	-	-	95,586	373

Table A2. Estimated seasonal target densities (n/m^3) from diel horizontal hydroacoustic surveys in the NF Reservoir, OR.

Season	Period	Total
Spring	Day	0.000733
	Crepuscular	0.001355
	Night	0.001231
Summer	Day	0.003613
	Crepuscular	0.001632
	Night	0.001993
Autumn	Day	0.000612
	Crepuscular	0.000461
	Night	0.000873
Winter	Day	0.000973
	Crepuscular	0.000988
	Night	0.001057

Table A3. Seasonal turbidity measurements from the NF Reservoir, OR

Date	Location	Average Turbidity (NTU)
5/18/2009	East	1.50
5/18/2009	West	1.68
8/24/2009	East	0.27
8/24/2009	West	0.30
11/30/2009	East	1.11
11/30/2009	West	1.16
1/11/2010	East	1.14
1/11/2010	West	1.71

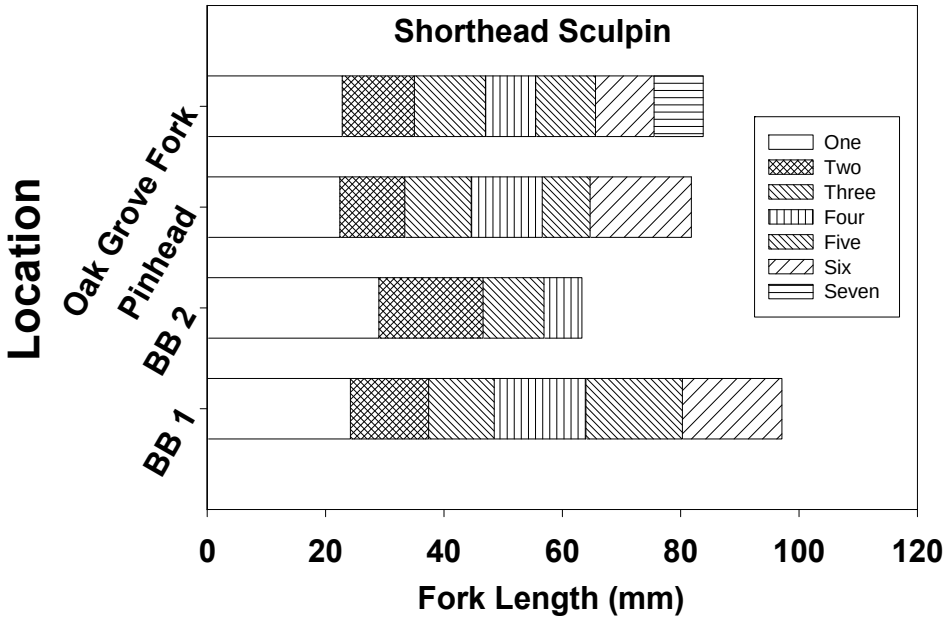

Figure A1. Length at age from modal size distribution measured from spring to spring for shorthead sculpin in tributary habitats in the Clackamas river.

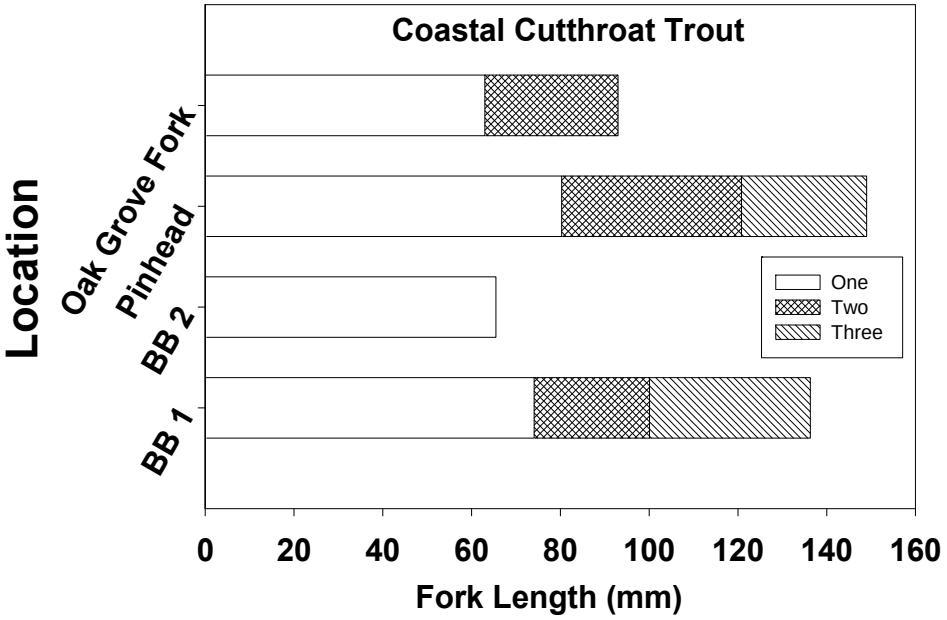

Figure A2. Length (measured) at age (from scales) for coastal cutthroat trout in tributary habitats in the Clackamas river.