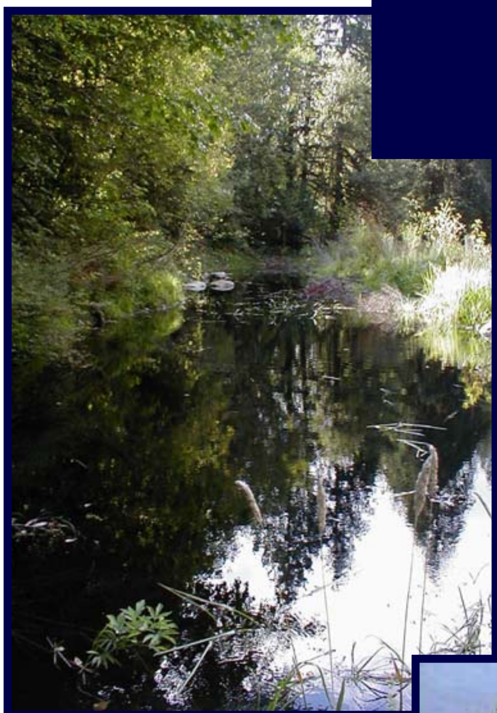
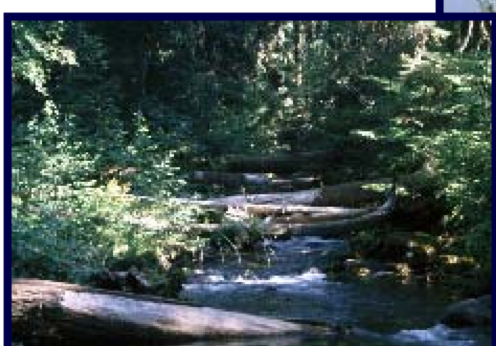
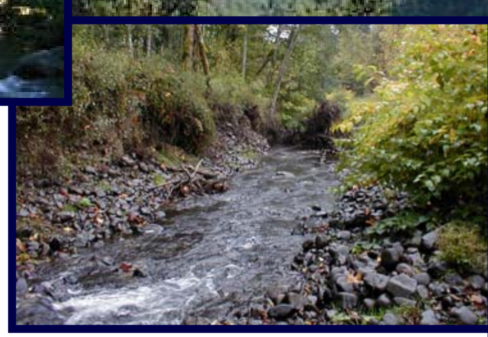
Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan



Restoring Salmon And Steelhead To Healthy, Harvestable Levels

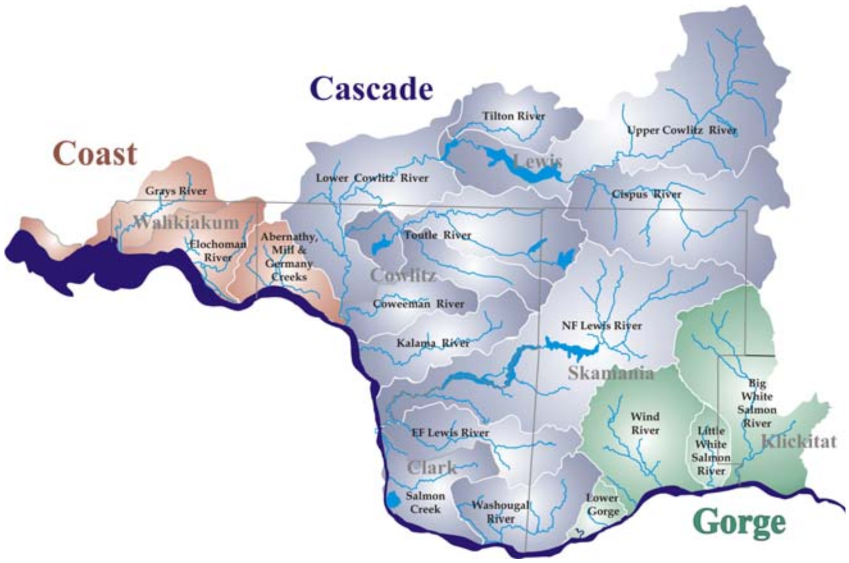


Clark, Cowlitz, Lewis, Skamania And Wahkiakum Counties



PLAN OVERVIEW

Lower Columbia Fish Recovery Board
December 15, 2004



Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan

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PLAN OVERVIEW

Lower Columbia Fish Recovery Board

December 15, 2004

The Lower Columbia Fish Recovery Board unanimously adopts

The Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan

With the understanding that

Implementation of the schedule and actions for local jurisdictions

Depends upon funding and other resources;

APPROVED THIS 10th DAY OF DECEMBER 2004.

Dave Andrew	Betty Sue Morris
John Barnett	Al McKee
Bill Dygert	Jeff Rasmussen
Mark Doumit	Don Swanson
Dennis Hadaller	Randy Sweet
Henry Johnson	Chuck TenPas
Tim Leavitt*	George Trott
Tom Linde	

* Endorsed post rata.

Preface

This is one in a series of volumes that together comprise a Recovery and Subbasin Plan for Washington lower Columbia River salmon and steelhead:

--	Plan Overview	*Synopsis of the planning process and regional and subbasin elements of the plan.*
Vol. I	Regional Plan	*Regional framework for recovery identifying species, limiting factors and threats, the scientific foundation for recovery, biological objectives, strategies, measures, and implementation.*
Vol. II	Subbasin Plans	*Subbasin vision, assessments, and management plan for each of 12 Washington lower Columbia River subbasins consistent with the Regional Plan. These volumes describe implementation of the regional plan at the subbasin level.*
		II.A. Lower Columbia Mainstem and Estuary
		II.B. Estuary Tributaries
		II.C. Grays Subbasin
		II.D. Elochoman Subbasin
		II.E. Cowlitz Subbasin
		II.F. Kalama Subbasin
		II.G. Lewis Subbasin
		II.H. Lower Columbia Tributaries
		II.I. Washougal Subbasin
		II.J. Wind Subbasin
		II.K. Little White Salmon Subbasin
		II.L. Columbia Gorge Tributaries
Appdx. A	Focal Fish Species	*Species overviews and status assessments for lower Columbia River Chinook salmon, coho salmon, chum salmon, steelhead, and bull trout.*
Appdx. B	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning*
Appdx. C	Program Directory	*Descriptions of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning*
Appdx. D	Economic Framework	*Potential costs and economic considerations for recovery and subbasin planning*
Appdx. E	Assessment Methods	*Methods and detailed discussions of assessments completed as part of this planning process*

CONTENTS

VISION

It is the vision of this plan to:

- *Recover Washington lower Columbia salmon, steelhead, and bull trout to healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices; and*
- *Sustain and enhance the health of other native fish and wildlife species in the lower Columbia through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships.*

This is a plan for the protection and restoration of native fish, aquatic habitats, and sensitive wildlife species in Washington lower Columbia River subbasins. It serves as 1) a recovery plan for Washington lower Columbia salmon and steelhead populations and 2) a Northwest Power and Conservation Council Fish and Wildlife Plan for eleven lower Columbia subbasins.

The plan is the product of a collaborative process facilitated by the Lower Columbia Fish Recovery Board (LCFRB) and involving federal and state agencies, tribes, local governments, and the public. It recognizes that recovery of fish and wildlife is a shared responsibility and can only be achieved through the cooperative and combined efforts of federal, tribal, state, and local interests. In order to ensure consistency in goals, strategies and actions and to eliminate needless duplication of effort, the process integrated planning for Federal Endangered Species Act (ESA) recovery, Northwest Power and Conservation Council (NPCC) fish and wildlife program, and Washington State watershed management and salmon recovery.

Recovery of fish and enhancement of wildlife cannot be accomplished by addressing a single threat or limiting factor. It requires a comprehensive approach that addresses the needs of each species throughout the their life history. It must work for fish and wildlife and the people of the region. This plan provides a roadmap for recovery. It melds science and biology with cultural, social, and economic considerations. The plan sets forth a "directional" approach based on objectives, strategies, measures and actions needed to address the full range of threats as they are currently understood. The aim is to reverse long term declining trends and establish a trajectory leading to recovery within 25 years. Since existing information is too uncertain to prescribe the exact course to recovery, progress will be evaluated regularly and, where necessary, the course adjusted.

Implementation of the plan will be achieved through a regional partnership of local, state, federal and tribal interests. The plan is not a regulatory document. It does not obligate any party but does establish specific responsibilities for actions that have been identified as important to fish recovery. It focuses on achieving outcomes and allows implementing agencies and other entities the flexibility to craft innovative, yet scientifically sound, approaches that best fit local conditions and values. Recovery partners will be asked to commit implementation through a six-year implementation schedule.

INTRODUCTION

This plan describes:

- A vision for recovery of salmon, steelhead, and bull trout, and the ecosystems upon which they depend, and for the protection and enhancement of other fish and wildlife species.
- An overview of the planning process.
- A description of fish and wildlife species of interest.
- A summary of the limiting factors and threats to these species.
- An explanation of the scientific foundation for recovery
- Recovery goals consistent with the vision.
- Regional strategies and measures for achieving recovery goals.
- Detailed monitoring and research plans.
- A framework for plan implementation including an institutional structure, adaptive management strategy, and list of actions and responsibilities.
- Detailed assessments of species status, limiting factors, and threats in each subbasin.
- Actions for implementing strategies and measures in each subbasin.
- Descriptions of Federal, state, and local programs that play a role in implementation.
- Extensive documentation of related information on species and assessment methods.

This is a third draft of this plan. It includes revisions incorporated following extensive review and comment by involved and interested parties and the public through an inclusive and transparent planning process.

Plan Organization

Volume I – A Regional Plan describes a comprehensive framework for recovery that considers local and regional contexts and tradeoffs.

Volumes II.A-II.L – A series of Subbasins Plans describe local conditions and detail implementation of the regional plan at the subbasin level.

Appendices A-E – Provide additional detail on focal species, other species, related programs, economic considerations, and assessment methods.

An Integrated Plan

The planning process integrates four interrelated initiatives to produce a single Recovery/Subbasin Plan for the lower Columbia:

- U.S. Endangered Species Act recovery planning for listed salmon, steelhead and trout.
- Northwest Power and Conservation Council (NPCC) subbasin planning for eight full and three partial subbasins which guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90.82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach ensures consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement actions.

Planning Area

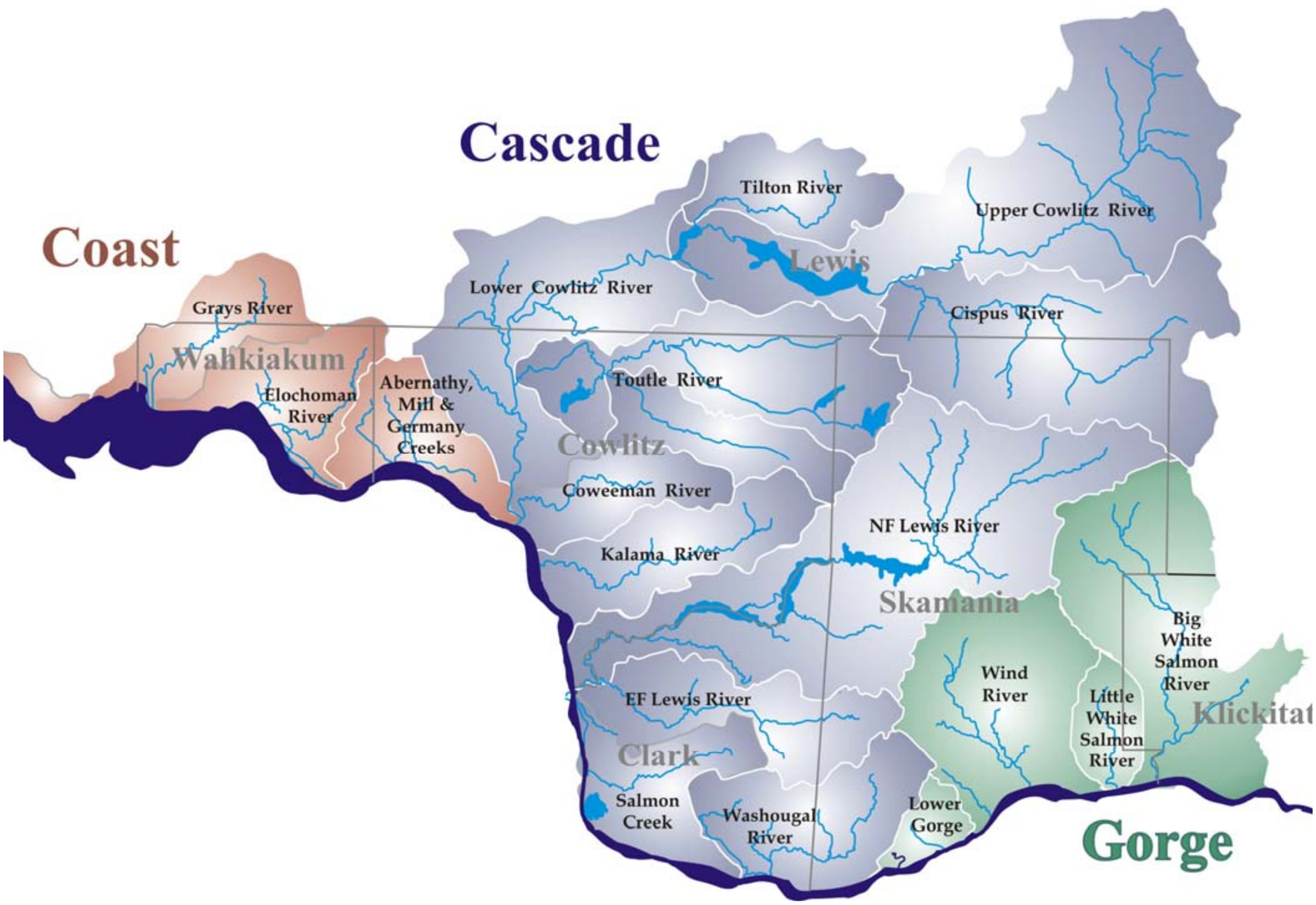
The planning area includes all Washington Columbia River subbasins from the Chinook River near the ocean to and including the Little White Salmon River in the gorge, as well as the Washington portion of the estuary and mainstem up to the Little White Salmon River.

Planning Horizon

The Plan uses a planning period of 25 years. The goal is to fully implement within this time period all actions needed to achieve recovery of salmon, steelhead, and bull trout and the biological objectives for other fish and wildlife species of interest. It is recognized, however, that full realization of habitat conditions and watershed process needed to reach the healthy and harvestable goals of this plan will likely take 75 years or more.

Planning Area Features

- *5,700 square miles*
- *1,700 river and stream miles*
- *Almost half a million people*
- *All of Clark, Cowlitz, Skamania, and Wahkiakum Counties and portions of Lewis and Pacific Counties.*
- *13 cities as well as numerous unincorporated communities.*
- *Lands of interest to Yakama Indian Nation and the Cowlitz and Chinook tribes where reserved fishing and hunting rights are exercised, natural resources are co-managed, and tribal trust lands are inhabited.*



Planning Organization & Participants

The LCFRB led and coordinated the development of the Plan. The Board was established by state statute (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington state agencies, regional organizations, local governments, and members of the public participated in the planning process. Participation was achieved through a steering committee, work groups, watershed planning units, and public meetings, workshops, and comment periods.

Community and Public Participation

The planning process involved a series of work groups and additional opportunities for community and public participation. These included:

- Numerous presentations made to agencies, local governments, groups, and organizations regarding recovery issues and the planning process.
- A 30-day public comment period and a series of workshops on the Plan's Technical Foundation.
- "Scenario Evaluation Team" meetings which brought together agency personnel, citizens, economic interests, timber companies, local government officials, and non-profit organizations to discuss plausible recovery scenarios.
- Four stakeholders workshops to review and comment on regional strategies and measures.
- A 60-day public comment period on the draft plan in conjunction with the NPCC subbasin plan review process.
- A 30-day public comment period and workshops on the second draft of the plan, which was revised based on comments received on the earlier draft.

SPECIES ADDRESSED

The primary focus is on salmon, steelhead and trout species listed or proposed for listing under the ESA. A wide variety of other fish and wildlife species will also benefit from the plan's ecosystem approach to salmonid recovery, and the plan identifies other fish and wildlife species that will be affected by salmon recovery or hydrosystem mitigation actions.

Species addressed by this plan are categorized as follows:

Focal Species – Salmon, steelhead, and trout that are listed or proposed for listing under the ESA received the highest level of attention in this plan.

Other Sensitive Species – Other state or federally-listed threatened or endangered species that may be affected by salmon recovery actions or hydro system construction and operations.

Species of Ecological Interest – Species that are important from a management perspective or are related to the general health of the subbasins in terms of environmental quality or habitat diversity.

Species of Recreational Interest – Non-native species of primarily of recreational interest.

This plan is a primary instrument guiding protection, enhancement, and recovery of focal salmonid species. Other fish and wildlife species that are the subject of other management plans and processes are treated in less detail than focal species.

Chum salmon in spawning colors

Focal Species

Chinook salmon.– Spring, tule Fall, and bright fall runs were included in the Lower Columbia River evolutionarily significant unit (ESU) listed as a threatened species under the ESA on March 24, 1999.

Chum salmon.– The lower Columbia River chum ESU was listed as threatened on March 25, 1999.

Steelhead.– The Lower Columbia steelhead ESU was listed as threatened under the ESA on March 19, 1998. The Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany steelhead populations are in the Southwest Washington ESU and are not listed under the ESA but are addressed by this plan.

Coho.– Lower Columbia coho are proposed for ESA listing as threatened.

Bull Trout.– On June 10, 1998, the United States Fish and Wildlife Service (USFWS) listed bull trout in the Columbia and Klamath river basins as threatened under the ESA. Bull trout are also subject of a draft species recovery plan.

Other Sensitive Species

- Bald Eagle
- Sandhill Crane
- Dusky Canada Goose
- Columbia Whitetail Deer
- Fisher
- Western Gray Squirrel
- Seals & Sea Lions
- Western Pond Turtle
- Oregon Spotted Frog
- Larch Mountain Salamander

Species of Ecological Significance

- Cutthroat Trout
- White Sturgeon
- Green Sturgeon
- Eulachon (Smelt)
- Pacific Lamprey
- Northern Pikeminnow
- American Shad
- Band-tailed Pigeon
- Caspian Tern
- Osprey
- Yellow Warbler
- Red-eyed Vireo
- River Otter

Species of Recreational Significance

- Walleye
- Smallmouth Bass
- Channel Catfish

Caspian tern

LIMITING FACTORS & THREATS

Comprehensive descriptions of limiting factors and threats to focal species identify the reasons for species declines and potential avenues for recovery. All local and out-of-basin limiting factors and threats that might affect species during their life cycle are discussed. The relative magnitudes of manageable impacts are quantified where the data allows.

Definitions

Limiting factors: conditions that directly or indirectly affects a species' numbers, productivity, distribution, or diversity through its influence on reproduction, growth, mortality, or migration.

Threats: specific human activities that affect limiting factors.

Example: stream flow would be a limiting factor and water withdrawal is a threat that affects stream flow.

Implications: threats are potentially manageable while limiting factors may also include things like ocean conditions that cannot be managed.

Stream Habitat

Analysis suggests stream habitat productivity in the region have been degraded by 20-80% relative to "properly functioning" condition benchmarks for salmon, steelhead, and trout. Fish have been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, and floodplain interactions. Corresponding threats include dams and other barriers, water withdrawals, urban and rural development, past forest practices, agriculture practices, mining, channel manipulations, and recreational activities. Detailed assessments of stream habitat conditions watershed conditions, and habitat forming processes may be found in subbasin volumes of the plan.

Estuary and Mainstem Habitat

Estuary and lower Columbia mainstem habitats play an important but poorly understood role in the anadromous fish life cycle. Large-scale changes in river flow, water circulation, sediment transport, and floodplain and wetland destruction or isolation have altered habitat conditions and processes important to migratory and resident fish and wildlife. Hydro flow regulation, channel alternations, and floodplain development and diking have all contributed to these habitat changes. Estuary conditions and influences are described in detail in a subbasin volume of the plan.

Hydropower

Habitat conditions for fish and particularly anadromous fish have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. Lower Columbia salmon, steelhead and trout are threatened by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage; and ecological changes in impoundments. Dams in the Lewis, Cowlitz, and White Salmon subbasins have blocked access by anadromous fishes to large areas of productive habitat.

Merwin Dam on the Lewis River

Harvest

Harvest of lower Columbia salmon and steelhead includes commercial, recreational, and tribal fisheries in the ocean from Alaska to northern California and in the mainstem Columbia and tributaries. Current fishing impact rates on wild salmon populations ranges from 2.5% for chum salmon to 45% for tule fall Chinook. Fisheries do not target weak listed salmon or steelhead populations but listed fish are incidentally caught in fisheries for hatchery and strong wild stocks.

Hatcheries

Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat resulting from the Columbia River hydrosystem and widespread habitat development. Hatcheries provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates.

Ecological Interactions

Ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Limiting factors include interactions with non-native species, effects of salmon on system productivity (e.g. nutrient cycling), and native predators of salmon. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alternation.

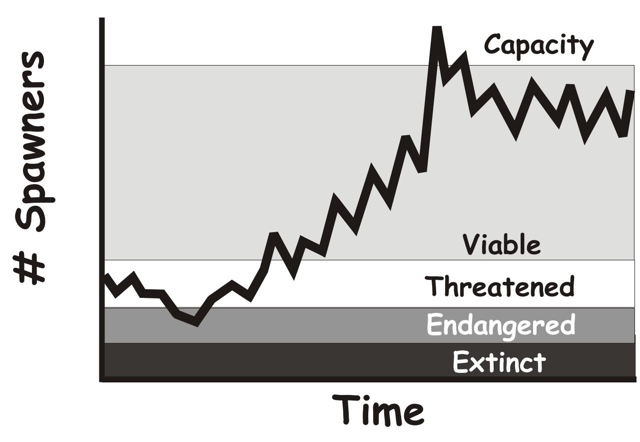
SCIENTIFIC FOUNDATION FOR RECOVERY

A strong scientific foundation is key to defining effective recovery objectives, regional strategies and measures, and subbasin restoration actions.

Understanding Extinction & Recovery

Extinction typically refers to the irreversible disappearance of a species or, in the case of Pacific salmon, an Evolutionarily Significant Unit (ESU). Salmon ESU's are comprised of a series of unique populations that return to different areas of the ESU. Extinction results from the interaction of fish biology and external factors that reduce population size to critical low levels that are no longer self-sustaining over time.

The federal ESA qualifies extinction risks at two levels: endangered with extinction and threatened with becoming endangered. ESA delisting can occur at a point when listed species and their ecosystems are restored and their continued existence is assured to the point that protections under the ESA are no longer needed. Decisions to delist are based on the species' biological status (biological de-listing criteria) and on the status of the threats to the species (threats criteria). ESA delisting does not require restoration of pristine system.



Considering Biological & Social Values

This plan addresses biological recovery for salmon and steelhead populations and ESUs as well as goals related to direct and indirect uses of fish, water, and land resources. Considerations of both biological and social values are implicit in any definition of recovery goals.

Characteristics of Healthy Species

Underlying biological characteristics are the ultimate determinants of population and ESU health. This plan incorporates NOAA Fisheries' Viable Salmonid Population (VSP) framework as a basis for biological status assessments and recovery objectives. The plan also incorporates the work of the Willamette/Lower Columbia Technical Recovery Team (TRT), which was convened by NOAA Fisheries to make recommendations on biological criteria for population and ESU-level viability. These criteria set forth the conditions needed to achieve a high probability of persistence into the future.

Naturally-produced Fish Spawning Naturally

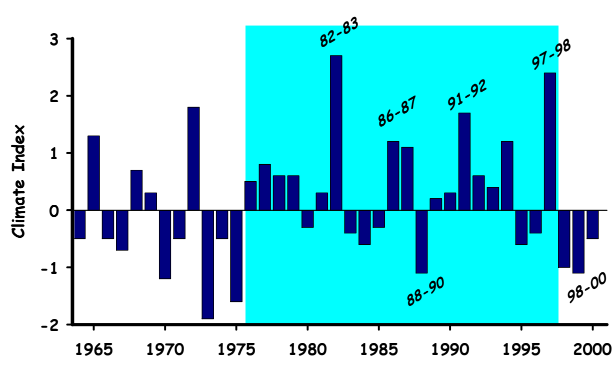
Recovery ultimately depends on naturally-produced fish spawning naturally. Populations maintained through a continuing influx of hatchery fish are not sustainable if they are likely to become extinct whenever the hatchery subsidy is removed. Hatcheries potentially represent a critical tool for preservation, reintroduction, and supplementation over the short term. In fact remnants of many lower Columbia River salmon populations currently exist only in hatcheries. However, no hatchery has demonstrated the capability of preserving the historical natural diversity and behavior necessary to preserve a species over many generations. This plan recognizes that current conditions and constraints on habitat restoration in some areas will require recovery using a combination of natural only and natural/hatchery populations. Hatcheries will continue to serve both production and fisheries enhancement purposes for the foreseeable future.

In-basin and Out-of-basin Influences

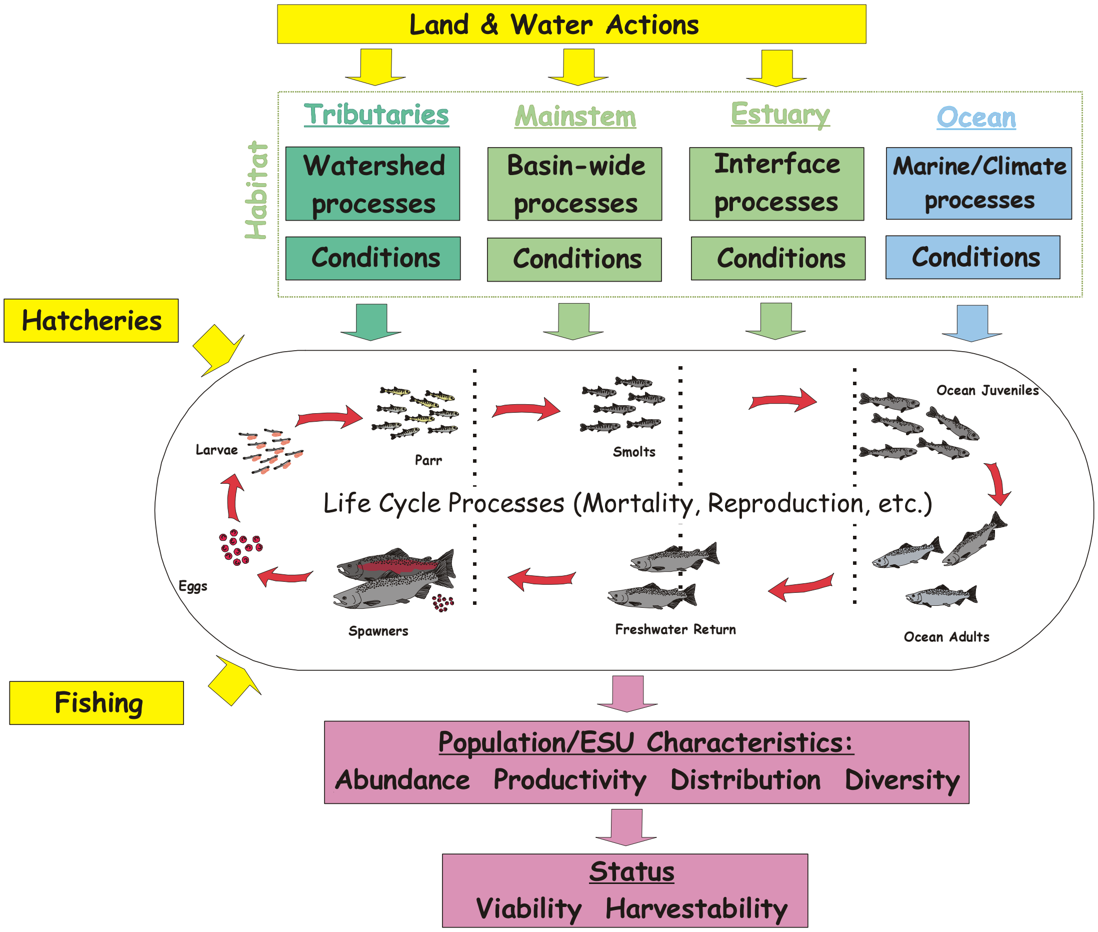
Effective recovery planning must consider in-basin and out-of-basin influences that affect salmon throughout their life cycle. A fish life cycle focus provides a systematic means of relating fish-specific recovery goals to limiting factors, threats, and recovery measures. A life cycle focus identifies life stage-specific numbers, birth rates, and death rates that account for the biological processes regulating fish population health. Life stage-specific population numbers and productivity (growth) rates provide a consistent way to estimate effects of each threat category. A life cycle approach incorporates all biological characteristics related to viability and also provides a means of considering wild and hatchery fish separately.

Ocean and Climate Variability

Recovery actions must be considered in light of the significant effects that variation in ocean conditions has on salmon survival. Periodic poor ocean cycles can significantly increase the extinction risk for a population compromised by human impacts. Recent large salmon runs suggest that we may have entered at least a short period of better-than-average ocean survival conditions. Rather than reducing the need for salmon recovery, this pattern provides an opportunity to implement substantive recovery actions needed to help a population withstand the next cycle of poor ocean conditions.



Ocean Conditions over Time



Linking Actions to Limiting Factors & Threats

Recovery actions need to be linked to the limiting factors and threats that affect each species. Factors and threats include a wide spectrum of human-induced mortality factors that affect fish throughout their life cycles. The plan weighs all the human-induced effects on mortality at the various life stages, identifies how mortality can be reduced overall, and determines how the distribution of mortality may be changed among life stages to achieve biological recovery and other social goals.

Science: Guidance with limitations

Expectations of recovery planning must be tempered by our imperfect understanding of the complex interaction of fish, limiting factors, and human activities. This plan recommends actions from fish managers, agency administrators, tribal leaders, elected officials, and the public based on the best available science. This scientific base provides a clear direction but does not resolve every uncertainty. However, to delay all action until more studies and research can be completed risks further deterioration of the species and ecosystems upon which they depend.

Dealing with Uncertainty

Incomplete human understanding of biological systems, and of the effects of human activities and management practices on those systems, results in uncertainty about the outcomes of the actions identified in the plan. The plan recognizes and accommodates uncertainty by explicitly identifying assumptions and working hypotheses, incorporating safety factors into recovery scenarios and population objectives, and identifying a strong monitoring, research, and evaluation program that provides the means for adjusting recovery actions when necessary.

RECOVERY GOALS

Biological objectives 1) describe changes needed to achieve the visions and goals of this plan, 2) provide guidance in designing strategies and measures, 3) establish the basis for measurable progress benchmarks, and 4) consider relationships between focal fish species and other fish and wildlife species of interest.

Recovery Criteria

The biological goals for salmon and steelhead in this plan are based on and explicitly incorporate the work of the Willamette/Lower Columbia TRT convened by NOAA Fisheries. TRT's recommendations address a hierarchy of ESU, strata, and population standards.

Essential Recovery Elements*

Stratified Approach.– Every life history (spring run, fall run, etc.) and ecological zone (Coast, Cascade, Gorge) stratum that historically existed should have a high probability of persistence.

Viable Populations.– Strata populations must average a medium-high persistence probability and with at least two populations at a negligible risk of extinction.

Representative populations.– Not every historical population needs to be restored, but selected populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.

Non-deterioration.– No population should be allowed to deteriorate until ESU recovery is assured. Currently-productive populations must be preserved. Recovery measures will be needed in most areas to arrest declining status and offset the effects of future impacts.

Safety factors.– Recovery efforts must target more than the minimum number of populations and more than the minimum population levels to ensure viability because not all attempts will be successful.

**Based on TRT recommendations*

Recovery Scenario

The recovery scenario identifies a combination of populations and population status levels that meet TRT recovery criteria for a viable ESU. The scenario represents one of many possible combinations that could meet the TRT's ESU- and strata-level viability criteria.

The preferred scenario was developed through a collaborative process with stakeholders based on biological considerations, expected progress as a result of existing programs, the absence of apparent impediments, and the existence of other management opportunities. Assumptions were made, in coordination with Oregon, regarding recovery potential for Oregon populations within lower Columbia salmon and steelhead ESUs to help ensure that the goals and actions in this plan were consistent with ESU recovery.

Scenario designations include:

Primary populations: Restored to high or greater viability.

Contributing populations: some level improvement will be needed to achieve a strat-wide average of medium viability.

Stabilizing populations: protected from further deterioration and maintained a current levels.

Population persistence categories identified by the Technical Recovery Team

Scale	Viability	Description	Persistence probability[1]
0	Very low	Either extinct or very high risk of extinction	0-40%
1	Low	Relatively high risk of extinction	40-74%
2	Medium	Medium risk of extinction	75-94%
3	High	Low (negligible) risk of extinction	95-99%
4	Very High	Very low risk of extinction	>99%

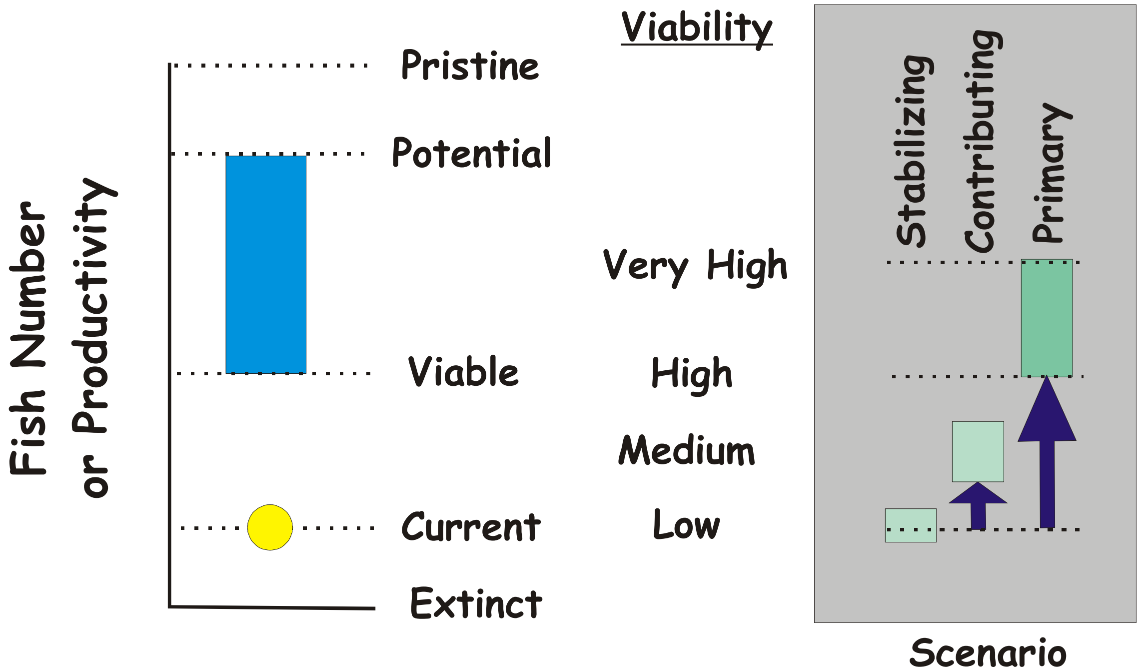
[1]*100-years.*

The scenario in this plan is consistent with the TRT's guidelines. It will achieve at least a medium average viability for each stratum (see above table). At least two Washington populations are targeted for improvement to high or very high levels of viability in every strata except for the Gorge. Recovery prospect in the Gorge are highly uncertain because of constraints imposed by Bonneville Dam. More than the minimum numbers of populations and improvement increments consistent with viability have been incorporated into the scenario to compensate for recovery uncertainties in the Gorge and to provide safety factors should not all attempts prove successful.

A key implication of the TRT's recommendations is that not every population needs to be restored to high levels to recover an ESU. The criteria allow efforts to be concentrated in subbasins where multiple species benefits and moderate to high quality habitat provide good prospects for cost effective results. Substantial improvements are not required in some severely degraded subbasins, although criteria require additional protection and restoration efforts to prevent further declines.

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
COAST	Grays/Chinook	**P**	--	--	**P***	**P**	--	**P**
	Elochoman/Skamokawa	**P**	--	--	**P**	**C**	--	**P**
	Mill/Abernathy/Germany	**C**	--	--	**P**	**P**	--	**C**
	Youngs Bay (OR)	**S**	--	--	**P**	**na**	--	**S**
	Big Creek (OR)	**S**	--	--	**C**	**na**	--	**P**
	Clatskanie (OR)	**P**	--	--	**C**	**na**	--	**S**
	Scappoose (OR)	**S**	--	--	**C**	**na**	--	**P**
CASCADE	Lower Cowlitz	**C**	--	--	**C**	**C**	--	**P**
	Upper Cowlitz	**S**	--	**P***	--	**C**	--	**C**
	Cispus	--	--	**P***	--	**C**	--	**C**
	Tilton	--	--	**S**	--	**C**	--	**C**
	SF Toutle	**X**	--	**C**	**X**	**P***	--	**P**
	NF Toutle	**S**	--	**X**	**X**	**P**	--	**P**
	Coweeman	**P***	--	--	**X**	**P**	--	**P**
	Kalama	**P**	--	**P**	**C**	**P***	**P**	**C**
	Lewis (NF)	**X**	**P***	**P**	**X**	**C**	**S**	**C**
	EF Lewis	**P***	--	--	**P**	**P**	**P**	**P**
	Salmon	**X**	--	--	**S**	**S**	--	**S**
	Washougal	**P**	--	--	**P***	**C**	**P***	**C**
	Sandy (OR)	**S**	**P**	**P**	**P**	**P**	--	**P***
	Clackamas (OR)	**C**	--	--	**C**	**P**	--	**P***
GORGE	Lower Gorge	**C**	--	--	**P***	**P**	--	**P**
	Upper Gorge	**S**	--	--	**C**	**S**	**P***	**P**
	White Salmon	**C**	--	**C**	--	--	--	**C**
	Hood (OR)	**S**	--	**P**	--	**P**	**P**	**C**

*P: Primary, C: Contributing, S: stabilizing, X: subset of larger population, *: high+ viability, '--': not present.*



Salmon and Steelhead Population Objectives

Abundance.– Population recovery objectives describe the numbers of fish necessary to reach stabilizing, contributing, or primary population levels. This plan identifies specific numerical objectives consistent with TRT criteria for population abundance based on population and habitat modeling.

Productivity.– Productivity is defined as the inherent population replacement rate and is typically expressed as a median rate of population increase or a spawner recruit per spawner replacement rate. Productivity or population growth rate objectives are described in terms of relative improvement increments.

Improvement increments identify the order of magnitude of improvements needed in each population to reach recovery goals. The magnitude of improvements provides the basis for the design of recovery strategies, measures, and actions.

Analyses highlight the need for substantial improvements in productivity for almost all populations in order to reach recovery goals. Net improvement increments for fall Chinook ranged from 0% for stabilizing populations to 200% for at least one population targeted for very high viability. Net productivity improvements for fall Chinook populations targeted for high viability averaged 30%. Improvement increments were not defined for spring Chinook because access has been eliminated to all historical habitat or because data were inadequate to quantify current populations trends. Net productivity increments to reach high viability were 30-1000% for chum and 10-80% for steelhead. Data were insufficient for comparable estimates for coho but it can be assumed that improvement increments are similar to or greater than those of steelhead.

Human Impacts and Threats. – This plan also identifies objectives for reducing human impacts and threats that constrain population viability. These incremental improvements are identified as starting points to indicate the general level of effort that will be required from each sector to achieve recovery. Impact reduction objectives describe changes in potentially manageable factors consistent with abundance and productivity objectives. Changes are referenced to a baseline period corresponding to species listing dates.

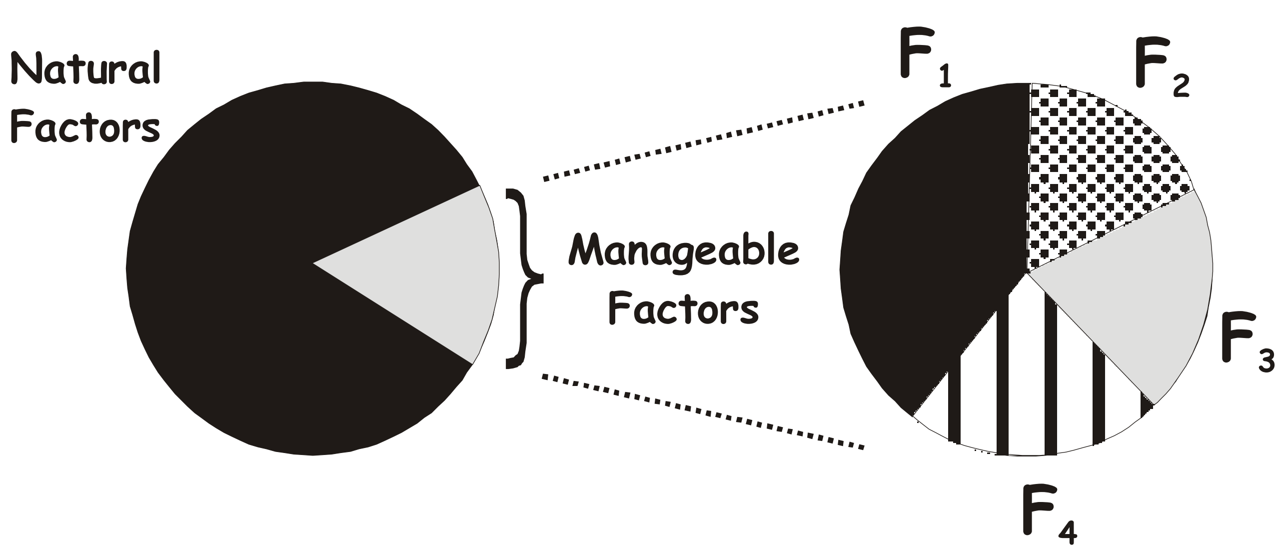
Impacts are estimates of the proportional reduction in population productivity associated with human-caused and other potentially manageable impacts including stream habitats, estuary/mainstem habitats, hydropower, harvest, hatcheries, and selected predators. Incremental improvements needed in each impact factor were estimated from the net productivity improvement needed to reach the population goal, the net effect of human and other potentially manageable impacts, and the distribution of impacts among the factors.

Impact estimates are based on a simple salmon life cycle modeling approach (Adult Equivalent Impacts Occurring Unconditionally or 'AEIOU') developed by the LCFRB for this plan. This approach has also been used in this plan to illustrate the relative significance of each factor with a series of pie diagrams.

Recovery strategies, measures, and actions detailed elsewhere in this plan address both quantifiable and unquantifiable threats. Specific threat criteria are not explicitly identified in this plan but the plan does incorporate substantive strategies and measures to reduce threats in every category.

Other Population Parameters. – The WLC-TRT developed guidelines based on population parameters including abundance, productivity, spatial structure, diversity, juvenile numbers, and habitat. This plan addresses all TRT parameters for ESU and strata. It identifies specific quantitative abundance and productivity objectives for each listed population. Specific population objectives were not identified for VSP parameters other than abundance and productivity because many different combinations of specific parameters can be expected to achieve the overarching population objectives. Benchmark values are identified for other VSP parameters to provide a systematic basis for their consideration during plan implementation and evaluation. All VSP parameters will be evaluated in future assessments of population status using the TRT's scoring system.

Harvestable Populations. – Initial efforts to stabilize and rebuild natural populations warrant fishery limitations with rates consistent with restoration of salmon and steelhead populations. As natural productivity is restored, it is anticipated that more fishery opportunities will be restored at sustainable levels. This plan includes long-term objectives for harvestable natural populations.



Bull Trout Objectives

Bull trout are subject of a draft recovery plan, although the USFWS recently decided to delay finishing the recovery plan in lieu of a 5-year review of the bull trout listing. Of the subbasins addressed by this plan, bull trout currently occur only in the upper Lewis River and possibly the White Salmon River.

This plan integrates regional goals and objectives identified in the draft Bull Trout Recovery Plan into subbasin-specific actions.

The overarching goal of the draft bull trout recovery plan is to ensure the long-term persistence of self-sustaining, complex interacting groups (or multiple local populations that may have overlapping spawning and rearing areas) of bull trout distributed across the species' native range. Specific objectives include:

1. Maintain current distribution within core areas and restore distribution in additional areas,
2. Maintain stable or increasing trends in abundance,
3. Restore and maintain suitable habitat conditions for all life history stages and strategies, and
4. Conserve genetic diversity and provide opportunity for genetic exchange.

Spawning Bull Trout

Other Sensitive Species

Objectives for other fish and wildlife species are generally based on other management plans and processes, and are included here for information purposes relative to the primary focus of this plan on salmonids.

Bald Eagle **–** Increase the viability of the bald eagle breeding population in the lower Columbia River, particularly through increased reproductive success.

Sandhill Crane **–** Support and maintain the wintering population of sandhill cranes in the lower Columbia River, while limiting crop depredation.

Dusky Canada Goose **–** Reverse the declining abundance trend and maintain a wintering population in the lower Columbia River, while limiting crop depredation.

Columbian White-tailed Deer **–** Increase productivity and abundance, thereby creating a stable, viable population.

Fisher **–** Minimize risks to populations in the process of becoming established while increasing quantity and quality of habitat and minimizing incidental mortality.

Western Gray Squirrel **–** Increase quantity and quality of habitat and reduce effects of nonnative species.

Seals and Sea Lions **–** Maintain current seasonal population abundance while limiting predation risks to adult salmonids.

Western Pond Turtle **–** Reverse the declining abundance trend in Washington and to re-establish in the Puget Sound and Columbia Gorge regions at least 5 self-sustaining populations of greater than 200 turtles composed of no more than 70% adults.

Oregon Spotted Frog **–** Increase quantity and quality of habitat and reduce effects of nonnative species.

Larch Mountain Salamander **–** Increase quantity and quality of habitat and minimize use of key habitats.

Eulachon (smelt)

Species of Ecological Significance

Coastal Cutthroat Trout – Reverse declining abundance trends and maintain life history diversity (resident, fluvial, and anadromous forms).

White Sturgeon **–** Continue management for a viable population that will maintain sufficient abundance to meet the continued cultural, economic, and ecological needs.

Green Sturgeon **–** Continue management for a viable population that will maintain sufficient abundance to meet the continued cultural, economic, and ecological needs.

Eulachon (Smelt) – Maintain or increase annual population abundance to continue to provide forage value for other species and harvest opportunities for commercial and recreational fisheries.

Pacific Lamprey – Reverse the decreasing abundance trend and manage for populations that can meet cultural and ecological needs.

Northern Pikeminnow – Decrease predation on juvenile salmonids by reducing the number of larger, predaceous pikeminnow in the population, while also maintaining pikeminnow population viability.

American Shad – Decrease abundance but maintain a viable population (range from 0.7 to 1.0 million, well below the recent record run sizes) while avoiding adverse impacts on other species, particularly the recovery of salmon and steelhead.

Band-tailed Pigeon – Increase quantity and quality of habitat.

Caspian Tern – Maintain population viability region-wide and decrease the population's vulnerability to catastrophic events while also managing predation on salmon.

Osprey – Increase the viability of the osprey breeding population in the lower Columbia River, particularly through increased reproductive success.

Yellow Warbler – Protect critical preferred habitat including riparian zones characterized by a dense deciduous shrub layer (1.5-4 m) with edge and small patch size (heterogeneity).

Red-eyed Vireo – Protect critical preferred habitat including riparian gallery forest with tall, closed canopy forests of deciduous trees (cottonwood, maple, or alder and ash), with a deciduous understory, forest stand sizes larger than 50 acres, and riparian corridor widths greater than 50 m.

River Otter – Maintain current population abundance.

Species of Recreational Significance

Walleye – Adaptively manage the population to maintain or reduce current abundance levels while minimizing adverse impacts on salmon, steelhead, and other native fishes.

Smallmouth Bass – Adaptively manage the population to maintain or reduce current abundance levels while minimizing adverse impacts on salmon, steelhead, and other native fishes.

Channel Catfish – Adaptively manage the population to limit adverse impacts on salmon, steelhead, and other native fishes.

American Shad

REGIONAL STRATEGIES & MEASURES

The regional recovery strategies involve substantive reductions in every threat category (stream habitats, estuary and mainstem habitats, hydropower, harvest, hatcheries, and ecological interactions). Strategies are based on underlying working hypotheses that describe assumptions, conclusions, or testable hypotheses. Explanations are included for each element to clarify the scientific basis, strength of rationale, and relationship to current practice.

Measures are more specific means by which strategies will be accomplished. The plan initially assumes that recovery will require substantive measures to address every significant threat due to uncertainty in the degree of benefit that will accrue from any given measure.

An even finer definition of recovery requirements is represented by actions that are described in the implementation chapter and subbasin volumes of the plan. Strategies, measures, and actions describe increasingly-specific activities for achieving recovery. Measures are generally described at the level of the desired physical or biological effects (e.g. protect and restore riparian habitat). Actions are generally described at the implementing organization and program level, and are related back to the desired biological or physical effect (e.g. Washington Department of Natural Resources will implement forest practices rules on private timber lands to protect riparian areas). Specific measures might address several strategies and specific actions might address several measures.

Strategies, measures, and actions included in the plan were identified based on species, and subbasin recovery goals. Additional measures and actions may affect fish but until additional information demonstrates otherwise, all measures and actions identified in the plan are assumed to be necessary to achieve recovery objectives. Priorities will evolve over time based on new information, progress in implementation, and adaptive management.

Integrated Regional Strategy

Working hypotheses emphasize that:

- It is feasible to recover Washington lower Columbia natural salmon and steelhead to healthy and harvestable levels.
- Substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required.
- Recovery cannot be achieved based solely on improvements for any one limiting factor or threat.
- Existing programs are insufficient to reach recovery goals,.
- Actions needed for salmon recovery will have broader ecosystem benefits for all fish and wildlife species of interest.
- Strategies and measures likely to contribute to recovery can be identified but estimates of the incremental improvements resulting from each specific action are uncertain.

Integrated Strategies include:

- Recognize the importance of implementing strategies and measures that address each limiting factor and threat category.
- Prescribe improvements in each factor/threat category in proportion to its magnitude of contribution to salmon declines.
- Identify an appropriate balance of strategies and measures that address regional, upstream, and downstream threats.
- Scale a suite of factor-specific recovery strategies and measures to meet biological objectives while also recognizing large uncertainty in the incremental contributions of individual actions.
- Focus near term actions on species at risk of extinction while also ensuring a long term balance with other species and the ecosystem.

Stream Habitats

Habitat strategies, measures, and actions were based on an extensive review of the available habitat information and analyses as well as new analysis of stream conditions, watershed conditions, and habitat forming processes. Modeling tools were applied to identify reach scale issues that need to be addressed and provide a prioritization scheme that is linked to the input data and to expectations of the actions proposed.

Working hypotheses include, but are not limited to such considerations as:

- Healthy, harvestable salmon populations depend on favorable stream habitats for migration, spawning, and rearing.
- Current stream habitat is much less favorable than necessary to support healthy natural salmon and steelhead populations.
- Substantial changes are needed to support recovery.
- Recovery can be achieved without restoration of pristine conditions and without restoration of optimum habitat in every subbasin.
- Some level of increased habitat protection and restoration will be required in every subbasin to arrest declining trends and restore populations.

Strategies include:

- Restoration of harvestable salmon and steelhead through better habitat access, protection, and restoration.
- Strong protection of habitats that currently support significant fish production for priority fish populations.
- Address both instream habitat conditions that limit fish and watershed stream habitat-forming processes that shape, create, or maintain habitat in any given location.

Numerous ***measures*** for protecting and restoring stream habitats are listed in the Management Plan under the broad topics of:

- Critical preservation areas
- Habitat protection & land-use planning
- Instream flows
- Habitat connectivity
- Forest land management
- Channel restoration
- Riparian and floodplain restoration
- Watershed process restoration
- Wetlands restoration
- Recreation management.

Habitat measures are relatively specific. For example, recommendations under the topic of land-use planning include:

- Discourage land-use conversion to more detrimental uses (e.g. forestry to crop land, crop land to residential).
- Establish urban growth boundaries based on resource protection criteria.
- Prevent increased watershed imperviousness.

Estuary and Lower River Habitat

The estuary and lower Columbia river play a critical role in the life cycles of all Columbia Basin salmon and steelhead. This plan addresses both historic and current factors limiting salmon and steelhead. Actions are linked to threats at a general level consistent with our current knowledge and analytical tools. Hypotheses, strategies, and measures are consistent with the Bi-State Estuary/Lower Mainstem Subbasin Plan and to the Lower Columbia River Estuary Partnership Comprehensive Conservation and Management Plan.

Some of the ***working hypotheses*** for estuary and lower river habitat include concepts such as:

- Complex and dynamic interactions between physical river and oceanographic processes, along with climate and human activities, affect fish and wildlife habitat in the estuary and lower mainstem.

- Human activities have altered how the natural processes interact, changing estuary and lower mainstem habitat conditions.
- Current understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in recovery and sustainability of natural resources.

To address these and other issues, planners have identified eight broad ***strategies*** for the lower river and estuary such as:

- Avoiding large scale habitat changes where risks to salmon and steelhead are uncertain.
- Protecting functioning habitats while also restoring impaired habitats to properly functioning conditions.
- Striving to understand, protect, and restore habitat-forming processes in the estuary and lower mainstem.

Recommended ***measures*** include:

- Restoring tidal swamp and marsh habitat in the estuary and tidal freshwaters.
- Restoring connectedness between river and floodplain.
- Limiting the effects of toxic contaminants on salmon and steelhead and wildlife fitness and survival in the estuary, lower mainstem, and nearshore ocean.
- Mitigating channel dredge activities in the estuary and lower mainstem.
- Improving knowledge of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem.

Hydropower

Near-term and long-term strategies and measures are identified to ensure that hydroelectric facilities and operations in subbasins and the mainstem Columbia River support recovery of naturally-spawning lower Columbia River fish.

Examples of ***working hypotheses*** include:

- Tributary hydropower development and operation has blocked access to large areas of historically productive habitat in some subbasins and affected habitat conditions and suitability downstream.
- Bonneville Dam affects migration and passage of juvenile and adult salmon and inhibits recovery.
- Construction and operation of the Columbia River hydropower system has contributed to changes in estuary and lower mainstem habitat and habitat forming processes that inhibits salmon and steelhead population resilience and recovery.

Corresponding ***strategies*** include:

- Restoring access of key populations to blocked habitats in historically accessible portions of subbasins.
- Assuring that the Columbia River hydropower system is managed to contribute to recovery of lower river as well as upstream populations.

Specific ***measures*** identified to reduce the effects of hydropower operations on salmon and steelhead recovery include:

- Implement anadromous fish reintroduction upstream of Cowlitz and Lewis hydroelectric projects as part of relicensing processes or requirements. Improve and operate effective juvenile and adult passage facilities at Bonneville Dam.
- Maintain adequate flows in Bonneville Dam tailrace and downstream habitats during salmon incubation and migration periods.
- Establish an annual Columbia River water budget that simulates peak seasonal discharge, increases flow variability during salmonid emigrations, and restores estuarine tidal channel complexity.

Harvest

Strategies, measures, and actions focus on two areas. The first is to limit harvest impacts on recovery efforts and to ultimately restore naturally-spawning fish populations to harvestable levels. The second is to preserve fishery opportunities focusing on hatchery fish and strong wild stocks in a manner that does not adversely affect recovery efforts. Measures are included to integrate consideration of recovery goals into Pacific Salmon Treaty, Pacific Fishery Management Council, and US v. Oregon processes and to improve marking programs and monitoring of fishery catch.

Working hypotheses help to set the stage for identifying strategies and measures. Examples include:

- Historic fishing rates, in conjunction with other factors, posed significant risks to the continued existence of many naturally spawning populations and were not sustainable.
- Recent changes in fishery management have substantially reduced harvest risks to naturally spawning populations.
- Additional fishery management opportunities exist for reducing population risks for some species, such as fall Chinook, but are limited for others, such as chum and steelhead.

Corresponding ***strategies*** include:

- Assure fishery impacts to lower Columbia naturally spawning populations are managed to contribute to recovery.
- Preserve fishery opportunity focused on hatchery fish and strong naturally spawning stocks in a manner that does not adversely affect recovery.

Harvest ***measures*** include:

- Fishery Management and Evaluation Plans for lower Columbia ESUs will be revised as needed to support recovery goals and priorities.
- Research and employ best available technology to reduce incidental mortality of non-target naturally-spawning fish in selective fisheries.
- Conduct periodic review of harvest and escapement relative to habitat productivity and capacity to assure harvest is properly managed for recovery.
- Improve tools to monitor and evaluate fishery catch to assure impacts to natural populations are maintained within agreed limits.

Hatcheries

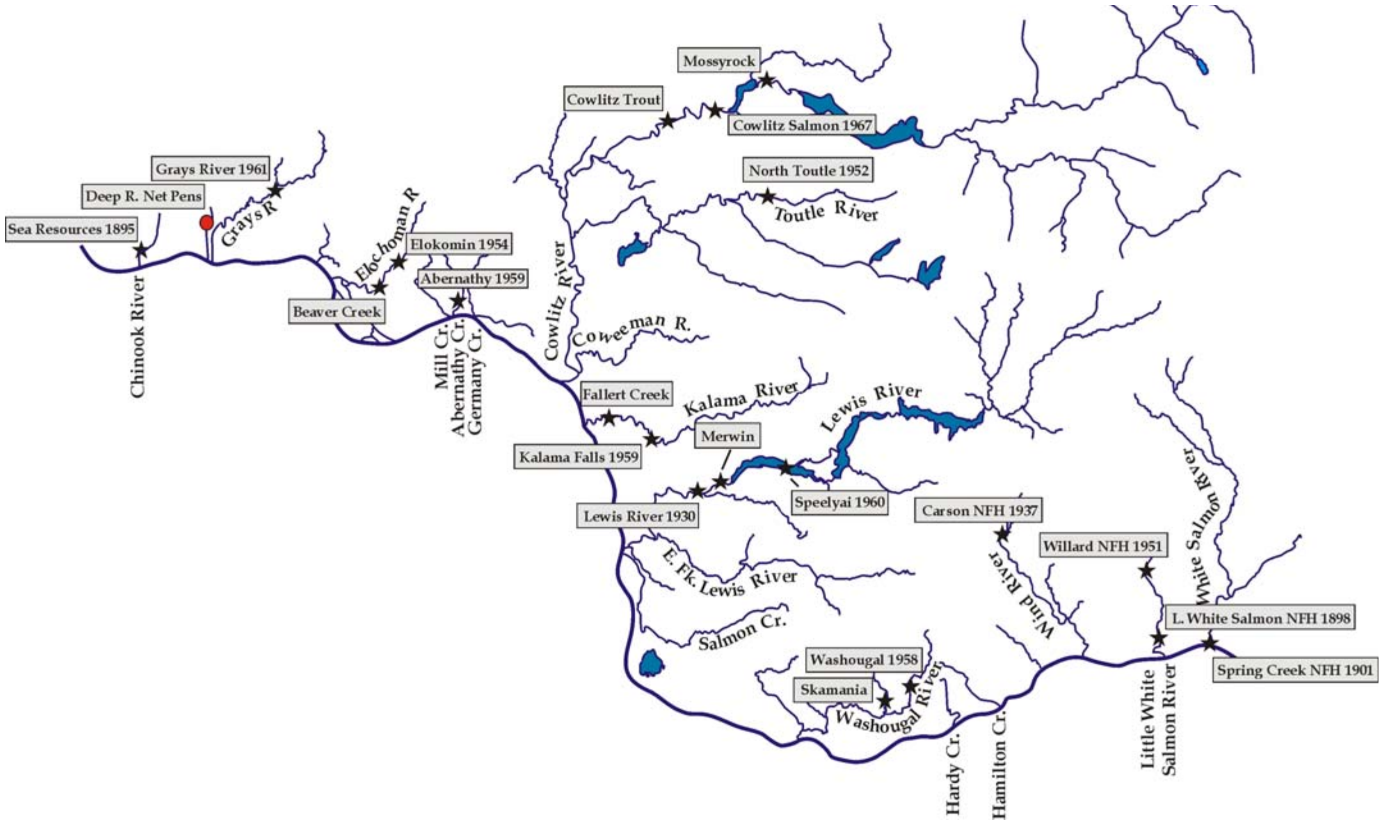
The hatchery strategy describes near-term and long-term strategies and measures to ensure that hatcheries support recovery of naturally-spawning fish. Some subbasins will be free of hatchery influence and hatchery programs. In other subbasins hatchery programs will serve specific conservation and harvest purposes consistent with goals for naturally-spawning populations. This mosaic of programs is designed to ensure that overall each ESU will be naturally self-sustaining.

Nine ***working hypotheses*** were developed that address the effects of hatcheries on natural salmonid populations. For example:

- Additional reductions in hatchery impacts are needed for recovery of natural populations.
- Changes in hatchery operations have and will continue to contribute to reduced risks to naturally spawning populations.
- Conservation hatchery programs can contribute to recovery through the preservation, reintroduction, and supplementation of natural populations.
- Hatcheries can provide harvest opportunities consistent with measures to maintain healthy harvestable naturally spawning populations.

Hatchery ***strategies*** include:

- Expanding hatchery reintroduction and supplementation to help recover natural populations when and where appropriate.



Major Lower Columbia region salmon and trout hatchery facilities

- Reconfiguring production-based hatchery programs to minimize impacts on natural populations and complement recovery objectives.

Hatchery ***measures*** include:

- Promote region-wide recovery by using hatcheries as tools for supplementation and reintroduction in appropriate watersheds.
- Operate hatcheries with appropriate risk containment measures for: 1) hatchery-origin adults returning to natural spawning areas, 2) release of hatchery juveniles, 3) handling of natural-origin adults at hatchery facilities, 4) water quality and effective disease control, and 5) mixed stock fisheries.
- Mark hatchery-produced fish to assure they are identifiable for harvest management and escapement accounting.
- Adaptively manage hatcheries to respond to future knowledge, enhance natural production, and improve operational efficiencies.
- Use appropriate broodstock in hatchery programs.

Ecological Interactions

Ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Strategies and measures are identified to address non-native species, effects of salmon on ecosystem productivity, and native predators of salmon.

Ecological interaction ***working hypotheses*** recognize that:

- Non-native, invasive, and exotic species often reduce or displace native species, particularly in human-altered habitats.
- Salmon are but one element in a complex ecosystem, have been a significant source of nutrients in freshwater systems, and are both predator and prey.

- Human-induced habitat changes have substantially exacerbated predation in the lower Columbia River mainstem and estuary.

Three region-wide ***strategies*** have been identified to address ecological interactions:

- Aggressive measures should be taken to avoid introductions of new species and to reduce the potential adverse effects of existing non-native species.
- The significance of salmon to the productivity of other species and the salmon themselves should be recognized.
- Manage predation by selected species while also maintaining a balance of predator populations.

Ten specific ***measures*** for ecological interactions have been developed. Several of these are:

- Implement regulatory, control, and education measures to prevent additional invasions.
- Take proactive steps to control or reduce the impacts of introduced, invasive, or exotic species.
- Manage established populations of introduced gamefish to limit or reduce significant predation or competition risks to salmon, and to optimize fishery benefits within these constraints.
- Consider ecological functions of salmon, including nutrients they deliver to watersheds, in setting escapement goals.

Other Fish and Wildlife Species

Many of the fish and wildlife species addressed in this plan are currently experiencing stable or increasing population trends; despite their current status, implementing an ecosystem-based approach to the recovery of ESA-listed species warrants evaluation of the effects of recovery actions on other fish and wildlife species. The strategies and measures suggested within this management plan have been formulated to minimize conflict among species-specific strategies and measures.

Other fish and wildlife species addressed in this plan are limited by many of the same factors as those identified for salmonids. Thus, it follows that many of the hypotheses, strategies, and measures developed for salmonids also apply to the other fish and wildlife species. In particular, regional strategies and measures for subbasin habitat, estuary and mainstem habitat, hydropower operation, and ecological interactions are most pertinent to the other fish and wildlife species.

MONITORING & RESEARCH

The plan identifies specific monitoring and research measures as well as working hypotheses, strategies, and explanations underlying those measures. Monitoring and evaluation will be integral to the successful implementation of this plan in the face of significant scientific uncertainty regarding the precise benefits that will result from any specific action.

Monitoring and research elements of this plan were adapted from and are consistent with other regional strategies and plans developed by the NPCC Independent Scientific Advisory Board, Washington Salmon Recovery Funding Board, Federal Columbia River Power System Biological Opinion, Upper Columbia Regional Technical Team, and Pacific Northwest Aquatic Monitoring Partnership.

Monitoring

Monitoring measures involve regular sampling and measurement of representative biological, physical, or programmatic parameters. Monitoring includes a mixture of activities of varying intensity, ranging from routine monitoring that involves repeated measurements of representative indices at regular intervals to statistical monitoring intended to provide inferences to larger areas and longer time periods. Monitoring measures include a mix of ongoing and new activities.

Research

Critical uncertainty research is focused on cause and effect relationships between fish, limiting factors/threats, and actions that address specific factors/threats. These critical uncertainties constrain our ability to identify or evaluate the effects of specific actions. The plan identifies a series of critical research questions for each threat category.

Types of Monitoring

Biological status monitoring focuses on population parameters including distribution, abundance, productivity, diversity to describe progress toward recovery objectives.

Habitat status monitoring focuses on trends in conditions in response to the cumulative effects of human activities and recovery measures and also establishes a baseline for evaluating causal relationships between limiting factors and a population response.

Action effectiveness monitoring determines if specific habitat, hydropower, hatchery, harvest, and ecological interaction measures produce the specific intended effect.

Implementation and compliance monitoring determines whether actions were implemented as planned or meet established laws, rules, and benchmarks.

Data Coordination and Management

Coordination and data management measures are included to ensure efficient implementation of a comprehensive and complementary program as well as accessibility and effective application of the associated data. An approach will be based on a detailed management needs assessment and data management plan.

PLAN IMPLEMENTATION

This plan provides a blueprint for salmon and steelhead recovery that includes specific strategies, measures, and actions needed to:

- Address all threats.
-
- Reverse long term declining trends and establish a trajectory toward recovery.
- Obtain sufficient information to measure progress.
- Make course corrections as necessary.

Implementation Mechanism

The pervasive scale of human activities that limit or threaten salmonids means that recovery will require a dedicated long-term collective social commitment to preserve and restore salmon and steelhead. The plan identifies the partners with the authority, jurisdiction, or resources needed to implement each action.

The plan does not obligate any party but does establish specific responsibilities for taking actions that have been identified as important to fish recovery. Obligation will come through the commitment of each implementing partner to undertake and complete their actions in a timely, sound, and thorough manner.

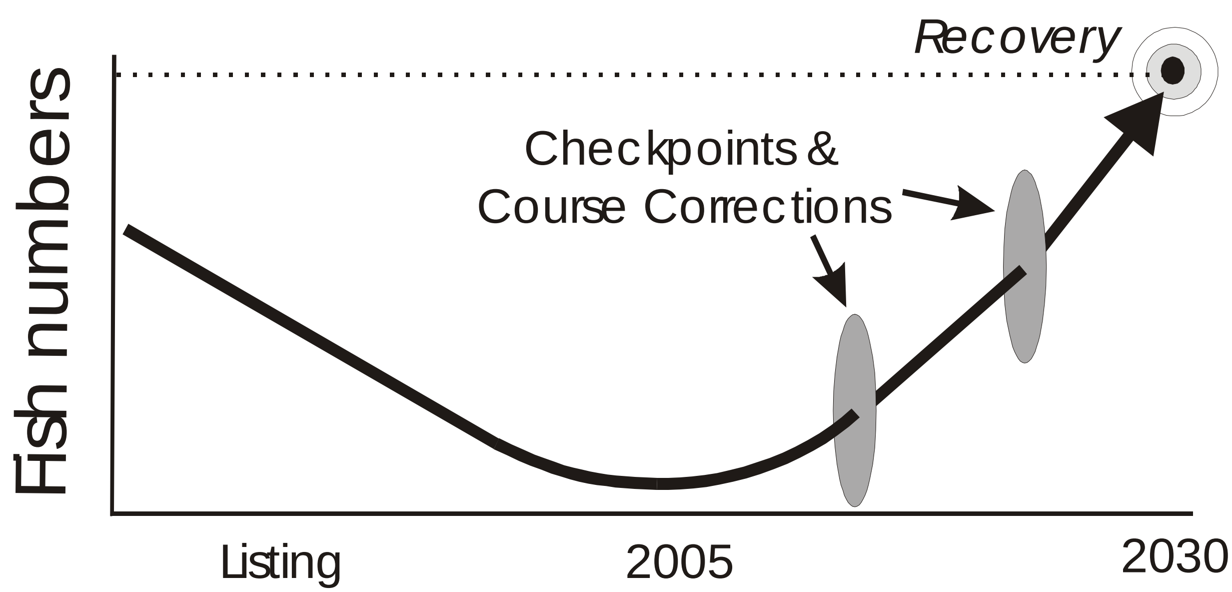
Institutional Structure

The institutional structure for plan implementation involves oversight, implementation, and facilitation/coordination responsibilities.

Key oversight bodies include NOAA Fisheries, U.S. Fish and Wildlife Service, tribal governments, the Washington Department of Fish and Wildlife, the Washington Governor's Office, and the Northwest Power and Conservation Council.

Implementation responsibilities will involve programs and projects by numerous Federal, State, local, and nongovernmental bodies. These entities are referred to as implementation sponsors.

The Lower Columbia Fish Recovery Board working with a steering committee will facilitate and coordinate efforts among oversight and implementing partners. The steering committee will include representatives of oversight bodies and a cross section of implementing partners. Facilitation/coordination will involve setting priorities, evaluating progress, tracking implementation, inventorying and synthesizing monitoring results, developing implementation partnerships and agreements, and revising the plan.



Implementation Schedules

The plan implementation process will involve preparation of a series of 6-year action schedules identifying tasks, schedules, priorities, costs, constraints, and responsibilities. Federal, state, tribal, local, and non-governmental partners will be requested to prepare an implementation schedule for their recovery actions. The individual action schedules will be used to develop a coordinated regional 6-year action schedule.

Economic & Cost Considerations

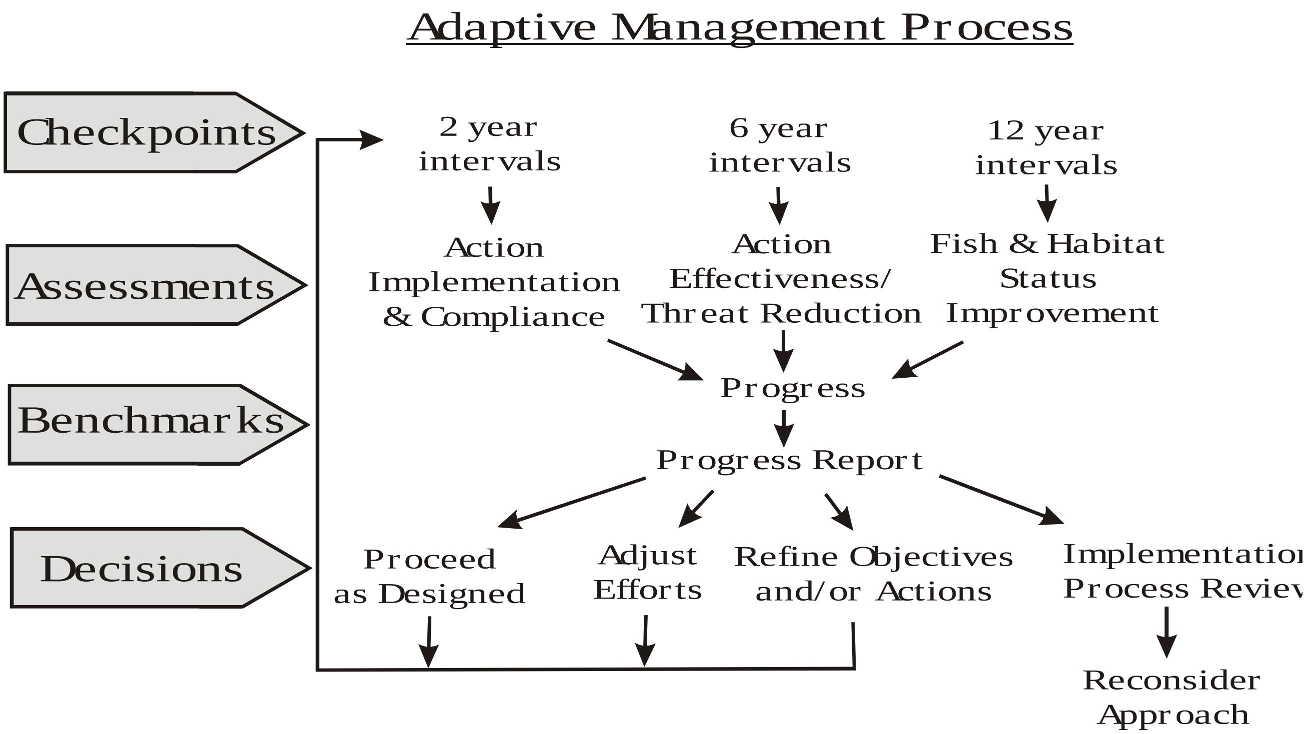
Strategies, measures and actions in this plan have been designed and selected based on their anticipated contribution to recovery goals. They are heavily based on biological and technical factors, although consideration was also given social, cultural, and general economic factors. Additional consideration of cost and economic factors will play an important function in developing specific implementation mechanisms and actions that are both scientifically sound and politically and fiscally feasible.

To establish an estimate of implementation costs, implementing partners are requested to provide an estimate of the incremental costs of recovery that will be incurred in addition to costs to their existing programs and activities. Partners are also requested to indicate how they will fund these costs and to identify fiscal constraints that would affect timely or full implementation of their actions. This information will be used along with biological, technical, social, and cultural considerations to help refine implementation priorities and to develop a regional funding strategy.

Adaptive Management

An adaptive management process and schedule is described that includes checkpoints, assessments, benchmarks, and decisions. ***Checkpoints*** are formal decision points where the need for changes in direction will be considered. ***Assessments*** are formal evaluations of progress and results. ***Benchmarks*** are standards or criteria that will drive decisions depending on observed progress in implementation efforts and effectiveness based on the 6-year implementation schedules prepared by the implementing partners.

Decisions identify refinements in efforts or new directions based on progress relative to benchmarks observed at checkpoints.



Decisions will be based on:

- Whether recovery strategies and measures have been implemented as planned.
- Whether specific strategies and measures significantly have reduced the corresponding threats.
- Whether fish and habitat conditions improved as a result of recovery actions.

Public Education & Outreach

Education refers to the development or promotion of general knowledge or training. Outreach refers to directed educational and involvement efforts directed toward specific constituencies and intended to focus on specific problems or actions.

It is a goal of public education and outreach to engage the public as an active partner in implementing and sustaining recovery efforts. A regional education and outreach program will be established to support, assist and coordinate with similar education and outreach efforts by individual implementing partners.

Enforcement of the Plan

This plan is not a regulatory document and is not enforceable. It relies largely on the cooperative efforts and support of federal and state agencies, tribal governments, local governments, businesses, non-profit organizations, and the people of the region.

Enforcement action alone is not a sufficient or effective means to achieve recovery. However, it is expected that agencies with such authority will exercise it as needed to ensure implementation of their recovery responsibilities. This includes enforcement of ESA regulations by NOAA Fisheries and the USFWS.

Plan Sufficiency

Evaluation of the sufficiency of this plan is based on: 1) substantive strategies, measures, an actions that address all current threats to the viability and harvestability of Washington lower Columbia salmon and steelhead populations, 2) incorporation of effective monitoring, evaluation, and adaptive management measures and actions as well as an institutional framework for plan implementation, and 3) assessments confirming that reductions in threats are of an order of magnitude consistent with recovery.

Threats to viability and harvestability include all categories of human activities that impact fish numbers, adaptive population characteristics, and habitats. This plan has cataloged threats at length and related them to fish limiting factors. Impacts of key factors in each threat category were quantified based on the best available information and were related to improvement increments needed to achieve biological objectives.

Monitoring, evaluation, and adaptive management components of the plan consider whether actions were implemented as designed, actions produce the expected effect, and the net effects of multiple actions produce the desired improvement in fish populations. Quantitative estimates of the impacts of key threat factors and expected responses projected from fish life cycle and habitat models provide testable hypotheses for the monitoring, evaluation, and adaptive management efforts.

The immediate test of plan sufficiency is whether current working hypotheses, strategies, measures, and actions provide a plausible scientific basis for reversing decline fish trends and providing a significant trajectory toward recovery. Existing information and tools are adequate to evaluate whether proposed actions are of an order of magnitude to significantly reduce threats to the level where a response in fish populations can feasibly be measured and a trajectory for recovery can be detected. These assessments will be completed as part of the plan development and implementation process.

Plan Interpretation & Revision

It is likely during the course of implementing the recovery plan that questions will arise that will require interpretation or clarification of the plan goals, objectives, strategies, measures, and actions. Revisions may also be warranted to address issues or new information that may arise during implementation or to facilitate effective plan implementation. The Implementation Steering Committee shall be responsible for such interpretations, clarifications, or revisions and may consult with federal state or local agencies or the NOAA Fisheries Technical Recovery Team (TRT) as deemed appropriate.

Monitoring, Research & Evaluation Plan

The LCFRB and the Implementation Steering Committee will direct and coordinate the implementation of the monitoring, research and evaluation provisions set forth in this plan. The program will also define the procedures and benchmarks for implementing the Adaptive Management Process. The LCFRB and Implementation Steering Committee shall convene and work with a Monitoring, Research, and Evaluation Working Group to develop implementation measures and responsibilities. The Working Group will consist of representatives from federal, state, regional, and local programs engaged in biological and habitat status monitoring, effectiveness monitoring, implementation/compliance monitoring and biological and habitat research. The working group will prepare and submit to the Implementation Steering Committee recommendations for a Monitoring, Research, and Evaluation Program.

Responsibilities and Schedule

All actions identified in this plan were deemed to be significant for recovery, hence can be considered a high priority. Some actions warrant more immediate implementation because of the acute nature of the problem they address and the availability of necessary infrastructure and resources.

Actions are organized by the entity that would be involved in implementation. Because multiple entities are involved in the implementation of certain actions, some actions are listed under more than one entity. In some cases, no single entity has full authority to implement an action, and successful implementation will depend on the coordination and cooperation of a number of agencies. In other cases, while one entity may have lead authority and implementation responsibility, effective implementation will depend on the involvement, support, and agreement of a number of agencies. In the process of developing implementation schedules, lead entities may be identified for an action involving two or more partners.

SUBBASINS

A series of Subbasins Plans (Volumes II.A-II.L) describe local conditions and detail implementation of the regional plan at the subbasin level. Each subbasin plan includes:

- An ***overview summary*** of key priorities.
- An ***assessment*** that describes the subbasin, species of interest, subbasin habitat conditions, stream habitat limitations, watershed process limitations, other factors such as hatcheries, harvest, hydropower, and out-of-subbasin effects. The assessment includes qualitative and quantitative information.
- A ***program and project inventory*** describing significant activities in the subbasin. (More detailed program descriptions may also be found in a regional program directory contained in Technical Appendix C.)
- A ***management plan*** that details a subbasin vision, biological objectives, integrated strategy, and specific measures and actions for each threat category.

The following descriptions summary for each subbasin.

Lower Columbia Mainstem and Estuary

The lower Columbia River mainstem is a critical migration corridor and rearing area for every population of salmon and steelhead in the Columbia River basin as well as a variety of other fish and wildlife species. Habitats and habitat shaping processes have been substantially altered by local development and changes in river dynamics that have accompanied extensive hydropower development throughout the system. The estuary subbasin plan is consistent with the joint Oregon and Washington subbasin plan. Priority actions were previously described under regional strategies and measures.

Estuary Tributaries

The Estuary Subbasin includes a series of small Washington tributaries from the ocean upstream to Deep River. These streams historically supported thousands of fall chinook, chum, and coho. All populations need to be restored to a high level of viability in these tributaries to meet regional recovery objectives. Priority actions include:

- Restoring passage at tide gates, culverts, and other artificial barriers.
- Restoring estuary, floodplain, and riparian habitats
- Managing forests pursuant to Forest and Fish Rules to protect and restore watershed processes,
- Addressing immediate risks with short term habitat fixes, and
- Reducing out-of-subbasin impacts.

Grays Subbasin

This subbasin is particularly important to regional recovery because it is one of two major basins in the coastal strata of the ESU. Populations of fall Chinook, winter steelhead, chum and coho need to be restored to a high level of viability in this subbasin to meet regional recovery objectives. Priority actions include:

- Reducing out-of-subbasin impacts,
- Managing forests pursuant to Forest and Fish Rules to restore watershed processes.
- Restoring valley floodplain function and stream habitat diversity.
- Aligning hatchery priorities with conservation objectives.

Elochoman Subbasin

This subbasin includes the Elochoman, Skamokawa, Mill, Abernathy, and Germany watersheds. Populations of fall Chinook, chum, coho and winter steelhead need to be restored to medium and high levels of viability to meet regional recovery objectives. The Elochoman/Skamokawa populations are particularly important for recovery. Priority actions include:

- Managing forest lands pursuant to Forest and Fish Rules to protect and restore watershed processes,
- Restoring lowland floodplains, riparian conditions, and stream habitat diversity.
- Reducing out-of-subbasin impacts,
- Aligning hatchery priorities with conservation objectives.

Cowlitz Subbasin

This subbasin is particularly important to regional recovery by virtue of its large size and diverse habitats. It includes lower Cowlitz, upper Cowlitz, Cispus, Tilton, Toutle, and Coweeman watersheds. One or more populations of tule fall Chinook, , spring Chinook, chum, winter steelhead, summer steelhead, and coho are present and many need to be restored to high levels of viability to meet regional recovery objectives. Priority actions include:

- Restoring access above dams to the upper portion of the basin.
- Protecting intact forests in headwaters.
- Managing forest land pursuant to Forest and Fish Rules to protect and restore watershed processes.
- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage at culverts and other artificial barriers.
- Restoring lowland floodplain function, riparian conditions, and stream habitat diversity.

- Addressing immediate risks with short term habitat fixes.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Kalama Subbasin

Populations of fall Chinook, spring Chinook, winter steelhead and summer steelhead need to be restored to a high level of viability to meet regional recovery objectives. Coho will need to improve to a medium level of viability and a chum population established and stabilized. Priority actions include:

- Managing forests pursuant to Forest and Fish Rules to restore watershed processes.
- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage at culverts and other artificial barriers.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Lewis Subbasin

This subbasin is particularly important to regional recovery due to its large size and diverse habitats. It includes the upper North Fork, lower North Fork, and East Fork watersheds. One or more populations of tule fall Chinook, bright fall Chinook, spring Chinook, chum, winter steelhead, summer steelhead, and coho are present and many need to be restored to high levels of viability to meet regional recovery objectives. Priority actions include:

- Restoring access above dams to the upper portion of the North Fork watershed.
- Protecting intact forests in headwaters.
- Managing forest land pursuant to Forest and Fish Rules to protect and restore watershed processes.
- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage at culverts and other artificial barriers.
- Restoring lowland floodplain function, riparian conditions, and stream habitat diversity.
- Addressing immediate risks with short term habitat fixes.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Lower Columbia Tributaries

This subbasin includes a series of small tributaries between the Lewis River and Bonneville Dam including Salmon, Lake, Duncan, Hardy, and Hamilton creeks. Salmon and Lake creeks have been heavily urbanized while the gorge tributaries are largely in forest lands. The urban streams will play a limited role in salmon recovery. Populations of fall chinook, winter steelhead, chum and coho in lower gorge tributaries will be important to recovery. Priority actions include:

- Restoring floodplain function, riparian conditions, and stream habitat diversity.
- Managing growth and development to protect watershed processes and habitat conditions.
- Managing forests pursuant to Forest and Fish Rules to restore watershed processes.
- Restoring passage at culverts and other artificial barriers.
- Addressing immediate risks with short term habitat fixes.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Washougal Subbasin

Fall chinook, chum, and summer steelhead need to be restored to a high level of viability and coho and winter steelhead that need to be restored to a medium level of viability. The subbasin is diverse with significant portions in forest, agriculture, rural residential, and urban uses. Priority actions include:

- Protecting intact forests in headwaters.
- Managing forest land pursuant to Forest and Fish Rules to protect and restore watershed processes.
- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage at culverts and other artificial barriers.
- Restoring lowland floodplain function, riparian conditions, and stream habitat diversity.
- Addressing immediate risks with short term habitat fixes.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Wind Subbasin

This subbasin historically supported abundant fall Chinook, winter steelhead, chum, and coho. Coho and summer steelhead need to be restored to a high level of viability to meet regional recovery objectives. Chum need to be restored to a medium level of viability. Priority actions include:

- Reducing out-of-subbasin impacts.
- Protecting intact forests in headwaters.
- Managing forest lands pursuant to Forest and Fish Rules and federal forest plans to protect watershed processes,
- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage, floodplain function, riparian function, and stream habitat diversity in critical areas.
- Aligning hatchery priorities with conservation objectives.

Little White Salmon Subbasin

This subbasin will play a limited role in salmon recovery but is significant for many resident fish and wildlife species. A limited amount of habitat is available for anadromous fish and much of the historical habitat for fall chinook and chum salmon was inundated by Bonneville Reservoir. Priority actions include:

- Managing growth and development to protect watershed processes and habitat conditions.
- Restoring passage at culverts and other artificial barriers.
- Addressing immediate risks with short term habitat fixes.
- Aligning hatchery priorities with conservation objectives.
- Reducing out-of-subbasin impacts.

Columbia Gorge Tributaries

This subbasin includes small tributaries between Bonneville Dam and the White Salmon River, of which Rock Creek is the largest. Gorge populations of coho salmon will need to be restored to a high level of viability and chum to a medium level of viability to meet regional recovery objectives. Priority actions include:

- Reducing out-of-subbasin impacts.
- Addressing immediate risks with short term habitat fixes.
- Managing forest lands pursuant to Forest and Fish Rules and federal forest plans to protect watershed processes.
- Managing growth and development to protect watershed processes and habitat conditions.

ACKNOWLEDGMENTS

This plan was developed by of the Lower Columbia Fish Recovery Board and its consultants under the guidance of the Lower Columbia Recovery Plan Steering Committee, a cooperative partnership between federal, state and local governments, tribes and concerned citizens.

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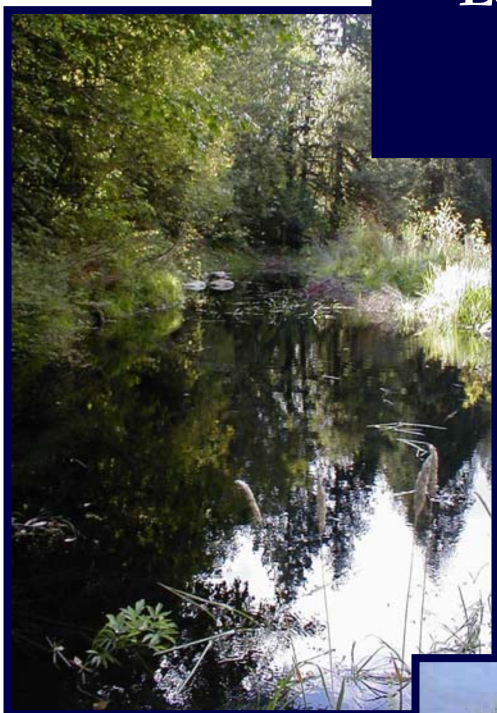
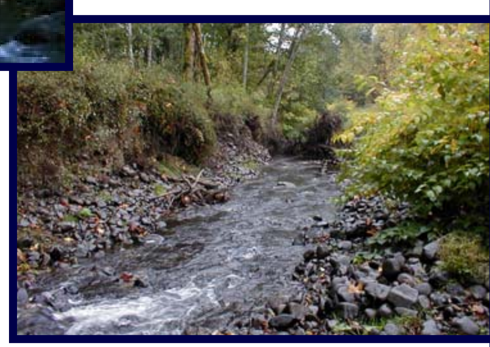
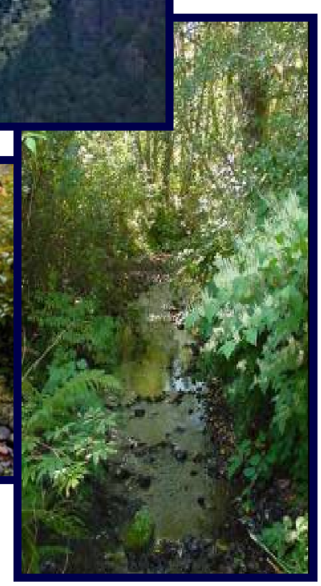
Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan



Restoring Salmon And Steelhead To Healthy, Harvestable Levels

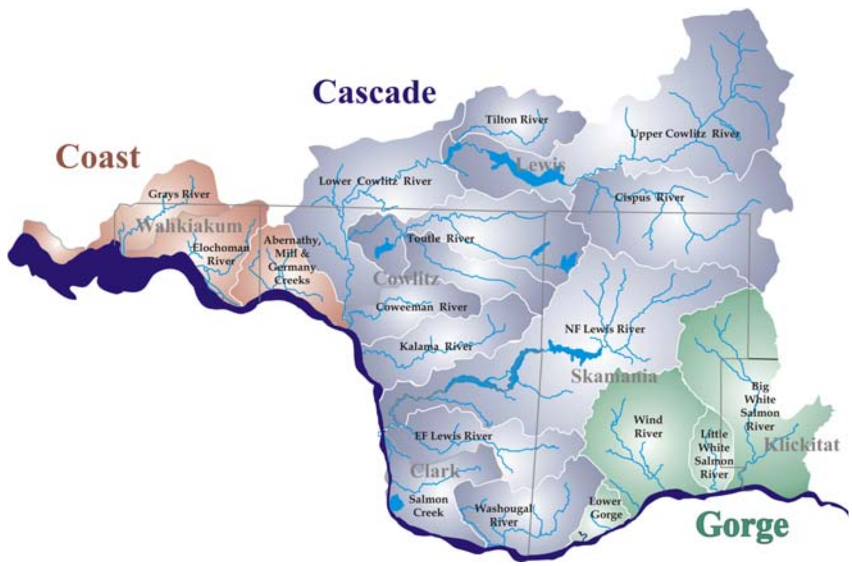
Clark, Cowlitz, Lewis, Skamania And Wahkiakum Counties





VOLUME I – REGIONAL PLAN

Lower Columbia Fish Recovery Board
December 15, 2004



Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan

VOLUME I – REGIONAL PLAN

Lower Columbia Fish Recovery Board

December 15, 2004

The Lower Columbia Fish Recovery Board unanimously adopts
The Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan
With the understanding that
Implementation of the schedule and actions for local jurisdictions
Depends upon funding and other resources;

APPROVED THIS 10th DAY OF DECEMBER 2004.

Dave Andrew	Betty Sue Morris
John Barnett	Al McKee
Bill Dygert	Jeff Rasmussen
Mark Doumit	Don Swanson
Dennis Hadaller	Randy Sweet
Henry Johnson	Chuck TenPas
Tim Leavitt*	George Trott
Tom Linde	

* Endorsed post rata.

Preface

This is one in a series of volumes that together comprise a Recovery and Subbasin Plan for Washington lower Columbia River salmon and steelhead:

--	Plan Overview	*Synopsis of the planning process and regional and subbasin elements of the plan.*
Vol. I	Regional Plan	*Regional framework for recovery identifying species, limiting factors and threats, the scientific foundation for recovery, biological objectives, strategies, measures, and implementation.*
Vol. II	Subbasin Plans	*Subbasin vision, assessments, and management plan for each of 12 Washington lower Columbia River subbasins consistent with the Regional Plan. These volumes describe implementation of the regional plan at the subbasin level.*
		II.A. Lower Columbia Mainstem and Estuary *II.B. Estuary Tributaries* *II.C. Grays Subbasin* *II.D. Elochoman Subbasin* *II.E. Cowlitz Subbasin* *II.F. Kalama Subbasin* *II.G. Lewis Subbasin* *II.H. Lower Columbia Tributaries* *II.I. Washougal Subbasin* *II.J. Wind Subbasin* *II.K. Little White Salmon Subbasin* *II.L. Columbia Gorge Tributaries*
Appdx. A	Focal Fish Species	*Species overviews and status assessments for lower Columbia River Chinook salmon, coho salmon, chum salmon, steelhead, and bull trout.*
Appdx. B	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning*
Appdx. C	Program Directory	*Descriptions of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning*
Appdx. D	Economic Framework	*Potential costs and economic considerations for recovery and subbasin planning*
Appdx. E	Assessment Methods	*Methods and detailed discussions of assessments completed as part of this planning process*

This plan was developed by of the Lower Columbia Fish Recovery Board and its consultants under the Guidance of the Lower Columbia Recovery Plan Steering Committee, a cooperative partnership between federal, state and local governments, tribes and concerned citizens.

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Contents

1 Introduction

This is an introduction section for the regional volume of the recovery plan. It discusses the scope and context of the overall Washington Lower Columbia Recovery/Subbasin planning effort being led by the Lower Columbia River Fish Recovery Board. It describes the healthy and harvestable planning goal for salmon and steelhead. It explains how this planning process addresses the federal Endangered Species Act (ESA), Northwest Power and Conservation Council (NPCC) subbasin plans for fish and wildlife adversely affected by the development and operation of the Columbia River hydropower system, and state salmon recovery and watershed management planning processes. It describes the area and time frame addressed by the plan. The section also provides an overview of the plan development process and the framework that brings different stakeholders and interested parties together as participants.

1.1 Vision

This plan is intended to serve as 1) a recovery plan for Washington lower Columbia salmon and steelhead populations and 2) a Northwest Power and Conservation Council Fish and Wildlife Plan for eleven lower Columbia subbasins. The vision is of a scientifically credible, socially and culturally acceptable, and economically and politically sustainable plan to:

- Restore the region's four fish species listed as threatened under the federal Endangered Species Act (ESA) to healthy, harvestable levels, and;
- Protect and enhance other fish and wildlife species that have been adversely affected by human actions, including the development and operation of the Federal Columbia River Power System.

Salmon, steelhead and trout of the lower Columbia basin, and its Washington tributaries, have been depleted to the point where Chinook salmon, chum salmon, steelhead trout, and bull trout have been listed as Threatened under the federal Endangered Species Act (ESA), and on May 28, 2004, Columbia River coho salmon were proposed for listing as threatened. Perhaps more importantly, these species together once supported thriving fisheries that are now greatly diminished and dependent mostly on hatchery production.

Other fish and wildlife species of the lower Columbia basin have been affected by the operation of the Federal Columbia River Power System and ecosystem changes stemming from a wide range of human activities. Some species such as sturgeon, lamprey, eulachon, and Columbian whitetail deer have been adversely affected by the loss of habitat upon which they depend. Other species, including northern pikeminnow, Caspian terns, and smallmouth bass, have thrived in altered habitat conditions which have altered the balance of predator-prey relationships. Finally, introduced non-native plant and animal species have displaced native species or compete with native species for habitat and nutrients. An example of such a species is American shad. Introduced in California during the late 1800s, two to four million adult shad return annually to the lower Columbia basin to spawn.

This plan provides a roadmap for the first stage of recovery implementation. It includes a comprehensive set of beneficial actions that are sound and address the range of threats as they are understood at this time. Adaptive management will be a critical element of plan implementation because existing information is too uncertain to definitively identify exactly how much of which actions will be sufficient to achieve recovery. And so the plan includes an implementation framework by which the plan will evolve based on results of monitoring, refinements in prioritization methods, additional information on costs and other economic factors, and specific implementation plans to be developed by implementing entities. The plan can succeed only if local, state, and federal interests take ownership and are involved in implementation and adaptive management.

VISION

Washington lower Columbia salmon, steelhead, and bull trout are recovered to healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices; and

The health of other native fish and wildlife species in the lower Columbia will be enhanced and sustained through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships.

1.2 An Integrated Plan

The planning process integrates the following four interrelated initiatives to produce a single Recovery/Subbasin Plan for the Washington portion of the lower Columbia that is intended to serve the following purposes:

- Endangered Species Act recovery planning for four salmonid species listed as threatened: Chinook salmon, chum salmon, steelhead, and bull trout. Coho salmon have also been included since they are a candidate species for listing.
- Northwest Power and Conservation Council (NPCC) fish and wildlife subbasin planning for eight full and three partial subbasins.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90-82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach provides significant benefits, including:

- Ensuring consistency and compatibility of goals, objectives, strategies, priorities and actions;
- Eliminating redundancy in the collection and analysis of data; and
- Establishing the framework for a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement efforts for restoration of listed salmonids and the enhancement of other fish and wildlife species of interest.

1.2.1 ESA Recovery Planning

All native salmonid species in the lower Columbia region have been listed or proposed for listing under the ESA. Listings may be made for species, subspecies, and distinct population segments. The basic unit used by NOAA Fisheries for listing and delisting anadromous salmon and steelhead species is the Evolutionarily Significant Unit (Waples 1991). An ESU is a distinctive group of Pacific salmon or steelhead populations that is uniquely adapted to a particular area or environment and cannot be replaced. Three ESUs have been listed under the ESA as “threatened” and one is proposed for listing. Bull trout are listed under the jurisdiction of the USFWS which defines listing units as distinct population segments.

- The Lower Columbia Chinook salmon Evolutionarily Significant Unit (ESU) was listed as threatened under the ESA on March 24, 1999.
- Lower Columbia chum salmon, including all naturally spawning populations in the Columbia and its tributaries in Washington and Oregon, were listed as threatened on March 25, 1999.
- On March 19, 1998, NMFS listed the Lower Columbia steelhead ESU as threatened under ESA. The Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany steelhead populations are in the Southwest Washington ESU and are not listed under the ESA.
- Columbia River coho were proposed for listing as threatened on May 28, 2004.
- On June 10, 1998, the United States Fish and Wildlife Service (USFWS) listed bull trout in the Columbia and Klamath river basins as threatened under the ESA.

- On July 5, 2002, the USFWS withdrew the Proposed Rule to List the Southwestern Washington/Columbia River Distinct Population Segment of the Coastal Cutthroat Trout as Threatened. However, Washington Department of Fish and Wildlife (WDFW) describes cutthroat as depressed in all rivers entering the Columbia from its mouth to the Kalama River, citing either long-term negative trends or short-term severe declines.

As the listing agency for anadromous salmonids, NOAA Fisheries is responsible for developing recovery plans under ESA §4(f) for Chinook and chum salmon and steelhead. The USFWS is responsible for developing a bull trout recovery plan. The intent of NOAA Fisheries is to develop recovery plans through a collaborative effort involving federal and state agencies, tribes, local governments, and the public. Under the proposed approach, local recovery plans and subbasin plans being developed in Washington and Oregon for the Lower Columbia and Upper Willamette ESUs will be used as the basis for an ESA recovery plan for NOAA's Willamette/Lower Columbia Recovery Domain, which includes the three listed Lower Columbia ESus and the listed Upper Willamette spring chinook and steelhead ESUs. The Lower Columbia Fish Recovery Board (LCFRB) is coordinating local recovery planning efforts for the Washington portion of the lower Columbia region. The state of Washington intends to submit the LCFRB plan to NOAA Fisheries for use as the basis for the Washington portion of the domain-wide plan

A coordinating policy forum—the Executive Committee for Lower Columbia and Willamette River Salmonid Recovery (ExCom)—has been established for this domain. This group, representing major state, federal, local, and tribal stakeholders, is coordinating development of a recovery plan for the Willamette/Lower Columbia domain. The Ex Com's goal is for a plan that is "highly likely to be implemented and effective for all threatened and endangered salmon species and their habitats" and that addresses ESA and other related planning needs. The Ex Com's responsibilities include working to align ongoing regional, state, and local processes with recovery planning; addressing bi-state and tribal coordination issues; concurring on recovery goals and other elements of recovery plans; and ensuring adequate integration of the scientific information with recovery actions and strategies.

NOAA Fisheries has also established the Willamette/Lower Columbia Technical Recovery Team (TRT) to make recommendations on biological criteria that would indicate when populations or ESUs had a high probability of persistence. The TRT is comprised of scientists from NOAA Fisheries, USFWS, state agencies, academic institutions, and private consulting firms. The TRT has submitted a series of recommendations to NOAA Fisheries. The biological goals for salmon and steelhead in this plan are based on and explicitly incorporate the work of the TRT.

Under ESA §4(f) a recovery plan must include the following:

- Site-specific management actions necessary for the conservation and survival of the species,
- Objective, measurable criteria which, when met, would result in a determination that the species be removed from the list (i.e., delisting), and
- Estimates of the time required and cost to carry out those measures needed to achieve recovery.

This plan contains recovery goals, a threats assessment, and actions necessary for the recovery of currently listed salmon and steelhead ESUs. The vision of the LCFRB plan is for all

Lower Columbia salmon and steelhead to be recovered to "healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries, through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices."

ESA delisting can occur at a point when a listed species and its ecosystem is restored and its future is safeguarded to the point that protections under the ESA are no longer needed. Decisions to delist are based on a species' biological status (biological delisting criteria) and on the status of the threats to the species (threats criteria), as identified in the ESA §4(a)(1). This plan's vision for recovery encompasses ESA recovery, in the sense that ESA delistings could be achieved while working toward the plan's vision for recovery.

The USFWS has federal jurisdiction over bull trout, which are listed as threatened under ESA, as well as cutthroat trout, which are currently not federally-listed. The Bull Trout Draft Recovery Plan, developed collaboratively with other federal, state, Tribal and private recovery unit team members, covers an extensive geographical area of the western states. The draft recovery plan represents four Distinct Population Segments, each of which is further segmented into recovery units which are the primary elements for recovery plan development. The LCFRB recovery plan builds on provisions of the USFWS Lower Columbia Recovery Unit plan to ensure that bull trout recovery efforts are integrated into the broader salmonid recovery strategies and actions for the lower Columbia. Much of the USFWS Lower Columbia Recovery Unit falls within the LCFRB planning area. Although the USFWS has delayed production of the final bull trout recovery plan, pending the outcome of a 5-year-status review, the LCFRB plan addresses bull trout recovery. The USFWS is a participant in the planning process and providing advice on bull trout conservation.

Well developed recovery or management plans exist for other listed species including bald eagle and Columbia whitetail deer. These plans augment this Plan and provide the basis for developing biological objectives and strategies for these species. This subbasin management plan will address the integration of the various species-specific management plans into a balanced approach for all focal species.

1.2.2 NPCC Subbasin Planning

The NPCC was created by Congress in 1980 to give Washington, Oregon, Idaho, and Montana a voice in how the region plans for its energy needs, while at the same time mitigating the effects of the Federal Columbia River Power System on fish and wildlife resources.[1] To this end, the Council has developed the Columbia Basin Fish and Wildlife Program. The program sets forth goals and strategies for the protection and enhancement of fish and wildlife resources. The Council uses the Program to solicit and evaluate proposals for on-the-ground projects and research. Priority proposals are forwarded to the Bonneville Power Administration (BPA) for funding. The Council has initiated efforts to update its Fish and Wildlife Program. A key element is the development of individual plans for the 62 subbasins within the Columbia basin. Eight of these subbasins fall totally within the lower Columbia region in Washington. Three others (Columbia Estuary, Lower Columbia, and Columbia Gorge) are shared with the state of Oregon. The LCFRB is under contract with the NPCC to develop subbasin plans for the eight

[1] The Northwest Power and Conservation Council (NPCC) was formerly referred to as the Northwest Power Planning Council.

Washington subbasins and to work with the Lower Columbia River Estuary Partnership to develop plans for the three shared subbasins.

Subbasin plans:

- Identify the goals for fish, wildlife, and habitat;
- Define objectives that measure progress toward the those goals;
- Establish strategies to achieve the objectives; and
- Incorporate and build upon existing fish and wildlife information and activities.

Completed subbasin plans will be adopted as part of the Council's Fish and Wildlife Program and will help direct BPA funding of projects that protect, mitigate and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system. The Council's effort is also linked to and accommodates the needs of other programs in the basin that affect fish and wildlife. Along with the NOAA Fisheries and the USFWS, the NPCC and BPA also intend to use the adopted subbasin plans to help meet the requirements of the 2000 Federal Columbia Power System Biological Opinion.

1.2.3 Washington Watershed Planning

The state Watershed Management Act (RCW 90.82) provides local communities the opportunity to plan for the future use of their water resources in consultation with state agencies. To facilitate this planning, the state has been divided into Water Resource Inventory Areas (WRIAs). There are five WRIAs in the lower Columbia. Watershed planning efforts are underway in all five areas. The LCFRB coordinates watershed planning in four of the five lower Columbia WRIAs and is an active participant in planning for the fifth WRIA. Watershed plans for these WRIAs will address issues associated with:

- Water quantity, including the availability and current use of water and actions needed to meet future needs for fish and people;
- Water quality, including current water quality problems, priorities for addressing these problems, and water quality monitoring;
- Stream flows, including the adequacy of existing flows for fish and other in-stream uses and measures to protect or enhance stream flows; and
- Habitat, including the current condition of fish habitat and measures to protect or enhance habitat to support salmon recovery efforts.

Water quantity and quality and stream flow studies and data collected by the watershed planning initiatives will be incorporated in the regional recovery plan. Habitat data collected by the recovery planning effort will be shared with the watershed planning effort. Policies, strategies, actions, and priorities will be coordinated to ensure that they are compatible and complement each other.

1.2.4 Washington Salmon Habitat Protection and Restoration

The Washington Salmon Recovery Act (RCW 77.85):

- Provides for the funding of habitat protection and restoration efforts;
- Requires local and regional program organizations to identify and prioritize project needs; and

- Directs that the Washington Department of Fish and Wildlife develop guidance for regional salmon recovery efforts.

The Salmon Recovery Funding Board (SRFB) coordinates the funding process on the statewide level. It establishes program policies and directions as well as grant requirements. It screens project proposals and awards grants. Lead entities coordinate the process on the local or regional level. They develop habitat protection and restoration strategies for their area. They solicit, evaluate, rank, and propose projects to the SRFB. The LCFRB serves as the lead entity for the lower Columbia region. In this capacity, the Board has developed and annually updated and expanded a lower Columbia habitat strategy which provides a basis for prioritizing proposed habitat projects. Development of the strategy has been merged with the recovery planning effort and strategy has evolved into a integral element of the Plan.

1.3 Geographic Planning Area

The 5,700 square mile planning area encompasses the entire Lower Columbia Salmon Recovery Region (except the White Salmon basin, omitted at the request of Klickitat County). It is comprised of eight full NPCC subbasins: the Grays, Elochoman, Cowlitz, Kalama, Lewis, Washougal, Wind, and Little White Salmon. Three additional subbasins are shared with the state of Oregon: Columbia Estuary, Lower Columbia, and Columbia Gorge.

The planning area includes the Washington portion of the mainstem and estuary of the lower Columbia River as well as 18 major and a number of lesser tributary watersheds (Figure 1). These include the Chinook, Grays, Skamokawa, Elochoman, Mill, Abernathy, Germany, Cowlitz, Coweeman, Kalama, Lewis, Lake, Washougal, Duncan, Hardy, Hamilton, Wind, and Little White Salmon rivers. In all, the tributaries total more than 1,700 river miles. The White Salmon subbasin was not included in the subbasin planning process. However, status and objectives were considered in this plan for salmon in this subbasin because these populations were part of the listed unit that includes other Washington lower Columbia River populations.

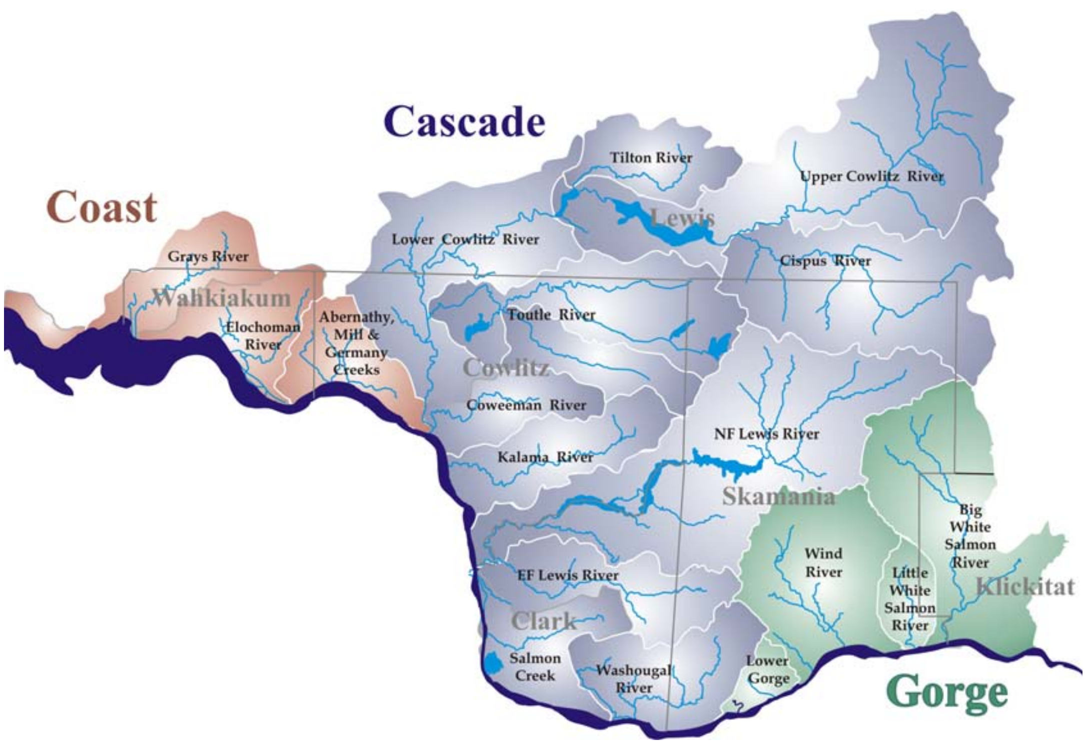


Figure 1. Lower Columbia River watersheds considered in this planning process.

1.4 Planning Horizon

The Plan uses a planning period or horizon of 25 years. The goal is to fully implement within this time period all actions needed achieve recovery of the listed salmon species and the biological objectives for other fish and wildlife species of interest. Declining species trajectories should be reversed and species should demonstrate improvements consistent with biological objectives. It is recognized, however, that full restoration of habitat conditions and watershed process for all species of interest will likely take 75 years or more.

1.5 Plan Development

The Plan was developed using a two-phased approach intended answer five key questions for the species of interest. These questions are:

- Where are we now?
- How did we get here?
- Where do we need to go?
- How do we get there?
- How do we know when we're there?

The first phase involved the development of technical information that provides a foundation for answering the first three questions. The technical foundation is a comprehensive collection and analysis of information relating to the Plan's focal fish and wildlife species and the environmental conditions and human activities that affect their health and viability. It describes and analyzes current conditions and trends, and explains the analytical methods used. Technical foundation material is contained in a series of Technical Appendices to the plan.

The second phase involved the development of the Plan itself. It focused on the last two of the five questions. The plan provides biological objectives; regional and subbasin strategies, measures and actions; implementation plans; and monitoring and adaptive management measures.

The Plan provides common goals and a coordinated course of action that is scientifically sound, acceptable to the public, and economically sustainable. Protection, restoration, and enhancement actions are selected to provide maximum benefit and ensure the efficient use of resources. The plan focuses on outcomes and allows implementing agencies and other entities the flexibility to craft innovative, yet scientifically sound, approaches that best fit local conditions and values.

1.6 Planning Organization and Participants

The LCFRB led and coordinated the development of the Plan. The Board was established by state statue (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. The LCFRB is committed to finding solutions that restore fish and provide for the needs of the citizens of the region. Adoption of the final plan will require consensus of all Board members.

Since the success of salmon and steelhead recovery and enhancement of other fish and wildlife species will require the support and coordinated efforts of federal, state, tribal, regional, and local entities, a collaborative approach was used to develop the Plan. Partners in the planning process include:

- Federal Agencies: NOAA Fisheries, USFWS, the U.S. Forest Service (USFS), and the U.S. Army Corps of Engineers (USACE).
- Tribal Governments: Cowlitz Tribe, the Yakama Nation, and the Chinook Tribe.
- Washington State Agencies: The WDFW, the Governor's Salmon Recovery Office (GSRO), the Department of Ecology (WDOE), the Department of Natural Resources (WDNR), the Department of Transportation (WSDOT), and the Department of Agriculture (WDOA).
- Regional Organizations: The NPCC, the Lower Columbia River Estuary Partnership (LCREP), the Lower Columbia/Willamette ESA Executive Committee, and the WRIA 25/26 and 27/28 Watershed Planning Units.
- Local Governments: Clark, Cowlitz, Lewis, Skamania, and Wahkiakum counties and the cities of Vancouver and Camas.

The partners participated through involvement on the LCFRB, the Recovery Planning Steering Committee (RPSC), working groups, public outreach, and other coordinated efforts.

The LCFRB utilized a RSPC to facilitate the Plan's development. The Steering Committee was responsible for the overall direction and oversight of the recovery planning initiative. The Committee maintained a work plan and schedule, monitored progress, reviewed draft materials, and advised on policy issues. RPSC members represented the interests of their organizations and were responsible for ensuring that decisions were properly communicated and supported within their organizations. The Committee makes decisions by consensus. Members included local governments and citizen representatives from the LCFRB, NOAA Fisheries, USFWS, NPCC, LCREP, WDFW, Governor's Salmon Recovery Office, Washington Department of Ecology, the USFS, the Cowlitz Tribe, the Yakama Nation, and the Chinook Tribe.

Work groups were used to address specific issues and prepare recommendations or documents for RPSC consideration. The work groups were used to secure the expertise or knowledge needed to successfully complete the Plan as well as to broaden participation in the planning process. The composition of a work group depended on the issues to be addressed or the tasks at hand. Members are selected based on their knowledge or expertise. Work groups included the following:

- The Fish Work Group that provided technical assistance and advice to the RPSC regarding the development of plan elements dealing with recovery goals and biological objectives and the status, life history and environmental needs of salmonids.
- The Factors Limiting Recovery Work Group that provided technical assistance and advice to the RPSC for developing plan elements dealing with factors limiting the recovery of salmonids and watershed assessment activities.
- The Programs Work Group that provided assistance and advice to the RPSC for developing a Plan element that identifies, inventories, and characterizes programs that affect fish resources and their recovery.
- The Recovery Scenario Work Group that assisted in the development of the salmon and steelhead recovery scenarios.

- The Regional Strategy Work Group that assisted in drafting the Plan's regional strategies and measures for Columbia estuary, mainstem, and tributary habitat, hatchery operations, hydroelectric projects, harvest management, and ecological interactions.
- The Estuary Science Panel that assisted with the estuary and mainstem assessment.

1.7 Community and Public Participation

- In addition to the use of work groups, opportunities for broader community and public participation were provided during various stages of the Plan's development.
    - A 30-day public comment period was held to solicit agency and public comments on the Plan's Technical Foundation. A series of public workshops were held to review and discuss the Technical Foundation.
    - Three Scenario Evaluation Team meetings brought together agency personnel, interested citizens, economic interests, timber companies, local government officials, and non-profit organizations to discuss plausible recovery scenarios.
    - Four workshops were held to bring together a broad cross section of stakeholders to review and comment on regional strategies and measures.
    - Numerous presentations were made to agencies, local governments, groups, and organizations regarding recovery issues and the planning process.
    - A 60-day public comment period on the draft plan in conjunction with the NPPC subbasin plan review process.
    - A 30-day public comment period will be held on this second draft of the plan which was revised based on comments received on the earlier draft. Public workshops are also being conducted as part of this review.

1.8 Coordination with Oregon

Recovery of listed lower Columbia River salmon ESUs will require significant improvements in both Washington and Oregon populations to meet prescribed standards. This plan assumes improvements in Oregon salmon populations that represent proportional contributions to recovery based on the relative numbers and status of Washington and Oregon ESUs. Specific population improvements were identified for Oregon as placeholders for an Oregon recovery planning process and do not represent specific agreements or obligations. Assumptions were necessary for analysis of whether the Washington Recovery Scenario was consistent with recovery criteria identified by a Willamette/Lower Columbia Technical Recovery Team. These assumptions were developed in collaboration with Oregon through the Willamette/Lower Columbia Executive Recovery committee.

2 Fish and Wildlife Species

This section describes the species addressed by this plan. While fundamentally a recovery plan for listed salmon, steelhead and trout, this plan also affects other species by virtue of the broad-based ecosystem focus of salmon and trout recovery as well as the need to address Federal Columbia River hydro system impacts on a variety of fish and wildlife species. This section includes brief descriptions of the life history, status, and limiting factors for each species. Additional detail on species may be found in Appendices A and B.

2.1 Background

This plan is primarily focused on listed salmon, steelhead, and trout – all ESA-listed and candidate salmonid species are included. The plan identifies a comprehensive ecosystem-based approach to salmonid recovery involving all factors and threats that affect these species throughout their life cycle. Because restoration of freshwater habitat and habitat forming processes will be fundamental to this approach, this plan will benefit a wide variety of fish and wildlife species that are part of or are affected by lower Columbia River aquatic ecosystems.

To recognize the ecosystem scope of this effort, the plan also included a representative subset of other significant fish and wildlife species that affect salmon, are affected by salmon recovery, or are useful for characterizing watershed status, functions, or management actions. Biological objectives and strategies are identified for all species. Objectives and strategies take different forms due to inherent differences in species significance, ecological interactions, information available, and management structures in place.

Selected species address both salmonid recovery and NPCC subbasin planning purposes. NPPC subbasin planning needs include species affected by construction and operation of the federal Columbia River hydropower system. The NPCC *Technical Guide of Subbasin Planners (NPCC 2001)* identified criteria for species selection based on designation as federal endangered or threatened species; ecological significance; cultural significance; and local significance. A species list was developed by the LCFRB and the WDFW based on a review of potential candidates of interest in recovery area. As part of the joint LCFRB/LCREP effort to develop the subbasin plan for the Columbia Estuary and Lower Columbia subbasin, a Planning Group[1] was formed to further develop and refine the species list. Additional refinements were included as part of the collaborative plan development process.

The list of species was divided into broad categories that help convey the purpose and significance that individual species play in the planning process (Table 1).

Focal Species.– Listed salmon, steelhead, and trout species received the highest level of attention in this plan. These species were elevated in importance by the focus of state and federal recovery planning efforts. Salmon and steelhead are of region-wide legal, ecological, cultural, economic, and recreational importance. Life cycle requirements of salmon and steelhead have far-reaching implications to landscape-level processes and habitat conditions both within and outside of the subbasins. The plan incorporates elements of an existing bull trout recovery plan developed by the U.S. Fish and Wildlife Service into a regional context that includes other fish and wildlife species of interest.

Other Sensitive Species.– These include other species of special conservation concern. Included are other state or federally-listed threatened or endangered species that may be affected by salmon recovery actions or hydro system construction and operations. Also included are species that are subject to other special conservation protections.

Species of Ecological Interest.– This category of species is important from a management perspective or is related to the general health of the subbasins in terms of quality of the environment or habitat diversity. Individual species may be of interest because of their value as an indicator of ecosystem health or of a specific habitat type. The category also includes significant predators of salmon.

[1] NOAA Fisheries, US Fish & Wildlife Service, WA Dept of Fish & Wildlife, OR Dept of Fish & Wildlife, LCREP, LCFRB, City of Portland, Clatsop County Economic Development, CREST, USACE.

Table 1. Species included in this plan, listing status, and planning context. Ecological significance refers to species that are important components or indicators of the biotic community. Cultural significance is based on historical or current roles in society. Economic significance denotes species directly responsible for economic costs or benefits. Recreational significance identifies species where economic benefits are in the form of use.

Species	Listed[1]	Ecological[2]	Cultural	Economic[2]	Recreation
Focal Species					
Fall Chinook	FT	X	X	X	X
Chum	FT	X	X	X	X[3]
Spring Chinook	FT	X	X	X	X
Winter Steelhead	FT	X	X	X	X
Summer Steelhead	FT	X	X	X	X
Coho	FC	X	X	X	X
Bull Trout	FT	X[4]			
Other Sensitive Species					
Bald Eagle	FT	X	X		
Sandhill Crane	WE			X[5]	X
Dusky Canada Goose				X[5]	X
Col. Whitetail Deer	FE	X[4]	X		
Fisher	FS, WE	X			
Western Gray Squirrel	FS, WT	X			
Seals & Sea Lions	FT[11]	X			
Western Pond Turtle	WE				
Oregon Spotted Frog	WE	X			
Larch Mt. Salamander	FS, WS	X			
Species of Ecological Significance					
Cutthroat Trout		X		X	X
White Sturgeon		X	X	X	X
Green Sturgeon		X		X	
Eulachon		X	X	X	X
Pacific Lamprey		X	X	X	
Northern Pikeminnow		X		X[8]	X
American Shad		X[7]		X	X
Band-tailed Pigeon		X			X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
River Otter		X[9]			
Species of Recreational Significance					
Walleye[7]		X		X	X
Smallmouth Bass[7]		X		X	X
Channel Catfish[7]		X		X	X

1 Listing status: FT = Federal threatened, FE = Federal endangered, FC = Federal candidate, FS = Federal species of concern, WE = Washington endangered, WT = Washington threatened, WS = Washington sensitive.
2 May be positive or negative ecological or economic impact; this column only indicates relative significance.
3Active recreation potential (e.g., harvest).
4 Likely ecologically important historically.
5 Seasonal crop damage.
6 Historically not present.
7 Non-native species.
8 Some economic importance for control program.
9 Indicator of ecosystem health.
10 Indicator of habitat type.
11 Stellar sea lion is federally listed as threatened, harbor seals and California sea lions are not listed.

Species of Recreational Interest.– This category of non-native species is primarily of recreational interest. These species might also interact with other species of interest.

Categories highlight the primary interest in any species but are not mutually exclusive. For instance many focal, other sensitive, and recreational species are ecologically significant.

Detailed descriptions of the biology and life history of each species are found in Technical Appendix A for focal salmonid species and Technical Appendix B for other fish and wildlife species. The following subsections briefly summarize the life history and status of each species.

2.2 Focal Species

A primary focus of this plan is the recovery of Chinook salmon, chum salmon, coho salmon, steelhead, and bull trout in the Washington lower Columbia region. These salmonid species are also considered focal species for subbasin planning pursuant to the criteria provided in the NPCC's *Technical Guide of Subbasin Planners (NPCC 2001)*. Chinook salmon, chum salmon, steelhead, and bull trout are all listed as Threatened under the U.S. Endangered Species Act. Coho are a candidate species for listing with a listing decision pending. Lower Columbia River chum salmon, chinook salmon, coho salmon, and steelhead along with upper Willamette steelhead and chinook salmon comprise a Willamette/Lower Columbia domain, as part of a multispecies approach that could address common regional recovery issues.

Available evidence clearly indicates that wild salmonid populations have declined significantly. The following are estimates of current and historical population sizes. Current abundance is based on recent year adult return observations. The historic estimates are approximations based on both habitat modeling and an estimate of distribution of the historic Lower Columbia returns.

Table 2. Historical and current abundance of wild salmon and steelhead in the Washington Lower Columbia Recovery Region.

Species Group	Approximate Historical Abundance	Recent Years Wild Escapement
Spring Chinook	125,000	800
Tule fall Chinook	140,000	6,500
Bright fall Chinook	19,000	9,000
Chum	870,000	6,000
Winter steelhead	100,000	3,500
Summer steelhead	28,000	1,500
Coho	430,000	6,000

Today's small wild runs are largely supported by, or at least genetically influenced by, strays from the 20 major hatcheries in the lower Columbia region. Only a few of the many populations are still considered to be genetically wild. Data is insufficient to produce a similar assessment of historical bull trout numbers. In the Lewis River, the only lower Columbia system where bull trout populations have been documented, the population is numbered in the hundreds.

2.2.1 Chinook Salmon

Lower Columbia River Chinook (*Oncorhynchus tshawytscha*) are classified as fall or spring run based on when adults return to fresh water (Table 3). Both spring and fall runs have been designated as part of a lower Columbia River Chinook ESU that includes Oregon and Washington populations in tributaries from the ocean to and including the Big White Salmon River in Washington and Hood River in Oregon.

Table 3. Life history and population characteristics of Chinook salmon originating in Washington portions of the lower Columbia.

Characteristic	Racial Features		
	Spring	Tule fall	Late fall bright
Number of extant populations	7 (including 4 that are possibly extinct)	13	1
Life history type	Stream	Ocean	Ocean
River entry timing	March – June	August – September	August – October
Spawn timing	August – September	September – November	November – January
Spawning habitat type	Headwater large tributaries	Mainstem large tributaries	Mainstem large tributaries
Emergence timing	December – January	January – April	March – May
Duration in freshwater	Usually 12-14 months	1-4 months, a few up to 12 months	1-4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	Mainstem, tributaries, sloughs, estuary	Mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months
Ocean migration	As far north as Alaska	As far north as Alaska	As far north as Alaska
Age at return	4-5 years	3-5 years	3-5 years
Estimated historical spawners	125,000	140,000	19,000
Recent natural spawners	800	6,500	9,000
Recent hatchery adults	12,600 (1990-2000)	37,000 (1991-1995)	NA

Fall Chinook populations occur in most Washington tributaries of the lower Columbia River (Figure 1). Fall Chinook spawn in large river mainstems and are “ocean type” Chinook that emigrate from freshwater as subyearlings. Most of the fall runs are called “tules” and are distinguished by their dark skin coloration and advanced state of maturation at the time of freshwater entry in August to September; they quickly spawn in September to November. Lower river "bright” Chinook, are later-returning, later-spawning fall Chinook salmon that return to the Lewis and Sandy rivers and are less mature when they enter the Columbia than are tule fall Chinook salmon.

Historically in Washington, spring Chinook returned to the Cowlitz, Lewis, Kalama, and Big White Salmon rivers. Spring Chinook spawn in upstream tributaries of large subbasins and are “stream type” Chinook that emigrate from freshwater as yearlings. Dams have reduced or eliminated access to upriver spring Chinook spawning areas on the Cowlitz, Lewis, Clackamas, Sandy, and Big White Salmon rivers. The spring run on the Big White Salmon River was extirpated following construction of Condit Dam. Remaining naturally-spawning spring-run Chinook salmon populations are low and heavily supported by naturally-spawning hatchery fish.

Lower Columbia Chinook salmon populations began declining by the early 1900s because of habitat alterations and unsustainable high harvest rates given the changing habitat conditions. Long- and short-term trends in abundance of individual populations are mostly negative, some severely so. About half of the populations comprising this ESU are very small, increasing genetic and demographic risks. Today, the once abundant natural runs of fall and spring Chinook have been largely replaced by hatchery production. Apart from the relatively large, and apparently healthy fall-run population in the Lewis River, production in the ESU appears to be predominantly hatchery-driven with few identifiable native, naturally reproducing populations.

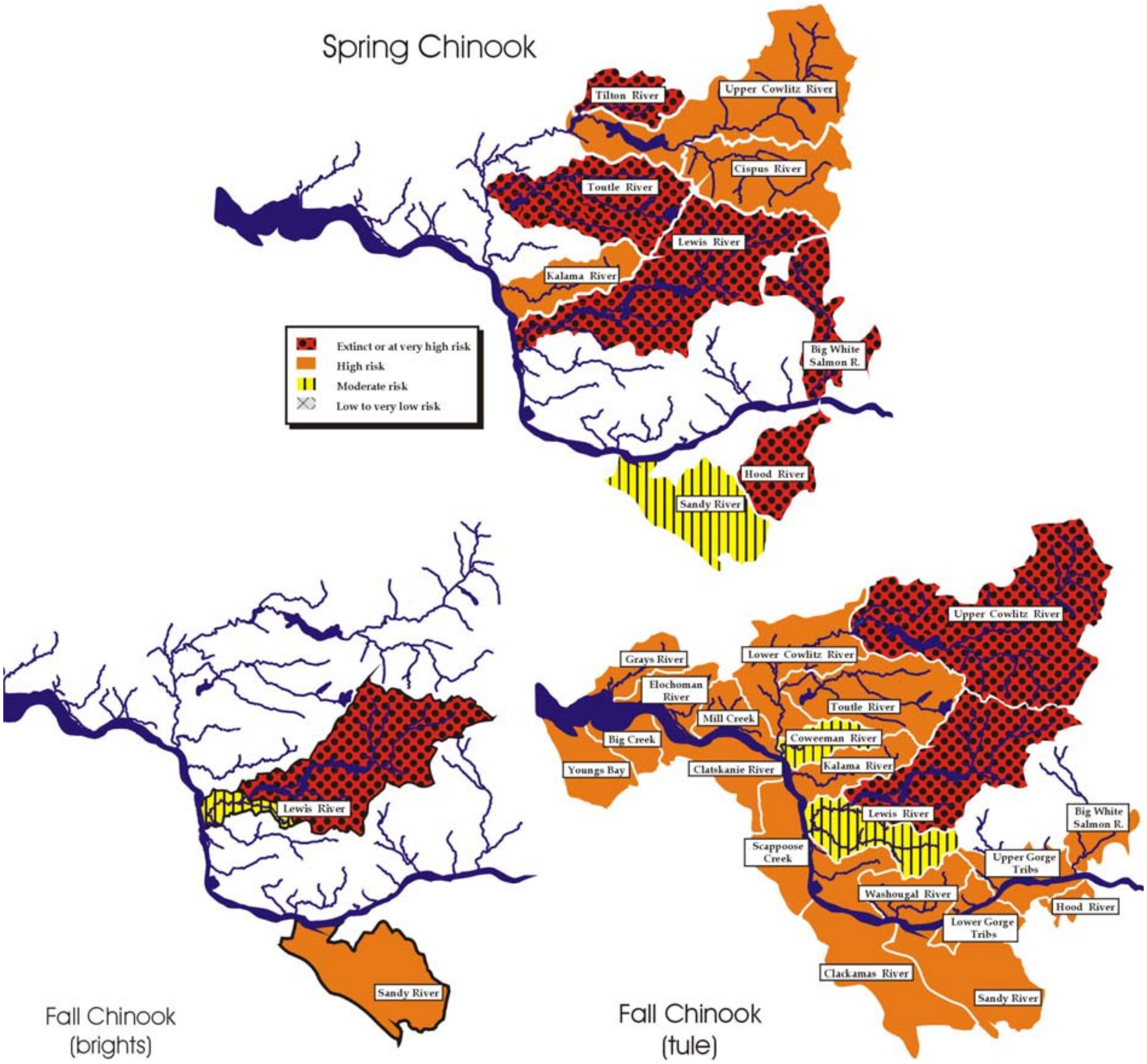


Figure 1. Historical demographically independent Lower Columbia Chinook salmon populations in the lower Columbia River ESU and their present status.

The Lower Columbia River Chinook Salmon ESU includes all native populations from the mouth of the Columbia River to the Cascade Crest, excluding populations above Willamette Falls. Exclusions from the ESU are stream-type spring Chinook found in the Klickitat River (mid-Columbia ESU) and the introduced Carson spring Chinook. Tule fall Chinook from the Wind and Little White Salmon rivers are included in the ESU, but introduced bright fall Chinook salmon populations in the Wind, White Salmon, and Klickitat rivers are not included. The

Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of chinook salmon in the Columbia River ESU. Washington accounts for seven of nine spring chinook, 13 of 20 early "tule" fall chinook, and 1 of 2 late "bright" fall chinook.

The Biological Review Team (BRT) established by National Marine Fisheries Service (NMFS) determined in 1998 that the estimated overall abundance of Chinook salmon in the lower Columbia ESU was not cause for immediate concern. However, they found that, apart from the relatively large, and apparently healthy fall-run population in the Lewis River, production in the ESU appears to be predominantly hatchery-driven with few identifiable native, naturally reproducing populations. Long- and short-term trends in abundance of individual populations are mostly negative, some severely so. About half of the populations comprising this ESU are very small, increasing the likelihood that risks because of genetic and demographic processes will be important. Numbers of naturally-spawning spring-run Chinook salmon are very low. The BRT cautioned that it is possible that some native spring Chinook runs are now extinct, but that this loss is masked by the presence of naturally spawning hatchery fish. The BRT was particularly concerned about the inability to identify any healthy native spring run populations. While studies show that genetic and life history characteristics of populations in the lower Columbia ESU still differ from those in other ESUs, the BRT identified the loss of fitness and diversity within the ESU as an important concern. The Lower Columbia River Chinook salmon ESU was listed as a threatened species under the ESA on March 24, 1999 and again proposed for listing on May 28, 2004 following changes in designations.

2.2.2 Chum Salmon

Chum salmon (*Oncorhynchus keta*) return to the Columbia River in late fall (Table 4). Chum spawn primarily in the lower reaches of rivers, digging their redds mostly along the edges of the mainstem, tributaries, or side channels. Many spawning sites are located in areas of upwelling groundwater. Chum fry emigrate from March through May shortly after emergence. Juveniles use estuaries to feed before beginning long-distance oceanic migrations. The period of estuarine residence appears to be a critical life history phase and may play a major role in determining the size of the subsequent adult run back to fresh water.

Table 4. Life history and population characteristics of chum salmon originating in Washington portions of the lower Columbia.

Characteristic	Chum salmon features
Number of extant populations	15
River entry timing	mid-October – December
Spawn timing	November – March
Spawning habitat type	Shallow, slow-moving mainstem, tributaries, or side channels
Emergence timing	February – April
Duration in freshwater	About 1 month
Rearing habitat	Edges/side channels of tributaries, mainstem, estuary
Estuarine use	Up to 4 months
Ocean migration	North Pacific and Bering Sea
Age at return	Primarily 3 & 4 years, a few 5 years
Estimated historical spawners	870,000
Recent natural spawners	6,000
Recent hatchery adults	300 (in 2002)

The lower Columbia River historically produced hundreds of thousands of chum but only a few thousand remain. Chum previously returned to tributaries as far upriver as the Walla Walla River but only a handful are now counted at Bonneville Dam. After substantial declines in the 1950s, returns remained relatively stable but low from 1956 to 2000, returns improved since 2001. The average recent year runs are less than 1% of the historical run size. Production is generally limited to areas downstream of Bonneville Dam (Figure 2). Chum salmon are presently at significant demographic risk and have likely lost much of their original genetic diversity.

NOAA Fisheries defined the Lower Columbia Chum Salmon ESU as including all naturally-spawning populations in the Columbia River and its tributaries in Washington and Oregon. The Willamette/Lower Columbia Technical Recovery Team identified 16 historical populations in the ESU. The NMFS BRT that examines the status of chum concluded that the Columbia River ESU is presently at significant risk. The BRT believes the current abundance is probably only 1% of historical levels and the ESU has undoubtedly lost some (perhaps much) of its original genetic diversity. Lower Columbia chum salmon, including all naturally-spawning populations in the Columbia and its tributaries in Washington and Oregon, were officially listed as threatened on March 25, 1999 and again proposed for listing on May 28, 2004 following changes in designations.

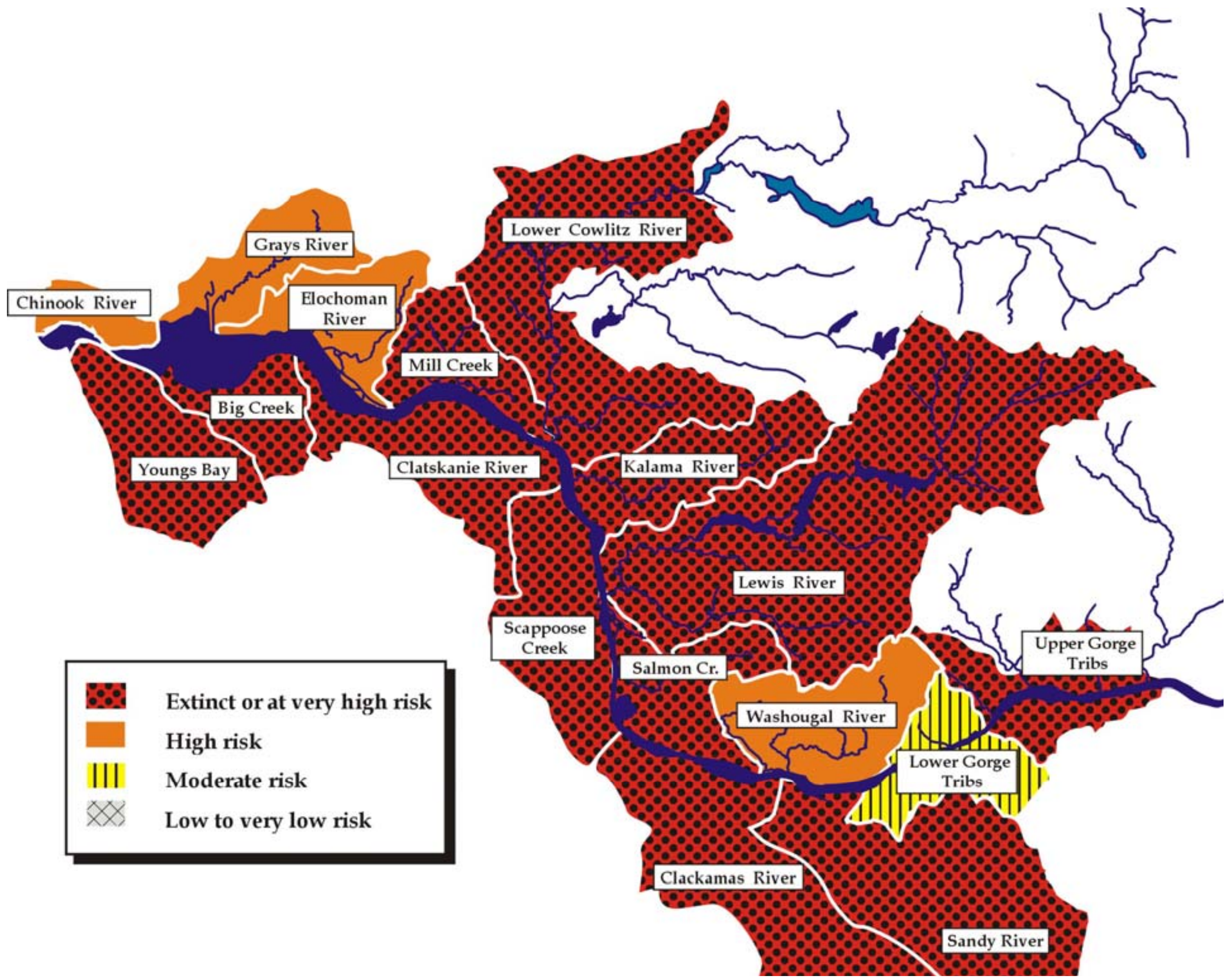


Figure 2. Historical demographically independent chum salmon populations in the lower Columbia River ESU.

2.2.3 Coho Salmon

Lower Columbia adult coho salmon (*Oncorhynchus kisutch*) return in late summer to late fall and spawn in fall or early winter. Eggs incubate over late fall and winter, juveniles rear in freshwater for more than a year, smolts leave freshwater in April – June of their second year, and immature fish spend 1.5 years feeding in coastal oceans. Two general coho stocks are present in the lower Columbia River today (Table 5): Type S refers to an ocean distribution generally south of the Columbia River with an early adult run timing in the Columbia River. Type N refers to an ocean distribution generally north of the Columbia River with a late run timing in the Columbia River.

Table 5. Life history and population characteristics of coho salmon originating in Washington portions of the Lower Columbia.

Characteristic	Racial Features	
	Early – Type S (south migrating)	Late – Type N (north migrating)
Number of extant populations	18	
River entry timing	mid-August – September	late September – December
Spawn timing	mid-October – early November	November – January
Spawning habitat type	Higher tributaries	Lower tributaries
Emergence timing	January – April	January – April
Duration in freshwater	12-15 months	12-15 months
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	Smaller tributaries, river edges, sloughs, off-channel ponds
Ocean migration	Coastal Washington, Oregon, Northern California	Coastal British Columbia, Washington, Oregon
Age at return	3 years, some 2-year jacks	3 years, some 2-year jacks
Estimated historical spawners	430,000	
Recent natural spawners	6,000 – mostly of hatchery origin	
Recent hatchery adults	4,800 (1987) - 91,400 (2001)	11,800 (1995) - 177,900 (2001)

Historically, coho were present in all lower Columbia River tributaries (Figure 3). Currently, very few wild coho salmon spawn in lower Columbia River subbasins and a number of local populations have become extinct. Coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. Widespread inter-basin (but within ESU) stock transfers have homogenized many populations. Unique natural populations of coho salmon can no longer be genetically distinguished in the lower Columbia River (excluding the Clackamas and Sandy rivers in Oregon), or along the Washington coast south of Point Grenville. The NOAA Fisheries Biological Review Team tentatively identified 25 historical lower Columbia River coho populations of which 18 occur in Washington.

In a 1995 status review of coho salmon, National Marine Fisheries Service (NMFS) found that, if an evolutionarily significant unit of coho salmon still exists in the lower Columbia River, it is not presently in danger of extinction, but is likely to become so. NOAA Fisheries was subsequently petitioned to list Lower Columbia coho salmon on an emergency basis and to designate critical habitat. They determined that the petition presented substantial scientific information that a listing may be warranted, but there was insufficient evidence to support an emergency listing. Lower Columbia coho were proposed for listing on May 28, 2004.

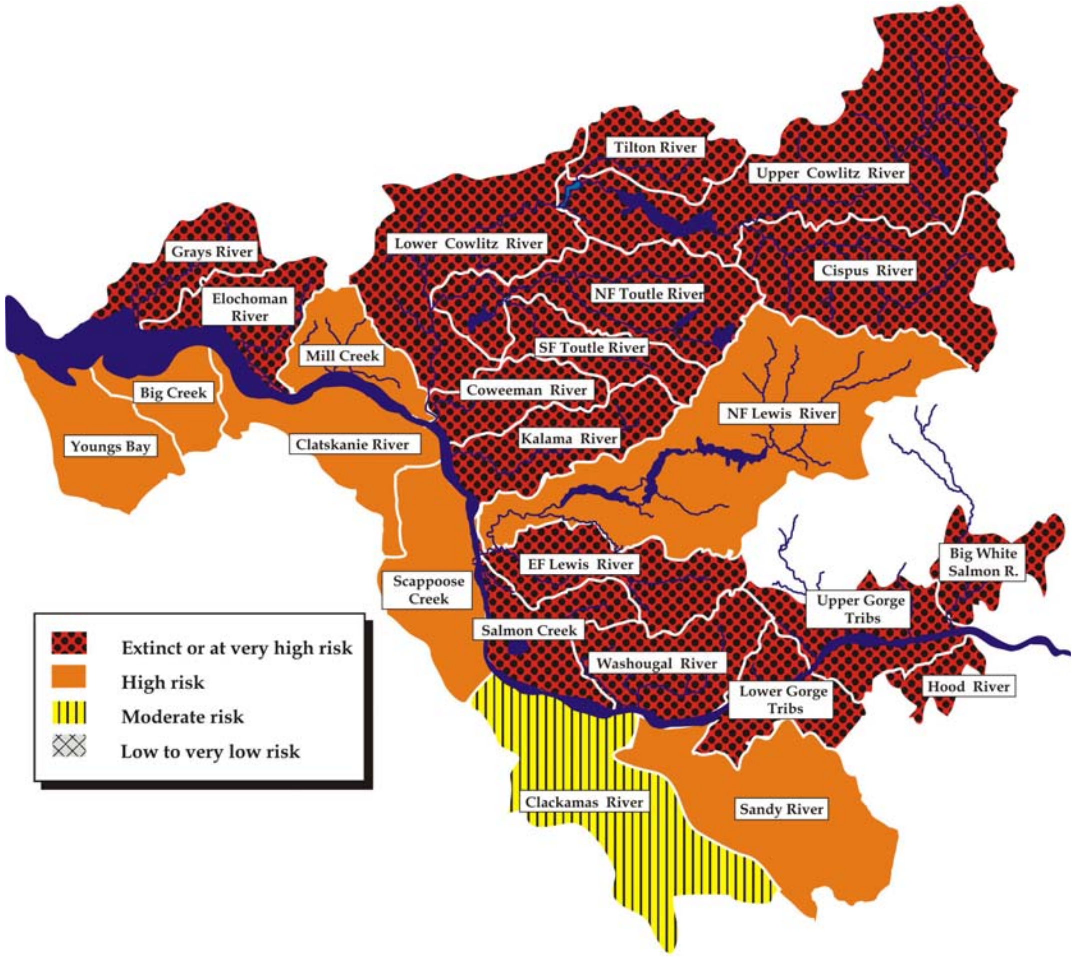


Figure 3. Distribution of historical coho salmon populations among Washington lower Columbia River subbasins.

2.2.4 Steelhead

Steelhead (*Oncorhynchus mykiss*) are rainbow trout that migrate to and from the ocean. Lower Columbia River steelhead include summer and winter runs (Table 6). Summer steelhead return from the ocean between May and November and generally spawn between January and June. Winter steelhead return to freshwater between November and April and generally spawn sometime during the months of March to June. Summer steelhead tend to spawn higher in the watershed than winter steelhead. Headwater areas are often inaccessible to winter steelhead because of natural barriers that are not passable during high flows common during winter steelhead migration. These barriers are often passable during the lower flow conditions when summer steelhead are migrating upstream.

Winter steelhead were historically present in all lower Columbia River subbasins (Figure 4) and also return to other Columbia River tributaries as far upriver as Oregon's Fifteenmile Creek. Summer steelhead were also present in some Washington lower Columbia River tributaries. Most of the aggregate Columbia River steelhead run is comprised of summer fish destined for inland tributaries.

Naturally-producing steelhead populations remain in most subbasins but numbers have been much reduced. Historical steelhead production in Washington basins of the lower Columbia River is believed to have been substantial. For example, total run size for steelhead in the

Cowlitz River alone was estimated to exceed 20,000 fish and 10,000 or more may have been produced in the Lewis basin. Major hydro projects in the Cowlitz and Lewis basins have blocked access to approximately 80% of the historical steelhead spawning and rearing habitat within both basins.

Table 6. **Life history and population characteristics of steelhead trout originating in Washington portions of the lower Columbia.**

	Racial Features	
Characteristic	**Summer steelhead**	**Winter steelhead**
Number of extant populations	5	14
River entry timing	May – November	November – April
Spawn timing	January – June	March – early June
Spawning habitat type	Clear water rivers and tributaries in upper watersheds	Clear water rivers and tributaries
Emergence timing	8-9 weeks after spawning, March – July	8-9 weeks after spawning, March – July
Duration in freshwater	1-3 years (mostly 2), smolt in April – June	1-3 years (mostly 2), smolt in April – June
Rearing habitat	River and tributary main channels	River and tributary main channels
Estuarine use	Briefly in the spring, peak abundance in May	Briefly in the spring, peak abundance in May
Ocean migration	North to Canada and Alaska, and into the North Pacific, along the continental shelf	North to Canada and Alaska, and into the North Pacific, along the continental shelf
Age at return	3 – 5, occasionally 6 years	3 – 5, occasionally 6 years
Estimated historical spawners	28,000	100,000
Recent natural spawners	1,500	3,500
Recent hatchery adults	1,900 (approximate average annual total returns to six lower Columbia hatcheries, 1995-2002)	9,200 (approximate average annual total returns to six lower Columbia hatcheries, 1995-2002)

Steelhead found in the lower Columbia River in Washington (as delineated by this recovery plan) fall into three separate ESUs defined by NMFS:

- The Southwest Washington ESU includes steelhead from the Grays and Elochoman rivers, and Skamokawa, Mill, Abernathy, and Germany creeks.
- The Lower Columbia ESU includes steelhead from the Cowlitz, Kalama, Lewis, Washougal, and Wind rivers and Salmon and Hardy creeks.
- The Middle Columbia ESU includes steelhead from the Little White Salmon and Big White Salmon rivers.

The Lower Columbia steelhead ESU has been listed as threatened under ESA and again proposed for listing on May 28, 2004 following changes in designations. The Willamette/Lower Columbia Technical Recovery Team has identified 23 historical populations in this ESU. Washington accounts for 5 of 6 summer and 14 of 17 winter steelhead populations. The listed ESU includes only naturally spawned populations of steelhead residing below naturally and man-made impassable barriers (e.g., impassable waterfalls and dams). The Southwest Washington steelhead ESU is not thought to be in danger of extinction. Therefore, the Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany populations are not listed under the ESA. However, all of the Columbia River populations in the Southwest Washington ESU were categorized as depressed by WDFW in 2002, with the exception of Mill Creek, which was listed as unknown.

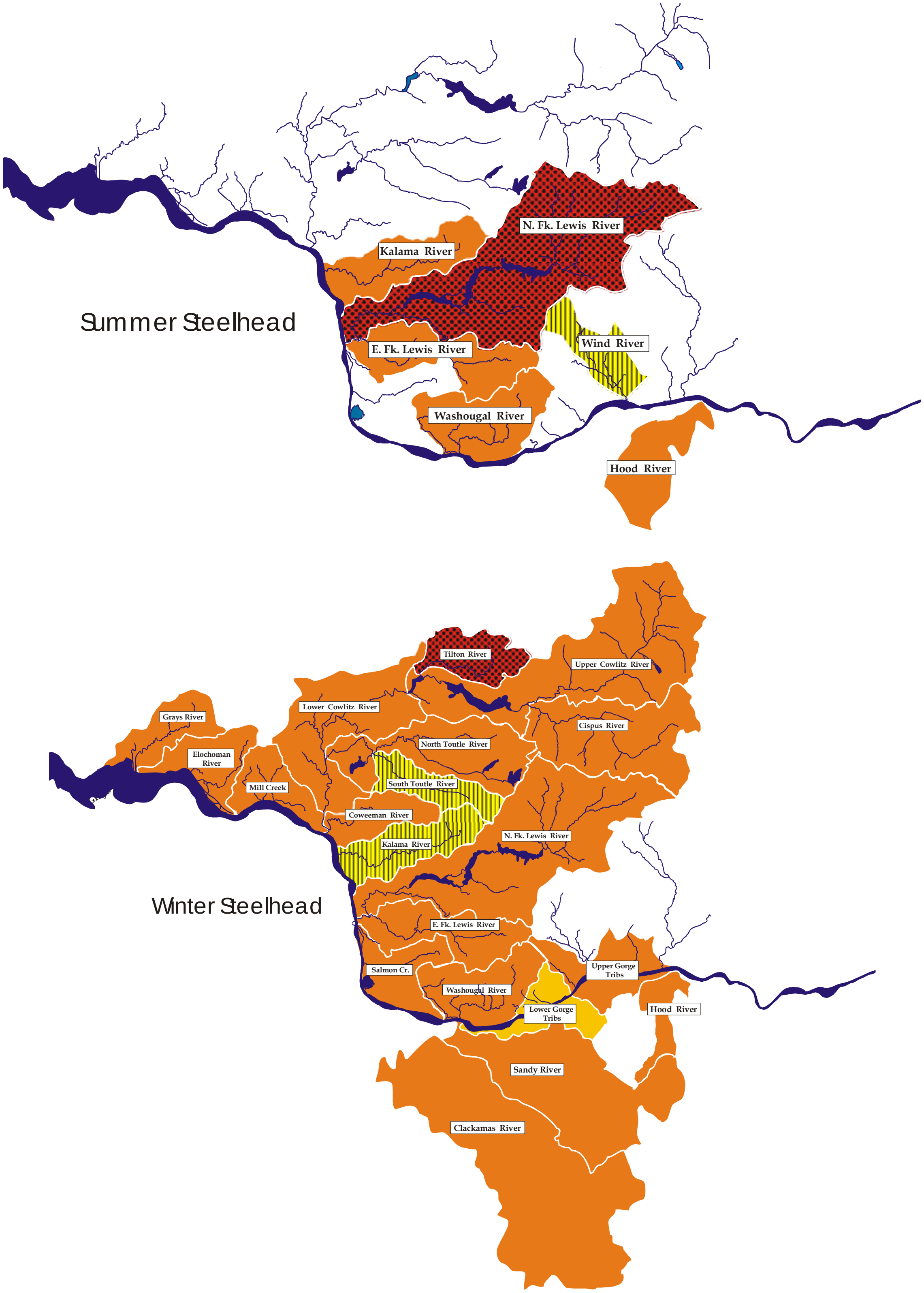


Figure 4. Historical demographically independent summer (upper) and winter steelhead (lower) populations in the lower Columbia River ESU.

2.2.5 Bull Trout

Bull trout (*Salvelinus confluentus*) are found primarily in cold streams; water temperature is consistently a principal factor influencing distribution of bull trout in many streams. Resident and migratory forms are known to coexist in the same subbasin or even in the same stream (Table 7). Resident forms live out their lives in the tributary where they were born and in nearby streams. Freshwater migratory forms include both fluvial and adfluvial strategies. The fluvial form migrates between main rivers and tributaries; the adfluvial form between lakes and streams. In the lower Columbia River, bull trout may exhibit resident or freshwater migratory life history patterns; anadromous bull trout have not been observed.

Table 7. Life history and population characteristics of bull trout originating in Washington portions of the lower Columbia.

Characteristic	Life History Form	
	Migratory	Resident
Number of extant populations	20 subpopulations	
Upstream spawning migration	April – September	April – September
Spawn timing	Early fall	Early fall
Spawning habitat type	Runs and tail-outs	Runs and tail-outs
Emergence timing	January – May	January – May
Natal area rearing	1-3 years	5-7 years
Downstream migration of juveniles	April - November	NA
Rearing habitat	Lake or large river	Headwater streams, higher gradient
Lake/river residence	2-6 years	NA
Age at spawning	4-12 years with annual or intermittent spawning	4-12 years with annual or intermittent spawning
Natural spawners	~10-40 in Cougar Creek, Yale Reservoir, Lewis River (1988-2003) ~100-900 in Rush/Pine Creeks, Swift Reservoir, Lewis River (1994-2003)	Unknown
Hatchery adults	None	None

Status of bull trout is difficult to ascertain because data are scarce. Adfluvial populations exist in Yale and Swift reservoirs in the Lewis River system. Bull trout have been reported in the Little White Salmon basin but never above Little White Salmon National Fish Hatchery. Populations might have historically inhabited the Cowlitz and Kalama subbasins, but no records of occurrence exist.

Because of widespread distribution, isolated populations, and variations in life history, bull trout populations are grouped by distinct population segments (DPS). Bull trout are also grouped by recovery units, which serve as subsets of a DPS. On June 10, 1998, the USFWS issued a final rule announcing the listing of bull trout in the Columbia and Klamath river basins as threatened under the ESA. According to WDFW, the bull trout populations in the Lewis River basin are considered at moderate risk of extinction. Within the Columbia River Basin Bull Trout DPS, the Lower Columbia River Recovery Unit includes the Lewis River and Klickitat River core areas in Washington. The Lewis River Core Area consists of the mainstem Lewis River and tributaries downstream to the confluence with the Columbia River, with the exclusion of the East Fork of the Lewis River. The Klickitat River Core Area includes the Klickitat River and all tributaries downstream to the confluence with the Columbia River. In the two core areas, local populations of bull trout exist in Cougar, Pine, and Rush creeks (tributaries of the Lewis River) and the West Fork of the Klickitat River. No local populations have been identified in the White Salmon River, but that area contains core habitat and, after migratory obstructions are addressed, could support bull trout that migrate from the Columbia River.

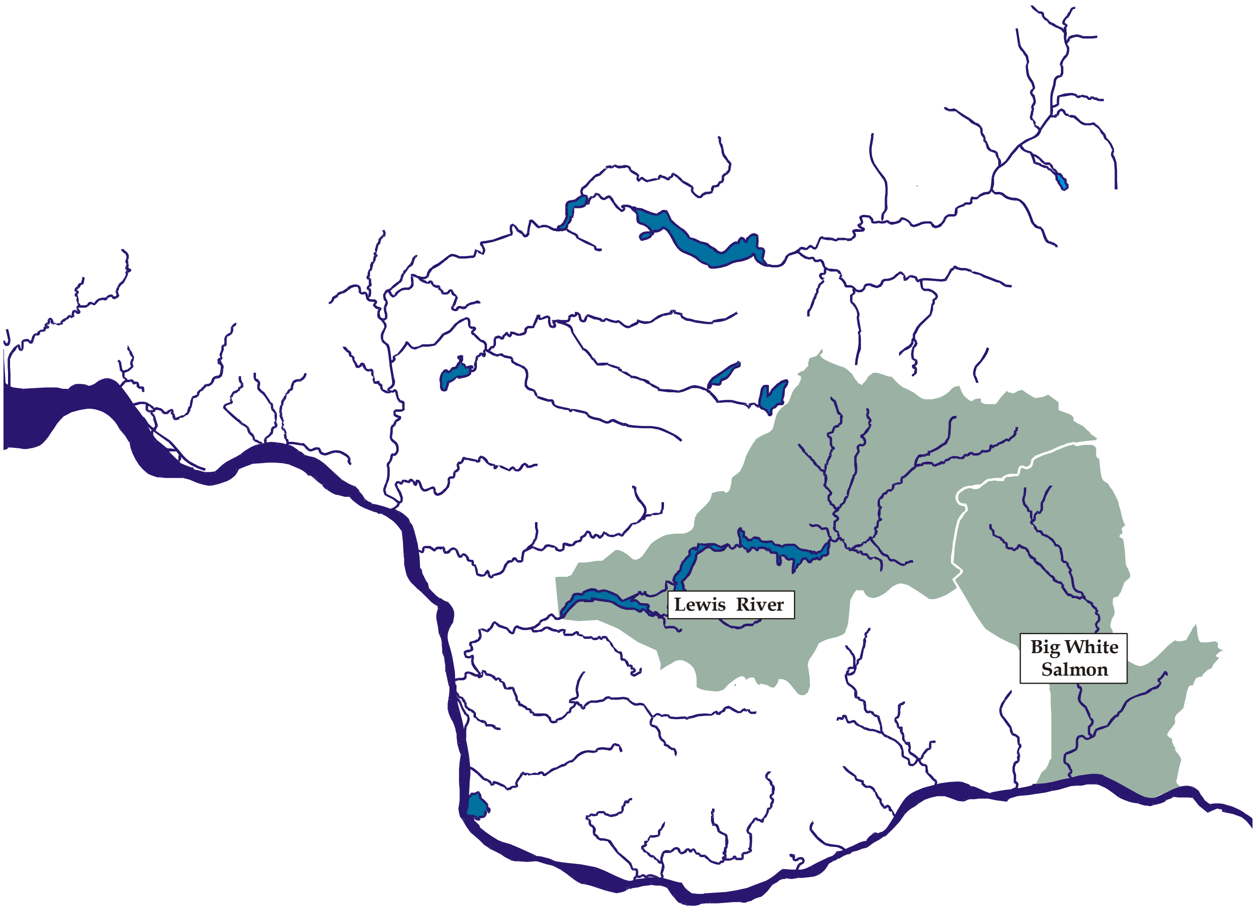


Figure 5. Distribution of historical bull trout populations among lower Columbia River subbasins.

2.3 Other Sensitive Species

2.3.1 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) were listed as endangered under the Endangered Species Act in 1978. In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized. Bald eagles are distributed throughout North America, breeding in most of their range. Resident and migratory bald eagles are found along the lower Columbia River. Breeding birds are year-round residents and do not migrate during the winter. All bald eagle nest sites in this area have been monitored for productivity since the late 1970s, and in recent years there were 96 occupied breeding territories. The area supports an additional wintering population of over 100 eagles. The lower Columbia River bald eagle population is one of only two regional populations in Washington that has exhibited low reproductive success representative of a decreasing population (the other regional population was in Hood Canal).

2.3.2 Sandhill Crane

The sandhill crane (*Grus Canadensis*) was listed as an endangered species by the State of Washington in 1981. The species was extirpated as a breeder from the state around 1941 by widespread habitat destruction and unregulated hunting. Cranes were again found summering in 1972 in Klickitat County, but it was not until 1979 that nesting was confirmed. Sandhill cranes were not historic breeders in the lower Columbia River, buy have always used the area for staging in migration and wintering. Approximately 2000-3000 sandhill cranes now use the lower Columbia River bottomlands during spring and fall migration..

2.3.3 Dusky Canada Goose

The dusky Canada goose (*Branta canadensis occidentalis*) is a distinctive race of medium size (about 6 lb) and dark brown plumage, that nests on the Copper River Delta, Alaska, migrates through southeastern coastal Alaska and coastal British Columbia, and winters primarily in southwestern Washington and western Oregon. Dusky Canada geese numbers began an abrupt decline after the 1964 Alaska earthquake raised the elevation of nesting area wetlands which precipitated a series of successional vegetation changes and also increased predation. A network of federal and state waterfowl refuges were established in the mid-1960s to provide attraction and protection. In the late 1990s, a group of landowners, agency personnel, and others also formed the Canada Goose Agricultural Depredation Working Group and developed a management plan to deal with increasing goose numbers and impacts on habitats. The plan outlines strategies to reduce numbers of several subspecies, protect the dusky subspecies, improve habitat on public lands, outline critical habitats for acquisition, and quantify the dollar value of agricultural crop losses.

2.3.4 Columbia Whitetail Deer

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*), a subspecies of the white-tailed deer, is on the federal Endangered Species List and is classified as endangered under Washington and Oregon state laws. This deer once ranged from Puget Sound to southern Oregon, where it lived in floodplain and riverside habitat. Habitat conversion and losses coupled with low productivity of the population are the most important threats now to the subbspecies. A recovery team, consisting of members from USFWS, Oregon Department of Fish and Wildlife

(ODFW), WDFW, and Oregon State University (OSU), has completed a Recovery Plan for Columbian white-tailed deer. The plan delineates the need to create three stable, secure, viable subpopulations. Recovery goals identify the need to secure additional habitat for population reintroduction, enforce hunting rules, and manage publicly owned lands.

2.3.5 Fisher

The fisher (*Martes pennanti*) is a Washington state endangered species and a federal species of concern. Overtrapping, and loss and alteration of habitats are considered the most significant reasons for the decline of fishers in Washington. Although extensive surveys for fishers have been conducted throughout their historical range, no known population of fishers exists in Washington. The apparent absence of fishers in Washington represents a significant gap (i.e., lack of population continuity) in the species range from Canada to Oregon and California. Riparian habitats, especially those with large diameter snags, live trees and downed logs, are considered high quality habitats for fishers, especially for resting and reproduction.

2.3.6 Western Gray Squirrel

The western gray squirrel (*Sciurus griseus*) is a Washington state threatened species and a Federal species of concern. Although the western gray squirrel was once abundant and widespread throughout oak-conifer forests, its range in Washington State has contracted to three disjunct populations. Population loss and fragmentation is largely due to disease (i.e., mange) associated with invasion of California ground squirrels and seasonal weather differences, which effect acorn production. Habitat loss and degradation is also a likely long-term factor. In the future, competition from the introduced eastern grey squirrel may also be an issue. In a 2003 Status Review and 12-month finding for a petition to list the Washington population of the western gray squirrel (68 FR 34682), the USFWS concluded that listing was not warranted because the Washington population of western gray squirrels is not a distinct population segment and, therefore, not a listable entity. The WDFW is in the process of writing a draft recovery plan, which is expected to be due out for public review in 2004.

2.3.7 Seals and Sea Lions

Harbor seals, Stellar sea lions, and California sea lions are seasonal residents of the lower Columbia River. Stellar sea lions are listed as federally endangered. Most seals and sea lions are concentrated in or near the estuary but individuals regularly range as far upstream as Bonneville Dam and Willamette Falls. Sea lions regularly travel long distances and marked individuals have been observed to travel between Washington, Oregon, and California. Following the adoption of the Marine Mammal Protection Act, seals and seas lions recovered steadily from critically low population sizes. These animals were historically regarded as a nuisance by fishers and were regularly shot or harassed. Seals and sea lions are predators on fish but diet studies indicate that non-salmonids comprise the majority of the diet. However, seals and sea lions do consume significant numbers of adult salmon and steelhead during some periods. Individual animals can become a fish passage problem where fish are artificially concentrated in the vicinity of locks, dams, and fish ladders.

2.3.8 Western Pond Turtle

The western pond turtle (*Clemmys marmorata*) is listed by Washington State as an endangered species. The species is not listed under the federal Endangered Species Act. This species was essentially extirpated in the Puget lowlands by the 1980s and their present range in

Washington is limited to two small populations in Skamania and Klickitat counties. In addition, two reintroduced populations are now currently found, one in south Puget Sound and one in the Columbia River Gorge.

2.3.9 Oregon Spotted Frog

The Oregon spotted frog (*Rana pretiosa*) is a Pacific Northwest endemic recently differentiated from a close relative, the Columbia spotted frog (*Rana luteiventris*). This species is listed as endangered in the State of Washington and is a federal candidate for protection under the Endangered Species Act. In Washington, the Oregon spotted frog was historically found in the Puget Trough from the Canadian border to the Columbia River and east into the southern Washington Cascades. Only one of eleven historically known population and two recently discovered populations are known to remain in Washington. Factors have included loss of wetland habitat and predation by introduced warmwater fish species (Centrarchidae, Percidae, and Ictaluridae) and the bullfrog (*Rana catesbeiana*).

2.3.10 Larch Mountain Salamander

The Larch Mountain salamander (*Plethodon larselli*) occurs only in Washington and Oregon. Its known distribution includes west-side habitats of the southern Cascades region in Washington and the Columbia Gorge area of Oregon and Washington. Populations of Larch Mountain salamanders are small, isolated, and occur in a limited geographic area. Larch Mountain salamanders depend on cool, moist environments; they require a suitable combination of slope, rock size, shade, and organic debris. Because the habitats preferred by these salamanders are naturally discontinuous, they are vulnerable to disturbances such as logging, rock extraction, and inundation that can alter these habitats and make them unsuitable. For these reasons, the Larch Mountain salamander is a Federally-listed species of concern as well as a sensitive species in the states of Washington and Oregon.

2.4 Species of Ecological Significance

2.4.1 Cutthroat Trout

Cutthroat trout (*Oncorhynchus clarki clarki*) are widely distributed in Washington lower Columbia River tributary systems, in both sea-run and resident forms. Cutthroat trout can rear to maturity in salt or fresh water, migrate large distances, remain in their natal area throughout their life, or exhibit any combination of these behaviors. Because most individuals are either resident or use small streams for a significant portion of their life, cutthroat trout are more affected by local habitat conditions than by mainstem Columbia River and estuary effects. Anadromous, fluvial, and resident life history forms of coastal cutthroat are reported in all Lower Columbia River drainages, and anadromous individuals are either documented or thought to be present in all Washington tributaries of the Columbia downstream of Bonneville Dam. Cutthroat have been documented in over 1,300 locations within the lower Columbia region. The total abundance of coastal cutthroat trout in the lower Columbia basin is difficult to estimate because of their wide range of life history types and poor data availability. However, numbers have declined in almost all lower river tributaries over the past 10–15 years. The USFWS has declined to list the Southwestern Washington/Columbia River DPS of the Coastal Cutthroat Trout as Threatened because some populations are relatively healthy and because of the ability of freshwater forms to produce anadromous progeny. However, WDFW describes cutthroat as depressed in all rivers entering the Columbia from its mouth to the Kalama River, citing either long-term negative trends or short-term severe declines.

2.4.2 White Sturgeon

White sturgeon (*Acipenser transmontanus*) live in large rivers along the Pacific coast of North America and move freely between freshwater and the ocean where they may remain for variable but prolonged periods. White sturgeon historically ranged all the way to the Canadian headwaters of the Columbia River and to Shoshone Falls in the upper Snake River. Columbia River white sturgeon were severely over-fished during the late 1800's prior to the adoption of significant fishery restrictions. Recovery required decades. The lower Columbia population is now among the largest and most productive sturgeon populations in the world and sustains excellent sport and commercial fisheries. However, many upriver populations have declined or disappeared. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey. Bonneville Reservoir continues to support a significant white sturgeon population although numbers and sizes are substantially less than in the lower river. Only the Kootenai River subpopulation of white sturgeon has been listed under the Endangered Species Act (endangered).

2.4.3 Green Sturgeon

Green sturgeon (*Acipenser medirostris*) also occur in the lower Columbia River but rarely range far upstream from the estuary. Green sturgeon are among the most ocean-going of the sturgeons, leaving freshwater around 1-4 years of age and generally only returning to spawn. Green sturgeon do not spawn in the Columbia River but originate from spawning populations in the Sacramento, Klamath, and Rogue rivers. Large numbers of sub-adult and adult green sturgeon gather in the Columbia River estuary during summer and early fall, and individuals are occasionally observed as far upriver as Bonneville Dam. NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted but green sturgeon remain a candidate species.

2.4.4 Eulachon

Eulachon or smelt (*Thaleichthys pacificus*) swarm into the lower Columbia River and tributaries to spawn during winter and early spring. Eulachon are a small, anadromous forage fish inhabiting the northeastern Pacific Ocean from Monterey Bay, California, to the Bering Sea and the Pribilof Islands. Huge schools of smelt spawn in the Columbia and Cowlitz mainstems during most years. Pulses of spawners are also seen sporadically in other tributaries including the Grays, Lewis, and Sandy. Smelt support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gill-net fishery in the Columbia. Smelt are eaten in large numbers by other fishes including sturgeon, birds, and marine mammals. Smelt numbers and run patterns can be quite variable and low runs followed ocean El Niños during the 1990's.

2.4.5 Pacific Lamprey

Pacific lamprey (*Entosphenus tridentatus*) are a native anadromous inhabitant of Pacific Northwest rivers including the Columbia. Lamprey spawn in small tributaries, historically as far upstream as Idaho and British Columbia, and die after spawning. Young lamprey, called ammocoetes, are algae filter feeders that burrow in sandy stream margins and side channels for up to 6 years before downstream migration. Adults are predators that feed only in the ocean and attach themselves to their prey with suction mouths. Relatively little is known about the status of Pacific lamprey. Most data suggests that populations in the Columbia basin have declined concurrent with hydroelectric development and other habitat changes.

2.4.6 Northern Pikeminnow

The northern pikeminnow *(Ptychocheilus oregonensis)* are large (10-20 inches), long-lived (10-15 years), predaceous minnows that are native to freshwater lakes and rivers of the Pacific slope of western North America from Oregon to northern British Columbia.. This opportunistic species has flourished with habitat changes in the mainstem Columbia River and its tributaries. Salmonids are a seasonal food of large pikeminnow and millions of juvenile salmonids are estimated to fall prey each year. Predation can be especially intense in dam forebays and tailraces were normal smolt migration behavior is disrupted by dam passage. A pikeminnow management program has been implemented in the Columbia and Snake rivers since the early 1990s in an attempt to reduce predation mortality by reducing numbers of the large, old pikeminnow that account for most of the losses.

2.4.7 American Shad

Millions of American shad (*Alosa sapidissima*) have colonized the Columbia River after their introduction from the East Coast into California's Sacramento River during the 1870s. Two to four million shad are counted at Bonneville Dam fish each year. Numbers increased steadily until the 1990s as passage improvements for salmon increased access to upriver reservoirs. Shad numbers now appear to have leveled off with some fluctuation based on annual conditions. Shad provide a significant sport fishery and some commercial fishing opportunity although market demand is limited and it is difficult to commercially harvest large numbers of shad without impacting wild salmon. Shad have also become an important link in the Columbia River food web. Divergent trends in shad and salmon numbers occur primarily because the same habitat changes that favor shad are detrimental for salmon but interactions among these species are poorly understood.

2.4.8 Band-tailed Pigeon

Band-tailed pigeons (*Columba fasciata*) are found in coniferous forest zones of mountainous areas of western North America including much of Western Washington. The band-tailed pigeon requires mineral springs as a source of calcium for egg-laying and the production of crop-milk for its young. The proximity of these mineral springs to suitable foraging habitats is an important limiting factor. Band-tailed pigeons are listed as a State and Federal Game species. Breeding Bird Survey data indicated the population of band-tailed pigeons in Washington declined significantly from 1968 to 1993. The hunting season in Washington underwent an emergency closure in 1991 due to a rapid decline in the population as determined from pigeon surveys. However, more recent data showed increases in population that allowed the reinstatement of a limited hunting season in 2002, after a 10-year restriction on hunting. A scarcity of mineral sites combined with the alteration of available nesting habitat jeopardizes band-tailed pigeon populations. Intensive hunting pressure in the past has also been held responsible for declines in the population.

2.4.9 Caspian Tern

Caspian terns (*Sterna caspia*) are a highly migratory species that are distributed throughout the world and present in large numbers in the Columbia River estuary. The species is not listed but is of conservation concern because of the concentration of breeding terns at relatively few sites and and ecological concern because of predation on listed salmon. Protection is provided by the Migratory Bird Treaty Act (1918) in the United States, the Migratory Bird Convention Act (1916) in Canada, and the Convention for the Protection of Migratory Birds and Game

Mammals (1936) in Mexico. Currently two-thirds of the Pacific Coast and one-quarter of the North American population nests in the Columbia River estuary. Dredging the navigational channel created several estuary islands that have been colonized by the birds. A series of Caspian tern management activities have been implemented to encourage significant numbers of nesting terns to nest on East Sand nearer the ocean where diet is more diverse than upstream at Rice Island where predation on salmonids is more significant.

2.4.10 Osprey

The osprey (*Pandion haliaetus*) is a large piscivorous bird of prey that nests and feeds along the lower Columbia River in spring and summer. Ospreys have nearly worldwide breeding distribution; birds that breed in the Pacific Northwest migrate to wintering grounds in southern Mexico and northern Central America. Ospreys nest in forested riparian areas along lakes, rivers, or coastlines; nests are situated atop trees, rock pinnacles, or artificial structures such as channel markers or power/light poles. Adult pairs are thought to mate for life and return to the same area annually for breeding. Along the lower Columbia River during 1997 and 1998, osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population. Ospreys feed almost exclusively on fish and are not particular about the species of fish they consume. In the lower Columbia and Willamette rivers, largescale suckers are an important part of the osprey's diet.

2.4.11 Yellow Warbler

Yellow warblers (*Dendroica petechia*) are an excellent indicator of riparian zone structure and function. They are a riparian obligate species most strongly associated with wetland habitats that contain Douglas spirea and deciduous tree cover. Within Washington, yellow warblers are apparently secure and are not of conservation concern.

2.4.12 Red-eyed Vireo

The red-eyed vireo (*Vireo olivaceus*) is locally common in riparian growth and strongly associated with tall, somewhat extensive, closed canopy forests of cottonwood, maple, or alder in the Puget Lowlands and along the Columbia River in Clark and Skamania Counties. Within Washington, the red-eyed vireo is locally common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The red-eyed vireo is an excellent indicator of riparian zone structure and function.

2.4.13 River Otter

The river otter (*Lutra canadensis*) is a top predator of most aquatic food chains that has adapted to a wide variety of aquatic habitats, from marine environments to high mountain lakes of North America. The river otter is a year-round resident of the lower Columbia River mainstem and estuary, although field observations and trapper data indicate that population numbers are relatively low. Otters on the lower Columbia River concentrate their time in shallow, tidal influenced back waters, sloughs, and streams throughout the estuary. Otter home ranges (approximately 11 river miles) are largely defined by local topography and overlap extensively. Otter diets vary seasonally and generally consist of a wide variety of fish species and aquatic invertebrates such as crabs, crayfish, and mussels.

2.5 Species of Recreational Significance

2.5.1 Walleye

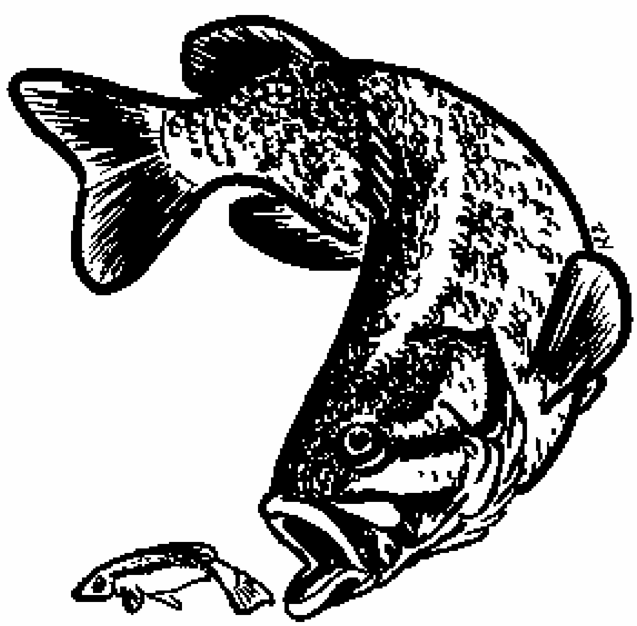
Walleye (*Stizostedium vitreum*) were introduced from the Mississippi River basin into the Grand Coulee area and over the last 40 years have gradually expanded downriver until significant populations are now found throughout the lower Columbia. Distribution in the lower Columbia is patchy. Walleye are every bit as voracious a predator on salmon smolts as pikeminnow but are not subject to the sport reward fishery program because predation is by small walleye that are not particularly vulnerable to the effects of fishing. A sport fishery for walleye has been gradually growing in the lower Columbia River since the early 1980s.

2.5.2 Smallmouth Bass

Because of their popularity with anglers, smallmouth bass (*Micropterus dolomeiui*) have been extensively transplanted throughout the continental United States including the Pacific Northwest. Numbers are generally small downstream from Bonneville Dam but greater in upstream reservoirs that have created large amounts of favorable slow water habitat where rocky shorelines and substrate provide structure. Smallmouth bass are omnivorous and occasionally eat juvenile salmonids although they do not comprise a large proportion of the diet except in a few areas (e.g. fall Chinook rearing areas of the Hanford Reach).

2.5.3 Channel Catfish

Channel catfish (*Ictalurus punctatus*) are another species that have been widely introduced outside this native range and can be found almost everywhere in the United States including the Pacific Northwest. Although channel catfish have inhabited Washington waters for more than a century, their abundance and distribution remain very limited. Small numbers of channel catfish can be found in some areas of the lower Columbia.



3 Limiting Factors and Threats

The combination of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations, has resulted in reduced Columbia River salmonid populations. Other fish and wildlife species have also been affected – many have decreased in numbers but others have increased. Understanding the threats and limiting factors and how they function is essential to the development of recovery actions. Thorough overviews of the threats and limiting factors have been provided in Volume I, Chapter 3 of the Technical Foundation. Extensive details of the local threats and limiting factors in each subbasin are presented in Volume II of the Technical Foundation.

This chapter summarizes the limiting factors and ongoing threats to salmon, steelhead, and trout species. Limiting factors are described in relation to the biological needs of the species, and the threats are those activities that lead to the limiting factors. By identifying the threats to recovery, specific recovery strategies and measures can be developed which would guide actions at the subbasin level to mitigate the threats. Limiting factors and threats for salmon and steelhead are described under the broad categories of stream habitat, mainstem and estuary habitat, hydropower, harvest, and hatchery operations. Limiting factors and threats are also summarized for other fish and wildlife species.

3.1 Habitat –Streams

3.1.1 Background

Healthy stream habitat is critical for recovering and sustaining populations of salmon, steelhead and trout in the lower Columbia region. Many essential habitat features have been altered or degraded by human activities such as dams, logging, agriculture, urban development, road building, gravel mining, channelization, and water withdrawals.

Properly functioning conditions (PFC) represent favorable or optimum habitat for salmon as described by NOAA Fisheries in the “matrix of pathways and indicators” approach to assessing habitat (NMFS 1996). PFCs generally represent a reasonable upper bound of the potential for habitat improvement although, in some cases, the large-scale changes required would be difficult to implement (e.g., levee removal). The attainment of PFC stream conditions throughout an ESU’s historical habitat would increase the likelihood that an ESU would recover. However, PFC conditions may not be necessary for populations to reach recovery. Likewise, populations may fall short of recovery despite having PFC habitat conditions if distribution has been substantially reduced or out-of-subbasin mortality factors are severe.

Estimates of current stream capacity to produce salmon and steelhead generally ranges from 6 to 84% of PFC benchmark conditions as determined using EDT modeling (Table 1). Species averages range from a low of 23% for chum to a high of 74% for summer steelhead. These percentages describe the scope for potential improvement and the relative scale of habitat degradation for different species and subbasins.

Similar estimates of declines in habitat conditions do not exist for bull trout. Bull trout prefer cold water and are often most abundant within headwater areas of subbasins. Bull trout are affected by many of the same habitat changes that have affected other salmon and steelhead species. In the lower Columbia, bull trout movement within historical headwater areas has also been limited by tributary dams, particularly in the Lewis River and White Salmon River subbasins.

Table 1. Current habitat condition by species relative to historical conditions. The current condition of stream habitat is expressed as a percentage of historical condition using the Ecosystem Diagnosis and Treatment (EDT) model and PFC as defined by NOAA Fisheries (NMFS 1996).

	Chinook					Steelhead	
Subbasin	Spring	Fall (tule)	Fall (bright)	Chum	Coho	Winter	Summer
Grays/Chinook	--	69	--	28	33	64	--
Eloch/Skam	--	70	--	28	41	64	--
Mill/Ab/Ger	--	66	--	28	68	75	--
L. Cowlitz	--	43	--	14	26	15	--
U. Cowlitz	47	46	--	--	47	61	--
Cispus	40	--		--	70	62	--
Tilton	27	--	--	--	8	20	--
NF Toutle	0	48	--	--	na	21	--
SF Toutle	0	--	--	--	14	40	--
Coweeman	--	64	--	--	30	64	--
Kalama	55	67	--	27	47	72	83
NF Lewis	53	--	93	--	50	76	na
EF Lewis	--	56	--	30	32	57	55
Salmon	--	na	--	0	17	28	--
Washougal	--	58	--	18	25	55	73
L. Gorge	--	74	--	41	46	90	--
U. Gorge (Wind)	--	39	--	14	47	57	86
White Salmon	na	na	--	na	na	--	--
Average	***32***	***58***	***93***	***23***	***38***	***54***	***74***

Note: "—" indicates that an historical population for the species and subbasin did not exist. "na" indicates that an historical population for the species was present in the subbasin, but EDT habitat analyses are not available.

3.1.2 Limiting Factors

The habitat limiting factors described below are believed to be impacting healthy life cycles and natural production of salmonids in the lower Columbia region. The information is based on the assessments and data gathering presented in the Technical Foundation and focused on limiting factors at the stream channel scale.

Passage Obstructions

Processes and Effects — Fish passage barriers that limit habitat connectivity and access to spawning and rearing habitats are a significant factor affecting salmon populations in many Northwest watersheds. Barriers in lower Columbia watersheds primarily include culverts and dams with occasional barriers such as irrigation diversion structures, fish weirs, beaver dams, road crossings, tide gates, channel alterations, and localized temperature increases. Passage barriers effectively remove habitat from the subbasin, thereby reducing habitat capacity. In situations where a substantial amount of historic spawning or rearing habitat has been blocked, such as in the Cowlitz or Lewis River subbasins, production potential of salmonid populations have been severely reduced. To some degree, depending on the species, formerly unused downstream habitats may compensate for the lost upstream habitat. For example, chinook or chum salmon may be able to adapt to spawning/rearing in subbasin mainstem habitats below barriers while coho salmon and steelhead are less likely to utilize mainstem habitats because they are more commonly found spawning in headwater portions within the subbasin. However, the degree to which downstream habitats may be utilized after the construction of passage barriers is limited by the downstream effects of those barriers, such as alterations of flow and temperature as a result of hydropower or flood control dam operations.

As early as 1881, Washington enacted legislation to protect fish access to habitat by disallowing the installation of barriers or providing for their removal. Recent efforts include an appropriation by the 1998 state legislature of $5.75 million to inventory and repair barriers throughout the state. Despite these efforts, barriers continue to be a problem in the lower Columbia region.

Although dams are responsible for the greatest share of blocked habitat, inadequate culverts make up approximately 86% of all barriers (WDFW SSHIAP data). Estimates made from culvert surveys throughout the state indicate that approximately half of culvert problems are related to private and public logging roads (State of Washington 1999). The 1950s saw the beginning of extensive road building associated with increased logging activities. Many early logging roads were not outfitted with properly-sized culverts, and despite recent efforts to upgrade critical road crossings, an extensive backlog of passage restoration projects remain.

In general, habitat connectivity, essential to these migratory species, is lost because of:

- Blockages to stream habitats because of structures,
- Blockages to stream habitats because of impaired water quality or channel morphology,
- Blockages to off-channel habitats,
- Blockages to estuarine habitats because of dikes, levees, and tide gates,
- Direct mortality because of structures, and
  Direct mortality because of stranding in diversion channels.

Current Conditions — The major hydropower systems on the Cowlitz and Lewis rivers are responsible for the greatest share of blocked habitat. Culverts and other barriers are also a concern throughout the region. A region-wide view of barriers to anadromous fish and the extent of upstream blocked habitat are depicted in Figure 1.

- In the Lewis River basin alone, the 240-foot high Merwin Dam has blocked 80% of the available steelhead habitat since 1931 (WDF/WDW 1993). The dam blocked the majority of the spring chinook habitat as well.
- In the Cowlitz basin, the three mainstem dams inundated a total of 48 miles of historical steelhead, chinook, and coho habitat.
- The Sediment Retention Structure (SRS) on the North Fork Toutle River is a total barrier to salmonids. The Toutle Trap just below the SRS, which is the trapping facility for all salmonids returning to the upper N.F. Toutle River, has been difficult to operate in recent years due to increasing amounts of debris and sediment coming down from the SRS.
- Throughout the region, as many as 800 culverts have been identified that block passage of salmonids. The bulk of these are associated with private and public logging roads.

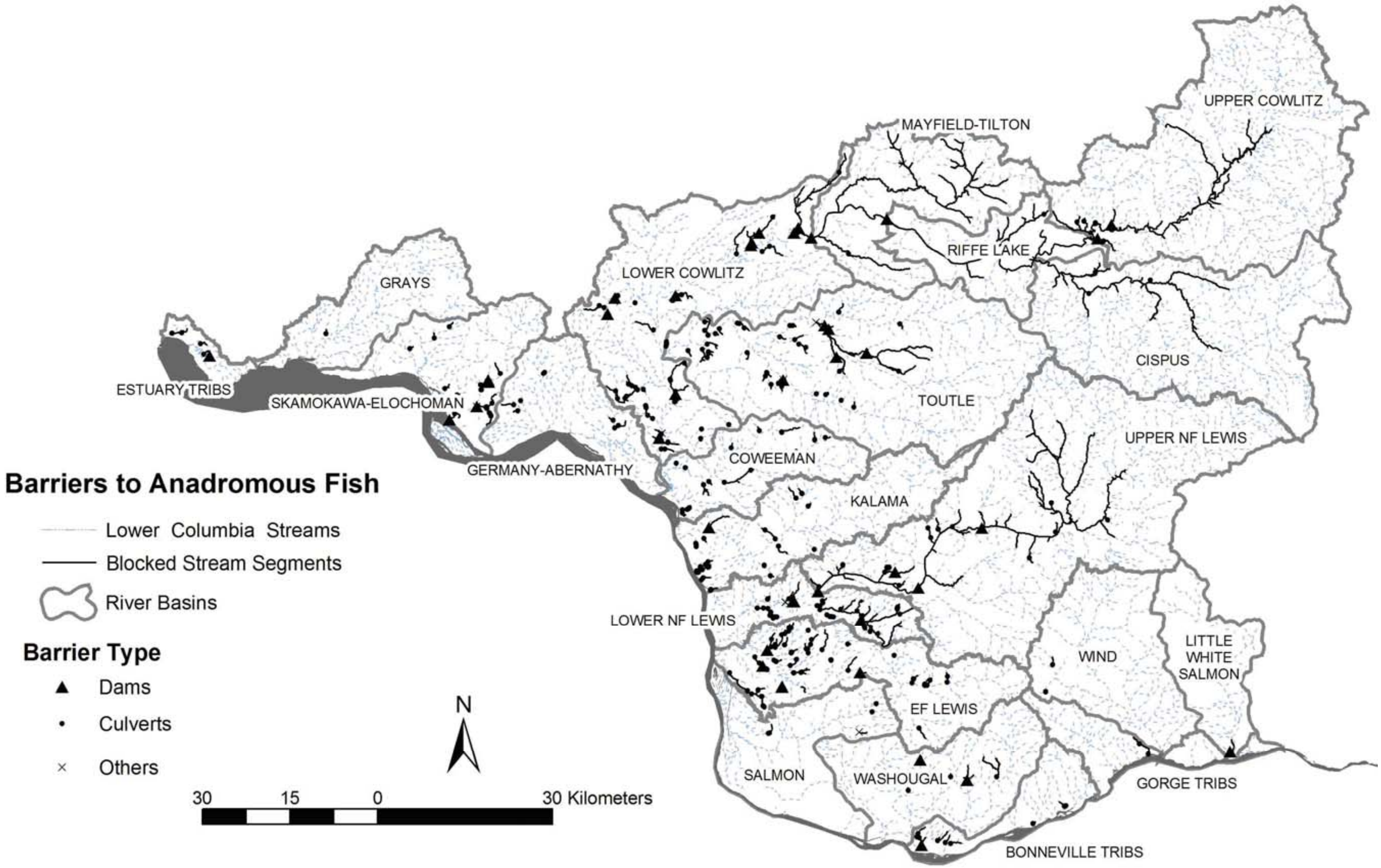


Figure 1. Regional map depicting blockages to anadromous fish and the extent of potentially accessible stream segments above blockages. Blockages and potential stream segments are included if passage for any anadromous species is obstructed. The primary source for these data is the Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP).

Stream Flow

Processes and Effects **—** Stream flow patterns are controlled by local climate, geology, basin topography, land cover, and ocean climate patterns. Two annual stream flow patterns dominate in the Lower Columbia region. High elevation basins typically experience a flow regime dominated by snowmelt, with peak flows occurring during spring melt conditions, whereas lower elevation basins experience winter peak flows as a result of winter rain storms.

Aquatic organisms have adapted to the range of habitat conditions that are created and maintained by natural streamflow regimes (Poff et al. 1997) and a range of streamflows are necessary for creating habitat diversity (Bisson et al. 1997). Streamflows in excess of natural conditions, however, can increase hillslope sediment delivery and alter channel morphology through bed and bank erosion, with subsequent impacts on aquatic habitats (Chamberlain et al. 1991). Alterations to winter and spring flows can affect incubation and emigration survival by increasing the likelihood of scouring eggs and alevins from the gravel or displacing juveniles from rearing habitats (e.g., Pearsons et al. 1992, Montgomery et al. 1996). Decreased summer low flow volumes can impact aquatic habitats through loss of available habitat area and increased risk of elevated stream temperatures. Alterations to summer and fall flows may impact spawner distributions and juvenile rearing success.

Characteristics of catchment land cover influence the rate, duration, and magnitude of water runoff in a basin. In the Pacific Northwest, alterations of land cover affect runoff by decreasing soil infiltration rates, interrupting subsurface flow, and increasing snow accumulation and melt rates.

Although western Washington is characterized as having abundant rainfall, a significant portion of annual precipitation is lost as evapo-transpiration due to the dense forest cover. Precipitation that is not lost to evapo-transpiration or deep groundwater storage enters streams via three primary methods:

- surface flow (rapid),
- shallow subsurface flow (slow), and
- groundwater flow (very slow).

In undisturbed basins in the Pacific Northwest, shallow subsurface flow accounts for nearly all of the runoff entering stream channels, except during periods of low flow when groundwater sources dominate (Ziemer and Lisle 1998). The lack of surface runoff in an undisturbed basin is due to the rate of infiltration exceeding precipitation. If the infiltration rate is changed, then precipitation that normally transmits slowly to stream channels as subsurface flow or that contributes to groundwater storage is instead rapidly transported as surface flow. This can decrease the amount of groundwater available to supply flow to streams in dry periods and can increase the magnitude and rate of peak flows during storm events. These conditions are especially prevalent in urbanizing basins, where native vegetation has been converted to impervious surfaces such as pavement, rooftops, and lawns (Leopold 1968, Fresh and Luchetti 2000). The drainage network in the form of gutters, drains, and storm sewers further increases the magnitude and rate of delivery of storm flows to downstream channels. Previous studies have indicated that 10-20% impervious area in a basin can alter stormflow volumes (Hollis 1975) and severely impact aquatic systems (Booth and Jackson 1997).

Infiltration rates are also decreased due to timber harvest operations, forest road building, and conversion of forest land to agriculture. Interception of subsurface flow due to forest road cuts is another major source of runoff manipulation. Excavation of road cuts on hillslopes penetrates the soil mantle, redirecting shallow subsurface flow into road ditches, which accelerates the delivery of water to stream channels.

Streamflow volumes may also be increased due to forest practices that increase snow accumulation and melt rates. Forest canopies naturally intercept snowfall, much of which melts in the canopy and reaches the forest floor as wet snow or meltwater (Ziemer and Lisle 1998). Removal of canopy cover increases the amount of snow that accumulates. In addition, melt rates may be increased due to the convective transfer of heat to the snow surface during storm events. In this way, the water available for runoff may be increased during rain-on-snow events (Coffin and Harr 1992).

In summary, salmon, steelhead and trout life histories are constrained because of:

- Altered magnitude of flows (decreased low flows, increased peak flows),
- Alterations to the duration of flow events,
- Alterations to the rate of change of flow,
- Alterations to the natural temporal pattern of stream flow,
- Channel de-watering,
- Lack of channel forming flows,
- Disrupted sediment transport processes, and
- Increased contaminant transport (urban and agriculture runoff).

Current Conditions — Stream flow impairment is difficult to assess without a sufficiently long time series of flow records, and even with such information, it is often difficult to distinguish true flow alterations from natural fluctuations. For this reason, land cover conditions that are known to influence the timing, rate, magnitude, and duration of stream flows are often used as indicators of potential stream flow impairment. These generally include one or more of such metrics as forest seral stage, percentage watershed imperviousness, and road density.

- The Integrated Watershed Assessment (IWA) identified hydrologic (runoff) impairments across the study area according to landscape characteristics including impervious surfaces, vegetation cover, and road densities (see Vol. II for presentation of subbasin-level results). IWA hydrology impairment results are depicted for the entire region in Figure 2. The greatest impairments are located in lower elevation portions of the basins, which are dominated by private timber lands. Functional conditions are most prevalent in upper watersheds in public land.
- Fish habitat modeling suggests that stream flow impairments are limiting fish production in many basins. The most impacted reaches are located in middle and upper basin areas within or downstream of areas with intensive timber harvest and road building activities.
- The Vancouver metropolitan area, along with the cities of Camas and Washougal, comprise the largest urban area in Southwest Washington and are located primarily in the Lake River/Salmon Creek and Washougal River basins in WRIA 28. Of land area in WRIA 28, 13% is urban land, with 20% in agricultural uses (WDOE WRIA data). These areas have high degrees of imperviousness with a substantial loss of native forests and wetlands. Urban development plays a relatively minor role throughout the remainder of the region. WRIAs 25 (Grays/Elochoman), 26 (Cowlitz), 27 (Lewis), and 29 (Wind) each have less than 2% of the land area in urban uses.

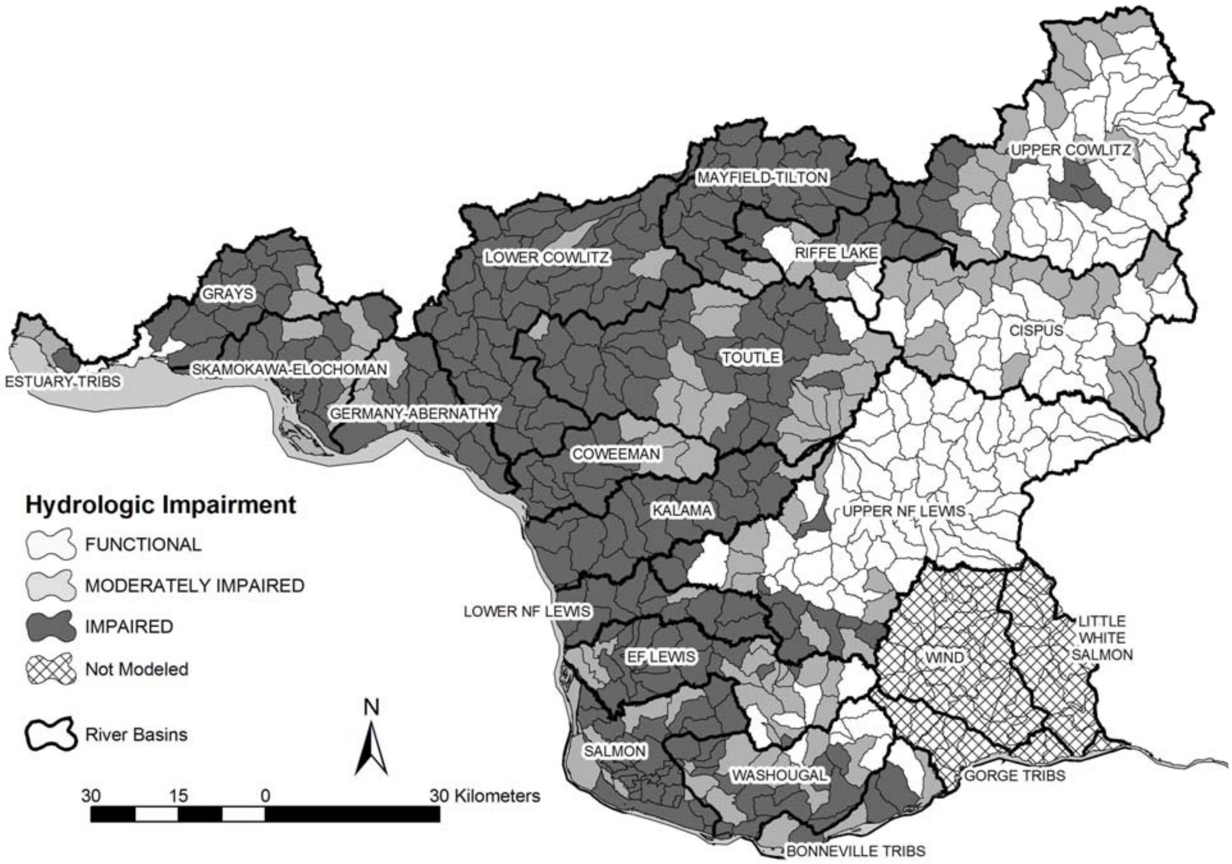


Figure 2. Map of hydrologic impairments across the lower Columbia region. Impairment categories were calculated as part of the Integrated Watershed Assessment (IWA). (see Vol. II for presentation of subbasin-level results). These impairment ratings represent local hydrology (runoff) conditions, not including upstream effects.

- Forest lands have received significant alteration, particularly those in the western portion of the region and those in lower elevation areas that are in private commercial timber land ownership. In WRIA 25, 79% of land area is forest land, and 83% of the land is private. This WRIA has received intensive timber harvests over the past 50 years. On the whole, WRIAs 26, 27, and 29 have received less alteration to forest lands, attributable to more than 40% of their land area in federal ownership.
- Many forest stands have been clearcut and are in early seral stages, with over 20 (or 3.5%) of 567 7th-field HUCs having over 20% of forest cover in early seral stages, and a few of these have over 40% in early seral stage conditions.
- The preponderance of roads in the region is another major influence on runoff conditions. There are approximately 24,000 miles of roads in the region, and the region has an average road density of 4.15 mi/sq mi. In many basins the forest road density exceeds 7 mi/sq mi.
- Analyses by the USFS on national forest lands in many upper basins indicate a risk of increased peak flows for moderate return interval flows (i.e. 2-year flow), attributed primarily to forest practices activities.
- Peak flow reductions created by the Cowlitz and Lewis River hydropower systems limit the potential for scour of salmon redds in downstream channels, however, these flow alterations may also limit the occurrence of channel-forming flows that may be important for the maintenance of key habitat types.

- Instream flow assessments, primarily the Toe-Width method, were applied to many lower Columbia streams in the fall of 1998 (Caldwell et al. 1999).[1] Most of these analyses indicated sub-optimal flows for both spawning and rearing life stages.

Water Quality

Processes and Effects **—** Clean, cool, and clear water is essential to salmonids. The health of aquatic habitats declines as temperature, turbidity, nutrients, and other parameters exceed natural ranges and if chemical and biological contaminants are found in significant quantities. Stream temperature is of particular concern in the Northwest due to its importance to fish and its response to land use activities. Brett (1952) found that juvenile Pacific salmonid species generally preferred temperatures in the range of 54-57°F (12°-14°C). Upper lethal limits have been found to be in the 75-81°F (24-27°C) range depending on species and acclimation temperatures (Brett 1952, Hynes 1970, Sullivan et al. 2000).

Stream temperature is readily altered by removing the riparian canopy cover and increasing the channel width. Both canopy cover and channel width are impacted by a variety of land uses. Temperature also has a negative correlation with dissolved oxygen although interactive effects of photosynthesis and groundwater inputs can alter this relationship (Hynes 1970). Current Washington State temperature standards are less than 64°F (18°C) for class A ("excellent") streams and 61°F (16°C) for class AA ("extraordinary") streams. In the lower Columbia region, most streams lying within national forest land are class AA, while most lower basin streams are designated class A. Streams that are monitored according to DOE protocols and regularly exceed the standards are included on the state's 303(d) list for impaired water bodies.

Turbidity is also a major concern in the Northwest, as it is readily increased by land use practices that produce and deliver fine sediment to stream channels. Turbidity has a strong impact on salmonid feeding success, egg incubation, respiration, and physiological stress.

Changes in nutrient dynamics can impact stream productivity. Forestry activities in riparian areas contribute organic debris and increase light availability, which increases primary production and can increase fish productivity. However, these benefits are often offset by detrimental impacts of logging to physical habitat. Increased nutrification also occurs due to agriculture where fertilizers and animal wastes increase the delivery of inorganic and organic compounds. Detrimental impacts from these inputs is seen most in slow-moving river and lake waters where algal blooms result in depleted dissolved oxygen, and anaerobic respiration can pollute waters.

Fecal coliform bacteria is also a concern in many lower Columbia basins and is usually related to livestock wastes and failing septic systems. Other pollutants occur to a lesser degree in lower Columbia basins and are related to mining wastes, urban runoff, and industry.

In summary, water quality characteristics that can limit salmonids include:

- Altered stream temperature regimes,
- Reduced dissolved oxygen concentrations,
- Excessive turbidity,
- Nutrient over-enrichment

[1] The Toe-Width is the distance from the toe of one streambank to the toe of the other streambank across the stream channel. This width of the stream is used in a power function equation to derive the flow needed for spawning and rearing salmon and steelhead.

- Bacteria, and
- Chemical contaminants (from point and non-point sources).

Current Conditions **—** The Washington State Department of Ecology 303(d) list of threatened and impaired water bodies represents the most comprehensive and uniform documentation of water quality impairments throughout the region. Water quality-impaired stream segments included on the 303(d) list include streams monitored by the WDOE or documented impairments submitted to WDOE by other entities. There are many impairments that are documented by various other organizations that do not appear on to the 303(d) list for a number of reasons. The 303(d) list therefore does not reflect all of the potential water quality concerns in lower Columbia streams. The streams listed on the draft 2002/2004 303(d) list are displayed in Figure 3. Only selected parameters are shown. There are also stream segments listed for a variety of other water quality parameters, including DDT, arsenic, lead, sediment bioassay, and others, but they comprise only a small portion of the listed streams.

- The most common water quality concern in the region regards water temperature. Over 150 streams in the lower Columbia region have one or more segments on the 303(d) list for temperature problems. However, many streams with temperature problems are not included on the 303(d) list. Most temperature exceedances have been attributed to reduction in riparian tree canopy cover, increased stream widths, and decreased low flow volumes during the summer. Temperature problems are scattered throughout the forested and developed areas of the region. Dissolved oxygen levels are a related problem and are of most concern in WRIA 28, although most of the listed stream segments are within the Vancouver metropolitan area and are not in significant salmon and steelhead streams.
- Fish habitat modeling indicates that high summer stream temperatures are a major limiting factor for steelhead and coho in many basins (habitat modeling results are presented for each subbasin in Vol. II of the Technical Foundation).
- The presence of fecal coliform bacteria is also considered a problem in the region, with over 30 stream segments on the 303(d) list. Most of the listed segments are within the urban and rural residential areas in WRIA 28 and are likely the result of failing septic systems. Runoff from livestock grazing also has been identified as a contributor to the bacteria problem in many areas.
- There are few sediment-related problems in the lower Columbia region that are on the 303(d) list. Chronic suspended sediment problems (measured by turbidity) are generally not a concern except for portions of the Toutle and Lewis basins that drain Mount St. Helens. Excessive delivery of fine sediment to stream channels during runoff events, however, is a concern throughout the region. This issue is discussed in detail in the Substrate and Sediment section.

Important Habitats and Habitat Complexity

Processes and Effects **—** Salmonids require an array of complex habitat types to carry out freshwater life stages. The distribution, dimensions, and quality of stream channel habitat units greatly affect the health of fish populations (Bjornn and Reiser 1991). Fish use pools, riffles, pocket-water, off-channel backwaters, and other habitat types depending on species, life-stage, activity-level, and stream conditions. Although fish use a variety of habitat types to different degrees depending on their lifestage, pools and backwater habitats are often regarded as the most crucial. For example, spawning often occurs at the downstream end of pools, where the right combinations of substrate and flow conditions are found. Pools also provide important cover and food resources for juvenile fish. Backwater and side channel habitat are especially important for some species, because they are often the site of upwelling, providing cool water in the summer as well as nutrient-rich water important for growth. They also provide refuge from flood flows. For these reasons, pool and side channel availability are commonly used as metrics to assess overall stream habitat condition. Functional connectivity between the various habitats for each life history stage is also critical (Mobrand et al. 1997).

Structural cover components in the stream channel, including woody debris, boulders, and overhanging banks, contribute to habitat complexity. The creation and maintenance of stream channel habitats is a function of the interaction between the underlying geology and the dynamics of flow, sediment, and large woody debris. Disrupting these physical processes may result in habitat unit types that are outside of natural ranges of quality and quantity. In the lower Columbia region, processes that drive channel conditions have been altered to various degrees by land management activities. The greatest impacts on stream habitat units have been practices that have directly altered stream channels such as splash dam logging, diking, channelization, stream clean-outs, gravel mining, and dam building. Upland and riparian land use practices that alter flow, sediment, and wood recruitment are less direct, but equally important, impacts.

Important habitats and habitat diversity can be reduced by:

- Complete loss of spawning, rearing, and/or migration habitats that normally provide good survival conditions at critical times of the life cycle
- Lack of stable instream woody debris,
- Altered habitat unit composition,
- Lack of instream cover components,
- Lack of habitat complexity
- Loss of habitat refugia,
- Loss of access from one habitat to the next in the life cycle, and
- Upland activities that compromise the creation, maintenance, and normal functioning of important habitats.

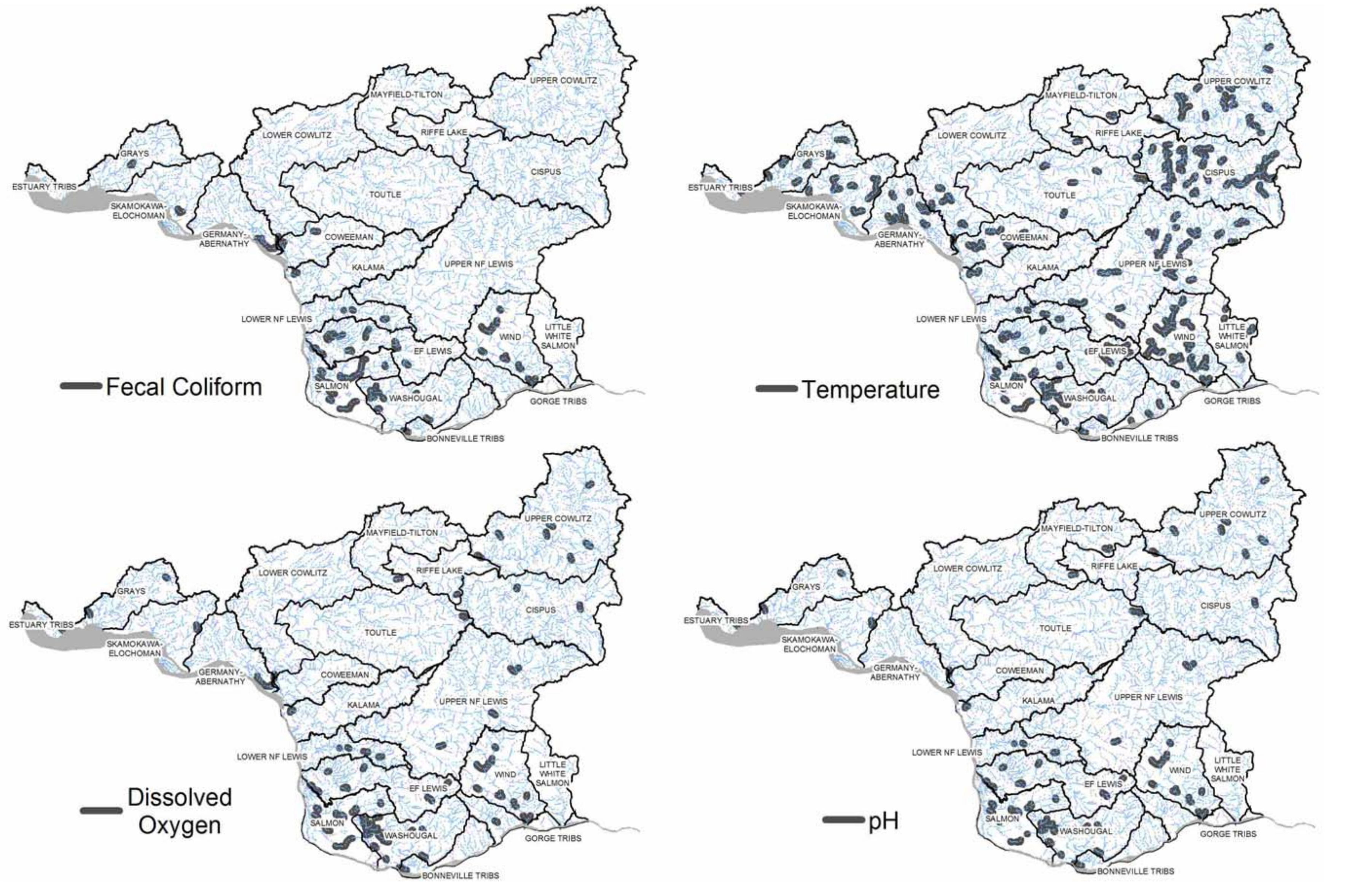


Figure 3. Map of stream segments on the 2002/2004 303(d) list for selected parameters. The selected parameters are the most widespread water quality impairments in the region.

Current Conditions — In many lower Columbia streams, habitat surveys provide information on pool and side channel availability. In other areas, local experts have provided information as part of the limiting factors analysis process, as described in each subbasin chapter in Volume II. Still, there is little information regarding specific stream channel conditions in many areas. In general, the evidence shows an overall decrease in side channel and pool habitats.

- The greatest loss of stream habitat has resulted from the Cowlitz and Lewis River hydropower systems, where many miles of stream channel lie beneath a series of reservoirs, and additional miles are blocked from access.
- The other major loss of habitat is in the lower reaches of stream systems that have been diked and channelized for agricultural, industrial, and residential uses. Coastal basins have been especially affected; historically, these systems had extensive networks of estuarine side channels that are now isolated or filled. Chum spawning habitat and coho winter rearing habitat have been particularly impacted by loss of off-channel and side channel areas.
- Upper basin stream systems have suffered less pool and side channel degradation, though the impacts to some fish populations may be greater because of the concentration of quality spawning and rearing habitat. As in the lower basins, side channels have been lost due primarily to erosion control, diking, and riprap. Some channels are impacted by stream channel incision that has persisted since past splash-damming and riparian timber harvest.
- The loss of pool habitat as a result of decreased large wood quantities and degraded riparian areas is also a concern. In most upper forested basins in the region, the quantity of pool habitat is in the low end of the range considered adequate for salmonids.

The presence of good side channel and pool habitats has been identified in some areas. These are most often associated with woody debris. An assessment in the upper Cowlitz basin indicated that streams containing LWD had 15 times the number of pools as streams without large wood (EA 1998 as cited in Wade 2000).

Substrate and Sediment

Processes and Effects — Proper substrate and sediment conditions are necessary for spawning, egg incubation, and early rearing of salmonids. Substrate and sediment are delivered to spawning and rearing areas during natural disturbance events, mediated by LWD and existing habitat complexity (Bisson et al. 1997). However, excessive fine sediment delivered to channels can suffocate salmonid eggs, inhibit emergence of fry from gravels, decrease feeding success, increase physiological stress, and through adsorption, may facilitate the transport and persistence of chemical contaminants (Welch et al. 1998). The size of substrate preferred by spawning salmon ranges from less than 0.4 in (1 cm) to over 4.7 in (12 cm) in diameter, depending on the species and size of the fish (Bjornn and Reiser 1991, Schuett-Hames et al. 2000). During redd construction, spawning substrates are cleared of fine sediments; however, during the incubation period, redds are susceptible to accumulation of fines.[2] Sediment accumulation can impede intergravel flow necessary to supply embryos with oxygen and carry away wastes. Embryo survival declines as percentage fines increases (Bjornn and Reiser 1991). Fine sediment may also limit the ability of alevins to move around and to ultimately emerge from the gravels. Studies have shown that alevins have trouble emerging when percent fines exceed 30-40% (Bjornn and Reiser 1991). Substrate conditions also are important for juvenile salmonid rearing. Substrates provide cover, protection from high flows, and macroinvertebrate production. Juvenile

[2] Fines are typically defined as sediment sizes less than 0.85 mm (0.033 inches) diameter, and percentage fines greater than about 17% are considered not properly functioning according to NMFS (NMFS 1996).

production and densities have been shown to decrease with increased gravel embeddedness (Crouse et al. 1981, Bjornn et al. 1977 [from Bjornn and Reiser 1991]). Embedded substrates may also reduce the availability of macroinvertebrate food resources (Bjornn et al. 1977, Hawkins et al. 1983).

Many factors can affect substrate conditions. Scouring of substrates may result from increased flood flows, alterations to channel geometry, loss of channel stability, splash dam logging, and debris flows. Gravel recruitment is reduced by dams, bank armoring, and channel alterations. Direct extraction of substrates has occurred in some areas due to gravel mining operations.

Increased sediment transport and delivery due to upslope land use has a major impact on in-stream habitats. Sediment is contributed to stream channels through surface erosion, gully erosion, and mass wasting (Ward and Elliot 1995). The amount of erosion resulting from these processes is related to climate, soil, slope, and vegetation conditions. Surface erosion primarily occurs as sheet and rill erosion on agricultural, urban, and range lands, but it also may occur on forest road surfaces or areas disturbed during timber harvest. Surface erosion can be extremely high in developing urban areas that are under construction, where erosion may increase from 2 to 40,000 times the preconstruction rate (McCuen 1998). Gully erosion results from concentrated flow and commonly generates sediment volumes an order of magnitude greater than sheet and rill erosion. Gullies are often associated with forest road ditches, where ditch and culvert design and/or maintenance are inadequate to effectively convey runoff volumes.

Mass wasting, in the form of landslides and debris flows, can deliver huge amounts of sediment to stream channels. Landslides may be rapid or slow (slumps) and can occur on shallow or steep slopes. Water saturation, vegetation removal, and human-induced flow concentration (i.e. roads) are often responsible for landslides in forested areas. Debris flows are caused by similar disturbances, though generally involve higher water content, initiate on steeper slopes, and travel farther than landslides. Debris flows are common in steep headwater or tributary channels and can contribute large amounts of sediment and woody debris to salmonid streams.

The ways in which substrate and sediment features can injure salmon include:

- Embedded substrates,
- Excessive suspended sediment (turbidity),
- Fine sediment in gravels (redd smothering),
- Lack of adequate spawning substrate,
- Excessive build-up of substrate, and
- Lack of boulder cover.

Current Conditions — Substrate conditions across the lower Columbia region vary with respect to channel types, position within the watershed, and natural and anthropogenic disturbances.

- Fish habitat modeling indicates that fine sediment is one of the primary factors limiting fish production for most salmonid populations in the lower Columbia region.
- Many stream reaches suffer from a lack of adequate spawning gravels and high concentrations of fines. Spawning gravels are often embedded with fines—a particular problem in coastal basins that have sedimentary geology and a high occurrence of mass wasting. Historical chum and chinook spawning sites on lower river segments are especially susceptible to accumulations of fines. Accumulations of fines near the mouths of streams

entering the Columbia River upstream of Bonneville Dam have increased since dam construction.

- High rates of sediment delivery have been a continual problem in the Toutle River watershed and other streams impacted by the Mt. St. Helens eruption, although conditions have been improving. Conditions have improved more quickly in the SF Toutle and Green River than in the NF Toutle, which received the greatest impact.
- The Sediment Retention Structure (SRS) on the mainstem NF Toutle contributes to sediment impairment in the Toutle River. The SRS was constructed after the 1980 Mt. St. Helens eruption in an effort to reduce downstream sediment aggradation and thus improve conveyance of flood waters in the lower Toutle and Cowlitz rivers. The structure has since been overtopped with sediment and has become a chronic source of fine sediment to downstream areas. The SRS is believed to be preventing the recovery of the system (Wade 2000).
- Past and current land use has created upslope land cover conditions that are susceptible to increased sediment production and delivery to streams. The IWA identified sediment supply problems across the study area according to landscape characteristics including topographical slope, soil erodability, and unsurfaced road densities. IWA sediment impairment results are depicted for the entire region in Figure 4 (see Vol. II for a presentation of subbasin-level results).

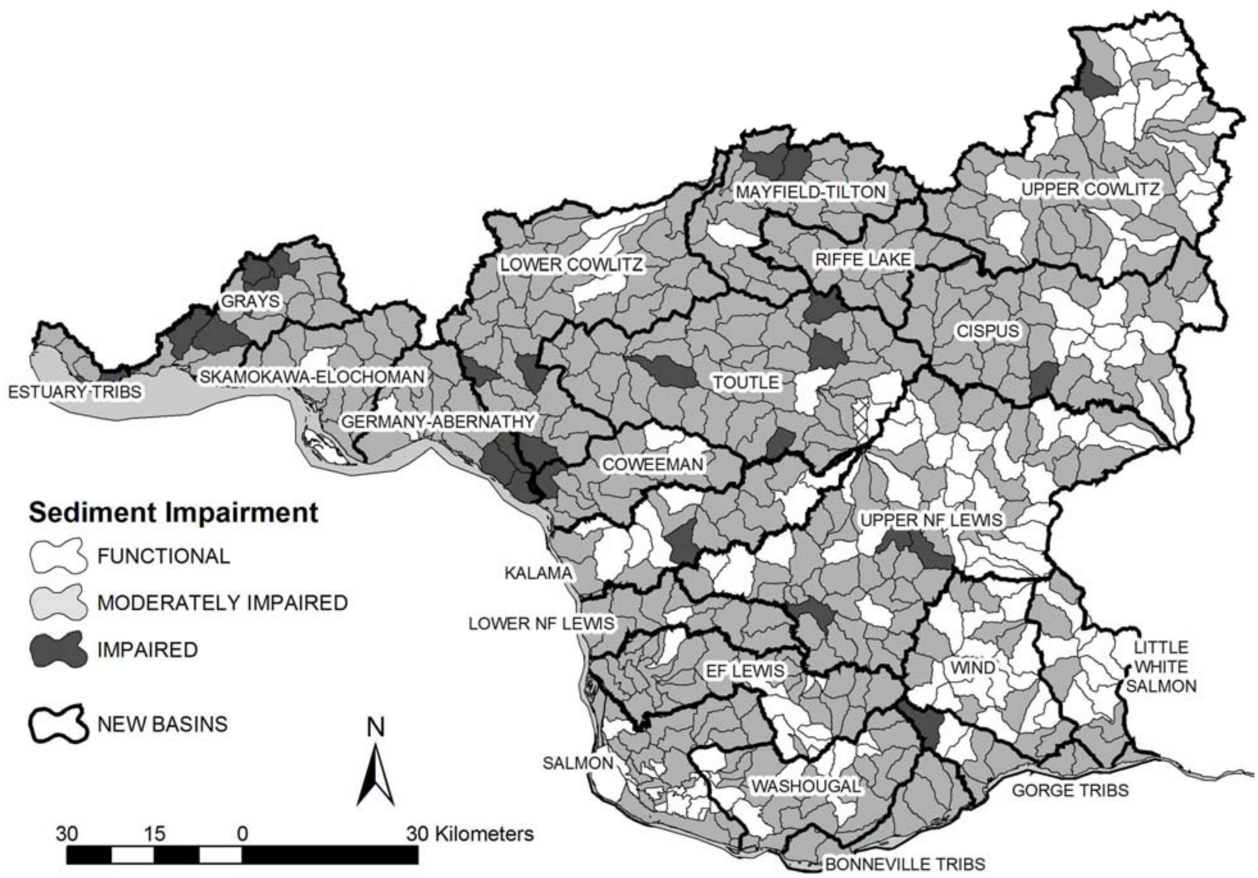


Figure 4. Map of sediment supply problems across the lower Columbia region. Impairment categories were calculated as part of the Integrated Watershed Assessment. (see Vol. II for presentation of subbasin-level results). These impairment ratings represent local sediment supply conditions, not including upstream effects.

Woody Debris

Processes and Effects — Woody debris is an important component of stream ecosystems. Removal of riparian vegetation can decrease wood recruitment as well as reduce bank stability (Beechie et al. 2000). Reduced bank stability increases sedimentation of pools and increases width to depth ratios, thus reducing the quality and quantity of pool habitat. Juvenile and adult salmonids rely directly on LWD for shade, protection from disturbance, and protection from predation (Bisson et al. 1988, Solazzi et al. 2000). Studies have shown that fish production is positively correlated with presence of large organic debris (Bjornn and Reiser 1991). Woody debris also retains organic matter, provides sites for macroinvertebrate colonization, and can trap salmon carcasses (Murphy and Meehan 1991, Cederholm et al. 1989). An indirect benefit of LWD to salmonids is its influence on stream channel morphology and habitat complexity. LWD tends to be stationary in small streams, where it affects local bank stability and creates patches of scour and deposition. In large streams, LWD moves more readily and often forms jams. Accumulations of LWD affect bank stability, scour, bar formation, and may also induce rapid channel adjustments (Keller and Swanson 1979). In some streams, LWD may also be important for the establishment of floodplain and riparian habitats (Abbe and Montgomery 1996).

Another significant attribute of LWD is the role it plays in pool formation. Stable woody debris traps sediments and can form steps in otherwise uniform channels. In some cases, LWD can create depositional areas in channels that would otherwise be composed of bedrock (Montgomery et al. 1996). Abundance of LWD has been positively correlated with pool area, pool volume, and pool frequency (Carlson et al. 1990, Beechie et al. 2000).

LWD is recruited to stream channels through bank erosion, mass wasting, blowdown, and debris torrents. Removal of riparian timber decreases the potential for future LWD recruitment. Although timber harvest may increase short-term wood loading in some instances, long-term recruitment and persistence of wood in streams is highest in older forest types (Bilby and Ward 1991, Beechie et al. 2000). LWD is removed from stream channels through fluvial transport or by direct removal. Direct removal of LWD was a common practice in the 1970s and 1980s when log jams were believed to impede fish passage. Wood removal has occurred in other locations in order to reduce flood potential (Shields and Nunnally 1984). As expected, the removal of LWD has been shown to alter channel morphology and decrease habitat complexity (Smith et al. 1993).

The loss of woody debris from the stream habitats can result in negative effects on salmonids because of:

- Reduced bank stability
- Reduced cover habitat and refuge from predationLoss of retention of organic matter, such as salmon carcasses
- Lost substrate for macroinvertbrate growth
- Reduced habitat-forming vectors, and
- Habitat simplification.

Current Conditions — The various agencies conducting stream surveys in the lower Columbia region define LWD differently. In general, minimum diameter to be considered for LWD ranges from about 4-14 inches (10-36 cm), while minimum lengths range from 6.5-49 ft (2.13-15 m). The definition of what constitutes poor conditions also varies, but is generally fewer than 80 pieces/mi or fewer than 0.2 pieces per channel width (NMFS 1996, Schuett-Hames et al. 2000, Wade 2000).

- LWD conditions are considered poor across much of the lower Columbia region. Only a handful of surveyed streams have good conditions.
- The amount of LWD affects the EDT habitat attribute ‘habitat diversity’. For many lower Columbia stream systems, EDT modeling indicates that habitat diversity is the habitat factor that is serving to depress population performance to the greatest extent.
- In many areas where LWD is adequate, it is concentrated in large jams, although many of the large jams that existed historically on low-gradient, large systems such as the Cowlitz, are no longer present (Mobrand Biometrics 1999).
- Low LWD abundance in many upper basins is attributed to past timber harvest and scour from splash dam logging. In other areas, poor conditions are attributed to past fires that have reduced recruitment. USFS and other crews removed instream wood in some streams during the 1980s because it was believed to impede fish passage while in other streams local residents have removed LWD due to flooding and erosion concerns.
- In general, it is believed that LWD recruitment potential is increasing in most basins due to re-growth of riparian forests. Current riparian buffer regulations prevent significant harvest along most streams, which will eventually serve to restore instream LWD levels (WFPB 2000). Restoration projects that involve the re-introduction of wood into stream systems have and will continue to increase instream LWD.

Channel Stability

Processes and Effects **—** Channel stability conditions affect the quality and quantity of instream habitats. Channel erosion can directly impact fish through redd scour or redd smothering. Channel erosion affects fish indirectly through impacts to the distribution and condition of key habitat types as well as through impacts to floodplain connections and riparian conditions. Excessive sediment delivered from unstable stream banks can suffocate salmonid eggs, inhibit emergence of fry from gravels, decrease feeding success, and increase physiological stress. Unstable banks also increase mass wasting and have subsequent effects on channel morphology. Bank stability processes vary depending on location in a catchment. In steep headwater systems, channels are typified by stable substrates (i.e. bedrock, boulders) and thus have greater resistance to erosion. With the exception of debris flows, sediment entering these channels is predominantly from upslope sources. Channels lower in the catchment, on the other hand, tend to have higher rates of bank erosion, with, in many instances, channel sources contributing far more sediment than upslope sources. It is in these channels that the impact of unstable streambanks is greatest on salmonids.

Patterns of erosion and deposition within stream channels have a strong influence on channel form, including meander formation and floodplain development. The distribution and dimensions of aquatic habitats, such as pools and riffles, are therefore governed in part by bank stability. A study on Salmon Creek, a lower Columbia tributary, found that landslides increased the amount of sediment stored in channel bars at the expense of pools (Perkins 1989 as cited in Montgomery and Buffington 1998). Factors that control bank stability include bank material composition, flow properties, channel geometry, and vegetation (Knighton 1998). While vegetation may not have the greatest controlling influence on stability, it is readily altered by land use, and therefore of particular concern. Root systems increase resistance to the erosive forces of flowing water and denser vegetation generally results in narrower and deeper channels. The woody roots of trees are particularly useful in providing long-term channel stability (Beschta 1991).

Land use activities that modify vegetation conditions and channel geometry can reduce bank stability. Timber harvesting and conversion of riparian forests to agriculture, residential, and other developed uses reduce vegetative cover on stream banks. These practices have been widespread in the lower Columbia region over the past century. Livestock grazing increases bank erosion through direct trampling and removal of vegetation (Trimble and Mendel 1995). Stream channelization may also increase channel erosion by increasing water depth, which increases shear stress (product of depth and slope) and therefore scour potential on the channel bed. Channel straightening increases stream gradient, which also increases scour potential and transport capacity (Knighton 1998). Increased runoff volumes due to upland land uses can increase stream power which can increase erosive forces. Increased streamflows due to urbanization can alter channels dramatically through widening and incision (Booth 1990). Alternatively, streambank reinforcement for erosion control, such as riprap, reduces habitat complexity and can result in diminished salmonid abundance (Knudsen and Dilley 1987).

These impairments affect salmon through:

- Bed scour,
- Channel down-cutting (incision),
- Debris flows,
- Landslides,
- Bank failures,
- Displacement of instream structural components, and
- Redd displacement / smothering.

***Current Conditions* —** Bank stability problems have been identified in most basins throughout the lower Columbia region. Loss of bank stability is attributed to a number of factors. These include most land use activities mentioned above, namely timber harvest, land use conversion, straightening and channelization, livestock grazing, and flow alterations. In some cases, the natural geology exacerbates instability. This is the case in areas underlain by sedimentary rock in coastal basins, mudflow deposits around Mt. St. Helens (Toutle and Lewis basins), and Bretz Flood deposits in lower portions of Columbia Gorge basins. Bank stability has been reduced in many lower catchment channels by riparian and floodplain development that has resulted in straightened and channelized streams. In some areas, natural channel movement is perceived as a bank stability problem when developed or agricultural property within the channel migration zone is threatened. There are bank stability concerns across the region.

- The stream channel has rapidly adjusted due to avulsions into gravel mining pits on Salmon Creek and the lower EF Lewis River. The impact of these avulsions on aquatic habitat may be minor in some cases.
- Livestock grazing has impacted streambanks. Efforts to exclude cattle with fences have reduced this impact.
- Timber harvests and road building have increased runoff and sediment supply to channels. Sediment inputs can increase in-channel sediment aggradation, resulting in high width-to-depth ratios and an elevated rate of channel movement. New forest practices rules that regulate road building, timber harvests on steep slopes, and riparian timber harvest should alleviate channel instability problems.

Despite these problem areas, the limiting factors analyses noted generally good bank stability conditions in the Jim Crow, Skamokawa, Elochoman, lower Cowlitz, Kalama, and

Washougal basins. Other areas of good bank stability are a result of erosion control projects which may present their own impacts on fish, as noted above.

Riparian Function

Riparian areas are the critical interface between upland and aquatic systems. Riparian vegetation directly and indirectly affects fish habitat suitability through influences on water temperature, habitat diversity, sedimentation, wood recruitment, and bank stability. Riparian degradation is often the causative factor of in-channel habitat impairments.

Processes and Effects **—** Riparian areas are an important interface between upland and aquatic systems (Gregory et al. 1991). Riparian vegetation directly and indirectly affects fish habitat suitability through influences on water temperature, habitat diversity, sedimentation, wood recruitment, and bank stability (Beschta 1991). Reaches with less canopy cover tend to exhibit higher maximum temperatures and larger diurnal temperature fluctuations than reaches with more canopy cover (Beschta et al. 1987, Sullivan et al. 1990). Shading from riparian canopy cover tends to be most important in summer due to high sun angles, reduced cloud cover, and longer days. In winter, canopy cover can inhibit the re-radiation of heat away from the stream, reducing the occurrence of extreme low temperatures (Beschta et al. 1987). Riparian cover also may be important for reducing wind velocities that contribute to convective heat loss (Sinokrot and Stefan 1993) and may have an important influence on the stream microclimate (Adams and Sullivan 1989, Rutherford et al. 1997), though these effects are not well understood. Canopy cover has a greater affect on small streams than large streams since wider streams are less likely to be shaded.

Riparian canopy cover provides other benefits in addition to moderating stream temperatures. Riparian canopies are an important source of allochthonous inputs (e.g. litterfall) of carbon and nitrogen to the stream system (Gregory et al. 1991, Beschta 1997a). Attenuation of light by tree canopies also may be an important factor affecting macroinvertebrate distribution and abundance. Meehan (1996) found a significant difference in macroinvertebrate abundance in shaded versus non-shaded reaches. Shade has also been shown to affect drift of benthic invertebrates. Algal growth and benthic productivity are affected by shade (Hynes 1970).

In addition to the benefits realized by adequate canopy cover, intact riparian forests also provide a source of LWD recruitment to stream channels. In small streams, fallen trees often remain where they fall and have a dramatic influence on habitat complexity. Wood has greater mobility in larger streams, where it more readily accumulates in jams. In-stream wood, as well as floodplain forests, provides roughness elements that increase flow resistance and reduces downstream flood effects. Trees also provide bank stability through erosion resistance created by roots. (See the Woody Debris section above for additional information on the importance of LWD to salmonids.)

Riparian degradation is common throughout the lower Columbia region, especially in lower elevation river valleys that have experienced intensive land-use pressures, and includes:

- Reduced stream canopy cover (temperature impacts),
- Reduced bank/soil stability,
- Reduced floodplain roughness,
- Reduced channel margin cover,
- Altered nutrient exchange processes,
- Disrupted hyporheic processes,
- Reduced wood recruitment,

- Altered species composition,
- Exotic and/or noxious species, and
- Loss of contaminant buffering capability.

Current Conditions — Riparian conditions are generally considered poor across the lower Columbia region. The IWA riparian assessment (Figure 5), which modeled riparian impairment across the region using vegetative cover characteristics, indicates that most of the region suffers from moderately impaired riparian conditions. The most intact riparian areas are located in the upper elevations of the upper Cowlitz and upper Lewis basins, while the greatest impairments are located in the lowest elevations, especially around the urbanized Vancouver, WA metropolitan area.

- Many lower elevation riparian zones that historically had forest cover have been converted to land uses such as agriculture, residential development, or transportation corridors.
- Cattle access to streambanks is an ongoing problem in many areas.
- Middle and upper basin riparian areas suffer from young forest stands and/or a predominance of deciduous vegetation due to past timber harvests. These conditions are expected to improve on forest lands with the relatively recent regulations (WAC 2000) that govern forest practices in riparian areas.

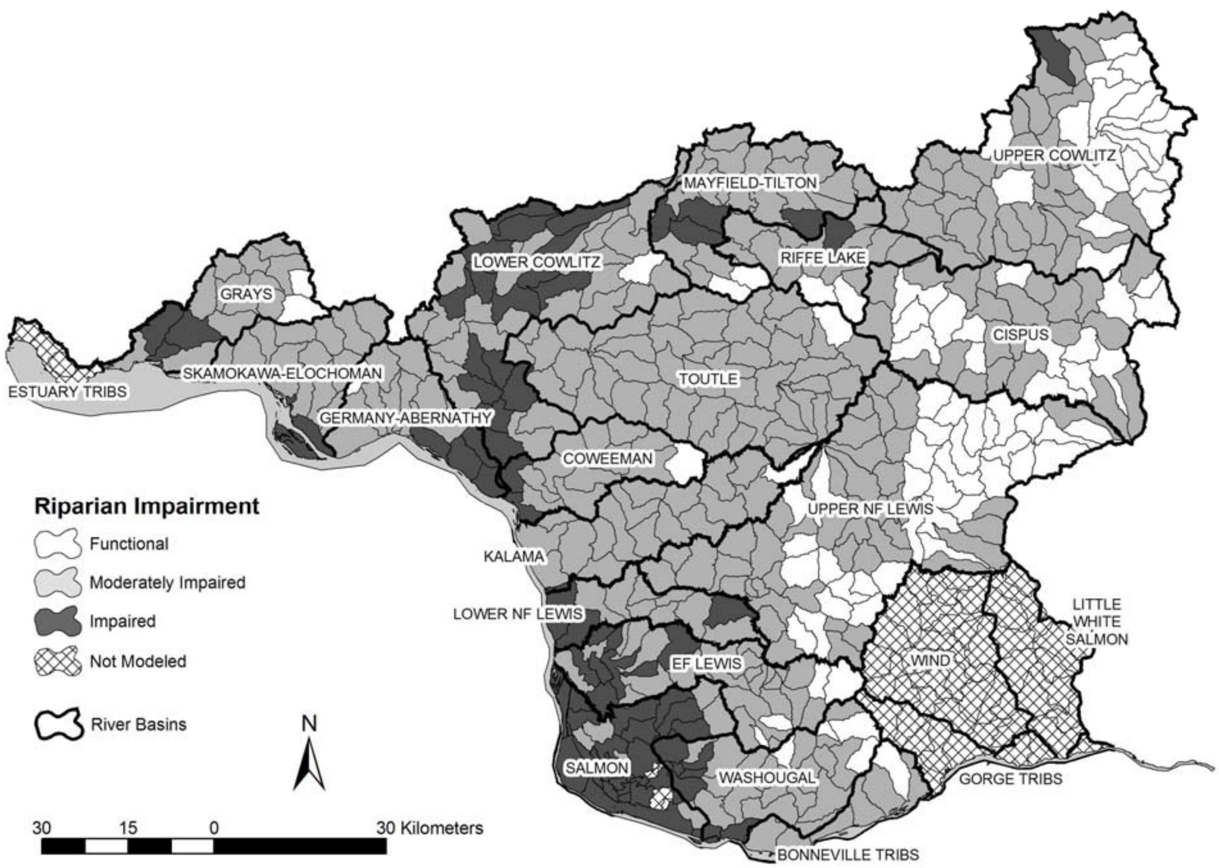


Figure 5. Map of riparian impairments across the lower Columbia region. Impairment categories were calculated as part of the Integrated Watershed Assessment. (see Vol. II for presentation of subbasin-level results).

Floodplain Function

Processes and Effects **—** The interaction of rivers with their floodplains is important for flood flow dampening, nutrient exchange, and maintenance of stream and off-channel habitats. For example, several researchers have demonstrated the importance of off-channel floodplain habitats for juvenile coho salmon rearing (Cederholm et al. 1988, Nickelson et al. 1992). As a stream accesses its floodplain, the increase in cross-sectional area decreases the flow velocity, reducing downstream flow volumes and limiting erosivity. If a stream is isolated from its floodplain, either through channel incision, diking, or floodplain filling, then the potential for downstream flooding and channel instability may be increased (Wyzga 1993, as cited in Knighton 1998). Floodplains also are important for nutrient exchanges between the stream and terrestrial vegetation. The stream hyporheic zones are especially important for maintenance of water quality, nutrient processing, and biological diversity (Edwards 1998). Hyporheic zones underlie most floodplain forests and are easily disrupted by activities that isolate floodplains or disrupt subsurface flow patterns.

Floodplains are isolated from rivers by human activities in a number of ways. Diking and channelization serve to fix the stream in a specific location, preventing overbank flows and meander migrations. This practice often occurs in combination with filling of floodplain sloughs, oxbow lakes, and side channels in order to facilitate development or create crop or pasture land. Floodplains can also be isolated from rivers through channel dredging intended to increase flow conveyance. As a result, flow magnitudes that historically would have inundated the floodplain are confined within the channel. Diking, dredging, and floodplain filling projects are often combined with channel straightening, which can increase stream gradients and in turn increase channel erosion potential. Road crossings of streams can limit floodplain function by forcing the stream into a particular location (e.g. at a bridge), preventing natural flooding and meander patterns.

Impairment of floodplain function can alter in-stream, riparian, and off-channel habitats. Floodplain alterations that reduce salmon, steelhead and trout viability include:

- Reduced availability of floodplain habitats,
- Altered nutrient exchange processes,
- Increased channel bed incision and bank erosion,
- Alterations to channel migration (restricted sediment-flow equilibrium processes),
- Downstream effects (flooding),
- Disrupted hyporheic processes, and
- Disrupted groundwater / surface water interactions.

Current Conditions **—** Floodplain function in the lower Columbia region has been altered by diking, channelization, channel incision, filling of side channels, and mining.

- Diking has occurred extensively within tidally influenced areas near the mouths of many streams. The effects on aquatic biota have been especially severe on coast range basins such as the Chinook and Grays rivers where a large percentage of off-channel estuary habitat has been isolated from the river. Dikes were constructed and floodplain channels were filled to create cropland. Recent strides have been taken to restore estuary habitat by breaching dikes and removing tide-gates.
- The lower reaches of many stream systems have been diked extensively for residential, commercial, and agricultural purposes. The most affected stream segments are the lower

Cowlitz and lower North Fork Lewis rivers, where channelization projects have isolated large amounts of historically available habitats.Transportation corridors are a ubiquitous cause of floodplain constriction on many streams, as roads tend to follow stream valley bottoms. Many streams have been artificially straightened to accommodate roadways.

3.1.3 Threats

Habitat threats are the human-derived activities that have created and/or are perpetuating the habitat limiting factors described above. Stream habitat threats are primarily related to past or current land-use practices. They include land and water uses with direct effects on stream channels, riparian areas, and floodplains, as well as effects on watershed process conditions that are believed to be impacting fish habitat. The sources of the threats (forestry, agriculture, urbanization, etc.) typically impact multiple limiting factors. (Impacts from large, hydropower dams are treated in a separate hydrosystem section below.)

Water Withdrawals

Water withdrawals for irrigation, livestock watering, or municipal use result in lower stream flows in some lower Columbia subbasins. The greatest period of risk is late summer and fall, when stream flows are naturally at their lowest and when fish are spawning. Flow withdrawals also impact fish by obstructing passage (dams, levees), stranding fish in diversion channels, and through impingement on intake screens. Significant water withdrawals only occur on a few lower Columbia streams. Threats to salmon include:

- Reduced instream flows and channel dewatering,
- Inadequate screening of intakes, and
- Passage obstructions (dams, weirs).

Dams, Culverts, and Other Barriers

Fish passage barriers that limit access to spawning and rearing habitats are a significant factor affecting salmon populations throughout the lower Columbia region. Numerically, the majority of barriers are culverts and dams with occasional other barriers, such as irrigation diversion structures, fish weirs, beaver dams, road crossings, tide gates, channel alterations, and localized temperature increases. Passage barriers effectively remove habitat from the subbasin, thereby reducing habitat capacity. In situations where a substantial amount of historical spawning or rearing habitat has been blocked, such as in the Cowlitz or Lewis River subbasins, production potential of salmonid populations have been severely reduced. (Large hydropower dams are addressed in a separate section below.) Ongoing threats to salmon from migration barriers include:

- Culverts on forest, agricultural, and urban roads,
- The Toutle River Sediment Retention Structure,
- Irrigation diversions,
- Fish weirs,
- Tide gates,
- Temperature or dissolved oxygen barriers, and
- Channel alterations.

Forest Practices

Forest harvest is the most widespread land use in the region and occurs most heavily on private timberlands. Forest roads can present one of the greatest threats to watershed processes. Improperly located, constructed, or maintained forest roads can degrade stream flow and sediment supply processes. Forest practice impacts on federal lands have decreased significantly over the past decade, since the implementation of the President's Forest Plan in 1994. With the implementation of the revised WA State Forest Practices Rules (FPRs) beginning in 2001, practices on state and private timberlands have also improved substantially. Despite the new protections, improvements to watershed hydrologic and sediment supply processes will only be fully recognized in the long-term. Moreover, ongoing monitoring will be necessary to determine the adequacy of these recent protections. Examples of forest practices that can be detrimental to salmonids include:

- Timber harvests on unstable slopes (increased landslide risk),
- Clear cutting in rain-on-snow zone (increase of water available for runoff),
- Unsurfaced forest road building and use (surface erosion),
- Increase to drainage network from road ditches (decreased time of concentration of runoff),
- Forest roads on steep, unstable slopes (increased landslide risk),
- Inadequate road maintenance (increased landslide and surface erosion risk),
- Application of forest fertilizers, herbicides, and pesticides,
- Increased wildfire risks (fuel buildup), and
- Timber harvests in riparian areas (loss of bank stability, large woody debris, and stream shade).

Agriculture / Grazing

Agricultural land uses occur in many of the lowland valley bottoms in the lower Columbia region. Crops and pasture land are often located adjacent to streams, with direct impacts on riparian areas and floodplains. Many floodplain areas were filled and levees constructed to expand or improve agricultural land. Runoff from agricultural lands can carry harmful contaminants originating from the application of pesticides, herbicides, and fertilizers. Livestock grazing can directly impact soil stability (trampling) and streamside vegetation (foraging), as well as deliver potentially harmful bacteria and nutrients (animal wastes). Threats to salmon from agriculture include:

- Clearing of riparian and/or upland vegetation,
- Livestock grazing on or near stream banks,
- Application of pesticides, herbicides, and fertilizers, as well as run-off of animal wastes,
- Floodplain diking and filling (to create or improve crop and pasture land), and
- Tide gate blockages.

Urban and Rural Development

The Vancouver metropolitan area, which lies primarily within the Lake River basin, makes up the largest urban area in the Washington lower Columbia region. There are also several other sizeable urban areas including Washougal/Camas, and Kelso/Longview. There is also considerable rural residential development throughout the region, much of it occurring within river valleys and often alongside streams. Rooftops, pavement, and landscaping increases impervious surfaces and decreases the ability of the soil to absorb rainwater, therefore increasing runoff volumes during storm events and decreasing groundwater recharge. The increase in the drainage network because of storm drains and road ditches further alters flow regimes by concentrating runoff. Studies have shown that measurable impacts to stream flow can occur once approximately 10% of a drainage basin is converted to impervious surfaces. Conversion of agriculture and forest land to residential or urban uses is a problem in many areas, and is especially prevalent in the expanding metropolitan areas in Clark County. Threats to salmon include:

- Incremental land use conversion (resulting in loss of watershed functions),
- Increased impervious surfaces (resulting in more frequent and stronger flash floods),
- Increased drainage network (resulting in more frequent and stronger flash floods),
- Contaminant runoff (automobiles, household hazardous wastes, yard chemicals),
- Clearing of riparian and/or upland vegetation,
- Combined sewage overflows and leaking septic systems,
- Industrial point-source discharges,
- Harassment and poaching of spawners,
- Floodplain filling (for development),
- Artificial channel confinement, and
- Fish passage obstructions (culverts).

Mining

Sand, gravel, and gold mining occurs along several Lower Columbia streams. Some by-products of mining are potentially harmful to water quality and aquatic biota if they are allowed to enter stream systems. Sand and gravel mining can impact stream channels by altering in-stream substrate and sediment volumes. In a few stream systems, including the EF Lewis and Salmon Creek, the stream channel has avulsed into stream-adjacent ponds created from the mining of floodplain sand and gravel. These avulsions have altered channel morphology and have generally destabilized channels. Ongoing threats to salmon from mining can include:

- Channel and/or floodplain substrate extraction,
- Floodplain filling,
- Mining contaminants in runoff,
- Increased water surface area (on and off-channel), and
- Stream channel avulsions.

Channel Manipulations

Changes to structural components within stream channels can have potentially detrimental impacts to habitat quality and quantity. Although strong regulatory mechanisms currently exist to prevent channel manipulations, there are cases where channel alterations have occurred. Considerable channel dredging, floodplain filling, and sediment retention damming occurred on the Toutle and lower Cowlitz Rivers following the 1980 Mt. St. Helens eruption, primarily to ensure the efficient conveyance of flood waters. Dredging has also occurred in other places to provide for flood conveyance. Structural components, including large woody debris and boulders, have been removed from some channels for flood conveyance and/or to facilitate river transportation or recreational uses. Many channels have been dredged, straightened, and floodplains filled to create agricultural land and to establish transportation corridors. Stream bank hardening has occurred along many channels to prevent erosion and/or to protect property. Threats to salmon from channel manipulations can include:

- Dredge and fill along streams and in off-channel habitats,

- Bank hardening,
- Clearing and snagging (fish passage, flood conveyance),
- Channel straightening and simplification, and
- Artificial confinement (for flood protection and to protect utility and transportation corridors).

Recreation

Boating, fishing, swimming, river floating, and dispersed camping in riparian areas all impact stream biota to some degree. Despite regulations, enforcement measures are often insufficient to prevent poaching of protected fish species. Even when protected, fish are caught and released and hooking mortality can occur. In some streams, such as the Washougal River, summertime swimming in mainstem pools may affect spawning success. Boating can also harass fish in some instances and boaters often advocate for removal of large woody debris, which can potentially degrade in-stream habitats. Dispersed recreation within riparian areas can denude riparian vegetation, contribute to erosion, and create human waste inputs to streams. Continuing threats to salmon include:

- Fishing – direct mortality, including poaching,
- Fishing – indirect mortality (catch and release and snagging),
- River recreation (harassment),
- Dispersed recreation impacts (human wastes, stream bank erosion), and
- Boating (harassment, snagging).

3.2 Estuary and Lower Mainstem Habitat

3.2.1 Background

Juvenile and adult salmon may be found in the Columbia River estuary at all times of the year, as different species, life history strategies, and size classes continually move into tidal waters. The lower Columbia River mainstem and estuary subbasins are treated generally in Volume I, Chapter 3 and in detail in Volume II, Chapter 1 of the Technical Foundation. This section is intended to briefly and succinctly describe the limiting factors and threats in the estuary and lower mainstem as they relate to salmonid survival, production, and life history diversity.

Estuaries have important impacts on juvenile salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995, Aitkin 1998 as cited in USACE 2001, Miller and Sadro 2003). Juvenile chinook salmon growth in estuaries is often superior to river-based growth (Rich 1920a, Reimers 1971, Schluchter and Lichatowich 1977). Estuarine habitats provide young salmonids with a productive feeding area, free of marine pelagic predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment. Studies conducted by Emmett and Schiewe (1997) in the early 1980s have shown that favorable estuarine conditions translate into higher salmonid survival. These findings are consistent with the results of Kareiva et al. (2001, as cited in Fresh et al. 2003); they demonstrated that improvement of juvenile salmon survival during the estuarine and early ocean stage would significantly improve salmon population growth rates.

Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for salmonid growth and survival in the estuary. In particular, tidal marsh habitats, tidal creeks, and associated complex dendritic channel networks may be especially important to subyearlings as areas of both high insect prey density, and as potential refuge from predators afforded by sinuous channels, overhanging vegetation, and undercut banks (McIvor and Odum 1988). Furthermore, areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids (Simenstad et al. in press, as cited in Bottom et al. 2001). For example, as subyearlings grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum and ocean-type chinook salmon that rear in the estuary for extended periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. Additionally, the connectedness of these habitats likely determines whether juvenile salmonids are able to access the full spectrum of habitats they require (Bottom et al. 1998).

Juvenile salmonids must continually adjust their habitat distribution in relation to twice-daily tidal fluctuations as well as seasonal and anthropogenic variations in river flow. Juveniles have been observed to move from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again (Healey 1982). These patterns of movement reinforce the belief that access to suitable low-tide refuge near marsh habitat is an important factor in production and survival of salmonid juveniles in the Columbia River estuary.

The importance of proximally available feeding and refuge areas may hold true even for species that move more quickly through the estuary. For example, Dawley (1989) found prey items in the majority of stomachs of salmon smolts known to migrate through the Columbia estuary quickly (i.e., days), indicating that these smolts are utilizing estuarine resources. Additionally, radio-tagged coho in Grays Harbor estuary moved alternatively from low velocity holding habitats to strong current passive downstream movement areas (Moser et al. 1991). Further, Fresh et al. (2003) reported that both small and large chinook salmon (i.e., ocean- and stream-type chinook from upper and lower basin populations) utilized peripheral marsh and forested wetland habitat in the Columbia River estuary. Consistent with these observations, Dittman et al. (1996) suggest that habitat sequences at the landscape level may be important even for species and life history types that move quickly through the estuary during the important smoltification process, as salmon gather the olfactory cues needed for successful homing and these cues may depend on the environmental gradients experienced during migrations.

3.2.2 Limiting Factors

Human-induced changes have substantially influenced current habitat conditions in the lower Columbia River mainstem and estuary. Adult migration behavior, health, and survival are all affected by conditions at the freshwater:saltwater interface and in lower river mainstem. Changes in river flow, circulation, water quality, contaminants, channel alterations, and predation may all be having impacts on adults and juveniles. Because estuaries also provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean, proximity of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for salmonid growth and survival in the estuary. Loss of connections among these habitats can determine whether juvenile salmonids are able to access the full spectrum of habitats they require.

Anthropogenic factors have substantially influenced current habitat conditions in the lower Columbia River mainstem and estuary. The primary anthropogenic factors that have determined estuary and lower mainstem habitat conditions include hydrosystem construction and operation (i.e., water regulation), channel confinement (primarily diking), channel manipulation (primarily dredging), and floodplain development and water withdrawal for urbanization and agriculture. Generally, these anthropogenic factors have influenced estuary and lower mainstem habitat conditions by altering hydrologic conditions, sediment transport mechanisms, and/or salinity and nutrient circulation processes. Often, there are no simple connections between a single factor and a single response, as many of the factors and responses are interrelated. Further, it is difficult to separate anthropogenic factors from concurrent natural variation when evaluating human impacts.

As one example on a broad scale, evaluations of anthropogenic factors are complicated by climatic effects. Variations in climate-driven Columbia River discharge occur in time scales from years to centuries (Chatters and Hoover 1986, 1992 as cited in Bottom et al. 2001). The Columbia Basin's response to climatic cycles is governed by the basin's latitudinal position; climate in the region displays a strong response to both the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation Index (ENSO) cycles (Mantua et al. 1997 as cited in Bottom et al. 2001). The effects of poor estuary and mainstem habitats are exaggerated during periods of low ocean productivity. However, despite our ability to measure changes in climate, Bottom et al. (2001) discussed the difficulty in separating climate versus anthropogenic effects on river discharge and the habitat-forming processes it governs.

River Flow

Flow effects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes (ISAB 2000, Bottom et al. 2001, USACE 2001, Johnson et al. 2003b). Flow regulation in the Columbia River basin has been a major contributor to the changes that have occurred in the estuary from historic conditions. The predevelopment flow cycle of the Columbia River has been modified by hydropower water regulation and irrigation withdrawal (Thomas 1983, Sherwood et al. 1990 as cited in Nez Perce et al. 1995, Weitkamp 1994, NMFS 2000c, Williams et al. 2000, Bottom et al. 2001, USACE 2001).

Before the development of the hydrosystem, Columbia River flows were characterized by high spring runoff from snowmelt and regular winter and spring floods. Dam construction and operation have altered Columbia River flow patterns substantially throughout its basin. Historic flow records at The Dalles, Bonneville Dam, and Beaver, Oregon, demonstrate that spring freshet flows have been reduced by about 50%, as water is stored for power generation and irrigation, and winter flows have increased about 30% (Figure 6) Flood control operations have reduced flood volume and frequency. Hydrosystem operations change to accommodate daily fluctuations in power demand and can result in significant daily flow variation downstream from some hydropower facilities.

Most of the spring freshet flow reduction is attributed to dam filling, about 20% is a result of irrigation withdrawals, and only a small portion (5%) is connected to climatic change (Bottom et al. 2001).

Reduction of maximum flow levels, dredged material deposition, and diking have all but eliminated overbank flows in the Columbia River (Bottom et al. 2001), resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Overbank flows were historically a vital source of new habitats. Moreover, historic springtime overbank flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands. Historic bankfull flow levels were common prior to 1975 but are rare today. Further, the season when overbank flow is most likely to occur today has shifted from spring to winter, as western subbasin winter floods (not interior subbasin spring freshets) are now the major source of peak flows (Bottom et al. 2001, Jay and Naik 2002).

Changes in flow patterns can affect salmon migration and survival through both direct and indirect effects. Juvenile and adult migration behavior and travel rates are closely related to river flow. Greater flows increase velocity, which increases juvenile and decreases adult travel rates. Extensive study has detailed the relationship between juvenile migration travel times and flow volume. The relationship is particularly strong at low to moderate flow volumes. Flow regulation and reservoir construction has increased smolt travel times through the Columbia and Snake mainstems many-fold, although the significance of this relationship to juvenile survival remains a subject of considerable controversy. The potential delay of emigrants reaching the estuary during a critical physiological window for smoltification or for ocean dispersion is a significant concern, especially for upriver salmon stocks, where delays are compounded across long migration distances. Moreover, increased travel times also increase exposure to Columbia River predation. For lower basin stocks, however, the mainstem journey is relatively short and only fish originating in the Wind, Big White Salmon, Little White Salmon, and Columbia Gorge tributaries are directly affected by passage through one mainstem dam (Bonneville).

Interactions of flow and dam passage can be particularly problematic for migrating salmon. General passage issues have been discussed in the subbasin habitat section of the Technical Foundation, but higher flows generally increase the survival of juveniles as they pass through the dams, because more fish can pass over the spillways, where mortality is low, than through the powerhouses, where turbine passage mortality can be significant. The increased spill typically associated with high flows also reduces travel time by avoiding fish delays in dam forebays. For this reason, many fish and hydrosystem managers implement a water budget of prescribed flows to facilitate fish migration rates and dam passage. In contrast, increased flow and spill can increase mortality and delay upstream passage of adults at dams as fish have a more difficult time locating the entrances to fishways and also are more likely to fall back after exiting the fish ladder (Reischel and Bjornn 2003).

Flow also affects habitat availability for mainstem spawning and rearing stocks. Significant numbers of chum and fall chinook spawn and rear in the mainstem and side channels of the Columbia downstream from Bonneville Dam. Flow patterns determine the amount of habitat available and can also dewater redds or strand juveniles (NMFS 2000c).

In summary, river flow changes in the estuary and lower mainstem impair salmon through:

- Changes in timing and magnitude of natural seasonal flow patterns,
- Loss of migration-stimulating flows,
- Lack of access to floodplain habitats,
- Reduced or fluctuating availability of spawning habitats
- Reduced sediment transport,
- Lack of sediment deposition, and
- Reduced large woody debris delivery.

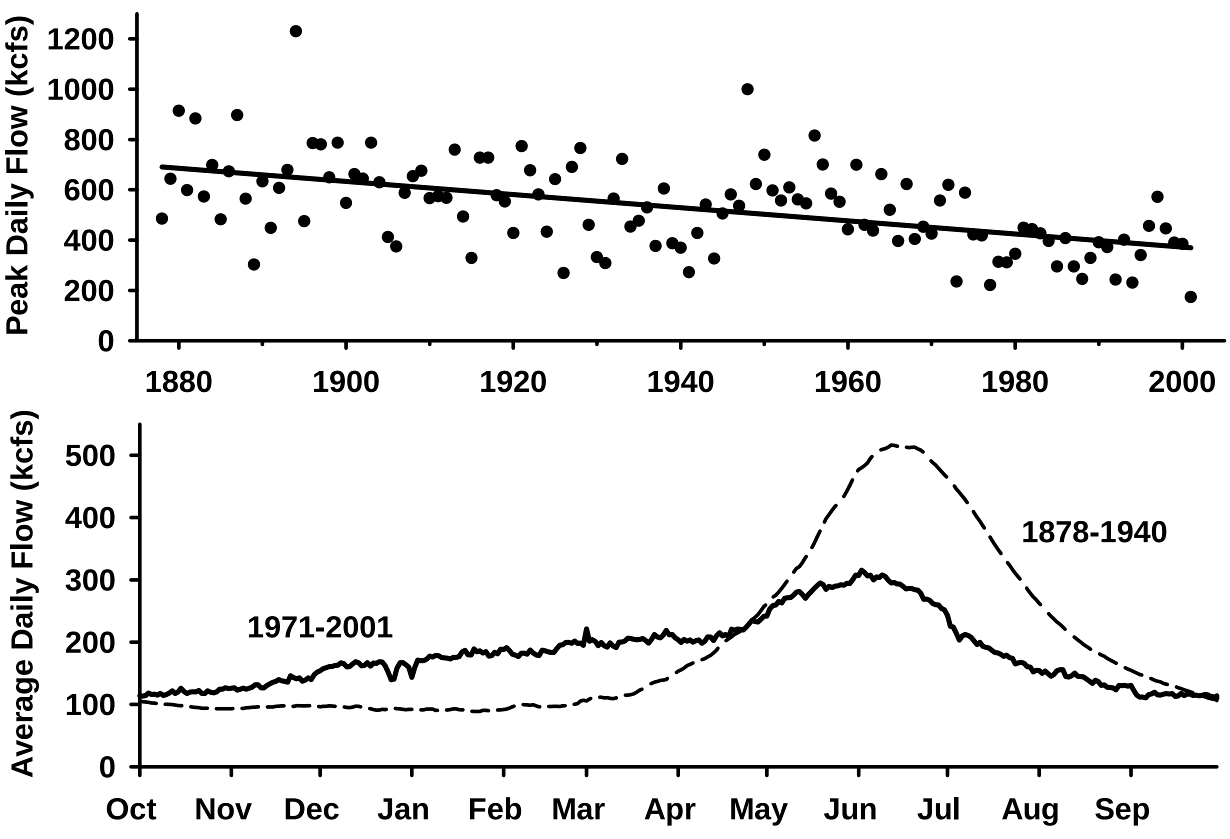


Figure 6. Historical changes in average daily flow patterns and flood frequency in the Columbia River at The Dalles.

Circulation

Small changes in salinity distribution may have significant effects on the ecology of fishes in the estuary, including salmonids. Salinity distribution is affected by tidal flow and river discharge, now both strongly influenced by upriver dam operation, the dredged shipping channel, and the jetties at the river mouth. Tidal energy and river discharge determines the location, size, shape, and salinity gradients of the estuary turbidity maximum zone, which affects seasonal species distributions and structure of entire fish, epibenthic, and benthic invertebrate prey species assemblages throughout the Columbia River estuary. Therefore, small changes in the distribution of salinity gradients may change the type of habitats available when juvenile salmon make the critical physiological transition from fresh to brackish water. These changes impact salmon through:

- Alterations of salinity patterns and food webs,
- Effects on physiology of smoltification, and
- Influences on predator and prey species distributions.

Water Temperature and Clarity

Flow regulation and reservoir construction have increased average water temperature in the Columbia River mainstem as illustrated in Figure 7. Summer water temperatures now regularly exceed optimums for salmon (NMFS 2000a). Water temperatures in fish ladders can be higher than ambient river temperatures, which compounds this problem.

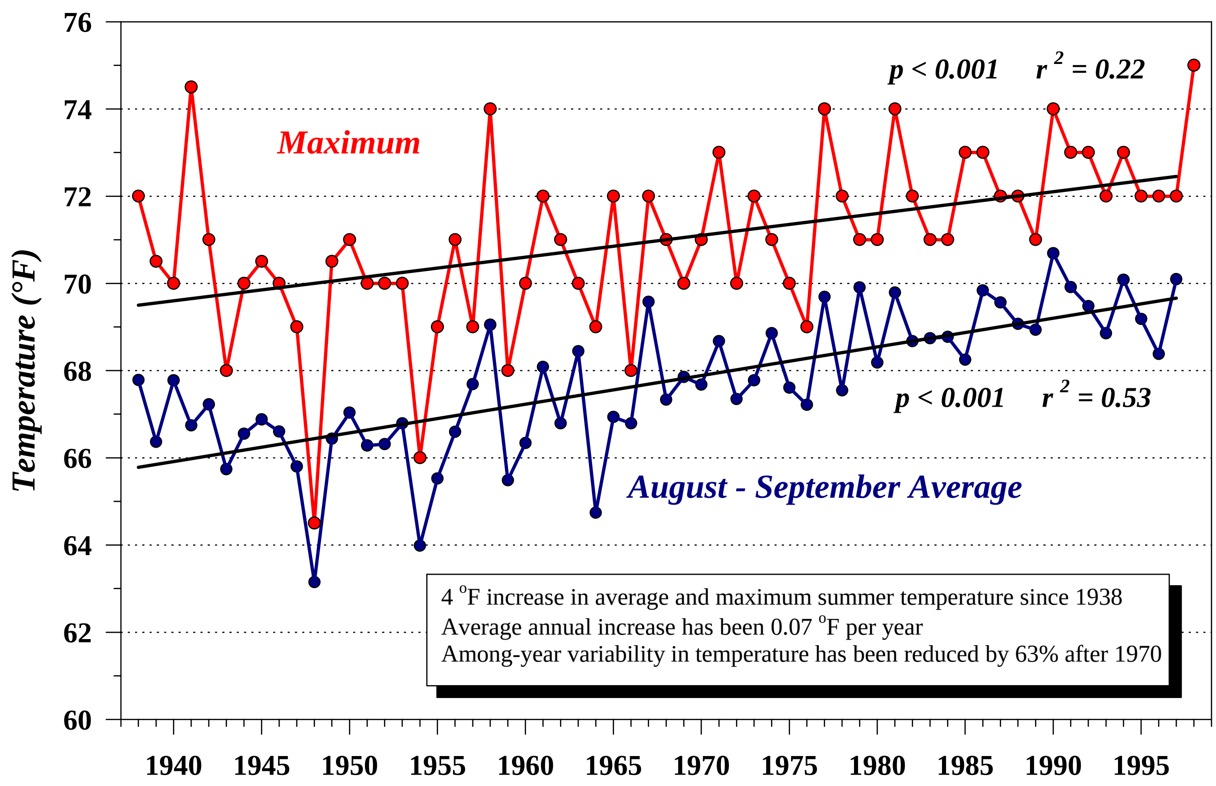


Figure 7. Historical changes in summer water temperatures at Bonneville Dam.

High water temperatures can cause migrating adult salmon to stop their migrations or seek cooler water that may not be in the direct migration route to their spawning grounds (NMFS 2000a). In the lower Columbia, many summer and fall migrating adults typically pull into the cooler Cowlitz, Lewis, and Wind River mouths before continuing up the Columbia. Warm temperatures can increase the fishes' susceptibility to disease, but the overall effects of delay in migration rate due to high water temperature are unknown. Since the early 1990s, some upper basin dams have been operated to provide cold water for downstream temperature control to benefit migrating juvenile and adult salmon.

Flow regulation and reservoir construction also have increased water clarity. Increased water clarity can affect salmon through food availability and susceptibility to predation.

In summary increased water temperatures and water clarity can impact salmon through:

- Exceedance of optimum temperatures,
- Altered migration patterns,
- Increased susceptibility to disease,
- Changes in food availability, and
- Increased susceptibility to predation.

Gas Supersaturation

There are important trade-offs between fish passage and gas saturation to be considered when formulating spillway operation policies at lower Columbia River dams. Supersaturating water with atmospheric gases, primarily nitrogen, can occur when water is spilled over high dams. These high concentrations of gases are absorbed into the fishes' bloodstream during respiration. When the gas comes out of solution, bubbles may form and subject the fish to gas bubble disease as in the bends suffered by human divers. The severity of gas bubble disease varies depending on species, life stage, body size, duration of exposure, water temperature, swimming depth, and total dissolved gas (Ebel et al. 1975, Fidler and Miller 1993).

High dissolved gas levels associated with dam operations have resulted in significant salmon mortality—especially before the problem was identified and measures taken to reduce its incidence (Ebel 1969). Measures implemented over the last 40 years include increasing headwater storage during spring, installing additional turbines, and installing flip-lip flow deflectors to reduce plunging and air entrainment of spilled water (Smith 1974). Monitoring shows that salmonid mortality continues to be associated with exceptionally high river flows (NMFS 2000). For instance, Bonneville Dam turbines exceeded 130% capacity for 24 days in 1997. During that time, daily prevalence of gas bubble disease was high in sockeye (14-100% for 3 weeks) but lower for chinook (0-6.5% prevalence).

Gas supersaturation poses the greatest risk for Washington lower Columbia basin salmon stocks that must pass Bonneville Dam or are destined for areas downstream. Gas levels equilibrate slowly; thus, gas levels at Bonneville Dam that are high enough to have impacts on fish may extend for long distances downstream. Dissolved gas saturation below lethal levels may still have chronic effects, such as increased susceptibility to disease or predation; these effects are poorly understood. The issue of gas supersaturation has been discussed in detail in the Total Maximum Daily Load report developed jointly by the Oregon Department of Environmental Quality and the Washington Department of Ecology for dissolved gas levels in the lower Columbia River (Pickett and Harding 2002). In summary, gas supersaturation affects salmon through:

- Direct mortality, or
- Chronic effects increasing susceptibility to disease or predation.

Contaminants

Environmental contaminants have been detected in lower Columbia River water, sediments, and biota at concentrations above available reference levels. Significant levels of dioxins/furans, DDT, and metals have been identified in lower Columbia River fish and sediment samples. In general, contaminant concentrations are often highest in industrial or urban areas, but may be found throughout the lower Columbia River mainstem and estuary as a result of transport and deposition mechanisms. Salmonids may uptake contaminants through direct contact or biomagnification through the food chain. Contaminants affect salmon through:

- Predisposition to disease,
- Increased stress, and
- Interrupted physiological processes.

Channel Alterations and Habitat Disconnection

Thomas (1983) suggested that channel confinement (i.e. diking) is particularly detrimental to estuary habitat capacity because it entirely removes habitat from the estuarine system, while other anthropogenic factors change estuary habitats from one type to another. The lower mainstem and estuary habitat in the Columbia River has, for the most part, been reduced to a single channel where floodplains have been reduced in size, off-channel habitat has been lost or disconnected from the main channel, and the amount of large woody debris has been reduced (NMFS 2000c). Dikes prevent overbank flow and affect the connectivity of the river and floodplain (Tetra Tech 1996); thus, the diked floodplain is higher than the historic floodplain and inundation of floodplain habitats only occurs during times of extremely high river discharge (Kukulka and Jay 2003). It is estimated that the historical estuary had 75 percent more tidal swamps than the current estuary partially because tidal and flood waters could reach floodplain areas that are now diked or otherwise disconnected from the main channel (USACE 2001, Johnson et al. 2003b).

Thomas (1983) documented substantial changes to estuary habitats from historic to current conditions in the area of RM 0-46.5. Estuary-wide tidal marsh and tidal swamp acreage has decreased 43% and 77%, respectively, from 1870 to 1983, primarily as a result of dikes and levees that have disconnected the main channel from these floodplain habitats and also from water regulation that has decreased historic peak flows that previously provided water to these habitats. Losses of tidal marsh habitat have been most extensive in Youngs Bay, where a loss of over 6,000 acres was documented. Extensive tidal swamp habitat has been lost in all estuary areas where this habitat was historically present. Losses of medium- and deep-water habitat acreage have been less severe (25% and 7%, respectively). Acreage of medium-depth water habitat was lost in all areas of the estuary except the upper estuary, where a slight increase in acreage was observed; acreage loss was greatest in the entrance, Cathlamet Bay, and Baker Bay areas of the estuary. Similarly, deep-water habitat acreage was lost in most areas of the estuary; losses were highest in the Baker Bay and upper estuary areas. Only shallows/flats estuary habitat realized a net increase 10% in acreage from 1870 to 1983. This increase in acreage was primarily a result of water regulation that has decreased historic peak erosive flows and decreased erosion following construction of the jetties at the river mouth. In total, 36,970 acres (23.7%) of the estuarine habitat acreage has been lost from 1870 to 1983. During this period, lost estuarine habitats were converted to the following non-estuarine habitats: developed floodplain (23,950 acres), natural and filled uplands (5,660 acres), non-estuarine swamp (3,320 acres), non-estuarine marsh (3,130 acres), and non-estuarine water (910 acres).

Development and maintenance of the shipping channel has greatly affected the morphology of the estuary. The extensive use of jetties and pile dikes to maintain the shipping channel has impacted natural flow patterns and large volumes of sediments are dredged annually. Dredged materials are disposed of in the ocean, in the flow adjacent to the shipping channel, along shorelines, or on upland sites. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year in the estuary. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays.

Juvenile salmonids in the estuary must continually adjust their habitat distribution in relation to twice-daily tidal fluctuations and seasonal and anthropogenic variations in river flow. Juveniles move from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again. Therefore, access to suitable low-tide refuge near marsh habitat is an important factor in production and survival of salmonid juveniles in the Columbia River estuary. Dike construction for agricultural or urban development has isolated the main channel from its historical floodplain in many places and prevented normal flows that previously provided water to these habitats. Poor and/or malfunctioning tide gates further reduce flow exchange and prevent juvenile passage among habitats.

Losses to lower mainstem and estuary salmonid habitat due to diking and dredging reduce salmon productivity through:

- Loss of natural habitats
- Reduced woody debris deliveries to rearing habitats
- Reduced water flow to side channel habitats
- Lack of access to productive rearing areas,
- Decreased macrodetritus inputs and foodweb productivity,
- Stranding of juveniles behind poor tide gates, and
- Reduced refuge from predators.

Sediment Transport

Sediments in the estuary may be marine- or freshwater-derived and are transported via suspension in the water column or bed load movement. Riverine sediments available for transport have decreased as a result of dam construction; reservoirs restrict bedload movement and trap upstream supply of sediments. Sand sediments are vital to natural habitat formation and maintenance in the estuary; dredging and disposal of sand and gravel have been among the major causes of estuarine habitat loss over the last century (Bottom et al. 2001).

Sediment transport is non-linearly related to flow; thus, it is difficult to accurately apportion causes of sediment transport reductions to climate change, water withdrawal, or flow regulation (Jay and Naik 2002). However, the largest single factor in reduced sediment transport appears to be the reduction of spring freshet flow as a result of water regulation and irrigation withdrawal. Recent analyses indicate a two-thirds reduction in sediment-transport capacity of the Columbia River relative to the pre-dam period (Sherwood et al. 1990, Gelfenbaum et al. 1999). Therefore, flow reductions affect estuary habitat formation and maintenance by reducing sediment transport (Bottom et al. 2001, USACE 2001). The reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001), which has important implications for habitat formation and food web dynamics.

Construction of the north and south jetties at the Columbia River mouth significantly increased sediment accretion in nearby marine littoral areas. Ocean currents that formerly transported sediments alongshore were disrupted and accretion, particularly in areas adjacent to the river mouth (i.e. Long Beach, Clatsop Spit), increased significantly in the late 1800s and early 1900s. Sediment accumulation rates have slowed since 1950, potentially as a result of reduced sediment supply from adjacent deltas or the Columbia River (Kaminsky et al. 1999). Because of the decreased sediment supply from the Columbia River and ebb-tidal deltas, recent modeling results indicate that the shorelines immediately north of the historic sediment source areas at the entrance to the Columbia River are susceptible to erosion in the future (Kaminsky et al. 2000).

Changes in lower mainstem and estuarine sediment budgets have impacted salmon by way of:

- Reduced estuarine habitat formation,
- Loss of habitat diversity, and
- Decreased predator avoidance capabilities.

Predation

Significant numbers of salmon are eaten by fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation likely has always been a significant source of mortality but has been exacerbated by habitat changes. Piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of emigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary, as discussed in section 2162688.1.1228652. Native fishes, particularly northern pikeminnow, prey on juvenile salmonids. Marine mammals prey on adult salmon, but the significance is unclear.

Fishes—including northern pikeminnow, walleye, smallmouth bass, and salmonids—prey on juvenile salmonids. Pikeminnow have been estimated to consume millions of juveniles per year in the lower Columbia, as outlined in Table 2.

Table 2. Projected abundance of northern pikeminnow, salmonid consumption rates, and estimated losses of juvenile salmonids to predation*

Location	Length (km)	Number of pikeminnow	Consumption Rate (smolts/predator day)	Estimated Losses (millions/year)
Estuary to Bonneville Dam	224	734,000	0.09	9.7
Bonneville Reservoir	74	208,000	0.03	1.0

* From NMFS (2000b).

Pikeminnow numbers likely have increased as favorable slack-water habitats have been created by impoundment and flow regulation. In unaltered systems, pikeminnow predation is limited by smolt migratory behavior; the smolts are suspended in the water column away from the bottom and shoreline habitats preferred by pikeminnow. However, dam passage has disrupted juvenile migratory behavior and provided low velocity refuges below dams where pikeminnow gather and feed on smolts (Friesen and Ward 1999). The diet of the large numbers of pikeminnow observed in the forebay and tailrace of Bonneville Dam is composed almost entirely of smolts. Pikeminnow also concentrate at dam bypass outfalls and hatchery release sites to prey on injured or disoriented fish, and pikeminnow eat many healthy smolts as well. Predation rates on salmonids are often much lower in areas away from the dams, although large numbers of predators in those areas can still impose significant mortality.

In 1990, responding to observed predation problems, a pikeminnow management program was instituted that pays rewards to anglers for each pikeminnow caught and retained over a prescribed size. Through 2001, over 1.7 million pikeminnow had been harvested, primarily in a sport reward fishery. Modeling results project that potential predation on juvenile salmonids by northern pikeminnow has decreased 25% since fishery implementation (Friesen and Ward 1999, NMFS 2000a). By paying only for pikeminnow over a certain size, the program takes advantage of their population characteristics—they are relatively long-lived and only the large individuals are fish predators. Relatively low exploitation rates of only 10-20% per year compound over time to substantially reduce pikeminnow survival to large predaceous sizes.

Walleye are voracious predators of fishes, including juvenile salmonids. On a fish-per-fish basis, walleye are as damaging as pikeminnow, but walleye are considerably less abundant and consume fewer juvenile salmonids (e.g. Rieman et al. 1991). Originally introduced into the upper Columbia basin, walleye since the 1970s gradually have spread downstream throughout the lower mainstem. Significant numbers of walleye have become established in Bonneville Reservoir and between Bonneville Dam and the estuary. Walleye population sizes are quite variable and driven by periodic large year classes that occur during warm, low flow springs. Walleye are subject to a small, directed sport fishery but were not included in the sport reward fishery because projected exploitation effects on salmonids were low. Unlike pikeminnow, most walleye predation occurs in smaller individuals not readily caught by anglers and unaffected by the compounding effects of annual exploitation.

Other introduced fishes—including smallmouth bass and channel catfish—also have been found to consume significant numbers of juvenile salmonids. However, these species are more significant problems in upstream areas than in the lower river where their abundance is low.

Piscivorous birds congregate near dams and in the estuary around man-made islands where they consume large numbers of outmigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary. Ruggerone (1986) estimated that gulls consumed 2% of the juvenile salmon and steelhead passing Wanapum Dam but comparable estimates have not been made for Bonneville Dam. Roby et al. (1998) estimated that avian predators consumed 10-30% of the total estuarine salmonid smolt population in 1997. (Additional discussion of bird predation in the estuary is included in section 45044960.1311136.0.)

Marine mammals prey on adult salmon, but the significance is unclear. Seals and sea lions are common in and immediately upstream of the Columbia River estuary and are regularly observed up to Bonneville Dam. Seals and sea lions are regularly reported to prey on adult salmon and steelhead, although diet studies indicate that other fish comprise the majority of their food. Large numbers of pinnipeds might translate into significant salmon mortality despite this occasional use. However, it is difficult to interpret the significance of this mortality factor for salmon, considering that large pinniped populations have always been present in the Columbia

River. However, current marine mammal predation may be proportionally more significant, since all sources of mortality on depressed stocks become more important. Their numbers were reduced by hunting (including bounty hunters) and harassment from the late 1800s until the Federal Marine Mammal Protection Act (FMMPA) was adopted in 1972. Their numbers have significantly increased since the adoption of FMMPA. Fishers historically viewed seals and sea lions as competitors and the old Fish Commission of Oregon funded a control program. These mammals can be troublesome to sport and commercial fishers by taking hooked or net-caught fish before they can be landed.

In summary, predation has been increased on salmonids by human-caused alterations including:

- Dams and impoundments,
- Decreased water flows,
- Predator habitat creation at artificial islands, and
- Introduced sport fishes.

3.2.3 Threats

The primary anthropogenic factors that have determined estuary and lower mainstem habitat conditions include hydrosystem construction and operation (water regulation), channel confinement (primarily diking), channel manipulation (primarily dredging), and floodplain development and water withdrawal for urbanization and agriculture. Generally, these anthropogenic factors have influenced estuary and lower mainstem habitat conditions by altering hydrologic conditions, sediment transport mechanisms, and/or salinity and nutrient circulation processes. Often, there are no simple connections between a single factor and a single response, as many of the factors and responses are interrelated.

Hydrosystem Alterations of Flow Patterns

Continued operation of upstream dams and irrigation withdrawals will affect estuarine circulation, deposition of sediments, and biological processes. Reduction of maximum flow levels, dredged material deposition, and diking have all but eliminated overbank flows in the Columbia River resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Water level fluctuations associated with hydropower peak operations may reduce habitat availability and strand juveniles during the downstream migration. Threats to salmon from altered flows include:

- Lack of sediments delivered to estuary,
- Disruption of natural flow patterns (that affect migration and predation)
- Altered estuarine salinity patterns and estuary turbidity maximum function,
- Loss of water-driven access to river edge and off-channel habitat,
- Decreased recruitment of macrodetritus (decreased foodweb productivity),
- Altered juvenile migrations and stranding, and
- Disrupted turbidity patterns (decreased predator avoidance).

Channel Alterations and Diking

Channel confinement (diking) is particularly detrimental to lower river and estuary habitat capacity because it entirely removes habitat from the estuarine system. The lower Columbia River mainstem has, for the most part, been reduced to a single channel where floodplains have been reduced in size, off-channel habitat has been lost or disconnected from the main channel, and the amount of large woody debris has been reduced. Dikes prevent over-bank flow and affect the connectivity of the river and floodplain.

Development and maintenance of the shipping channel has greatly affected the bathymetry of the estuary, which affects tidal flow, salinity gradients, and the estuary turbidity maximum. The shipping channel has been maintained through the extensive use of jetties, pile dikes, and maintenance dredging, all of which has impacted natural flow patterns. Dredged materials are disposed of in the ocean, in the flow adjacent to the shipping channel, along shorelines, or on upland sites. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays. Continuing threats to salmon from channel alterations include:

- Conversion of wetlands and estuaries to other uses,
- Existing dikes that eliminate habitat availability or connectivity,
- Altered habitats behind dikes and levees,
- Poor or malfunctioning tide gates that strand juveniles,
- Continued dredging of the shipping channel, and
- Dredge material-created habitat for predators.

Contaminants

Environmental contaminants enter the lower Columbia River ecosystem through a variety of point and non-point sources, as well as from upstream. Point sources include outfalls at the numerous industrial facilities from Longview to Vancouver; non-point sources include agricultural and residential application of pesticides, insecticides, and herbicides and overland flow from impervious surfaces in developed areas. Salmonids may uptake contaminants through direct contact or biomagnification through the food chain. Continuing threats to salmon from contaminants include:

- Agricultural pesticides an fertilizers,
- Industrial discharges,
- Non-point urban and residential run-off of pollutants

3.3 Habitat – Ocean

3.3.1 Background

Just 7 years after record low returns that many feared were the last gasps of endangered salmon and steelhead populations, record high numbers of salmon and steelhead were counted at Bonneville Dam.3 Although dominated by hatchery fish, the 868,000 chinook, 260,000 coho, 115,000 sockeye, and 630,000 steelhead counted at Bonneville Dam in 2001 represent 5- to 25-fold increases from recent low counts of 189,000 chinook, 10,000 coho, 9,000 sockeye, and 162,000 steelhead.

Have fears of salmon extinction been overblown? Are the increases in response to two decades of costly protection and restoration? Have salmon recovered and is ESA listing no longer warranted? At least partial answers to these questions can be found by examining ocean productivity patterns and their effects on salmon survival.

Biologists have only recently come to understand the importance of the ocean in the variation of salmon and steelhead numbers. Salmon management traditionally assumed relatively constant—or at least randomly variable—ocean conditions. After all, how could a water body so vast change from year to year? Anadromy was a tremendously successful life history pattern that traded high mortality over the long migration from freshwater to salt and back, against the large size and fecundity that could be gained in productive ocean pastures.

However, large fluctuations in smolt-to-adult survival over the last three decades have demonstrated that ocean conditions are much more dynamic than previously thought. We now understand that the ocean is subject to annual and longer-term climate cycles just as the land is subject to periodic droughts and floods. Land and ocean weather patterns are related and their combination drives natural variation in salmon survival and productivity as those seen in recent years (Hartman et al. 2000).

3.3.2 Limiting Factors

Ocean Climate Patterns

Fluctuating ocean conditions and regional weather follow large-scale atmospheric pressure gradients and circulation patterns. The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather patterns is typified by cool ocean temperatures and cool/wet weather patterns on land. Of the several indices that describe ocean conditions, the most widely known is the ENSO. It is based on sea surface temperatures in the Pacific Ocean off the coast of South America. The PDO is a similar index based on conditions in the north Pacific. The PDO often, but not always, tracks with the ENSO. ENSO episodes can have substantial short-term impacts on salmonid production, while the PDO has long term (decadal length) effects (Hare et al 1999).

Annual weather patterns tend to occur in successive years rather than randomly. Thus, warm dry years tend to occur in close association with a higher than average frequency and cool, wet years also tend to co-occur. Periods of warm, dry or cool, wet conditions are called regimes; transition periods are called regime shifts. Recent history is dominated by a high frequency of warm dry years, along with some of the largest El Niños on record—particularly in 1982-83 and 1997-98, as illustrated by Figure 8. In contrast, the 1960s and early 1970s were dominated by a

[3] 403,000 in 1994 and 411,000 in 1995; 1.9 million in 2001 and 1.4 million in 2002.

cool, wet regime. A close examination of the historical record reveals a long, irregular series of periodic regime shifts in ocean conditions. Many climatologists suspect that the conditions observed since 1998 may herald a return to the cool wet regime that prevailed during the 1960s and early 1970s.

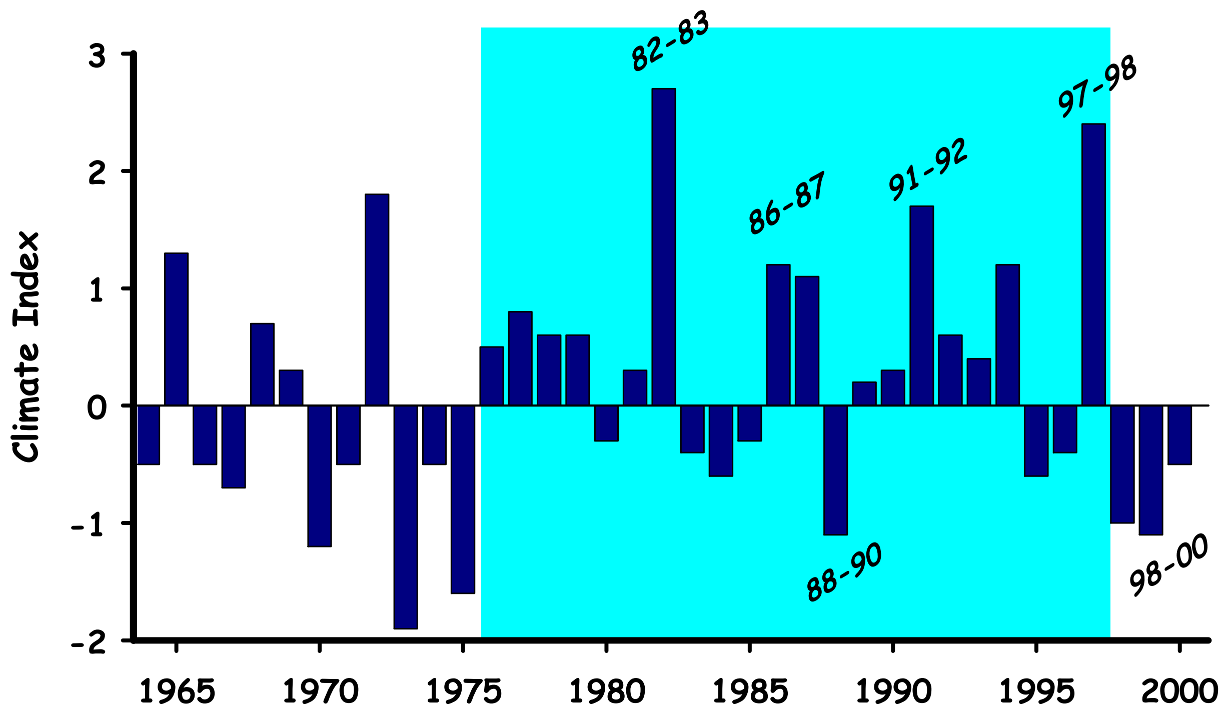


Figure 8. Annual variation in the multivariate El Niño southern oscillation (ENSO) index for December. Recent strong El Niño (positive values) and La Niña (negative values) years are labeled.

Climate and Ocean Productivity

Significant changes in oceanographic conditions are associated with El Niño/La Niña patterns. During El Niño, deep, warm, nutrient-poor layers of water push northward along the Oregon and Washington coasts. These layers block upwelling of cool nutrient-laden subsurface waters, which in turn reduces primary productivity by phytoplankton and secondary productivity by zooplankton. Juvenile salmon reaching the ocean find limited food resources and this reduces their growth and survival. Unproductive El Niño conditions also affect bird and pinniped survival and productivity. For instance, Welch et al. (1997) noted widespread mortality of northern fulmars (an offshore seabird) from Oregon to Vancouver Island with substantial numbers of starving birds washing ashore in the winters of 1994 and 1995. In addition, warm waters bring large numbers of predaceous mackerel, tuna, and even marlin into Northwest waters to further reduce salmon survival prospects. In contrast, La Niña conditions are associated with strong upwelling of cool nutrient-rich water, high productivity along the Oregon and Washington coasts, and good growth and survival of Northwest salmon stocks.

El Niño produces the opposite effect on productivity in the North Pacific off Canada and Alaska. Northern salmon stocks in Alaska generally appear to benefit from improved ocean productivity and increased smolt-to-adult survival rates during warm, dry periods (Downton and Miller 1998, Hare et al. 1999). Physical and biological domains in the North Pacific are divided by a transition zone called the Subarctic Front (Figure 9). Shifts in the location and structure of this front associated with ocean climate patterns drive differences in salmonid predator abundance and food resources in the North and Far North Pacific (NMFS 1996, Pearcy 1992). High atmospheric pressure along the Pacific Northwest coast during El Niño years is associated with low pressure off the Aleutian Island chain that increases upwelling in the Gulf of Alaska and provides very productive conditions for Alaska salmon. Pacific Northwest and Alaska salmon survival is thus inversely correlated: when ocean conditions are good in the Pacific Northwest, they tend to be poor in Alaska. When Alaska salmon returns are high, Pacific Northwest salmon returns are typically low.

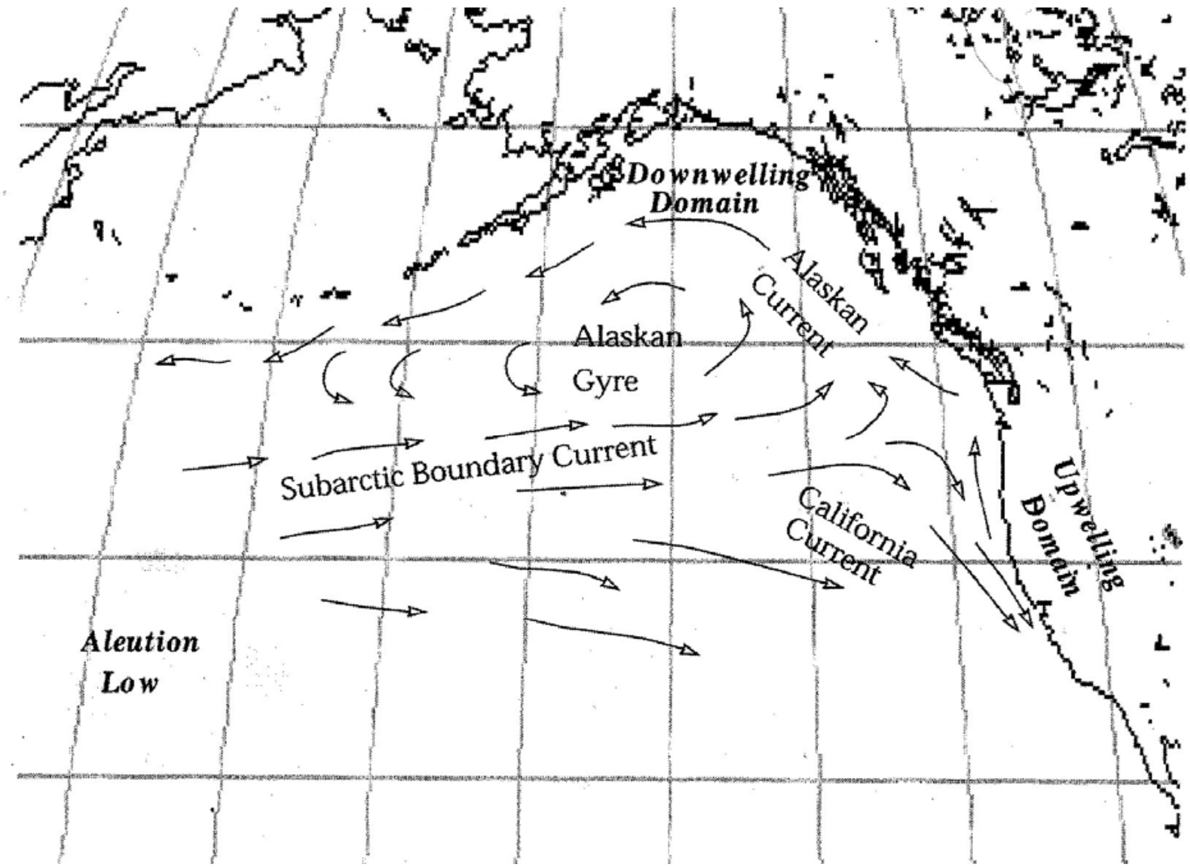


Figure 9. North Pacific currents and production domains. Years with an intense winter Aleutian low shift (warm dry in the Pacific Northwest) the subarctic current northward, strengthen the Alaskan current and increase the downwelling domain production. Years with a weak Aleutian low (cool wet in the Pacific Northwest) shift the subarctic current southward and strengthen the California current and the upwelling domain production (Anderson 2000).

Climate effects on ocean productivity can be compounded by parallel effects in freshwater. In the Pacific Northwest, cool, wet patterns that improve ocean survival and growth also increase precipitation, increase streamflow, and reduce temperature. Increased stream flow and cooler temperatures increase stream habitat quantity and quality for rearing salmonids. These changes also improve migration survival conditions for both juveniles and adults. Conversely, salmon productivity is reduced by low flows and warm temperatures during drought years that are often associated with El Niño. El Niños thus produce compound impacts by reducing both freshwater and saltwater survival conditions.

The PDO is a decadal or longer pattern of climate and oceanic conditions in the North Pacific Ocean associated with the Aleutian low pressure system. The PDO causes shifts in sea surface temperatures and plankton abundance on a decadal time scale (WDFW and PNPTT

2000, Mantua et al. 1997). The most recent shift occurred in 1977 (Ebbesmeyer et al. 1991), resulting in warmer coastal sea surface temperatures, cooler temperatures in the central Pacific Ocean, and more abundant plankton. While ocean conditions are affected by the PDO, the phenomenon also influences freshwater environments as well, as precipitation and temperature patterns on land are also affected by the PDO. The PDO regimes have been related to abundance patterns in zooplankton, and subsequent production of Alaskan pink and sockeye salmon (Hare and Francis 1977). The most recent PDO shift has been related to increases in production of pink, chum, and sockeye salmon in the North Pacific Ocean (Beamish and Bouillon 1993). It is possible that PDO effects on salmonid production can be more important than the shorter term ENSO-driven variation.

Effects on Fish Abundance and Survival Patterns

The regime shift to predominantly warm, dry conditions from 1975 to 1998 produced widespread effects on salmon and other ocean fishes throughout the North Pacific (Beamish and Bouillon 1993, McKinnell et al. 2001, Pyper et al. 2001). Abrupt declines in salmon populations coincided with the regime change throughout the Pacific Northwest (Hare et al 1999).

Although trends in ocean conditions are a major driving force in the survival and abundance patterns of Pacific salmon and steelhead, the degree of effect varies among species and populations within species. Migration patterns in the ocean may differ dramatically and expose different stocks to different conditions in different parts of the ocean. Some species have broad, offshore migration patterns that may extend as far as the Gulf of Alaska (steelhead, chum, some chinook). Others have migration patterns along the Washington, British Columbia, Oregon and California coasts (chinook, coho, cutthroat). Thus, ocean conditions do not have coincident effects on survival across species or populations.

Oregon and Washington coho stocks are particularly sensitive to El Niño effects because of their local ocean distribution pattern. Coronado and Hilborn (1998) estimated ocean survival rates for CWT marked coho from Pacific Northwest hatcheries during 1971–1990. Trends changed in 1983 toward decreasing survival south of mid-British Columbia and increasing survival north of mid-British Columbia. They noted similar survival trends between hatchery, net pen, and wild coho and concluded that; “the dominant factor affecting coho salmon survival since the 1970s is ocean conditions.” Tschaplinski (2000) found that marine survival of coho smolts from Carnation Creek, British Columbia, varied up to 6-fold between years (0.05 to 0.30). Holtby et al. (1990) found that variation in survival was significantly correlated to early ocean growth rates and sea-surface salinities related to upwelling of nutrient-rich water.

Widespread changes in ocean conditions have had similar dramatic effects on ocean survival of steelhead (Figure 10). Cooper and Johnson (1992) showed that variation in steelhead run sizes and smolt-to-adult survival was highly correlated between runs up and down the West Coast. Smolt-to-adult survival rates generally varied 10-fold between good and bad years. Ocean survival rates for three West Coast steelhead populations where good annual index data were available showed high variability and a generally declining trend since the late 1970s (Figure 10).

Similar survival patterns have been documented for other Pacific salmon species including sockeye (Farley and Murphy 1997, Kruse 1998, Peterman et al. 1998, McKinnell et al. 2001) and pink salmon (Pyper et al. 2001).

Warm, dry regimes result in generally lower survival rates and abundance, and they also increase variability in survival and wide swings in salmon abundance. Some of the largest

Columbia River fish runs in recorded history occurred during 1985–1987 and 2001–2002 after strong El Niño conditions in 1982–83 and 1997–98 were followed by several years of cool wet conditions.

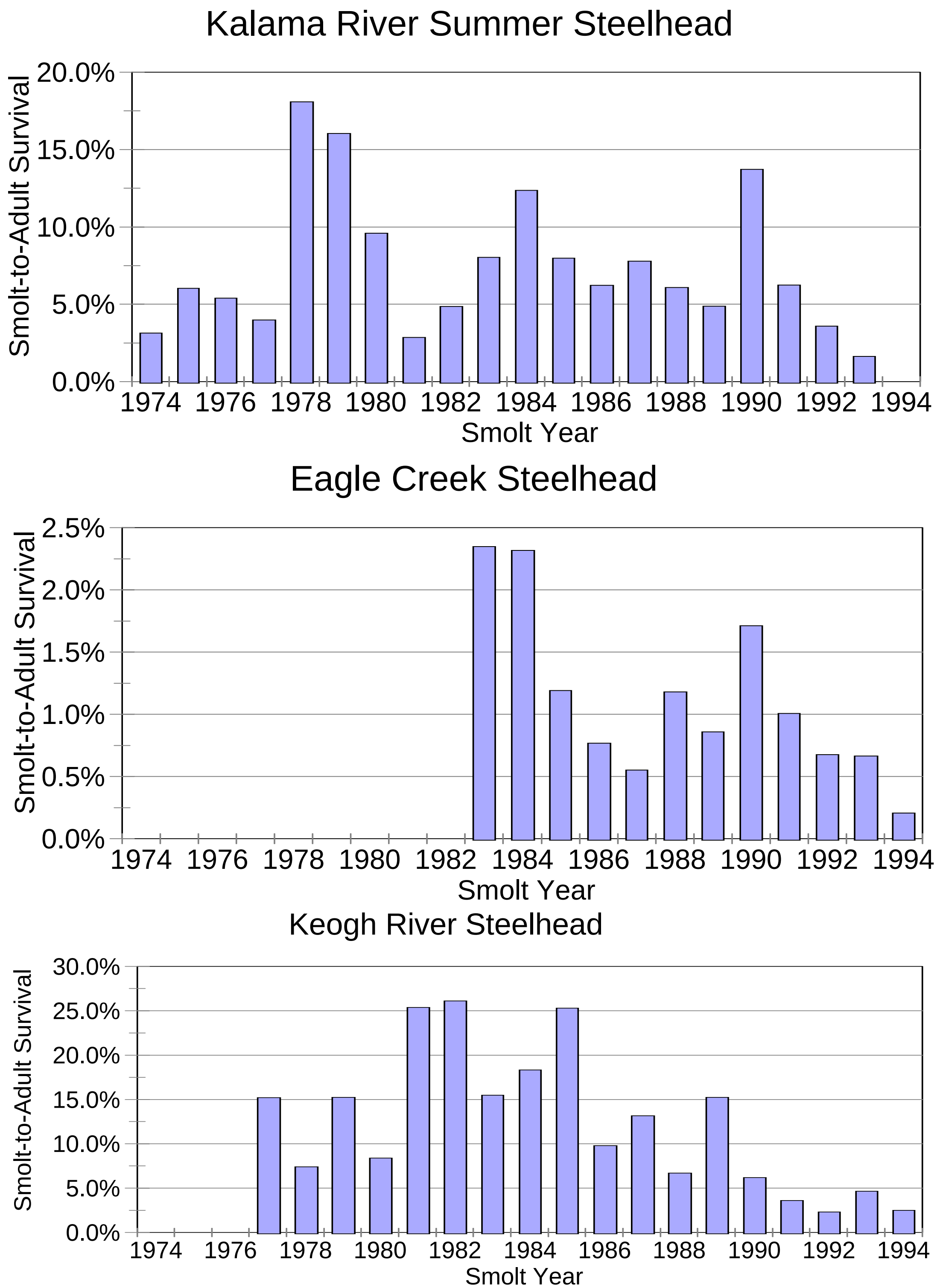


Figure 10. Annual means of smolt-to-adult survival rate of winter and summer steelhead from Kalama River Hatchery, winter steelhead from Eagle Creek National Fish Hatchery, and wild winter steelhead from the Keogh River, British Columbia.

3.3.3 Threats

There are very few management actions that can be taken relative to the effects of ocean conditions on salmon survival and productivity. The most notable aspect that humans can control to at least some extent is the number of smolts that leave freshwater each year. This can be accomplished through managing spawner escapements, hatchery releases, and habitat conditions. It is therefore essential that managers have a thorough understanding of the ways in which oceanic variations influence the production of returning adult salmon and of the importance of maintaining abundant smolt production.

The reduced productivity that accompanied an extended series of warm dry, conditions after 1975 has, together with numerous anthropogenic impacts, brought many weak Pacific Northwest salmon stocks to the brink of extinction and precipitated widespread ESA listings. Salmon numbers naturally ebb and flow as ocean conditions vary. Healthy salmon populations are productive enough to withstand these natural fluctuations. Weak salmon populations may be severely stressed during periods of poor ocean survival. Weak populations may disappear or lose the genetic diversity needed to withstand the next cycle of low ocean productivity (Lawson 1993).

Looked at over decades, ocean productivity patterns confound our ability to recognize and measure risk factors and the benefits of protection and restoration actions implemented to date. For instance, a favorable climate regime counteracted the detrimental impacts of Columbia River basin hydrosystem development after 1945, while an unfavorable climate regime negated the beneficial effects of salmon mitigation efforts after 1977 (Anderson 2000). Similarly, productive ocean conditions during the 1960s and early 1970s masked declines in wild fish numbers and inflated expectations for increasing hatchery coho production.

Fluctuations in fish run size and studies of ocean conditions over the last 20 years have greatly increased our understanding of the influence of inter-decadal climate patterns on salmon population dynamics, but do not fundamentally alter recent assessments of status and extinction risks. Extinction is most likely during extended periods of poor ocean conditions like those coincident with the ESA listing of many West Coast salmon and steelhead during the 1990s. Large salmon returns in the last few years are a temporary response to improved ocean conditions following the 1997–98 El Niño; they are not likely to represent the average future condition.

Recent improvements in ocean survival may portend a regime shift to generally more favorable conditions for salmon. The large spike in recent runs and a cool, wet climate would provide a respite for many salmon populations driven to critical low levels by recent conditions. The respite provides us with the opportunity to continue protection and restoration to forestall extinction when the ocean again turns sour—as it inevitably will. The risk is that temporary increases in survival and abundance may erode the sense of urgency for salmon recovery efforts.

The Natural Research Council (1996) concluded:

Any favorable changes in ocean conditions—which could occur and could increase the productivity of some salmon populations for a time—should be regarded as opportunities for improving management techniques. They should not be regarded as reasons to abandon or reduce rehabilitation efforts, because conditions will change again.

The bottom line is that, regardless of the marine survival rate that results from the myriad interrelated climate and oceanic patterns, the number of smolts entering the ocean for any given local population directly influences the number of returning adults. In the simplest view, whether marine survival is good or poor, more smolts will produce more adults, assuming the effects of marine competition from neighboring stocks is minimal. In fact, when the ocean is in a low productivity phase, it is even more important to maximize smolt production to ensure sufficient spawners for the future. Because marine survival patterns are difficult to predict, maximizing smolt production under poor survival regimes will also set the stage for a rapid rebound of harvestable surpluses when the regime shifts.

One exception to the notion that additional smolts will result in additional adult returns may be occurring at the broadest scale, as regards massive hatchery releases affecting ocean carrying capacity. Over the years, the oceans were considered to be an endless resource that could support unlimited production of salmon. However, recent research is beginning to detect the possibility of ocean carrying capacity limits. Extensive hatchery fish releases may have implications for overall survival rates. This phenomenon is further described in section 4.6.2.4. On the local scale, however, the relationship between smolt production and adult production holds true regardless of whether ocean-wide hatchery releases are contributing to pervasive competition. Survival of a given local stock appears to depend on the species, location, and marine conditions the stock encounters.

In summary, the ocean-related threats to salmon viability and productivity include:

- Susceptibility of weak populations to extirpation during periods of marine survival downturns,
- Management complacency when marine survival is good,
- Inability to produce sufficient smolts that maximize adult returns, and
- Marine competition from hatchery stocks.

3.4 Hydropower

3.4.1 Background

Hydropower development in the lower Columbia Basin has created additional limiting factors for salmon such as restricted migrations, altered habitats, and increased predation and competition in the altered habitats. The ongoing operation of hydropower facilities will continue to pose threats to existing salmon populations and will present limitations to rebuilding populations. The only mainstem hydropower facility in the lower Columbia region is the Bonneville Dam, but operations of numerous dams upstream of Bonneville strongly influence water and flow levels which affect salmon in the lower Columbia. Significant tributary hydropower dams in the lower Columbia region are on the Cowlitz and Lewis rivers.

3.4.2 Limiting Factors

Flow Alterations

Changes in flow patterns can affect salmon migration and survival through both direct and indirect effects. Juvenile and adult migration behavior and travel rates are closely related to river flow. Flow fluctuations may stimulate or delay juvenile emigration or adult migration, thereby affecting synchrony of juvenile arrival in the estuary or adult arrival at the spawning grounds. Greater flows increase velocity, which increases juvenile and decreases adult travel rates. Higher flows generally increase the survival of juveniles as they pass through the dams, because more fish can pass over the spillways, where mortality is low, than through the powerhouses, where turbine passage mortality can be significant. In contrast, increased flow and spill can increase mortality and delay upstream passage of adults at dams as fish have a more difficult time locating the entrances to fishways and also are more likely to fall back after exiting the fish ladder. Flow also affects habitat availability for mainstem spawning and rearing stocks. Rapid diurnal changes in flow can disrupt spawners, leave redds dewatered, or strand juveniles. Hydropower flow alterations impact salmon by:

- Delayed migrations,
- Reducing survival through hydropower facilities,
- Disrupting spawning activities, and
- Stranding juveniles.

Water Quality

Flow regulation and reservoir construction have increased average water temperatures beyond optimums for salmon in the Columbia River mainstem. High water temperatures can cause migrating adult salmon to stop or delay their migrations. Warm temperatures can also increase the fishes' susceptibility to disease. Flow regulation and reservoir construction also have increased water clarity. Increased water clarity can affect salmon through food availability and susceptibility to predation. Water supersaturated with atmospheric gases, primarily nitrogen, can occur when water is spilled over high dams and has resulted in significant salmon mortality. Gas supersaturation poses the greatest risk for Washington lower Columbia basin salmon stocks that must pass Bonneville Dam or areas immediately downstream in the mainstem. Significant levels of dioxins/furans, DDT, and metals have been identified in lower Columbia River fish, sediment, and water samples. Water quality issues associated with hydropower operations limit salmon by:

- Temperatures elevated beyond tolerance limits,

- Delayed upstream migration,
- Increased susceptibility to disease,
- Gas bubble disease (supersaturated water), and
- Increased exposure to contaminants.

Altered Ecosystems

Modifications of riverine habitat to impoundments result in changes in habitat availability, migration patterns, feeding ecology, predation, and competition. For example, the Bonneville Dam impoundment has inundated limited spawning habitat in the lower reaches of upper Gorge tributaries. Downstream migration is significantly slower through impoundments. Food webs are different in the impoundments than in natural rivers. Predation is a major source of mortality in mainstem impoundments and just downstream of Bonneville Dam. Other fishes—including northern pikeminnow, walleye, smallmouth bass, and salmonids—prey on juvenile salmonids. Pikeminnow have been estimated to consume millions of juveniles per year in the lower Columbia. Similar losses occur at Cowlitz and Lewis river hydropower dams. Together, these factors result in significant limitations of salmon by:

- Loss of spawning and rearing habitats,
- Migration and emigration delays,
- Increased predation on juveniles,
- Increased juvenile competition, and
- Changes in food availability.

Migration Barriers

Blocked Habitat **—** The major hydropower systems on the Cowlitz and Lewis rivers are responsible for the greatest share of blocked habitat in the lower Columbia region. (Culverts and other barriers are also a concern throughout the region, but are treated in the stream habitat section above.) In the Lewis River basin alone, the 240-foot high Merwin Dam has blocked 80% of steelhead habitat, all spring Chinook, and the majority of fall Chinook habitat since 1931. In the Cowlitz basin, the three mainstem dams inundated a total of 48 miles of historical steelhead, Chinook, and coho habitat. Efforts are underway to reestablish spawners upstream of the Cowlitz dams but survival of downstream migrants has been poor thus far.

Adult Dam Passage **—** On the mainstem Columbia, Bonneville Dam affects upstream migration of adults as well as downstream migration of juveniles. Fish ladders provide for upstream dam passage of adult salmon but are not 100% effective. Salmon may have difficulty locating ladder entrances and fish also may fall back over the dam after exiting from the fish ladder (Reichel and Bjornn 2003). These problems can result in significant upstream passage losses at dams. Average per dam survival rates in the lower Columbia River mainstem have been estimated at approximately 89% for spring chinook, 94% for fall chinook, and 95% for steelhead based on fish counts at successive dams, fallbacks after dam passage, harvest, and tributary escapements (*US v. Oregon* Technical Advisory Committee, unpublished data).

Fallback of adult salmon and steelhead after dam passage can be substantial; high levels of fallback are typically associated with periods of high flow and spill (Bjornn and Peary 1992). Keefer and Bjornn (1999) estimated recent fallback rates at Bonneville Dam of 12-15% for chinook (1996–98), 4-13% for sockeye (1997), and 5-10% for steelhead (1996–97). Fallback was substantially greater at the Bradford Island ladder exit at Bonneville Dam than the Washington shore ladder (Bjornn et al. 1998); 14-21% of sockeye and chinook salmon fell back over the dam (Reichel and Bjornn 2003). Adult salmonids that fall back over dams do not translate into a total loss as some fish may re-enter the fish ladder, successfully pass the dam, and continue upstream migration.

Passage delays in dam tailraces result from dynamic and complex flow patterns and the relatively small volume of water comprising ladder attraction flows. Fish may require a few hours or a few days to locate ladders once they reach the tailrace (Table 3). The delay is generally longer when flows are high and when large amounts of water are being spilled (NMFS 2000). Ladder systems at Columbia River dams are operated to produce hydraulic conditions that maximize fish attraction and minimize delay. Operations are based on criteria developed by NMFS, ACOE, and state and tribal fishery managers. The criteria relate to such factors as water depth and head on the gate entrances, collection channels, ladder flows and ladder exits (NMFS 2000).

Table 3. Median entry times in days into Bonneville Dam fish bypass system by upstream chinook and steelhead migrants, 1996–97.

Species	1996	1997
Chinook	2.0	2.2
Steelhead	1.9	0.3

From NMFS (2000a)

Passage delays at dams are at least partially offset by more rapid movement of fish through slackwater reservoirs, so the net effect of dam and reservoir construction on upstream travel time for adults is unclear. The OFC (1960) found that, prior to impoundments in the Snake River, chinook migration rates averaged 11-15 mi/day (17.7-24.1 km/day). Chinook salmon migration rates through the Snake River reservoirs in 1991-93 ranged from 19.3 to 40.4 mi/day (31-65 km/day), while migration rates through free-flowing river sections above Lower Granite Dam ranged were generally less than 6.8 mi/day (11 km/day) (Bjornn 1998). Bjornn et al. (1999) estimated that median travel time for salmon to pass the four dams and reservoirs in the lower Snake River in 1993 was the same or less with the dams as without the dams. Quinn et al. (1997) found that travel time between Bonneville and McNary dams over the last 40 years has decreased.

Juvenile Dam Passage **—** Delay and mortality of juvenile salmon at mainstem dams has proved to be one of the most difficult and contentious problems associated with hydropower development. Smolts typically migrate near mid-channel in the upper water column where water velocities are greatest. Delay results as juveniles stack up in dam forebays during daylight, when they are reluctant to sound to enter turbine or spillway intakes. Juveniles may experience substantially different mortality rates depending on whether passage occurs via turbines, spill, or a fish bypass system. Fish passage at Bonneville Dam is particularly complex, with two passage routes at each of the two powerhouses, plus an unattached spillway.

The turbines are typically the most hazardous passage route. Mortality results from abrupt pressure changes in the turbines and from mechanical injury. Iwamoto and Williams (1993) reviewed fish survival data through the Columbia River system and concluded that turbine survival, taken as a whole, averaged 90% per dam. Balloon tag tests conducted by Normandeau Associates Inc. indicated survival rates in the mid-90% range (Normandeau Associates Inc. et al. 1995, 1996, 1999).

Spillways are a much safer passage route than turbines (Whitney et al. 1997). Holmes (1952) reported that spillway survival at Bonneville Dam was 97% using pooled data and 96%

using weighted averages. Improvements to spillway and tailrace configurations have been implemented since Holmes' study, and more recent research at other Columbia and Snake River projects have estimated typical spill survival to be around 98-100% (NMFS 2000). Historical operations attempted to minimize spill in order to maximize power generation. Current practices provide dedicated spill to facilitate dam passage by juveniles.

Juvenile bypass systems to divert fish from turbine intakes are now in place at most mainstem dams in the Columbia River system, including Bonneville Dam. Most systems involve submersible traveling screens that project downward into the intakes of turbines and deflect fish upward from the turbine intake into the gatewell. Fish guidance efficiency (FGE) measures the proportion of fish entering turbine intakes that is guided into the bypass system (Brege et al. 1988). FGE varies by species, stock, fish condition, time of day, dam, turbine unit, season, environmental conditions, and project operation (NMFS 2000). Typical values for Bonneville Dam range from 16 to 48% (Table 4). Bypass mortality rates are typically quite low (<1%). The Bonneville second powerhouse bypass has been a conspicuous exception; past survival problems have recently been ameliorated by modifying the collection channel to improve hydraulic conditions and a new conveyance pipe and outfall have been installed to reduce predation problems (Gilbreath and Prentice 1999).

Table 4. Average juvenile fish guidance efficiencies (NMFS 2000) and 1988–97 bypass mortality rates (Martinson et al. 1998) at Bonneville Dam.

	Fish Guidance Efficiency (%)		Bypass Mortality	
Species	**Powerhouse 1**	**Powerhouse 2**	**Powerhouse 1**	**Powerhouse 2**
Yearling Chinook	38	44	0.1%	1.5%
Subyearling Chinook	16	18	0.4%	1.4%
Steelhead	41	48	0.1%	1.1%
Coho	—	—	0.1%	0.9%
Sockeye	—	—	0.4%	7.9%

In summary, Lower Columbia salmon are limited by hydropower migration barriers including:

- Complete blockages of spawning and rearing habitat,
- Adult upstream delays and mortalities
- Juvenile downstream delays and mortalities, and
- Increased susceptibility to predation.

3.4.3 Threats

Hydropower operations directly affect fish passage, stream flow patterns, sediment transport dynamics, stream water quality, and stream habitat, as described in the preceding section on Limiting Factors. The Columbia River mainstem dam at Bonneville, and the hydropower systems on the mainstem Lewis and Cowlitz rivers have significant impacts on fish populations. Only a few other hydropower operations exist in the lower Columbia region, and they have relatively minor impacts on fish populations.

Water Management

Water and flow management at Bonneville Dam and all upstream hydropower, flood control, and irrigation operations has significantly altered Columbia River flows from their natural patterns. For this reason, many fish and hydrosystem managers support implementation of a water budget of prescribed flows to facilitate fish migration rates and dam passage. However, in times of low flows, fish water needs may be superseded by hydroelectric or other needs. Seasonal and daily flow fluctuations also can result in gas supersaturation, stranding of juveniles, disruption of mainstem spawning, and dewatering of redds. Threats to salmon from hydropower water management include:

- Alteration of the natural diurnal and seasonal flow pattern (including abrogation of the prescribed water budget),
- Gas supersaturation during high flows,
- Stranding of juveniles,
- Disrupted spawners, and
- Dewatered redds.

Obstructed and/or Delayed Passage

Continued blockages to significant upstream habitats by hydroelectric dams on the Cowlitz and Lewis rivers is one of the most substantial salmon recovery problems in the lower Columbia region. Attempts to rebuild salmon runs upstream of the Cowlitz dams are encountering numerous obstacles to both upstream and downstream migrant survival. At Bonneville Dam on the mainstem, fish ladders provide for upstream dam passage of adult salmon but are not 100% effective. For example, approximately 10% of adults fall back over the dam and either die or reenter the fish ladders. Likewise, approximately 10% of downstream-migrating juveniles die as they pass Bonneville Dam. Certain species, such as chum salmon, do not negotiate fish ladders very well; access to historical habitats in the mainstem have been blocked by Bonneville Dam. Ongoing threats to salmon from hydropower obstructions and delays include:

- Passage obstructions – blocked spawning and rearing habitat,
- Poor passage facilities,
- Poor passage conditions (inappropriate flows), and
- Passage delays and mortality of juveniles and adults.

Ecological Changes from Impoundments

Hydroelectric dams have altered the natural habitats of lower Columbia salmon by creating slow-moving impoundments upstream and preventing natural sediment flow to downstream areas. Because of physical habitat changes, ecological communities have shifted and predators have flourished. These alterations will continue to present threats to the survival and productivity of salmon, including:

- Habitat alterations in impoundments,
- Predation in impoundments and tailraces,
- Competition for food in impoundments,
- Lack of sediments downstream of dams, and
- Changes to stream temperature regime.

3.5 Harvest

3.5.1 Background

This section provides an overview of fisheries and fishery regulatory processes that would be considered when analyzing potential fishery impacts to focal fish species of the lower Columbia River. It is intended to illustrate the complexities in fishery management involving salmon and steelhead which travel through various freshwater and ocean jurisdictions during their life cycle and are subject to numerous catch allocation agreements, conservation requirements, and legal mandates. The section explains the different types of fishery impacts, the types of fisheries and areas in which fisheries occur, and the multitude of jurisdictions and processes these fish are subjected to. This section also provides perspective on historic and current harvest impacts for each species, including an estimate of change in hatchery and wild harvest rates from the 1930s to date, and an illustration of current harvest distribution (who is catching the fish) between ocean and freshwater fisheries. The section also displays several examples of management criteria, including ESA mandates, which drive the harvest of individual species in the various fisheries to which they contribute. Catch and effort numbers illustrate the magnitude of targeted or incidental catches as the majority of present-day effort is focused on harvestable hatchery fish and healthy wild fish.

In the early part of the 20th century, nearly all commercial fisheries in this region operated in freshwater, where they harvested only mature salmon. Ocean fisheries became more important in the late 1950s as more restrictions were imposed on freshwater and coastal estuary fisheries. Ocean harvest of salmon peaked in the 1970s and 1980s. In recent years, ocean commercial and recreational harvest of salmon has generally been reduced as a result of international treaties, fisheries conservation acts, regional conservation goals, the Endangered Species Act, and state and tribal management agreements.

Analysis of fisheries questions may consider a variety of direct and indirect effects. Direct effects include mortality in fisheries that are managed to specifically harvest target stocks. Indirect effects include incidental mortality of fish that are caught and released, encounter fishing gear but are not landed, or are harvested incidentally to the target species or stock. Indirect effects also might include genetic, growth, or reproductive changes when fishing rates are high and selective by size, age, or run timing. The emphasis of weak stock management has changed over the last 25 years, as ocean and freshwater fisheries have been widely reduced and refocused on hatchery-origin or healthy wild fish using a combination of time, area, and mark-selective regulations: Although direct harvest of weak stocks or populations, including many of those of Washington’s lower Columbia River, has never been a desirable management practice, incidental fishery impacts have now become much more important in managing weak stocks than directed harvest. On the other hand, limits intended to protect weak stocks in mixed stock fisheries reduce access to healthy wild or hatchery runs. Relatively small numbers or proportions of a protected stock may be impacted in a mixed stock fishery, but the regulatory consequences of those small impact allowances can result in significant reduction in harvest opportunity in mixed stock fisheries.

Fishery impact analyses may be conducted at population or fishery-specific levels. Population-specific analyses would treat impacts by all fisheries in aggregate. Fishery-specific analyses would consider fine-scale impacts. By nature of their wide ranging travels, anadromous salmonids can be exposed to a wide variety of fisheries from their lower Columbia watershed of origin all the way to Canada and Alaska (Figure 11). This broad distribution can substantially complicate analysis and attempts to limit impacts on specific stocks.

Analysis of fishing and harvest is also complicated by the need to consider fisheries impacts at both the species impact and population goal levels. Fishing mortality can be considered an impact that interacts with other factors to affect salmon productivity and viability and thus needs to be addressed as part of recovery planning and actions. However, directed harvest or increased accessibility to other populations in mixed stock fisheries are also key elements of broad recovery goals, because recovery objectives include sustaining healthy, harvestable populations.

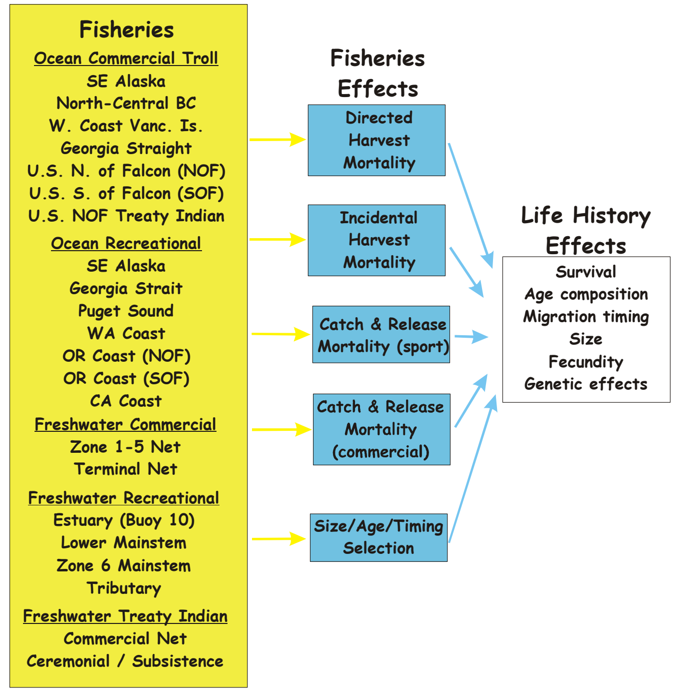


Figure 11. Fisheries, fisheries effects, and life history effects.

Fisheries Types and Areas

By nature of their wide-ranging migrations, anadromous salmonids can be exposed to a variety of fisheries from their basin of origin all the way to Canada and Alaska. Lower Columbia River salmonids are harvested in commercial, sport, and tribal fisheries throughout the West Coast of the United States and Canada. The following sections are a brief description of different regional fisheries.

Canada/Alaska Ocean — Numerous fisheries in Canada and Southeast Alaska harvest far-north migrating chinook stocks from the lower Columbia River basin. Some Columbia River coho salmon are also harvested in many Canadian fisheries. Canadian marine fisheries include commercial troll and net fisheries as well as recreational sport fisheries in northern BC, Central BC, West Coast of Vancouver Island, Strait of Georgia, and Strait of Juan de Fuca. In Southeast Alaska, treaty (i.e. US/Canada agreement described below) chinook marine fisheries include commercial troll and net fisheries as well as recreational sport fisheries. In recent years, chinook harvest in terminal fisheries and harvest of Alaska hatchery production has increased, although these harvests are not subject to PST limitations.

In June 1999, under the PST, Canada and the US agreed on a framework for chinook fishing regimes for 1999–2008 wherein Southeast Alaska (all gear), northern BC (troll and recreational), and West Coast Vancouver Island (troll and outside recreational) fisheries are to be regulated under aggregate abundance-based management (AABM) regimes. These fishery regimes establish catch ceilings derived from estimates of total aggregate abundance of all stocks contributing to specific components of the fisheries and target fisheries harvest rates. Eventually, the US and Canada plan to incorporate management regimes for AABM fisheries based on total mortality rather than catch. For fisheries not driven by AABM regimes, the 1999 agreement established conservation obligations to reduce harvest rates on depressed chinook stocks by 36.5% for Canadian fisheries and 40% for US fisheries, relative to levels observed during 1979-1982.

The June 1999 agreement included commitments to develop abundance-based regimes for fisheries along the Washington-British Columbia border. The purpose is to conserve natural coho production units from Washington, Oregon, and southern BC by establishing exploitation rate constraints based on projected resource status. These regimes are still under development.

***United States West Coast Ocean* —** Ocean fisheries along the U.S. West Coast are separated into four major management areas (Figure 12):

1. US/Canada border to Cape Falcon, Oregon
2. Cape Falcon, Oregon to Humbug Mountain, Oregon
3. Humbug Mountain, Oregon, to Horse Mountain, California
4. Horse Mountain, California to the US/Mexico border.

These management areas are further divided into subareas depending on the type of fishery. Numerous treaty Indian commercial troll, non-Indian commercial troll, and recreational marine fisheries exist along the West Coast (Figure 13 and Figure 14).

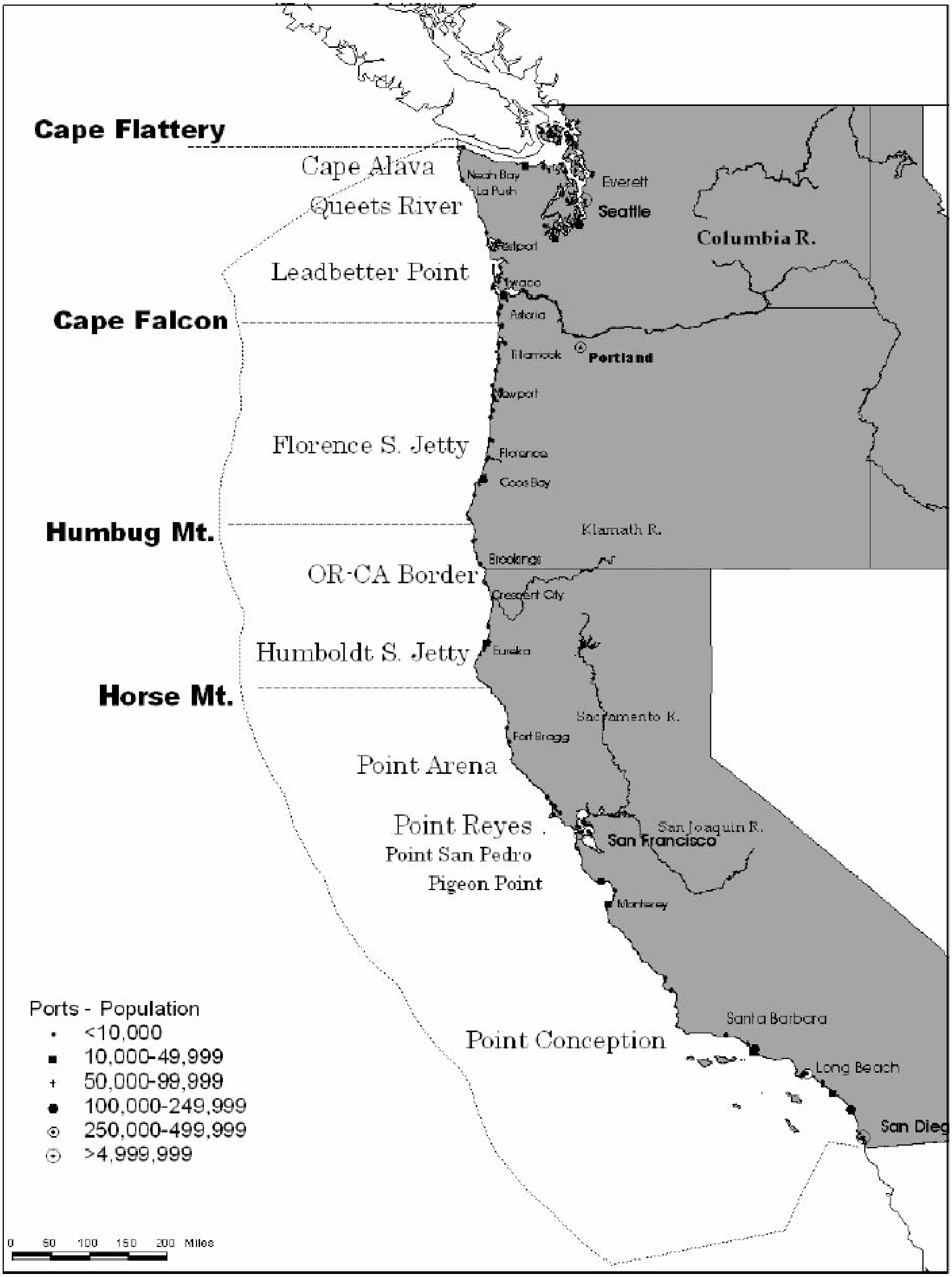


Figure 12. Major management areas in US West Coast ocean fisheries.

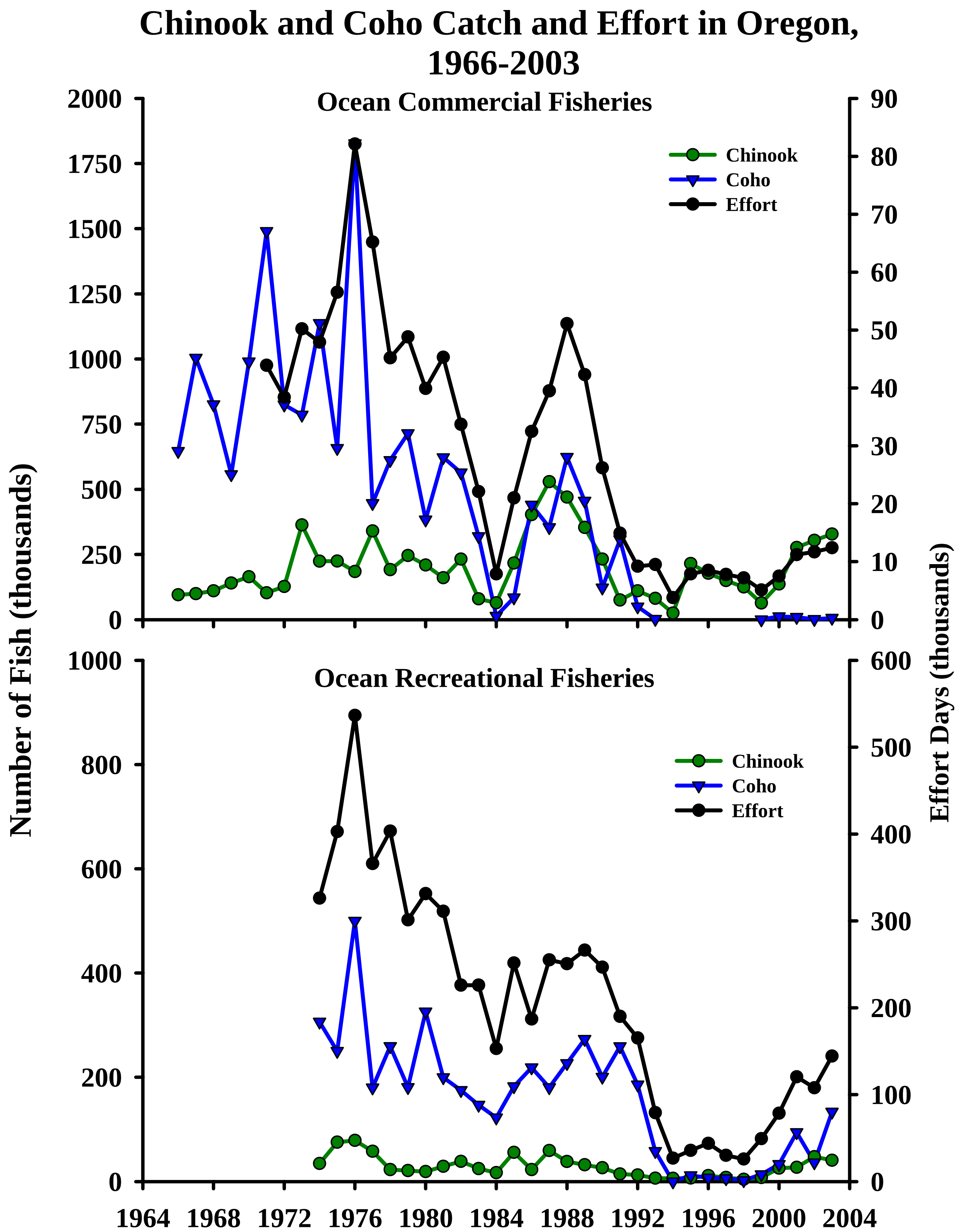


Figure 13. Commercial and recreational ocean catch and effort for chinook and coho in Oregon, 1966–2003.

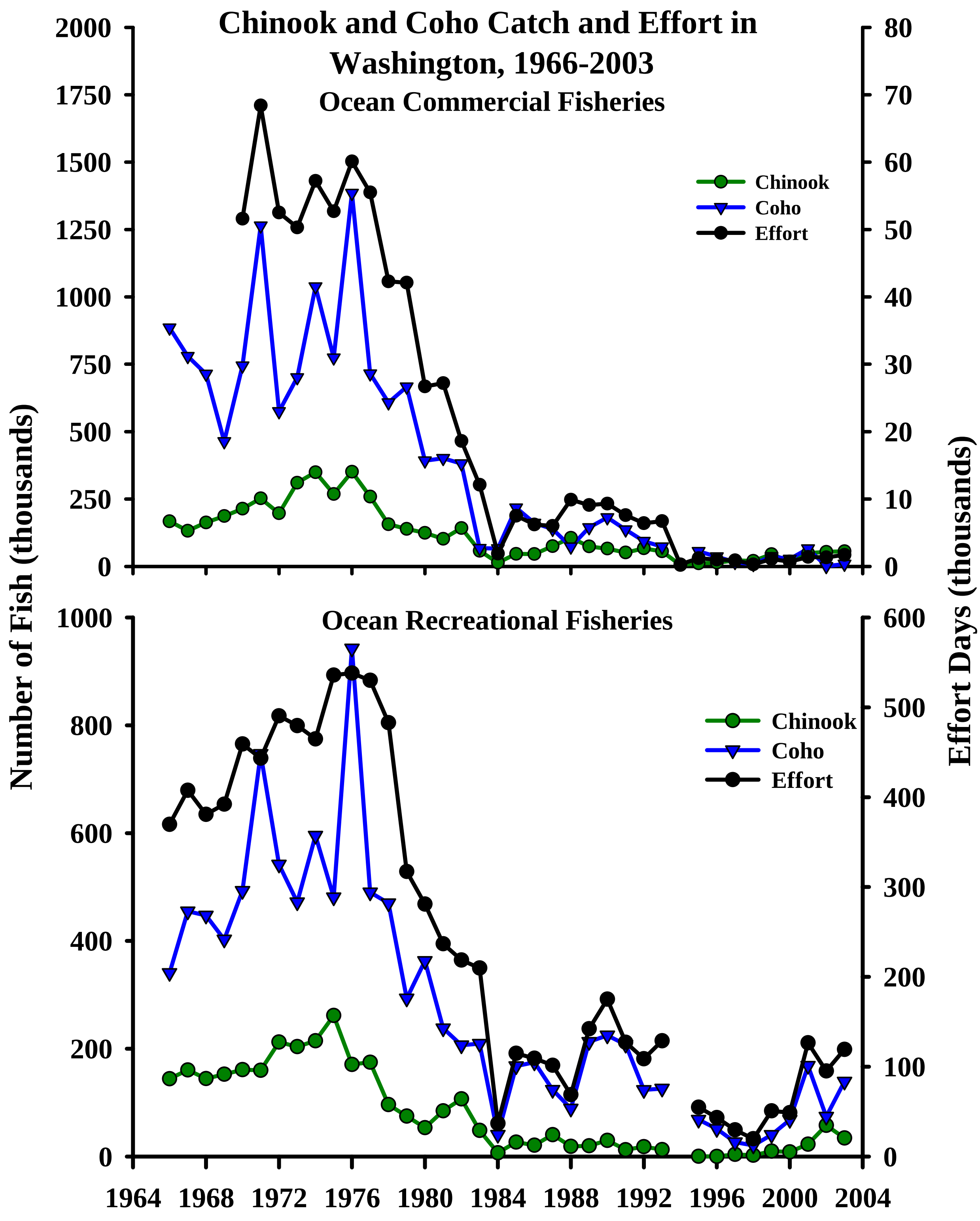


Figure 14. Commercial and recreational ocean catch and effort of chinook and coho in Washington, 1966–2003.

Lower Columbia River Commercial **—** Europeans began using Pacific salmon about 1830 and, by 1861, commercial fisheries became important. In 1866, salmon canning began in the Northwest and the non-Indian commercial fishery grew rapidly. Salmon and steelhead landings exceeded 40 million pounds annually several times between 1883 and 1925 (Figure 15). Since 1938, landings have ranged from a high of 31.6 million pounds (2,122,500 fish) to a low of 0.9 million pounds in 1995 and 1999 (around 68,000 fish).

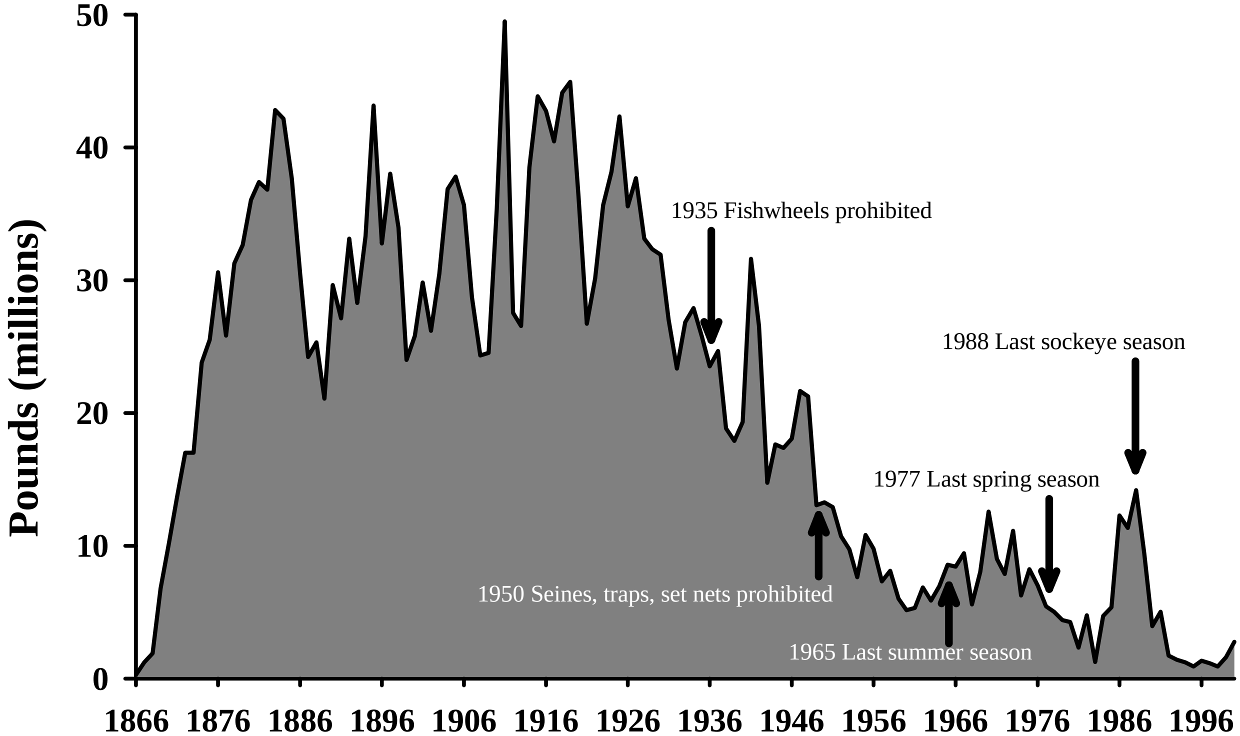


Figure 15. Commercial landings of salmon and steelhead from the Columbia River in pounds, 1866–1999 (ODFW and WDFW 2000).

Since the early 1940s, Columbia River commercial landings of salmon and steelhead have steadily declined, reflecting changes in fisheries in response to declines in salmonid abundance. Recent annual commercial harvests have fluctuated for each species, primarily depending on variable abundance of hatchery production (Figure 16). In the late 1950s, non-Indian commercial harvest comprised almost 100% of the Columbia River commercial fisheries landings; the percentage steadily declined to about 25% in 1995. The non-Indian percentage of commercial landings has increased to about 50% in recent years (Figure 17). Treaty Indian commercial landings became a larger portion of the total Columbia River commercial landings following a 1968 federal court ruling regarding equitable Indian and non-Indian harvest sharing (Figure 17).

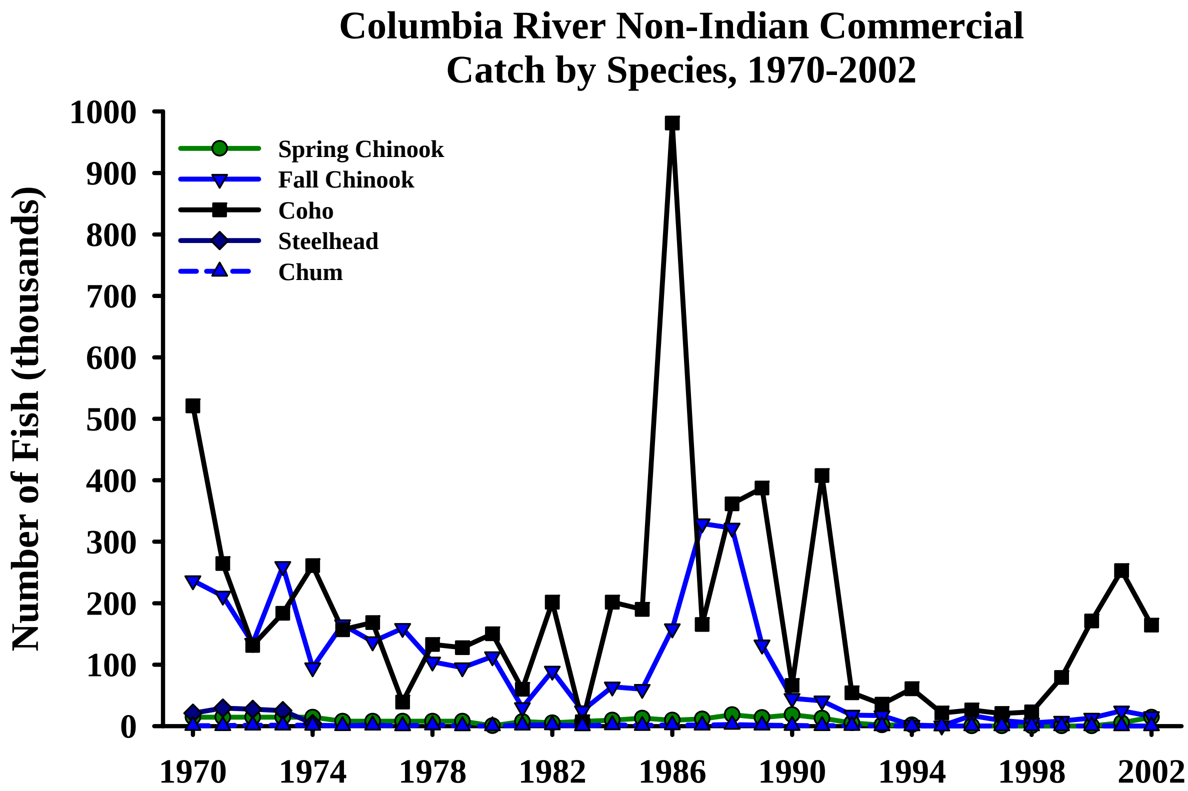


Figure 16. Non-Indian commercial fishery catch in the Columbia River, 1970–2002.

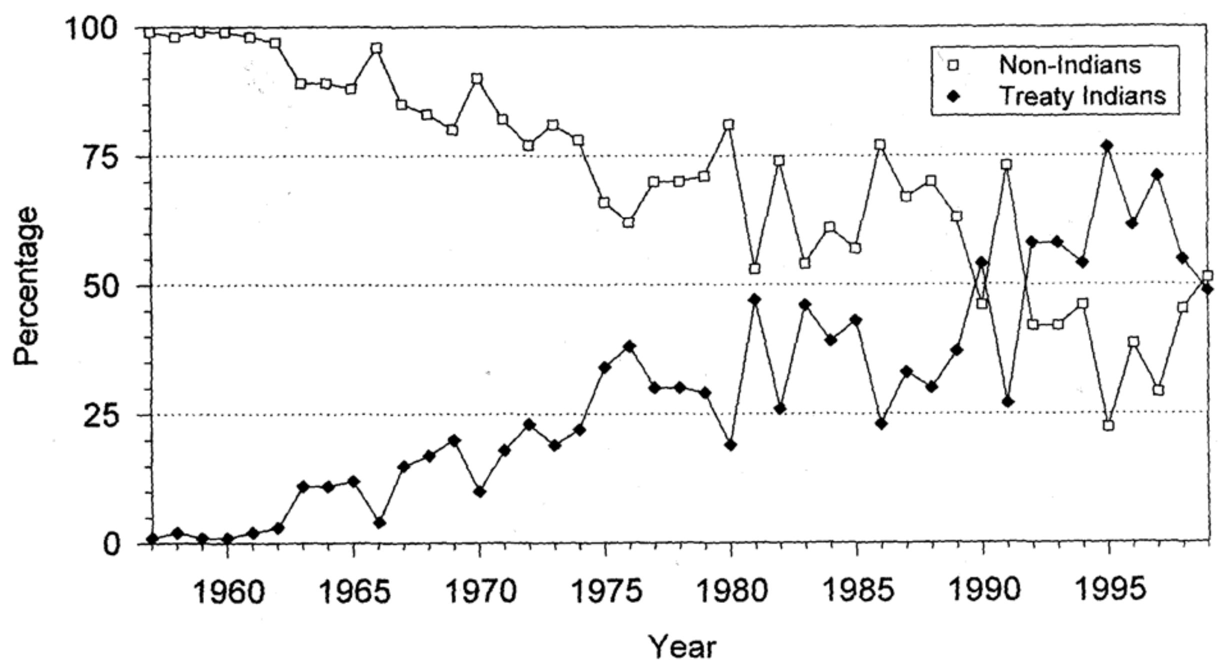


Figure 17. Percentage of Columbia River commercial landings of salmon and steelhead in pounds made by non-Indians and treaty Indians, 1957–02 (ODFW and WDFW 2004).

Lower Columbia River non-Indian commercial fisheries occur below Bonneville Dam in the mainstem (statistical Zones 1-5) or in select off-channel fishing areas (statistical Zones 7, 71, 74, and 80). Commercial fishing seasons in the mainstem Columbia River are established by the Columbia River Compact, while Select Area seasons are established by the state in which the fishery occurs. Zone 6 (from above Bonneville Dam to McNary Dam) was open to non-Indian commercial fishing until 1956; gill nets, set lines, and seines were used, although seines were finally prohibited in 1950. In 1957, Zone 6 was closed to non-Indian commercial fishing (see further discussion under Treaty Indian Fishery below).

The number of drift gill net licenses in the commercial fishery declined after 1938, with a low of 597 in 1969, but increased to a high of 1,524 in 1979. In 1980, a limited entry vessel permit moratorium went into effect. In the mid-1980s, 288 licenses were purchased and permanently retired; 135 licenses were bought back by Washington in 1995–96. In 1999, Columbia River commercial licenses totaled 591.

The number of seasons and fishing days allowed for the commercial mainstem fishery has declined dramatically since 1938. Initially, fishing seasons were closed only in March and April and from August 25–September 10. There has been no summer fishing season since 1964 and no spring season since 1977. Throughout the 1980s and 1990s, August and September seasons have been limited by time, area, and harvest quotas. Before 1943, over 270 fishing days were allowed annually. From 1977 through the 1980s an average of 38 fishing days were allowed annually and, in the 1990s, 29 average annual fishing days were allowed.

Commercial fishing in Columbia River off-channel areas was initiated in 1962 with the adoption of salmon seasons for Youngs Bay, Oregon. Initially, openings were concurrent with the late fall mainstem gill net seasons; however, seasons have been separate since 1977. Recent declines in mainstem fishing opportunities prompted Bonneville Power Administration (BPA) to fund a research project to expand net-pen programs to select off-channel fishing areas. The result of this effort was the Select Area Fishery Enhancement (SAFE) project, which has expanded to Tongue Point/South Channel and Blind/Knappa Slough in Oregon and Deep River and Steamboat Slough in Washington. These fisheries primarily target hatchery coho returning to the release sites; Select Area bright fall chinook also are targeted in the Youngs Bay fishery.

Lower Columbia River Recreational — Before 1975, lower Columbia River recreational fisheries primarily targeted salmon and steelhead. Season closures for spring and summer chinook and declines of other salmonids transitioned much of the effort to sturgeon (Figure 18). Recent-year improvements in salmonid returns and selective fishery opportunities in the recreational fishery have resulted in a rebound in salmonid angler effort, and catch of certain salmonids has also increased in the mainstem Columbia (Figure 19).

The lower Columbia River mainstem below Bonneville Dam is separated into two main areas for recreational harvest; Buoy 10 (ocean/in-river boundary) to the Rocky Point/Tongue Point line, and the Rocky Point/Tongue Point line to Bonneville Dam. Recreational harvest does occur in Zone 6 above Bonneville Dam, but catch is very low compared to the fisheries below Bonneville.

The Buoy 10 fishery is extremely popular, especially with small boat anglers. Chinook and coho are the targeted species, although other salmonids are harvested. The main harvest and effort time is mid-August to Labor Day and effort can be substantial, especially in years of high salmon abundance. During 1986-2000, effort in the Buoy 10 fishery ranged from 9,300 angler trips in 1994 to 186,000 angler trips in 1988.

Before 1975, recreational fisheries in the lower Columbia mainstem primarily focused on salmon and steelhead. During 1975-1983 fishery closures for spring chinook and summer steelhead severely reduced salmonid angling opportunities. During 1984–1993, improved upriver summer steelhead, upriver fall chinook, and lower river spring chinook runs provided greater salmonid angling opportunities. Poor returns in the mid- to late 1990s again limited recreation salmon fishing opportunities. Since 2001, improved spring chinook runs and selective fishery implementation has increased angler effort by approximately 100,000 trips, increasing the lower Columbia salmon and steelhead sport fishing effort to about 250,000 trips per year. Since 1986, lower Columbia sturgeon angler effort has ranged from approximately 140,000 to 200,000 trips per year.

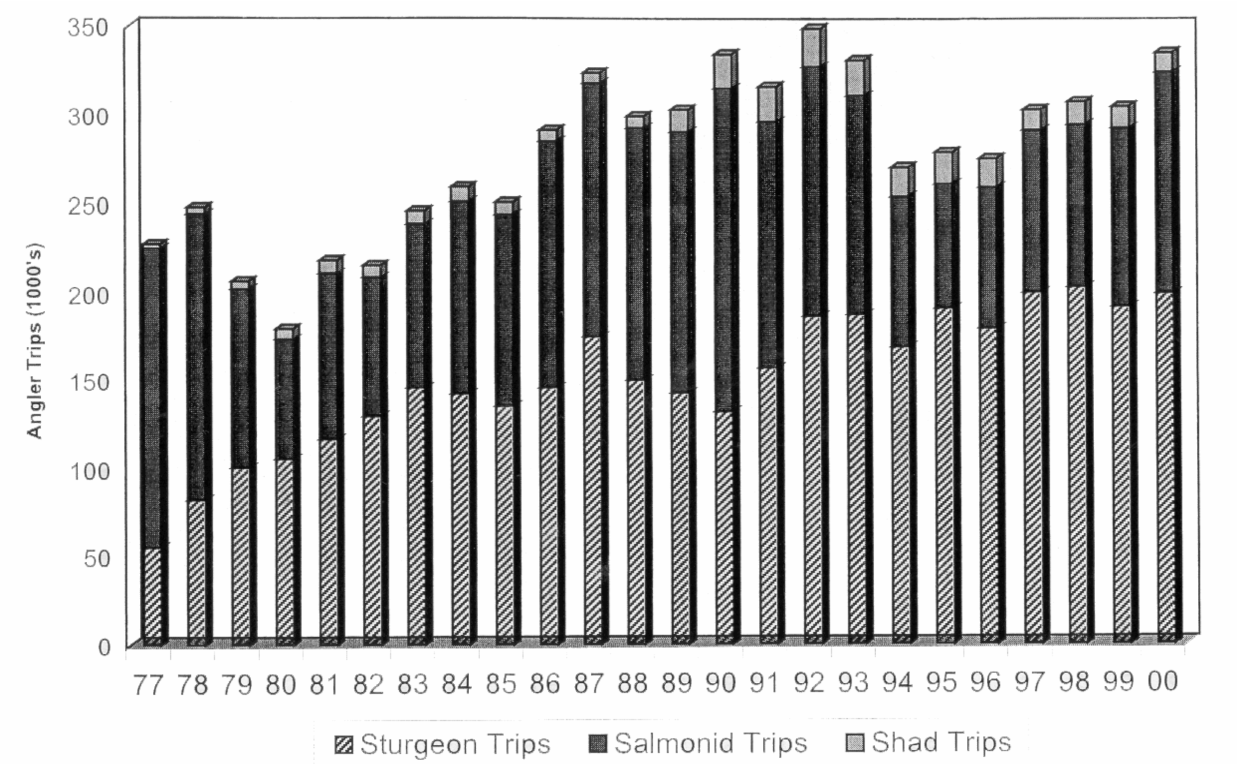


Figure 18. Angler effort by species on the lower Columbia River, 1977–2000.

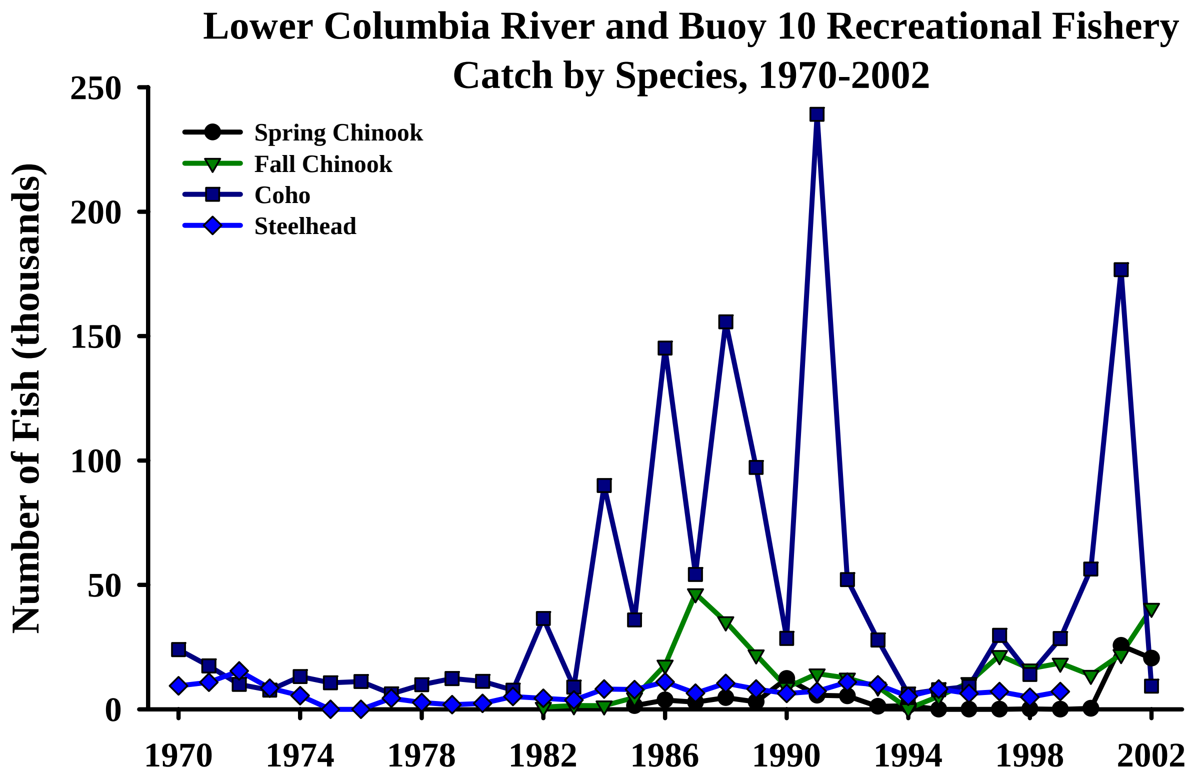


Figure 19. Recreational fishery catch in the lower Columbia River, 1970–2002.

Lower Columbia Tributary Recreational — Salmon and steelhead sport fishing occurs in most Washington lower Columbia River tributaries. Tributary harvest is managed consistent with objectives of the WDFW wild salmonid policy. They are principally managed to meet wild salmon and steelhead escapement objectives and to meet the objectives of the artificial propagation programs (WDFW FMEP, 2003). Fishing seasons are established based on forecasts of salmon and steelhead returning to the tributaries. In years when returns are forecasted below escapement requirements, harvest is reduced or eliminated. Harvest reductions are made by time and area closures, gear restrictions, or changes in bag limits.

Most of the tributary harvest is focused on hatchery-produced returns of steelhead, chinook, and coho. An exception is in the North Lewis River where tributary harvest of the healthy, wild fall chinook return is allowed in most years. Hatchery-produced winter and summer steelhead, spring chinook, and coho are marked as juveniles with an adipose fin-clip, which enables tributary sport anglers to identify hatchery fish for retention and release unmarked wild fish. Hatchery-produced fall chinook are not all marked, so fall chinook fisheries retain both wild and hatchery fish. However, fishing for fall chinook is prohibited in the Coweeman and East Fork Lewis rivers, where no hatchery fish are released. Trout fisheries in the streams are regulated to minimize impacts to anadromous salmonids. The general season commences June 1, after salmon smolts have migrated, and minimum size limits and gear restrictions also offer protection for juvenile salmonids.

Tributary spring chinook fisheries generally occur from February to August with a peak in April-May. Fall chinook fisheries occur from August to January, with a tule peak in late August-mid September and a Lewis bright peak in mid September-mid October. Coho fisheries occur during August-January with two peaks; early coho catch peaks in September and late coho in October. Fisheries targeting winter steelhead are concentrated from December through February and close by March 15, except the Cowlitz, Kalama, Lewis, and Washougal extend to May 31. Summer steelhead enter tributary fisheries from March through October with most of the catch occurring from late May through August (WDFW, 2003).

Tributary sport harvest of hatchery salmon and steelhead can be significant (see species sections below). Steelhead tributary fisheries harvest 30-70% of the returning hatchery adults. Steelhead returning to hatcheries are often recycled downstream to provide an additional sport catch opportunity. Harvest of hatchery spring chinook can also be substantial if forecasts indicate a strong return. Harvest rates are typically 20-40%, but can range as high as 70% in the Lewis River if there are no regulatory restrictions. Fall chinook and coho tributary harvest rates typically range from 5 to 25%, but the total numbers of fish harvested can be substantial in many years, due to large numbers of adult coho and fall chinook returning to the rivers.

***Treaty Indian* —** Treaty Indian harvest includes commercial, and ceremonial and subsistence (C&S) fisheries. The treaty Indian set net fishery above Bonneville Dam (statistical Zone 6) involves members of the four Columbia River treaty Indian tribes: Yakama Nation, Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation. The tribal C&S fisheries are of highest priority and generally occur before tribal commercial fishing. The Columbia River treaty tribes regulate treaty Indian C&S fisheries in Zone 6.

Indian and non-Indian commercial harvest was permitted in Zone 6 until 1956. The boundaries of Zone 6 were from Bonneville Dam upstream to the mouth of the Deschutes River during this period. In 1957, joint action by Oregon and Washington closed Zone 6 to commercial fishing, but treaty Indian fisheries were permitted during 1957-1968 through tribal ordinances. In 1968, the states reestablished commercial fishing in Zone 6 exclusively for treaty Indian harvest. In 1969, the upstream boundary of the zone was extended to the mouth of the Umatilla River, river mouth closure and dam sanctuary areas were established, and gear restrictions were set. The fishery is conducted primarily with set gill nets, although some dip netting still occurs primarily at Cascade Locks, the Lone Pine site, and below John Day Dam.

Similar to the non-Indian commercial fishery, the number of seasons and fishing days allowed for the treaty Indian commercial fishery has declined dramatically. Despite the decline in fishing opportunity, the percentage of Columbia River commercial fishery landings made by treaty Indians has steadily increased since the late 1950s (Figure 20). In 1999, 59 commercial fishing days were allowed in the treaty Indian fishery, although most of those days were in February and March during the targeted sturgeon fishery. Fishing effort targeting fall salmonids occurs in late August and September. Fall chinook harvest increased substantially in 2001 and 2002 as a result of significant increases in fall chinook returns. As with non-Indian harvest, treaty Indian harvest of salmon increased in 2001 and 2002 as a result of a significant increase in Columbia River salmon abundance (Figure 20).

C&S fisheries are usually open year-round; ceremonial fishing is conducted with gill nets via tribal permit while subsistence fishing is conducted by individuals primarily using dip nets, hook and line, or gill nets. Some tribal permits allow subsistence fishing with gill nets when commercial fisheries are closed. Spring chinook salmon are the most important ceremonial fish for the Columbia River treaty tribes. Significant tribal commercial harvest of spring chinook occurred in 2001 for the first time since 1977 as a result of a substantial increase in upper Columbia spring chinook returns (Figure 20), and a Columbia River management agreement which establishes ESA fishery impact limits based on and abundance-based management strategy.

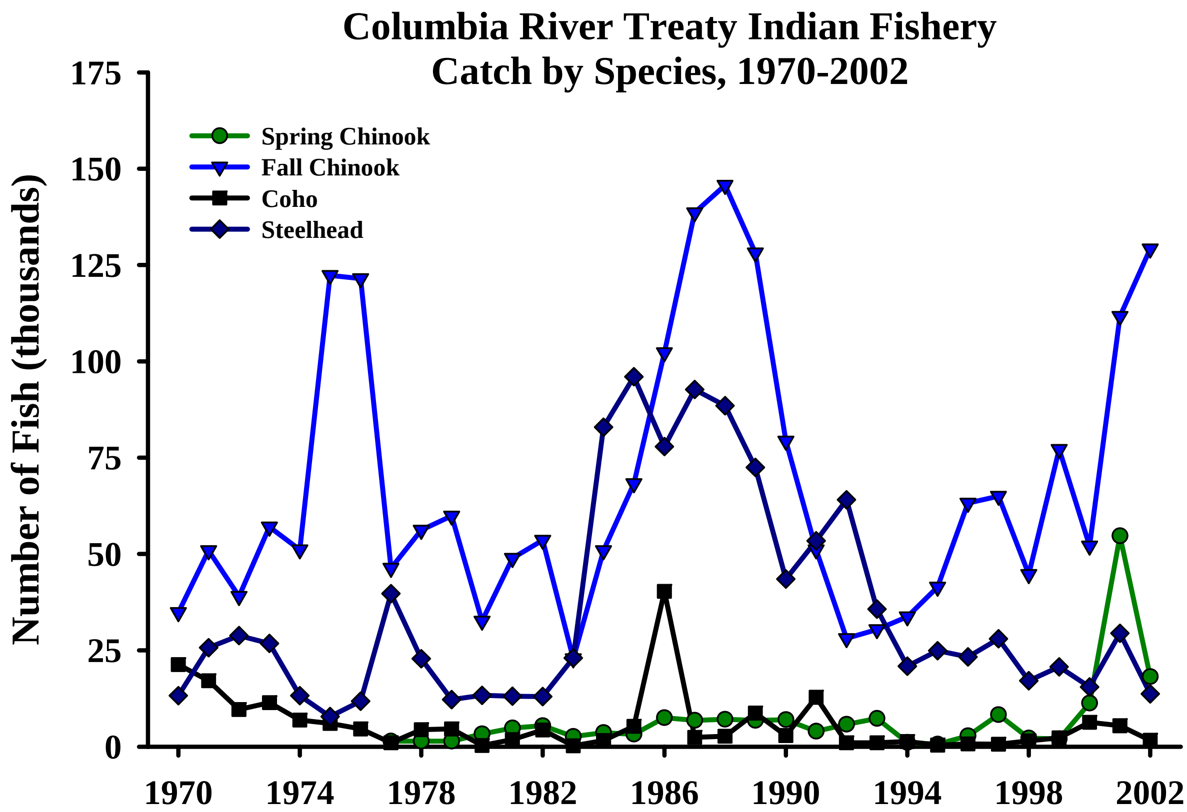


Figure 20. Treaty Indian fishery catch, 1970–2002.

Fisheries Management Structure

Because of their exposure to fisheries across large geographic regions of the West Coast, Pacific salmon and steelhead management is governed by numerous regional organizations. Fisheries of the Columbia River are established within the guidelines and constraints of the Pacific Salmon Treaty (PST), the Columbia River Fish Management Plan (CRFMP), the Endangered Species Act (ESA) administered by NOAA Fisheries, The Pacific Fishery Management Council (PFMC), the states of Oregon and Washington, the Columbia River Compact, and management agreements negotiated between the parties to *US v. Oregon*.

Pacific Salmon Commission — Management of Pacific salmon has long been a matter of common concern to the United States and Canada. After many years of negotiation, the PST was signed in 1985 to set long-term goals for the benefit of the salmon and the two countries. The principal goals of the treaty are to enable both countries, through better conservation and enhancement, to increase production of salmon and to ensure that the benefits resulting from each country's efforts accrue to that country.

The Pacific Salmon Commission (PSC) is the body formed by the governments of Canada and the United States to implement the treaty. The Commission itself does not regulate the salmon fisheries but provides regulatory advice and recommendations to the two countries. It has responsibility for all salmon originating in the waters of one country which are 1) subject to interception by the other, 2) affect management of the other country's salmon, or 3) biologically affect the stocks of the other country. In addition, the PSC is charged with taking into account the conservation of steelhead trout while fulfilling its other functions.

The Commission has a dual role; to conserve Pacific salmon in order to achieve optimum production, and to divide the harvests so that each country reaps the benefits of its investment in salmon management. The Commission has a variety of tools at hand to achieve its mandate. It may recommend that the countries implement harvest limitations, time and area closures, gear restrictions, or other measures to control harvests. In addition, the Commission may recommend use of enhancement techniques to strengthen weak runs, mitigate for damage done by logging, mining or dam building, or for other purposes. The PSC gives both countries a forum through which to resolve the difficult problems surrounding salmon harvest management.

PSC members represent the interests of commercial and recreational fisheries as well as federal, state, and tribal governments. Each country has one vote; the agreement of both is required for any recommendation or decision. Four regional panels (Southern, Northern, Transboundary, and Fraser River) provide technical and regulatory advice; panel membership reflects a range of governmental and fishing interests.

***Pacific Fishery Management Council* —** The Magnuson-Stevens Fishery Conservation and Management Act of 1976 is the principal law governing marine fisheries in the United States. The Act was adopted for the purposes of managing fisheries 3-200 miles offshore of the US coastline, phasing out foreign fishing activity within this zone, recovering overfished stocks, and conserving and managing fishery resources. In 1996, Congress passed the Sustainable Fisheries Act, which revised the Magnuson Act and reauthorized it through 1999; later reauthorization bills have been presented but have not been enacted. The Pacific Fishery Management Council (PFMC) is one of eight regional fishery management councils established by the Magnuson Act. The PFMC is responsible for fisheries off the coasts of California, Oregon, and Washington. Thus, the Council is responsible for all ocean fisheries, including salmon, groundfish, pelagic fish, etc., and does not focus solely on salmonids.

Chinook and coho salmon are the main salmon species managed by the PFMC in waters extending from the Canadian border to Mexico, and 3-200 nautical miles offshore (Figure 12). In odd-numbered years, the Council may also manage special fisheries near the Canadian border for pink salmon. Sockeye, chum, and steelhead are rarely caught in the Council’s ocean fisheries. The Council’s Salmon Fishery Management Plan (SFMP) describes the goals and methods for salmon management. Central parts of the plan are annual spawner escapement goals for the major salmon stocks and an allocation of the harvest among different fisheries or locations (i.e. allocations are set for ocean or inland commercial, recreational, or tribal fisheries as well as for specific ports). The Council uses management tools such as season length, quotas, bag limits, and gear restrictions to achieve fishery management goals.

Annually, a preseason process of meetings and public hearings is used to develop recommendations for management of the ocean fisheries. Past harvest data and preseason salmon abundance forecasts are the primary basis for management decisions concerning season structure and harvest quotas. Final recommendations are adopted annually in April and implemented by NOAA Fisheries beginning in May. The Salmon Technical Team (STT) provides technical information and data analysis to the Council; the team is comprised of eight representatives from state, federal, and tribal fisheries management agencies. The Salmon Advisory Subpanel (SAS) has 17 members who represent commercial, recreational, and tribal interests, as well as a public representative and a conservation representative.

Impacts to each species vary widely, depending on many complicated factors which include annual salmon abundance and ESA restrictions. The PFMC evaluates ESA consultation standards each year and provides guidance for the upcoming ocean fishing season. The standards for 2003 are presented for those ESUs with potential connections to lower Columbia River salmonids (Table 5). Further ESA restrictions apply to specific inside Columbia River fisheries and are discussed in the species-specific sections to follow.

***North of Falcon* —** Folded into the PFMC management process is a parallel public process referred to as North of Falcon (NOF). The NOF process integrates management of ocean fisheries between Cape Falcon (on the north Oregon coast) and the Canadian border with inland area fisheries. Columbia River fisheries are a significant part of the NOF process. Coordination and shaping of the ocean and freshwater fisheries occurs to assure that fish conservation objectives are met and there is reasonable sharing of the conservation burden between the fisheries and various user groups. In this process there are allocation agreements reached between Oregon and Washington ocean and freshwater commercial and sport fisheries as well as mandated allocation agreements between the states and treaty Indian tribes. Conditions for incidental take permits concerning ESA-listed Columbia River populations are often developed during the NOF process.

***State Fishery Regulations* —** Regulations for lower Columbia tributary sport fisheries are developed through state public process and adopted into law by the respective Fish and Wildlife Commissions of Washington and Oregon for their jurisdictional waters. Mainstem Columbia joint waters are coordinated for consistency in the Compact forum (see below) but are adopted into law by the respective states. The state regulatory process includes adoption of permanent rules as well as emergency regulations to enable quicker adjustments of fisheries when needed to meet conservation objectives or provide additional harvest opportunity. The state regulations are made consistent with management strategies reached in the NOF process.

***US v. Oregon* —** In 1968, the US District Court ruled that Columbia River treaty Indians were entitled to an equitable share of the upper Columbia River fish returns, in a court case known as *US v. Oregon*. After 20 years of legal tests and negotiations, the CRFMP was adopted by District Court order in 1988 and agreed to by the parties: the United States; the states of Oregon, Washington, and Idaho; and the four treaty Indian tribes. The purpose of the CRFMP as defined by the court was to:

. . . provide a framework within which the Parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-Indian fisheries. In order to achieve the goals of the CRFMP, the Parties intend to use habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management to ensure that Columbia River fish runs continue to provide a broad range of benefits in perpetuity.

In 1996, the parties to *US v. Oregon* negotiated three-year (1996–98) management agreements: one each for upper Columbia fall chinook and uppe Columbia spring chinook, summer chinook, and sockeye. The agreements were a result of a 1995 court settlement where the parties agreed to discuss the possibility of amending the CRFMP. The 1996–1998 management agreements formed the basis for recent agreements, and included escapement goals, production measures and harvest allocations. Annual agreements have occurred for fall chinook, coho, and summer steelhead during 1999-2003. A 5-year agreement for harvest was reached for spring chinook, summer chinook, and sockeye for the period 2001–2005. The CRFMP is currently being negotiated for a longer-term agreement for all species to be in place by 2004.

Table 5. List of species managed by the PFMC with potential impacts on lower Columbia River salmonids.

ESU	Stock Representation in Salmon FMP	ESA Consultation Standard	Council Guidance for 2003
Lower Columbia River chinook—threatened	Sandy, Cowlitz, Kalama, Lewis spring	No specific requirements	Meet hatchery escapement goals
	Sandy, Cowlitz, Kalama fall	Brood year adult equivalent exploitation rate on Coweeman tule fall chinook ≤ 49%	Same as consultation standard
	North Fork Lewis fall	5,700 MSY level adult spawning escapement	Same as consultation standard
Upper Willamette chinook— threatened	Upper Willamette River spring	No specific requirements; rare occurrence in Council fisheries	Same as consultation standard
Upper Columbia River spring chinook—endangered	Upper Columbia River spring	No specific requirements; rare occurrence in Council fisheries	No additional constraints; Ocean fishery impacts minor
Snake River fall chinook— threatened	Snake River fall	30% reduction from the 1988–93 average adult (age 3 & 4) exploitation rate for all ocean fisheries	Same as consultation standard
Snake River spring/summer chinook— threatened	Snake River spring/ summer	No specific requirements; rare occurrence in Council fisheries	Same as consultation standard
Oregon Coast coho—threatened	S. central OR coast N. central OR coast N. OR coast	15% (in 2003) combined marine/ freshwater exploitation rate	Same as consultation standard
Lower Columbia River/Southwest Washington coho—candidate	Sandy and Clackamas River	No specific requirements	≤ 20% ocean exploitation rate

Columbia River Compact — In 1918, the US Congress ratified a compact between Oregon and Washington covering concurrent jurisdiction of Columbia River fisheries. The Columbia River Compact comprises the Washington Fish and Wildlife Commission (WFWC) and the Oregon Fish and Wildlife Commission (OFWC). In recent years, the commissions have delegated decision-making authority to the state fish and wildlife agency's director or designee. Periodic hearings to adopt or review seasonal commercial regulations are held just before major fishing seasons to consider current information and establish season dates and gear restrictions. Additional hearings are held in-season when updated information concerning run size, attainment of escapement goals, or catch guidelines indicates a need to adjust the season.

The Compact jurisdiction includes the Columbia River from the mouth to just upstream of McNary Dam. The Compact sets fishing seasons in the non-Indian commercial Zones 1-5 (Mouth to Bonneville Dam) and in the treaty Indian commercial area Zone 6 (Bonneville Dam to McNary Dam) (Figure 21).

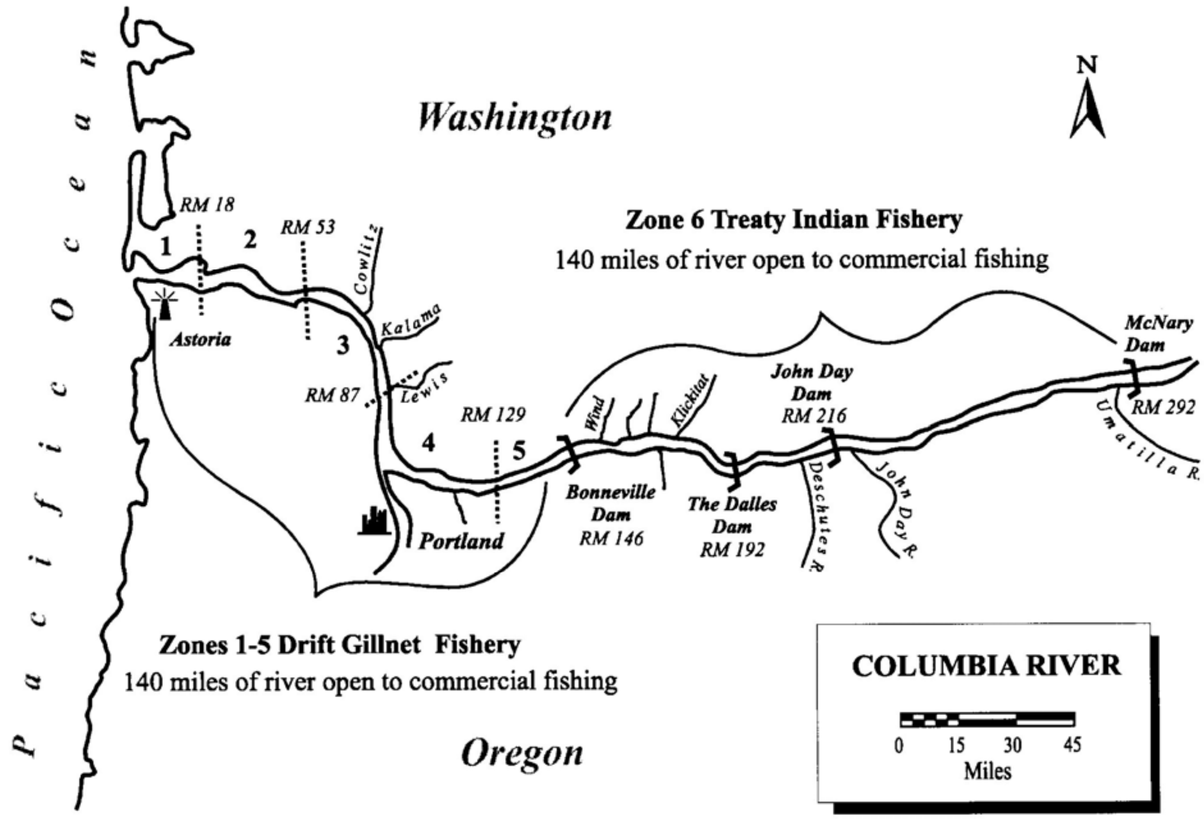


Figure 21. Columbia River commercial fishing zones.

Endangered Species Act (ESA) — Throughout the 1990s, 12 Columbia River basin Evolutionarily Significant Units (ESUs) were listed as threatened (T) or endangered (E):

- Snake River fall chinook (T—April 1992)
- Snake River spring/summer chinook (T—April 1992)
- lower Columbia River chinook (T—March 1999)
- upper Willamette River chinook (T—March 1999)
- upper Columbia River spring chinook (T—March 1999)
- Columbia River chum (T—March 1999)
- Snake River sockeye (E—November 1991)
- upper Columbia River steelhead (E—August 1997)
- Snake River steelhead (T—August 1997)
- lower Columbia River steelhead (T—March 1998)
- upper Willamette River steelhead (T—March 1999)
- middle Columbia River steelhead (T—March 1999)

An additional ESU (lower Columbia/SW Washington coho) was designated as a candidate species in July 1995. NOAA Fisheries also reviewed the status of this ESU and its boundary designations in 2001-2003, but has not published findings on the review. In addition, numerous other listed or candidate ESUs along the California, Oregon, and Washington coasts affect ocean fisheries targeted on harvesting Columbia River salmonids. Because of the ESA status of many Columbia River salmonids, harvest managers must consult annually with NOAA Fisheries to assure fishers are regulated to meet no-jeopardy standards established for ESA-listed species. NOAA Fisheries issues incidental take permits to regulatory agencies and Tribes for fisheries that have satisfied ESA regulatory requirements.

3.5.2 Limiting Factors

Overall Fishing Impacts

Currently, harvest occurs in the Canada/Alaska ocean, U.S. West Coast ocean, lower Columbia River commercial and recreational, tributary recreational, and in-river treaty Indian (including commercial, ceremonial, and subsistence) fisheries, as described above. Total exploitation rates have decreased for lower Columbia salmon and steelhead, especially since the 1970s.

An approximation of current fishing impact rates on lower Columbia River naturally spawning salmon populations ranges from 2.5% for chum salmon to 45% for tule fall Chinook (Table 6). Fishery impact rates for hatchery produced spring Chinook, coho, and steelhead are higher than for naturally-spawning fish of the same species because of selective fishing regulations. These rates, for naturally-spawning and hatchery fish, include estimates of direct harvest mortality as well as estimates of incidental mortality in catch and release fisheries. These rates generally reflect recent year (2001-2003) fishery regulations and quotas controlled by weak stock impact limits and annual abundance of healthy targeted fish. Actual harvest rates will vary for each year dependent on annual stock status of multiple west coast salmon populations, however, these rates generally reflect expected impacts of harvest on lower Columbia naturally-spawning and hatchery salmon and steelhead under current harvest management plans.

Table 6. Approximate annual exploitation rates (% harvested) for naturally-spawning lower Columbia salmon and steelhead under current management controls (represents 2001-2003 fishing period).

	AK./Can. Ocean	West Coast Ocean	Col. R. Comm.	Col. R. Sport	Trib. Sport	Wild Total	Hatchery Total	Historic Highs
Spring Chinook	13	5	1	1	2	22	53	65
Fall Chinook (Tule)	15	15	5	5	5	45	45	80
Fall Chinook (Bright)	19	3	6	2	10	40	na	65
Chum	0	0	1.5	0	1	2.5	2.5	60
Coho	<1	9	6	2	1	18	51	85
Steelhead	0	<1	3	0.5	5	8.5	70	75

Rates are very low for chum salmon, which are not encountered by ocean fisheries and return to freshwater in late fall when significant Columbia River commercial fisheries no longer occur. Chum are no longer targeted in Columbia commercial seasons and prohibited from retention in sport fisheries. Columbia River fall Chinook are subject to freshwater and ocean fisheries from Alaska to their rivers of origin in fisheries targeting abundant Chinook stocks originating from Alaska, Canada, Washington, Oregon, and California. Columbia tule fall Chinook harvest is also constrained by a Recovery Exploitation Rate (RER) developed by NOAA Fisheries for management of Coweeman naturally pawning fall Chinook. Harvest of lower Columbia bright fall Chinook is managed to achieve an escapement goal of 5,700 natural spawners in the North Fork Lewis. Steelhead, like chum, are not encountered by ocean fisheries and non-Indian commercial steelhead fisheries are prohibited in the Columbia River. Selective fisheries for adipose fin-clipped hatchery spring Chinook (since 2001), coho (since 1999), and steelhead (since 1984) have substantially reduced fishing mortality rates for naturally-spawning populations and allowed concentration of fisheries on abundant hatchery fish. Selective fisheries occur in the Columbia River and tributaries, for spring Chinook and steelhead, and in the ocean, Columbia River, and tributaries for coho. Columbia River hatchery fall Chinook are not marked for selective fisheries, but likely will be in the future because of recent legislation enacted by Congress.

Weak stock management (the practice of limiting fisheries based on annual abundance of particular stocks of concern) of Columbia River fisheries became increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction (Table 7). In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s.

Table 7. Summary of major events affecting harvest of Columbia River salmon and steelhead.

Year	Event
1918	Columbia River Compact for joint state salmon fishery management ratified by Congress
1935	Fish wheels, seines, and traps prohibited in Washington (Oregon follows)
1943	Columbia River commercial seasons reduced (from 270 to 200 days)
1949	Columbia River commercial seasons reduced to 170 days
1956-59	Ocean fishery begins to expand; Columbia River commercial seasons reduced to 100 days
1964	Last Columbia River summer Chinook season
1968	U.S. v. Oregon court settlement- Tribal fishing rights and states' management authority defined
1973	Congress passes Endangered Species Act
1976	Congress passes Magnuson-Stevens Fishery Conservation and Management Act
1977	Columbia River Fish Management Plan – 5 yrs (U.S. v. Oregon court order)
	Columbia River spring seasons closed
1980	Northwest Power and Conservation Act
1983-88	New Columbia River Fish Management Plan negotiated (conservation, allocation)
1984	Ocean and freshwater coordinated weak stock management (North of Falcon) began
	Selective fisheries for hatchery steelhead begin
1988	Renewed Columbia River Fish Management plan-10 yrs duration. adopted by Federal Court
1991	ESA listing of Snake River sockeye
1992	ESA consultation and harvest limitations for Snake River sockeye
1992	ESA listing of Snake River spring, summer, and fall Chinook
1993	Ocean and freshwater ESA consultation & limitations for Snake R. fall and spring/summer Chinook
1994	Annual U.S. Oregon negotiations begin concerning ESA constraints and Indian and non-Indian allocation
1996	Congress passes Sustainable Fisheries Act (reauthorizes Magnuson-Stevens Act)
	Three year ESA agreement reached in U.S. v. Oregon for spring/summer Chinook
1997	ESA listing of upper Columbia and Snake River steelhead
1998	ESA listing of lower Columbia steelhead
	ESA consultation and harvest limitations for steelhead
	ESA management of Oregon coastal coho
	Selective fisheries for hatchery coho begin
	Renegotiation of Columbia River Fish Management Plan begins
1999	ESA listing of lower Columbia, Willamette, and upper Columbia spring Chinook, lower Columbia fall Chinook, Columbia River chum, middle Columbia and Willamette steelhead, and Oregon state listing of lower Columbia coho
	ESA consultation and harvest limitations for 1999 listings
	U.S. - Canada Treaty Agreement for Abundance Based Management Plan
2001	U.S. v. Oregon 5-year Agreement for management of listed spring Chinook, summer Chinook, and sockeye
	Selective fisheries for hatchery spring Chinook begin

Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regulated by impact limits on weak populations mixed with the strong. Each fishery is controlled by a series of regulating factors. Many of the regulating factors that affect harvest impacts on Columbia River stocks are associated with treaties, laws, policies, or guidelines established for the management of other stocks or combined stocks, but indirectly control impacts of Columbia River fish as well (Table 8). Harvest managers configure fisheries to optimize harvest of strong stocks within the series of constraints for weak stock protection. Listed fish generally comprise a small percentage of the total fish caught by any fishery. Every listed fish may correspond to tens, hundreds, or thousands of other stocks in the total catch. As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks and recreational trips to communities which provide access to fishing, with significant economic consequences.

Table 8. Current harvest regulating factors affecting lower Columbia naturally-spawning salmon and steelhead and the fisheries in which certain regulatory factors apply.

	Regulating Factor	Fisheries Applied To
Lower Columbia Spring Chinook	Hatchery escapement goal	All U.S. fisheries
	Abundance Based Management Agreement	PSC Ocean
	Tule fall Chinook abundance	West Coast Ocean
	Willamette ESA (15% limit)	Columbia River
	Upriver ESA (2% limit)	Columbia River
	Selective fisheries	Columbia River, Tributary
	Commercial gear restrictions	Columbia River
	FMEP	Tributary sport
Fall Chinook Tules	Abundance Based Management Agreement	PSC Ocean
	Hatchery escapement goals	All U.S. fisheries
	Coweeman ESA (49% limit)	West Coast Ocean, Columbia River
	Coweeman, EF Lewis closures	Tributary sport
	Snake Fall Chinook ESA (8.25% non-Indian limit)	Columbia River
	FMEP	Tributary sport
Fall Chinook Lower Brights	Abundance Based Management Agreement	PSC Ocean
	NF Lewis wild escapement goal (5,700)	All U.S. fisheries
	Snake Fall Chinook ESA (8.25% non-Indian limit)	Columbia River
	FMEP	Tributary sport
Chum	Sport retention closed	Columbia River, Tributary
	November commercial closed	Columbia River
	Late October commercial area closures	Columbia River
	FMEP	Tributary sport
	Columbia Chum ESA (2-5% limit)	Columbia River
Coho	Hatchery escapement goals	All U.S. fisheries
	OCN Coho ESA (abundance limit, typical 8-15%)	West Coast Ocean
	Oregon state coho ESA (typical 13% limit)	Columbia River
	Sport selective fisheries	Columbia River, Tributary
	Commercial select area fisheries	Columbia River
	Commercial time/area closures	Columbia River
Steelhead	Commercial harvest prohibition	Columbia River
	Selective sport fisheries	Columbia River, Tributary
	Wild/Hatchery escapement goals	Tributary fisheries
	Commercial mesh size restrictions	Columbia River
	U.S. v. Oregon ESA (Indian-15%,NI-2%)	Columbia River, Tributary sport
	FMEP	

Fishery impact limits to protect listed weak populations are generally based on risk assessments that identify points where fisheries do not pose jeopardy to the continued persistence of a listed group of fish. In many cases, these assessments identify the point where additional fishery reductions provide little reduction in extinction risks. A population may continue to be at significant risk of extinction but those risks are no longer substantially affected by the specified fishing levels. Often, no level of fishery reduction will be adequate to meet naturally-spawning population escapement goals related to population viability. In those cases, elimination of harvest will not in itself lead to the recovery of a population. However, prudent and careful management of harvest can help close the gap in a coordinated effort to achieve recovery.

Sources of Fishing Effects

***Directed Harvest Mortality* —** Harvest mortality occurs in fisheries directed at a particular species or stock; this harvest can occur in single (terminal) or mixed (intercept) stock fisheries. The most effective method for targeting a specific stock is the prosecution of single stock fisheries. Single stock fisheries most commonly occur in terminal harvest areas where one stock is known to be present through the use of stock identification techniques, historical run timing data, or escapement survey methods.

In mixed stock fisheries, the management challenge is to harvest from mixed populations having various available surpluses, sometimes including populations with no surplus, as the populations move through the fishery area at various rates and abundances. Harvest of a specific stock in the mix can be achieved by management decisions (e.g. fishery openings when the targeted stock is abundant relative to other stocks), fishery adaptations (e.g. gear designed to target specific stock/species), or fishery regulations (e.g. prohibitions of retaining certain species). Stock identification techniques are constantly being improved to assist managers in making informed and timely fishery decisions. For example, scale pattern analysis, CWT analysis, and genetic stock identification techniques have been applied in-season to determine the stocks present in a fishery, providing managers with timely stock composition data. Time and area fishery openings are also effective in targeting specific stocks and reducing impact to other stocks when information is available about the migration timing and migration route of a specific stock. In many cases where the targeted stock is a distinct size relative to other stocks in the fishery, gear modifications, such as specific mesh size requirements, can be effective in harvesting certain size fish while allowing other fish to escape the fishery. In the Columbia River, certain fisheries are focused on harvesting adipose fin-clipped hatchery-reared fish only by targeting marked hatchery fish while utilizing gear modifications to allow protected stocks to escape. Regulations prohibiting harvest of wild fish (i.e. nonadipose fin-clipped fish) have been relatively successful. However, the occurrence of delayed mortality as a result of releasing wild fish captured in commercial fisheries is presently unmeasured.

***Incidental Harvest Mortality* —** Salmonid migration timing and routes are dynamic and considerable variation can occur from year to year. Thus, despite the various methods discussed above to target a specific stock and minimize effects on weak stocks, incidental harvest of non-targeted stocks still occurs. Most fisheries have specific reporting requirements and limits for incidental bycatch that are intended to lessen the harvest impacts to non-targeted stocks. In the case of the Columbia River, specific incidental harvest percentages are set for protected stocks; fisheries are managed so as not to exceed these harvest limits of protected stocks.

Access to strong stocks in Columbia River and ocean fisheries is regulated by impact limits on weak populations mixed with the strong. Each fishery is controlled by a series of regulating factors. Many regulating factors that affect harvest impacts on Columbia River stocks are associated with laws, policies, or guidelines established to manage other individual or combined stocks, but indirectly control impacts of Columbia River fish as well. Harvest managers configure fisheries to optimize harvest of strong stocks within the series of constraints for weak stock protection. ESA-listed fish generally comprise a small percentage of the total fish caught by any fishery. Every harvested ESA-listed fish may correspond to tens, hundreds, or even thousands of other fish in the total catch. As a result of weak stock fishery constraints, strong hatchery and wild runs may go unharvested. Small reductions in fishing rates on ESA-listed populations can translate to larger reductions in catch of other stocks, with substantial economic consequences.

***Catch and Release Mortality* —** Catch and release regulations have been used for years to manage sport fisheries. Generally, catch and release restrictions allow resident fish to grow older and larger, thereby creating improved angling opportunities. More recently, catch and release has been employed in anadromous fish management practices to enable retention of hatchery salmon and steelhead and release of wild fish in mixed-stock fisheries. Because of the wide range of knowledge among sport anglers regarding proper fish handling techniques and the different degrees of how fish species react to handling stress, mortality occurs as a result of catch and release. Although sport fishing catch and release mortality varies widely among fisheries, it is believed to be low compared to other harvest-related mortality.

Catch and release has been employed in the Columbia River commercial fishery since 1950 for non-legal size sturgeon and since 1975 for steelhead. Catch and release is a relatively new concept for commercial salmon fishing, and has recently become a significant part of managing Columbia River spring chinook stocks. Recent recovery efforts in the Columbia Basin have focused on maintaining and rebuilding native wild stocks. The hatchery practice of marking released fish with an adipose fin clip has allowed fishery managers to implement fisheries which harvest only hatchery fish while requiring the release of protected wild stocks. Significant gear modifications are continually being evaluated and utilized to reduce any handling mortality that can occur as a result of being caught and released by the commercial fishery. Delayed catch and release mortality of wild fish in these hatchery-selective fisheries is not completely understood and is presently being evaluated.

***Gear or Fishery Selectivity* —** Commercial fishing gear can be size-selective, depending on the type of gear (i.e. gill net vs. seine) or the size of gear (i.e. mesh size). As mentioned in the mixed stock fishery discussion, size selectivity can be a desired result if the gear is designed to harvest a specific size stock or species. However, commercial fishing gear size selectivity can also be undesirable. For example, if a fishery disproportionately harvests the larger individuals in a population, the remaining smaller individuals comprise the effective population (i.e. those individuals that spawn in any given year). If this process is repeated annually, the effect on the adult population is a decreased average size at maturity or potentially a modified age composition.

Fisheries may also be selective for a particular timing or segment of the run, depending on management practices. For example, a fishery may disproportionately harvest the early portion of a run because of market- or industry-driven needs. Because run timing is heritable (Garrison and Rosentreter 1981), fisheries may alter run timing traits due to systematic temporal removals from populations over time. Although there is evidence that run timing alterations have occurred in certain stocks, it is not a forgone outcome for all stocks exposed to fisheries. In the Columbia River, hatchery coho-targeted fisheries, in conjunction with hatchery practices, have altered run timing (Cramer and Cramer 1994). Hatchery coho brood stock was often obtained from the early part of the run, which generally resulted in early run timing for hatchery adults.

Effort in fisheries targeting hatchery fish is concentrated during the time of hatchery fish abundance. Consequently, consistent harvest of wild fish with the early run trait can also occur, thereby reducing this early run trait in the spawning population and altering run timing of the wild stock. Effects of selective fisheries are most likely to occur if harvest rates are high; lower harvest rates will likely mitigate for selectivity.

Effects of Fisheries on Population Biology and Structure

Fishing has direct and indirect effects on salmon populations, especially if harvest rates are high and/or prolonged. Harvest can influence the number, biomass, age, size, and fecundity of spawners, as well as the genetic characteristics and population structure. In many lower Columbia salmon populations, as well as others, the biological characteristics of contemporary populations have been shaped by continued harvest patterns.

***Abundance* —** Following other mortality causes in each returning cohort, harvest clearly determines the number of adult salmon remaining to perpetuate the population. Much of the future discussion about recovery and sustainability will be focused on a new paradigm for determining the number of salmon required to fill the habitat to capacity (Schoonmaker et al. 2003).

In addition to the important function of salmon spawning escapement for supplying eggs for subsequent generations, recent scientific evidence has shown that adult salmon carcasses provide a significant source of nutrients delivered from marine to freshwater ecosystems (Kline et al. 1993, Bilby et al. 1996, Cederholm et al. 1999). Not only do the carcasses form the basis of a nutrient pathway via primary production, but flesh and eggs are directly consumed by aquatic insects (Wipfli et al. 1999) and by rearing fish (Bilby et al. 1996). This biological feedback loop benefits future salmon production. The chronic depression of salmon biomass to freshwater ecosystems may be contributing to reduced carrying capacity for salmon (Cederholm et al. 1999, Knudsen 2002). Probably the most important implication for Pacific salmon is that the production relationship (returning adults per spawner) is influenced not only by the number of eggs deposited in the gravel, but also by the amount of biomass delivered and retained in the watershed (Cederholm et al. 1999). The carrying capacity for freshwater production depends on both the physical space available and the amount of nutrients provided to the system. This varies, depending on the freshwater life history of the species and the nutrient interdependence among species but, in any case, there is a feedback mechanism relating the number of adults allowed to escape harvest directly to the productivity of the system. This biological control factor must be considered in contemporary productivity analyses.

***Age, Size, Sex, Fecundity* —** Selective fishing (as described above) affects salmon population age, size, sex, and fecundity structure directly by influencing certain characteristics in the targeted populations or indirectly by gradually influencing the population's heritable characteristics (discussed below). Gear or run timing selectivity may influence the annual productivity of the population by removing the older, larger individuals, too many of one sex, or the larger females carrying the most eggs. Fishing-influenced changes in the average sizes and ages of salmon populations have been well documented (Ricker 1981). For example, body size is related to redd digging success (Beacham and Murray 1987) and/or fecundity -- larger fish usually carry more eggs (Sandercock 1991). When too many individuals with the most reproductive potential are removed, the population's productivity is reduced.

***Genetics* —** As fisheries are continually prosecuted, the genetics of the target populations can be gradually changed, especially if there is selection for certain sizes of fish or portions of the run timing (Reisenbichler 1997). Because of their tendency to home to their natal streams, Pacific salmon have evolved a diversity of genetic and phenotypic population characteristics (Waples 1991a). Every spawning population is potentially a unique genotype (Healey and Prince 1995). There is even evidence of genetically controlled divergence within a single, relatively small spawning area (Woody et. al. 2000). Examples of apparently heritable ecological strategies for success include variations in body size correlated with differences in stream flows (Beacham and Murray 1987), run timing for spawning and incubation survival (Smoker et al. 1998), duration of egg incubation (Woody 1998), and a variety of freshwater rearing strategies (e.g., Wood et al. 1987, Bisson et al. 1997). Lastly, as numbers are reduced by harvest, especially in small populations, all the attributes controlled by genetic diversity are threatened by inbreeding and/or genetic drift (Reisenbichler 1997).

Population Structure and and Diversity — Reduced abundance also affects the structure and biodiversity of populations. Salmon populations are generally structured hierarchically with genetic relatedness usually corresponding to geographical distance (Allendorf and Waples 1995). Independent populations are defined as a group of the same species that spawns in a particular location and season and which, for the most part, do not interbreed with other spawning groups (Myers et al. 2003). Each independent population evolves characteristics of productivity, body size, run timing, fecundity, etc. that correspond with the habitat features it experiences throughout its life history. The combination of these features across populations constitutes the biodiversity of a group of populations, commonly referred to as a stock when mixed together for harvest management purposes. As harvest usually occurs at the stock level, a similar harvest rate is applied to the mixture of populations, some having higher production potential than others. Heavy harvest rates, especially when combined with habitat problems and natural variation, can therefore drive the weaker populations to low levels, even to extinction (e.g., Walters and Cahoon 1985). As weaker populations are diminished or eliminated, the total biodiversity and genetic variation within and between the hierarchical populations is reduced (Riddell 1993). Setting harvest rates to maximize use of high productivity hatchery populations is particularly troublesome for intermingled wild populations that cannot withstand the hatchery harvest rate (NRC 1996, Knudsen 2002). The use of selective fisheries for marked hatchery fish is expected to ameliorate this effect on lower Columbia spring need to decide chinook, coho, and steelhead.

In summary, salmon and steelhead production is impacted by fishing activities that:

- Depress the number of successful spawners,
- Reduce the number of carcasses in freshwater ecosystems,
- Alter the size and age of returning spawners,
- Alter the run timing of spawners,
- Alter the fecundity of spawners,
- Change any of the spawners' genetic characteristics, and/or
- Alters the population structure or diversity.

3.5.3 Threats

There are a number of ongoing harvest-related threats to salmon and steelhead viability and productivity. Many fishing threats are species-specific and they will be addressed below accordingly. Other fishing-related threats apply across all or most species and can be characterized generally as:

- Unmet (or unidentified) escapement goals,
- Technical inability to identify the optimal carrying capacity of spawners,
- Social/political inability to further constrain fishing, and
- Complexity of management institutions causing an inability to get agreement.

Spring Chinook Fishery

Most wild spring Chinook escapements are extremely low and are based primarily on strays from hatchery programs. The exploitation rate of spring Chinook has fluctuated over time, ranging from 20 to 65%. Currently, most of the harvest of lower Columbia wild spring Chinook (about 18% of the total runs) occurs in the ocean incidental to target fisheries for Alaskan, Canadian, Columbia River hatchery, and California hatchery Chinook stocks. Current fishing impact rates on wild spring Chinook in Columbia basin fisheries account for an additional average of 4%. The mortality of wild spring Chinook in Columbia River fisheries is now incidental to target fisheries for fin-clipped Willamette, lower Columbia, and upper Columbia hatchery fish. There is likely unreported retention of wild spring Chinook in the fisheries. Furthermore, catch and release fishing is known to result in unseen mortalities, including the increased incidence of spawners that die before depositing eggs into the gravel. Fishing-induced threats to sufficient escapements of wild spring Chinook include:

- Harvest in ocean fisheries,
- Incidental in-river harvest,
- Release mortalities from hatchery-selective fisheries, and
- Poaching.

Fall Chinook Fishery

The majority of lower Columbia fall Chinook populations are considered to be depressed (not meeting escapement expectations). Recent fishing rates on lower Columbia fall Chinook have averaged 40-45%, approximately half of the 70-80% rate until the 1990s. Columbia River tule fall Chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska (about 30% of the total run size), as well as the Columbia River commercial gill net and sport fisheries (about 15% more). Lower Columbia tule fall Chinook are an important contributor to Washington ocean troll and sport fisheries as well as the Columbia River estuary sport fishery. Fishing rates are generally greater on fall tule than late fall bright Chinook. Unlike spring Chinook, hatchery fall Chinook are not fin-marked, so harvest rates are the same for hatchery and wild fish. Columbia River and tributary fisheries quotas are set for tules according to a limit of 49% for Coweeman fall Chinook and for lower river brights by an escapement target of 5,700 to the North Fork Lewis River. Fishing-related threats to wild fall Chinook include:

- Harvest in ocean and freshwater fisheries,
- Inability to distinguish wild from hatchery fish in fisheries, and
- Poaching.

Coho Fishery

Wild coho stocks in Lower Columbia River tributaries in Washington are considered depressed, primarily because of chronically low escapement and production and much of the small natural production is thought to be from hatchery strays. The primary fisheries targeting Columbia River hatchery coho salmon occur in West Coast ocean and Columbia River mainstem fisheries. Most of these fisheries have hatchery-selective harvest regulations or time and area strategies to limit impacts to wild coho. The exploitation rate of coho prior to the 1990s fluctuated from approximately 60% to 90% but now the exploitation rate of wild coho is about 15% to 20%, while the exploitation of hatchery coho has remained similar to the 1990s rate of approximately 50%. Wild coho are harvested in Washington, Oregon, California, and Canadian Ocean commercial and sport fisheries (about 9% of the total run), and in Columbia River sport, commercial, and treaty Indian fisheries and tributary sport fisheries (about 9% more). Regulations in most fisheries specify the release of all wild (non-finclipped) coho but some coho are likely retained and others die after release. Fishing-related threats to wild coho salmon escapements include:

- Ocean and in-river harvest,
- Release mortalities from hatchery-selective fisheries, and
- Poaching.

Chum Fishery

Chum salmon were once very abundant in the Columbia River Basin, with commercial landings ranging from 1 to 8 million pounds (80,000 to 650,000 fish) in most years before the early 1940s. Chum escapements have been extremely small since the late 1950s, but improved somewhat recently. The total estimated escapement in 2002 was just under 20,000. NOAA Fisheries' biological opinions now limit the incidental impact of Columbia River fisheries targeting other species to an expected 2% and not to exceed 5% of the annual return of chum listed under the ESA. No sport or commercial fisheries specifically target chum salmon and the current impacts of 3% or less are incidental to fisheries for other species. Even though no fisheries target chum salmon, fishing activities result in the following threats:

- Incidental catch in sport and commercial fisheries, and
- Poaching.

Steelhead Fishery

Historical abundance of steelhead is undocumented. However, no existing summer or winter steelhead runs are meeting escapement goals and, of the six historical summer steelhead populations and the 17 winter steelhead populations in the Lower Columbia ESU. Fishing rates on wild steelhead have been reduced from their historical peaks in the 1960s by over 90% following prohibition of commercial steelhead harvest in the mainstem (1975), hatchery-only retention regulations in the Columbia River mainstem starting in 1986, and hatchery-only retention regulations in the tributaries during the late 1980s and early 1990s. Interception of steelhead in ocean salmon fisheries is rare. Currently, the primary fisheries targeting steelhead occur in the Columbia River mainstem and tributaries; these fisheries harvest primarily hatchery fish and wild fish mortality is incidental (less than 10% of the wild run). Ongoing threats to wild steelhead populations from fishing include:

- Incidental handling in fisheries targeting other species, and
- Poaching.

Bull Trout Fishery

Abundance data for lower Columbia bull trout is very limited. The primary populations for which there is any significant data are in Yale and Swift reservoirs and their tributaries in the Lewis River system. Fishing for bull trout is closed in Washington. Hooking mortality may occur from catch and release of bull trout in fisheries targeting other fish, particularly the coho and kokanee fisheries in Merwin and Yale reservoirs. Incidental catch of bull trout is thought to be low, however. In the Lewis River system, incidental take of bull trout is thought to be greater above Swift Reservoir. WDFW has actively set fishery regulations to protect bull trout in reservoirs and tributaries in the Lewis River basin. Ongoing threats to bull trout from fishing include:

- Incidental handling in fisheries targeting other species,
- Poaching.

3.6 Hatchery

3.6.1 Background

Salmon and steelhead production in the lower Columbia region is currently dominated by hatchery fish, as was expected when the hatchery mitigation programs were developed. There are 20 salmon and steelhead production hatcheries in the lower Columbia Basin as well as a number of associated rearing facilities and acclimation sites. Lower Columbia hatcheries are used for producing fish for sport and commercial harvest, augmenting and/or supplementing natural production, and as conservation banks for severely depleted populations. These hatcheries have played a major role in producing salmon for harvest. They have also impacted wild populations. Fisheries managers and the public are struggling to find the balance between hatchery facilities that can; 1) produce fish for harvest, 2) augment natural production, 3) help to rebuild depleted wild populations, and/or 4) serve as conservation banks for severely reduced populations, all while minimizing impacts on natural production. Although strides are being made in reducing the impacts of hatcheries, wild salmon and steelhead are still being limited and threatened by hatchery practices.

Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins (Table 9). Two-thirds (34 million) are tule fall Chinook, 9.6 million are coho, spring Chinook total 5.4 million, steelhead 2.5 million, and chum 0.5 million. Fall Chinook and chum are released as subyearlings; other species are released primarily as yearlings. Subyearling survival rates are much lower than those of yearlings, so release numbers are not directly comparable among species. Oregon also releases significant numbers of fall Chinook, spring Chinook, coho, and steelhead from Lower Columbia and Willamette Basin hatcheries.

The view of hatcheries has undergone a fundamental paradigm shift over the last 30 years as risks to naturally spawning populations have become better understood. After artificial production practices were first perfected in the early 1900s, hatcheries were seen as an inexhaustible source of fish for harvest. Many hatcheries were initially built as mitigation to offset the detrimental effects of development on salmon habitat and access. For instance, most lower Columbia River hatcheries were built to compensate for dam construction that blocked access to spawning grounds in the upper Lewis and Cowlitz rivers or reduced production from the upper Columbia and Snake rivers. However, the significance of local adaptation to population health was poorly understood and hatcheries regularly mixed stocks from different basins which further exacerbated the effects of hatchery selection practices and domestication. Further, widespread hatchery releases masked the declines of naturally spawning fish as the habitat declined. The view was that hatchery fish could be substituted for naturally spawning fish without lasting consequences and that there was little need to protect remaining naturally spawning populations and the habitats that supported them.

Attitudes changed with recognition of the potential risks of hatcheries and hatchery fish to the diversity and productivity of the remaining naturally spawning populations and our ability to accurately assess naturally spawning population status. Prevailing opinion shifted to the perspective that hatcheries did more harm than good. Widespread hatchery closures were advocated to protect the remaining naturally spawning fish. Controversy and confusion resulted as many people had difficulty reconciling the need for more fish to prevent extinction with the idea that hatcheries produced more fish but these fish were somehow undesirable.

Table 9. Summary of lower Columbia River salmonid release numbers (thousands) in Washington subbasin hatchery programs as of 2004.

	Chinook					Steelhead	
Subbasin	**Spring**	**Fall (tule)**	**Fall (bright)**	**Chum**	**Coho**	**Winter**	**Summer**
Deep	200	0	0	0	400	0	0
Chinook	0	107.5	0	147.5	52	0	0
Grays	0	0	0	300	150	40	0
Eloch/Skam	0	2,000	0	0	930	90	30
Mill/Ab/Ger	0	0	0	0	0	0	0
L. Cowlitz	967	5,000	0	0	3,200	652.5	500
U. Cowlitz	300	0	0	0	0	287.5	0
Tilton	0	0	0	0	0	100	0
NF Toutle	0	2,500	0	0	800	0	25
SF Toutle	0	0	0	0	0	0	25
Coweeman	0	0	0	0	0	20	0
Kalama	500	5,000	0	0	700	90	90
NF Lewis	1,050	0	0	0	1,695	100	225
EF Lewis	0	0	0	0	0	90	25
Salmon	0	0	0	0	0	20	0
Washougal	0	4,000	0	0	500	60	60
Steamboat Slough	0	0	0	0	200	0	0
L. Gorge	0	0	0	100	0	0	0
Wind	1,420	0	0	0	0	0	0
Lit. White Salmon	1,000	0	2,000	0	1,000	0	0
White Salmon	0	0	0	0	0	0	0
Spring Creek	0	15,100	0	0	0	0	0
Totals	***5,437***	***33,707.5***	***2,000***	***547.5***	***9,627.5***	***1,550***	***980***

We now know that each extreme view contains elements of the truth. Hatcheries are not a panacea for salmon enhancement or recovery. Nor are they the root cause of salmon decline. Hatcheries, like any good tool, can generate valuable benefits but can also cause significant adverse impacts if not prudently and properly employed.

There are 20 salmon and steelhead production hatcheries in the lower Columbia basin (Figure 22) as well as a number of associated rearing facilities and acclimation sites. These hatcheries have played a major role in producing salmon for harvest. Fisheries managers and the public are attempting to find the balance between hatchery facilities that can; 1) produce excess fish for harvest, 2) augment natural production, 3) help to rebuild depleted wild populations, and/or 4) serve as conservation banks for severely reduced populations, all while minimizing impacts on natural production. The long history of hatcheries in the lower Columbia, and their associated effects on wild fish, cannot be erased simply by closing all hatcheries. To do so would eliminate important hatchery-based fisheries and some key natural production, especially tule fall chinook and coho, now largely supported by hatchery augmentation. Rather, modifying hatchery programs so they support an integrated, comprehensive approach to rehabilitating depleted populations, and providing fish for harvest while minimizing impacts to wild fish, should be the goal for hatcheries into the future (NRC 1996).

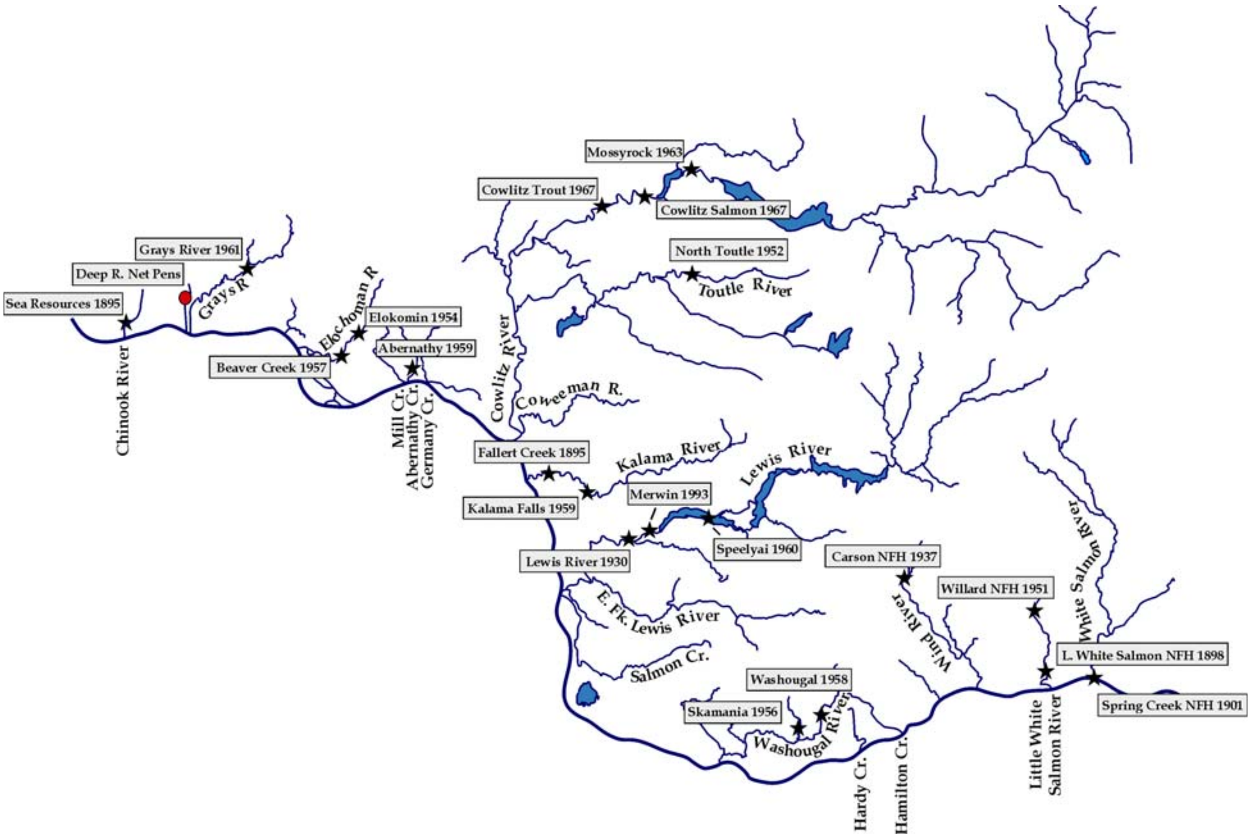


Figure 22. Lower Columbia production fish hatcheries and beginning dates of operation.

Types of Hatcheries

To set the stage for a discussion of hatcheries and their role in past, present, and future lower Columbia salmon production and restoration, requires some basic definitions of the various types of hatchery programs. These range on a continuum from major production facilities to small genetic conservation programs and can be organized according to the programs' history and purpose. Multiple programs with different or complimentary purposes may be found at a single facility.

Production hatcheries are used primarily to rear and release large numbers of fish that support fisheries. These are usually characterized by large physical plants and may incorporate satellite rearing and acclimation facilities. Many production hatcheries were originally constructed to mitigate for lost habitat upstream of dams.

Augmentation programs are usually more closely tied to local natural production but are primarily oriented to producing fish for harvest (Kapuscinski 1997). In most cases, the differences between the hatchery and natural fish are difficult to discern and natural reproduction is largely supported by hatchery fish. These programs are often associated with large production hatcheries and incorporate satellite rearing and acclimation facilities.

Supplementation programs use artificial propagation in an attempt to maintain or increase natural production, while maintaining the long-term fitness of the target population and keeping the ecological and genetic impacts on non-target populations within specified biological limits (RASP 1992).

Conservation hatcheries use artificial propagation techniques to maintain populations when they are at critically low numbers. They may include the use of captive broodstock but ultimately are aimed at rebuilding wild populations through supplementation strategies (Waples et al. 1991). There are currently no true conservation hatchery programs in the lower Columbia planning area.

This hatchery section describes detrimental effects that hatchery programs can potentially have on natural fish populations. This section is intended to illustrate the types of potential risks associated with hatchery operations in general and describe the specific lower Columbia basin hatchery programs in the context of those risk factors, including magnitude and time of hatchery fish released by species, adult returns of hatchery and natural fish, genetics, hatchery/wild interaction potential, the effects of water quality and diseases, passage problems, mixed harvest potential, and programs to supplement wild fish. The section is not intended, however, to quantify the risks to natural fish populations nor reach conclusions concerning presence or absence of risk factors in particular hatchery programs in the lower Columbia basin. Rather, it provides perspective on the overall importance of hatcheries in the lower Columbia as well as specific details on individual programs that can be used, during development of the Management Plan, in formulating risk assessments for impacted natural fish populations and the risks to fisheries and fisheries agreements as a result of potential adjustments to present hatchery programs.

Lower Columbia Basin Hatchery Operations

Throughout the twentieth century, the primary purpose for construction of lower Columbia basin production hatcheries was to enhance fisheries and to mitigate for reduced ability of the habitat to produce natural fish at historical levels (Lichatowich 1999). Almost all hatchery program production of salmon and steelhead in the lower Columbia basin is funded by federal monies as mitigation for fishery losses associated with the development of mainstem Columbia River federal dams, or from licensed operators of the tributary dams in the Cowlitz and Lewis rivers (Radtke and Davis 2000). As efforts move forward to restore those same natural populations that the hatchery programs were intended to replace, hatchery programs will continue to be evaluated for compatibility with natural populations (ISAB 2003). As wild population rebuilding unfolds, however, the objective to maintain adequate salmon and steelhead hatchery production to support fisheries in the lower Columbia should not be dismissed.

The balance of hatchery and natural fish is currently dominated by hatchery fish as was expected when the hatchery mitigation programs were developed. For perspective on the role of Columbia River hatchery fish, by 1987, hatchery-origin fish dominated returns: 95% of coho, 70% of spring chinook, 80% of summer chinook, 50% of fall chinook, and 70% of steelhead were produced by hatcheries (CBFWA 1990, cited in NRC 1996). As natural population recovery is implemented, the fish balance should begin to swing back towards natural production over time, although the rate and magnitude of the swing will depend on the relative success in rebuilding natural populations, with consideration given to total adult production and the public's demand for harvest opportunities, now principally provided by hatchery production.

Hatchery production in the lower Columbia River watershed began in the late 1800s. The first Washington hatchery was built on Baker's Bay near the mouth of the Columbia River in 1894 (Wahle and Smith 1979). Soon after, state and federal hatchery operations began to enhance commercial fisheries; by the 1890s, many hatchery and egg-take stations were operating between the Chinook River (near the Columbia River mouth) and the Little Spokane River (upper basin).

In 1895, the first state-operated hatchery in Washington was built on the Lower Kalama River and is still in operation. The first federal chinook salmon hatchery on the lower Columbia River was built on the Little White Salmon River in 1897 (Nelson and Bodle 1990). Hatchery production exploded during the early 1900s. By 1905, approximately 62 million fry were released annually.

Throughout the 1900s, the negative effects of agricultural development, timber activities, and other land use practices, and the development of the Columbia River dam complex increased the need to mitigate for reduced natural production. Artificial production appeared to be the only means available to fishery managers to compensate for fish losses and the resulting decline in fish available for harvest.

The first half of the twentieth century witnessed an explosive increase of hatcheries and hatchery production. From 1913 to 1930, about 320 million chinook salmon fry were released into the lower Columbia River by Washington state hatcheries alone; similar production numbers are estimated for Oregon and federal hatchery efforts. Hatchery operations dropped during the Great Depression and were temporarily interrupted during World War II, and production declined to one-tenth of that seen during pre-war years at Washington state hatcheries.

In response to the construction of Bonneville and Grand Coulee dams, Congress passed the Mitchell Act in 1938, which required the construction of hatcheries to compensate for fish losses caused by the dams as well as by logging and pollution. A 1946 amendment to the Mitchell Act led to the development of the Lower Columbia River Fishery Development Plan, which initiated the major phase of hatchery construction in the Columbia River basin. The plan was later expanded to include the upper Columbia River and the Snake River.

NOAA Fisheries is in the process of preparing an Environmental Impact Statement (EIS) for the funding and operation of Columbia River hatcheries authorized under the Mitchell Act (Public Law 75-502). The EIS will evaluate the environmental impacts of a full range of alternatives for funding and operation of Columbia River Hatchery programs consistent with the Mitchell Act, Endangered Species Act (ESA), Tribal trust responsibilities, and broader NOAA Fisheries objectives for sustainable fisheries under the Magnuson-Stevens Fisheries Conservation and Management Act. Currently, funds are provided to the Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), and Confederated Tribes and Bands of the Yakama Nation (Yakama) for the operation and maintenance of 18 hatcheries, which stock the mainstem Columbia River and its tributaries with close to 65 million salmon and steelhead annually. These funds also provide for the marking of hatchery fish and support associated monitoring, reform, and scientific investigations.

The EIS will potentially address the following issues: 1) How will hatchery operations positively or negatively affect the distribution, diversity, and abundance of the various populations of steelhead, chinook, chum, and coho salmon found within the project area; 2) How will hatchery operations impact the other fish and wildlife species in the region; 3) What are the impacts of hatchery water withdrawals and releases of water used for fish rearing; 4) How are Tribal fisheries rights affected by hatchery production; and 5) Will hatchery operations have disproportional impacts on lower income groups? NOAA Fisheries expects to complete a final EIS and make ESA determinations on hatchery programs supported through the Mitchell Act by the fall of 2006.

Although most of the lost natural salmonid production was located in the upper Columbia and Snake River basins, only four of the 39 propagation facilities authorized by the Mitchell Act were constructed above The Dalles Dam in the mid-Columbia River. Facilities were not constructed in the upper basin because of concerns with the ability of fish to bypass dams in the upper watershed and because the primary goal of the program was to provide fish for harvest in the ocean and lower river fisheries (Myers et al. 1998).

In 1990, total annual hatchery juvenile production (202.5 million) plus estimated wild production (about 145.2 million) equaled about 347.7 million juveniles in the Columbia River, while historical wild juvenile abundance equaled about 264.5 million (Kaczynski and Palmisano 1992). However, the number of juveniles effectively migrating to the lower Columbia and successfully reaching the estuary is likely still less than historical numbers after adjusting for modern-day passage mortality through dam structures and post-release mortality suffered by the hatchery fish.

Hatchery programs in the lower Columbia basin have included all salmonids native to the region. (Species-specific hatchery program information is presented in the Program section below.) Salmonids often have been transferred among watersheds, regions, states, and countries, either to initiate or maintain hatchery populations or naturally spawning populations. The transfer of non-native fish into some areas has shifted the genetic profiles of some hatchery and natural populations so that the affected population is genetically more similar to distant hatchery populations than to local populations (Howell et al. 1985, Kostow 1995, Marshall et al. 1995). Until recently, the transfer of hatchery salmon between distant watersheds and facilities was a common practice (Matthews and Waples 1991, WDF et al. 1993, Kostow 1995). However, agencies recently have initiated policies to reduce the exchange of non-indigenous genetic material among watersheds. For example, Washington chinook salmon managers adopted a statewide plan in 1991 to reduce the number of out-of-basin hatchery-to-hatchery transfers. However, the plan did not explicitly prohibit introductions of non-native salmonids into natural populations; rather, the plan included genetic guidelines specifying which transfers between areas were acceptable.

3.6.2 Limiting Factors

Hatchery programs provide one of the few alternatives for mitigating the large losses of salmon populations, for example, in instances where dams completely block access to salmon spawning areas. However, poorly designed hatchery programs often are detrimental to wild salmon production (Cone and Ridlington 1996, Walters et al. 1988, NRC 1996, Lichatowich 1999). Comprehensive analyses of the impacts of hatcheries on wild salmon involve investigating a variety of effects, many poorly understood.

Hatchery effects on wild fish can be positive and/or negative. Hatchery managers have numerous operational choices (left panel, Figure 23) that affect the biology and productivity (center panel, Figure 23), and thereby influence the life cycle, of both the hatchery fish and the wild fish with which they interact (right panel, Figure 23). Direct and indirect effects and hatchery releases can impact natural stocks in a number of possible ways. The following sections present more detailed information on how hatchery practices can result in life cycle effects on wild populations; the magnitude and actual occurrence of these effects vary among hatcheries and depend on specific operational procedures at individual facilities.

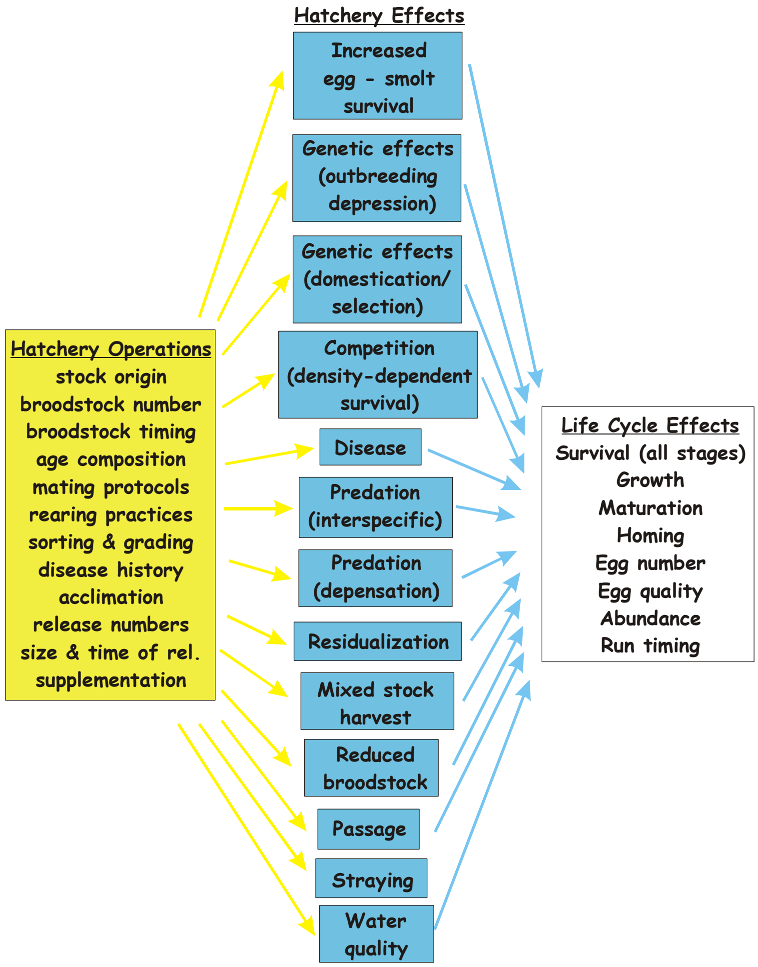


Figure 23. Potential links between hatchery operating procedures and effects on salmonids.

Increased Egg to Smolt Survival

Hatcheries substantially increase net productivity by increasing egg-to-smolt survival; because hatcheries are able to control the incubation and rearing environment, they usually can achieve higher egg-to-smolt survival than is realized in the natural environment. Because hatcheries allow greater than normal survival, individuals that would have died in the natural environment often survive to increase competition, predation, genetic effects, disease proliferation, and mixed stock fisheries effects among each other and their wild counterparts. Hatchery fish have also exhibited reduced fitness and survival per individual compared to wild fish (NRC 1996, Reisenbichler 1997). When hatchery fish stray and spawn in the wild, the fitness of natural offspring populations can likewise be reduced (Waples 1991, Reisenbichler 1997).

On the other hand, because of their ability to produce many offspring from relatively few adults, hatchery programs have been widely considered for supplementation of weak natural runs (Cuenco et al. 1993), although this approach remains controversial (NRC 1996). Conservation hatchery programs are a key component in ongoing attempts to preserve and rebuild several listed Columbia basin salmon stocks (Waples and Do 1994).

Genetic Effects

Genetic effects of hatchery practices can influence wild fish populations because hatchery fish become genetically different from local wild fish within a few generations (Resisenbichler 1997). In general, the genetic effects of hatcheries and hatchery fish can be grouped into three major categories (Waples 1991, Krueger and May 1991): 1) the genetic effects of artificial propagation on the hatchery fish, 2) the direct genetic effects of hatchery fish spawning with wild fish in the natural habitat, and 3) the indirect genetic effects of hatchery fish on wild populations due to competition, predation, disease transfer, changes in fishing mortality, or any other factor that affects the abundance or effective population size of the wild population (Campton 1995). Here we will discuss direct genetic effects; the third point is addressed under subsequent headings.

Genetic differences in hatchery fish

The reasons for genetic differences in hatchery fish are attributable to:

- Taking broodstock from a non-local population,
- Random effects (genetic drift or founder effects) of small hatchery population size,
- Artificial selection by hatchery personnel,
- Increased survival of individuals poorly suited to natural habitat (relaxed selection), and
- Natural selection of fish that are well adapted to hatchery survival (domestication selection) (Reisenbichler 1997).

Loss of genetic variation within a population generally occurs through either genetic drift or selection as listed above. *Genetic drift* is most commonly identified by the loss of infrequent alleles and a resulting increase in homozygosity in small populations. The rate of genetic drift is governed by the effective population size (i.e., the number of spawners that effectively contribute gametes to the next generation), rather than the simple number of fish in the population. The artificial reduction in effective population size may be caused by the use of males to fertilize multiple females. Simon et al. (1986) found that survival from smolt to age 2+ was significantly and positively correlated ($P<0.01$) to effective population size. Waples and Teel (1990) found effective population sizes of chinook salmon in some hatcheries to be less than 100 even when returns were greater than 1,000 fish. The loss of genetic variability to genetic drift has been documented for salmonids (Allendorf and Phelps 1980, Ryman and Stahl 1980; Waples and Teel 1990) and is commonly discussed in hatchery manuals regarding spawner numbers and sex ratios (Hershberger and Iwamoto 1983, Kapuscinski and Jacobsen 1987). New guidelines for hatchery practices issued by state and federal agencies on the West Coast have been designed to eliminate artificial reductions in effective population size.

Selection can be either purposeful or inadvertent, but its consequences are the same in either case. Genetic variability is lost when only a segment of the population, not representative of the whole, is selected for broodstock. This effect was widespread among historic hatchery programs (e.g., see Cramer et al. 1991 regarding coho hatcheries). Most commonly, it results from the practice of taking eggs from the first fish arriving at the hatchery and then ceasing the egg take once the egg-incubation capacity of the hatchery is reached. Furthermore, because we cannot predict how the entire gene complex of a population will be affected by selection for a specific trait, selection should be avoided where enhancement of natural populations is desired (Krueger et al. 1981). Several studies have demonstrated that selective breeding in hatcheries has reduced viability as a result of the loss of genetic variability (Ryman 1970, Kincaid 1976, Allendorf and Utter 1979, Allendorf and Phelps 1980, Ryman and Stahl 1980).

Domestication selection results from unintentional selection for survival in a hatchery environment (Resienbichler 1997). This selection may result from culling the slow growing fish, from disease treatments, or from the effects of growth differences in the hatchery on survival to maturity. A particular type of domestication selection that is difficult to eliminate relates to how hatchery practices can provide selective advantages to fish that spawn during a specific time of the spawning season. For example, the earliest spawning fish in a hatchery also produce the earliest emergent fry and therefore the largest smolts at release. Numerous studies have demonstrated with every salmonid species that survival to adulthood increases as smolt size at a given time increases. Thus, when a hatchery eliminates the environmental perils of early spawning, a new selective advantage is provided to early spawning fish. Hatchery practices can minimize this selectivity scenario by taking eggs throughout the spawning period and may also control growth by regulating water temperature.

Genetic influence of hatchery fish on natural spawners — Spawning of hatchery salmonids in the wild with naturally produced fish has the potential to adversely affect genetic characteristics of natural populations (Campton 1995, Reisenbichler 1997). For hatchery fish to have a genetic impact on naturally spawning fish, two conditions must be true: 1) the hatchery fish must be genetically different from the natural fish, and 2) the hatchery and natural fish (or their descendants) must interbreed. The magnitude of genetic impact will depend on the extent to which these two conditions are true (see discussion on straying below).

Three types of genetic risks have been identified which may impact the long-term productivity of wild populations, including:

- Loss of between-population identity or variation,
- Decreases in within-population genetic variation, and
- Decreased fitness (Campton 1995).

The loss of between-population variation or diversity is a primary genetic risk of introducing non-indigenous fish to wild populations. When populations having different genetic profiles interbreed, they may tend toward homogeneity (Campton 1995). For example, populations of wild steelhead on the northwest coast of Washington, where nonnative hatchery steelhead had been extensively stocked since the 1940s, were genetically more homogenous than wild, unstocked steelhead in British Columbia (Reisenbichler and Phelps 1989). Lower Columbia River wild coho salmon are now genetically indistinguishable from hatchery fish stocked for a number of years in large numbers (Flagg et al. 1995). In the long run, this potential loss of diversity weakens the biological resiliency essential to the variable structure required for a healthy salmon ESU.

The loss of within-population variation results when hatchery populations with reduced genetic variation, as described above, spawn naturally with local populations (genetic swamping). The genetic variation of the local populations is subsequently reduced, especially when the number of hatchery fish is large (high stray rates or widespread dispersal of hatchery juveniles). For example, an introduced stock of coho salmon that is substantially different from the native stock might survive at roughly 20% the rate of the native stock, while a similar stock introduced from a nearby stream might survive at roughly 80% of the rate of the native stock (Reisenbichler 1986).

Loss of fitness, as expressed by reduced reproductive success and survival, occurs from the interbreeding of two genetically diverged populations, such as hatchery fish and wild fish, and is referred to as outbreeding depression (Campton 1995). A number of studies have revealed that feral hatchery fish spawning in the wild, either with each other or with wild fish, clearly have reduced reproductive success, lower juvenile growth and survival, and lower marine survival than their wild counterparts (Reisenbichler and McIntyre 1977, Nickelson et al. 1986, Leider et al. 1990). In particular, naturally spawning Skamania stock steelhead introduced into the Kalama River (1- to 2-month differences in time of spawning) were only 28% as successful at producing smolt offspring as the native fish (Chilcote et al. 1986). Survival of wild Kalama steelhead was reduced to 43% of normal when a wild fish mated with a Skamania stock hatchery steelhead (Chilcote et al. 1986). Also, studies with hatchery releases have indicated hatchery fish derived from local populations perform much better in their native environment than do hatchery fish from other populations (Bams 1976, Altukhov and Salmenkova 1986).

In summary, genetic limitations to wild salmon and steelhead productivity result from hatchery operations through:

- Genetic drift and selection in hatchery populations,
- Domestication of hatchery populations (loss of fitness for survival in the wild), and
- Hatchery-produced strays intermingling with and outnumbering wild fish, including loss of between-population identity or variation, decreases in within-population genetic variation, and decreased fitness.

Population Mixing

Populations can be mixed, and result in genetic and life history effects, through a number of management activities. Obviously, massive releases of smolts from hatcheries and widespread outplanting from production hatcheries have the single most dramatic effect. Hatchery transfers, intentional augmentation and supplementation of natural production, and straying from hatchery programs all contribute to negative impacts on wild populations. The ISAB (2003) concluded that hatchery programs based on hatchery broodstock lines, and which allow the hatchery products to interact intensively with natural populations, almost certainly impose a large cost on the affected natural populations.

Hatchery Transfers — Most hatchery populations have been affected to some degree by transfers between hatcheries to fill egg-take goals years of low return. Examples within the Columbia basin of hatchery populations that have undergone substantial transfers are early-type coho (Cramer et al. 1991) and tule fall chinook. Many hatcheries have been founded with broodstock from other hatcheries. As examples, Skamania steelhead, Carson spring chinook, and Cowlitz coho have been used at a number of hatcheries.

Populations are also mixed when brood fish are taken at a dam where more than one population must pass. For example, the Bonneville upriver bright stock of fall chinook was developed at Bonneville Hatchery by taking their broodstock from bright fall chinook trapped out of the fish ladder at Bonneville Dam. These fish were a mixture of fall chinook that originally spawned throughout the Columbia basin above Bonneville Dam. Similarly, Carson stock spring chinook were developed at Carson National Fish Hatchery by trapping spring chinook at Bonneville Dam as broodstock.

Supplementation **—** Although the original purpose of most Northwest hatcheries was to provide harvest opportunities in the face of declining salmonid abundance, augmentation and supplementation of natural production have become the focus of some recent salmonid recovery efforts (RASP 1992, Cuenco 1993, ISAB 2003). Augmentation and supplementation are generally aimed at either enhancing existing stocks of anadromous fish or reintroducing stocks formerly present in particular subbasins. Hatchery programs designed to supplement endangered or exploited salmonid populations, like more traditional hatchery programs, can reduce population fitness because the animals are reared under low-mortality conditions that can favor maladaptive traits. The scale of hatchery operations and practices employed in smaller supplementation programs can often be considerably less than those at hatcheries designed to provide for harvest opportunities. However, supplementation programs have similar concerns regarding genetic and ecological effects as other hatchery programs (ISAB 2003). In the extreme case of continual, large-scale augmentation, where the hatchery and natural populations are integrated, the empirical basis is inadequate for determining the cost to the natural population (ISAB 2003). The ISAB (2003) recognized that Columbia Basin supplementation occurs at a number of intentional and unintentional levels:

> "*Most of the hatchery programs are not integrated with natural production because they rely extensively on fish of hatchery origin for their broodstock. Nevertheless, the hatchery productions from these programs are present in large numbers on the breeding grounds of many natural spawning stocks. In some cases this is deliberate, in others it is inadvertent. Either way, this constitutes a supplementation action.*"

Developing and improving supplementation, as well as standard, hatchery programs will continue to be a key component in ongoing attempts to preserve and rebuild listed Columbia basin salmon stocks.

Straying **–** For hatchery and wild fish to interbreed, they must spawn in the same place at the same time. The degree of genetic mixing and the effects on life history that occurs when hatchery fish are released in a wild population varies dramatically, depending on the ability of the hatchery fish to survive to maturity and on temporal isolation mechanisms. Leider et al. (1986) found that 36% of all wild summer steelhead in the Kalama River mated with hatchery fish, even though spawning by hatchery fish peaked one month earlier than wild fish. The high rate of interbreeding in the Kalama River resulted from the much greater abundance of hatchery fish than wild fish.

Hatchery or fish management practices that lead to straying of hatchery fish at the time of return are key factors governing the risk of reduced diversity and fitness in locally adapted populations. Evidence indicates that straying is more likely among some races of salmon than others. Chapman et al (1991) reviewed the evidence on straying of spring and summer chinook throughout the Columbia basin and found high homing fidelity to nearly every hatchery. However, straying of spring chinook from Lookingglass Hatchery in the Grand Ronde basin into other tributaries of the Grand Ronde River was significant in the 1980s. Quinn and Fresh (1984) documented evidence from Cowlitz River spring chinook that social interaction aids in homing; straying rates increase as spawner abundance declines. To reduce the potential for straying, hatchery programs routinely release hatchery salmon from acclimation ponds to improve homing fidelity. Research by ODFW (2002) on coastal steelhead populations showed that direct stream releases did not increase the potential straying relative to acclimation.

Management practices which may increase the straying rate are: 1) broodstock transfers, 2) mixed broodstock origins, 3) Releasing hatchery fish close to the mouth of the stream to which adults are intended to return, 4) off-station releases of fish, 5) not acclimating fish prior to releases, and 6) rearing juveniles in other basins/water sources prior to release. Environmental conditions affecting straying rates include protracted periods of low flow and high water temperatures at the time and place adult fish are targeted to return.

In summary, mixing populations between hatcheries and between hatchery and wild fish may impact Lower Columbia salmon by:

- Increasing the likelihood of deleterious genetic effects,
- Reduced population diversity and fitness, and
- low-mortality conditions that can favor maladaptive traits, and
- increasing straying of hatchery fish.

Competition

The potential for intra- and inter-specific competition for food or space between hatchery and wild stocks depends on the degree of spatial and temporal overlap in resource demand and supply (Steward and Bjornn 1990, McMichael et al. 2000). The capacity for hatchery fish to significantly alter the behavior and survival of wild fish via competition remains a controversial subject (Steward and Bjornn 1990). There are five areas where competition and crowding may occur between hatchery and natural fish: in rearing streams, during downstream migration, in mainstem reservoirs, in the estuary, and in the ocean.

Rearing Stream — Streams in which juvenile salmonids rear have a limited amount of the resources necessary for survival and growth. When hatchery fish are released into streams where wild fish are present, there can be competition for food and space (McMichael et al. 2000). Competition between wild and hatchery individuals is most likely to occur if the fish are of the same species and they share the same habitat and diet. Juvenile salmon establish and defend foraging territories through aggressive contests (Nielsen 1992). When hatchery fish are released into streams where there are wild fish, hatchery fish may be more aggressive, disrupting natural social interactions (Nielsen 1994). Often hatchery-reared individuals may be larger than wild fish in the same stream, and occupy the best feeding territories, placing their wild counterparts at a disadvantage and reducing the number of wild fish in the natural habitat (McMichael et al. 1997). Because carrying capacity of many streams and watersheds has been degraded by contamination, development, logging, and other causes, the effects of competition on wild salmonids may be further exacerbated.

Downstream Migration — Few studies have directly addressed the possibility of density dependent competition during juvenile emigration (Hard 1994). Since salmonid smolts actively feed during their downstream migration (Becker 1973; Muir and Emmett 1988, Sagar and Glova 1988), it is reasonable to conjecture that increased density from hatchery releases could increase competition for wild smolts.

Reservoirs — Salmonid smolts actively feed during normal downstream migration (Becker 1973, Muir and Emmelt 1988, Sagar and Glova 1988). Muir and Coley (1994) hypothesized that smolts passing through reservoirs were negatively affected by starvation and that increased hatchery production could further deplete food resources. From 1987 to 1991, empty stomachs were observed in 26% to 38% of the yearling chinook salmon smolts sampled at Lower Granite Dam and in 1991, compared to less than 55 empty stomachs at McNary and Bonneville dams

(Muir and Coley 1994). This data suggests that, in some reservoir areas or portions of reservoir areas, food availability is limited and that increased hatchery production could compound the problem. The areas where food is limited and the effect of reduced feeding success on smolt performance and survival are unknown (Muir and Coley 1994). Neither Chapman et al. (1994) nor Witty et al. (1995) found documentation of density-related interaction in Snake and Columbia River reservoirs. Ultimate impacts on adult fish production would vary greatly in any one year as a result of multiple additional influences on smolt-to-adult survival, including flow-related passage time through the reservoirs and on to the estuary.

***Estuarine Conditions* —** The estuary is clearly an important rearing area for juvenile anadromous salmonids of all species and sizes as they move toward the ocean (Healey 1991). Extensive hatchery production programs may have at times exceeded the carrying capacity of the Columbia River estuary, resulting in competition between natural and hatchery fish. Furthermore, the productivity of the Columbia River estuary likely has decreased over time as a result of habitat degradation, which would increase the likelihood for competition in the estuary. Simenstad and Wissmar (1984) cautioned that estuary conditions may limit rearing production of juvenile chinook, and many other studies have demonstrated the importance of the estuary to survival and population fitness (Miller et al. 2003).

The intensity and magnitude of competition in estuaries depends partially on the residence time of hatchery and natural juvenile salmonids. Duration of estuary use probably depends partially upon fish size at arrival (Chapman et al. 1994). Chapman et al. (1994) concluded that the survival of juveniles transported to below Bonneville Dam at a size too small to ensure high initial marine survival may depend upon growth in the estuary for successful ocean entry. Some workers (Reimers 1973, Neilson et al. 1985) have suggested that the amount of time spent in estuaries may relate to competition for food; that estuarine residence time increases with increased competition, because fish take longer to reach the threshold size needed for successful ocean entry. Thus, if large numbers of hatchery fish are present in the estuary, growth and survival of wild fish could be reduced (Chapman et al. 1994). In contrast, Levings et al. (1986) reported that the presence of hatchery chinook salmon did not affect residency times and growth rates of wild juveniles in a British Columbia estuary and that hatchery fish used the estuary for about half the time that wild fry were present (40-50 days).

Natural populations of salmon and steelhead migrate from natal streams over an extended period (Neeley et al. 1993, Neeley et al. 1994); consequently, they also enter the estuary over an extended period (Raymond 1979). Hatchery fish are generally—but not always—released over a shorter period, resulting in a mass emigration into natural environments. In recent years, managed releases of water, commonly called water budgets, have been used to aid mass and fast migration of hatchery and wild smolts through the migration corridor. Decisions regarding the mode of travel in the migration corridor (i.e., in-river migration or collection/transportation) are made by managers to expedite movement of smolts to the estuary (Williams et al. 1998). Water budget management, combined with large releases of hatchery fish, result in large numbers of juvenile salmon and steelhead in the estuary during spring months when the estuary productivity is low. Fish that arrive in the estuary later in the season may benefit from increased food supplies. Chapman et al. (1994) notes that subyearling chinook released later in the summer returned at significantly higher rates than subyearlings released early in the summer.

Ocean Conditions — There has been a general consensus that most density-dependent mechanisms at sea, if they occur, take place very early; probably within the first few weeks after smolts enter the ocean (Gunsolus 1978, Peterman 1982, 1987, Fisher and Pearcy 1988, Beamish et al. 2004). Factors which may contribute to competition in the ocean include: hatchery-reared fish that successfully forage upon reaching the ocean (Paszkowski and Olla 1985a, 1985b), food production in the ocean varies in time and space (Healey and Groot 1987), migratory salmonids remain in fairly cohesive groups (Pearcy 1984), and migration routes of different stocks and species may overlap (Steward and Bjornn 1990). Therefore, competition is possible between hatchery and wild fish in the ocean, particularly in nearshore areas (Peterman and Routledge 1983, Peterman 1989, and Emlen et al. 1990) and especially during periods of low ocean productivity (Steward and Bjornn 1990). McCarl and Rettig (1983) found evidence for density-dependent mortality in the area referred to as the Oregon Production Index Area (OPIA) which includes the Pacific coastal water bounded on the north by Leadbetter Point, Washington, south to Monterey Bay, California. They suggested that variability in smolt survival increased with the number of smolts, and hatchery smolts should be limited if the stability of fisheries was an important goal. However, Nickelson (1986) challenged these claims, suggesting that wild and hatchery fish do not occur together at sea and that there is no evidence supporting density-dependent mortality at sea. Witty et al. (1995) suggest that nearshore density-dependent mortality may occur when large numbers of hatchery juveniles are present during years of low ocean productivity.

Density interactions also may occur at sea away from nearshore areas. Several researchers have reported indications that oceanic carrying capacity can be taxed, with feed-back density effects in salmon populations (Chapman and Witty 1993). Adult size tends to decline in large populations of Fraser River pink salmon (Peterman 1987) noted that the average weight of pink salmon was less during years of larger hatchery populations. Chum salmon culture programs in Japan suggested the presence of density-dependent production limitations, expressed in mean size of adult fish produced as mass enhancement efforts proceeded (Kaeriyama 1989). Eggers et al. (1983) found that mean length of sockeye in Bristol Bay related inversely to magnitude of the return. Eggers et al. (1983) noted that the effect of density-dependent growth was reduced in years of higher ocean temperatures, suggesting that temperature effects moderated depression of growth in years of high fish density. Peterman (1987) reported that density-dependent processes, associated with available food during early ocean rearing, can reduce fish size. Taken together, these studies indicate a strong potential for oceanic competition between hatchery and wild salmon.

In summary, hatchery fish may compete for food and/or space with Lower Columbia wild fish throughout their shared life history, resulting in:

- Reduced survival of juveniles,
- Exacerbation of poor food availability in reservoirs,
- Exceeding the carrying capacity of the estuary,
- Reduced size fish upon ocean entry,
- Lower marine survival, and
- Reduced numbers of wild adults returning to spawn.

Disease

Hatchery programs often succeed or fail depending upon success in controlling pathogens. Types, abundance, and virulence (epidemiology) of pathogens and parasites in hatchery fish are generally known, but less is known about diseases and parasites in natural fishes of the Columbia River basin or the vectors and amounts of disease transmitted from hatchery to wild fish (Steward and Bjornn 1990). Hatchery fish are always confined to some degree, which creates opportunities for epizootic outbreaks. Often, but not always, hatchery fish are infected by pathogens in the hatchery water supply or by natural fish entering the hatchery. Regardless of control measures, hatcheries release some fish infected with pathogens and parasites although every attempt is made by hatchery managers and biologists to minimize release of impaired fish to the natural environment.

Disease is thought to result in significant post-release mortality among hatchery fish, being either directly responsible for mortality or predisposing fish to mortality from other causes (Steward and Bjornn 1990). Steward and Bjornn (1990) found little evidence to suggest that the transmission of disease from infected hatchery fish to wild salmonids is widespread. However, there has been little research on this subject, and since most disease-related losses probably go undetected, researchers have concluded that the full impact of disease on stocks is probably underestimated (Goede 1986, Steward and Bjornn 1990). Increasing fish abundance through the release of large numbers of hatchery fish could alter normal population mechanisms and trigger outbreaks of pathogens in natural fish, both in tributary rearing areas and in mainstem migration corridors. McMichael et al. (2000) reported that disease incidence in cohabiting hatchery and wild fish increased with temperature and was likely influenced by the stress of interaction. Disease management practices as outlined by IHOT and the Pacific Northwest Fish Health Protection Committee have reduced the abundance and virulence of pathogens in hatchery populations.

Hatchery programs therefore affect disease processes in salmon and steelhead through:

- Disease spread within hatchery fish and to wild fish,
- Increased likelihood and virulence of epizootics, and
- Altered population mechanisms and increased stress

Predation

The two primary predator-prey relationships that can result from hatchery and wild fish interactions include predation by hatchery fish on natural fish and the functional response of non-salmonid fish preying on natural fish as a result of increased numbers of hatchery and natural salmonids. Predator-prey interactions between hatchery steelhead and naturally produced salmon has been identified as a concern (Chapman and Witty 1993). Hatchery chinook salmon predation on wild chinook salmon has been reported by Sholes and Hallock (1979). Fresh (1997) cited several studies that indicated hatchery coho, steelhead, and chinook preyed on wild fry of conspecifics as well as pink and chum fry.

Residualism of hatchery salmon and steelhead is common (McMichael et al. 2000). Cannamela (1992) assumed total residualization rates of 10-25% based on Partridge (1985, 1986) and Chrisp and Bjornn (1978). Residual steelhead commonly exceed 10 in (250 mm) TL in Columbia River basin migration corridors, a threshold size at which piscivorous behavior of steelhead or rainbow trout increases markedly (Ginetz and Larkin 1976, Parkinson et al. 1989, Horner 1978, Partridge 1985,1986, Beauchamp 1990). However, most residual steelhead observed are in poor condition and likely do not survive long enough to become piscivorous (Petit, Idaho Department of Fish and Game, personal communication). This hypothesis is consistent with findings by Mauser (1991, unpublished), Partridge (1986), and Schuck (1991, unpublished) as described by Cannamela (1992). Recent hatchery management practices to address residualism concerns include targeting the size at release for steelhead to a range of 185-220 mm. Constructing dams and associated fish handling facilities and hatcheries have established places in the migration corridor where hatchery and wild smolts concentrate, thus greatly increasing the opportunity for predation. Creating reservoirs has increased the area of the river's cross-section and decreased the velocity and turbidity of the flow, thus enhancing the efficiency of the predators (Junge and Oakley 1966).

Large concentrations of hatchery fish may adversely affect wild juveniles by stimulating functional responses from bird and non-salmonid fish predators (Steward and Bjornn 1990). In the Columbia basin migration corridor, this response is likely to occur at the head of reservoirs, at the face of dams, and at turbine spillway and bypass discharge areas. There is evidence that prey availability immediately below mainstem dams on the Columbia River affects predation rates by northern pikeminnow on juvenile salmonids (Petersen and DeAngelis 1992). Below McNary Dam, Vigg (1988) demonstrated that the predation rate of northern pikeminnow on juvenile salmonids increased with increased salmonid density to an asymptote at higher salmonid densities. Conversely, Cada et al. (1994) note that the importance of predation by northern pikeminnow and other predators at the Columbia River hydroelectric projects may be lessened by the possibility that many fish being consumed are hatchery smolts; they speculate that hatchery fish are more vulnerable than wild fish. Large numbers of hatchery fish may provide a swamping effect and reduce the predation on naturally produced salmonids.

In summary, hatchery fish can result in increased predation on wild salmon through:

- Direct inter- and intra-specific predation of hatchery fish on wild fish,
- Increasing susceptibility to predators at structures, or
- Increased attraction of predators when large numbers of hatchery fish are mixed with wild fish.

Mixed Stock Harvest

Because hatchery and naturally produced salmon and steelhead are often captured in the same ocean and river fisheries, when hatchery production stimulates harvest effort, the catch of naturally produced fish can be increased as well. Since hatcheries provide an environment where the survival rate to smolting is much greater than in the wild, the proportion of returning adults needed to support the population is much less and, therefore, the targeted harvest rate has been at times much greater than the commingled wild populations can sustain. Thus, stimulating harvest has been a notable impact of hatchery programs on natural production (Hilborn 1992). Harvest managers have grappled with the challenge of regulating the fisheries so that surplus hatchery fish can be harvested without over-harvesting the wild fish that are intermixed in the same fishery.

Harvest management strategies focused on hatchery fish harvest were common practice for several species in the lower Columbia for many years (Flagg et al. 1995). Fishery strategies which maximized harvest of surplus hatchery fish were consistent with the mitigation objectives which established the hatchery programs. Current harvest management strategies have transitioned to minimize harvest of weak wild stocks to meet conservation objectives under ESA (see previous section on Fishing). Seasons are structured and regulated in an attempt to provide reasonable opportunity to harvest hatchery and healthy wild stocks within the limits of the weak stock management focus.

Selective harvest of adipose fin-clipped hatchery steelhead, coho, and spring chinook, and release of unclipped wild fish, is now required in all lower Columbia and tributary sport fisheries. Hatchery-origin fall chinook are not currently adipose fin-clipped for selective harvest and selective regulations are not in place for fall chinook fisheries. Wild fish harvest rates are also controlled by annual structure of fishing seasons (see previous section on Fishing). The lower Columbia commercial fishery now uses tangle-net gear and on-board fish recovery boxes to enable release of wild spring chinook and retention of adipose fin-clipped hatchery spring chinook. The commercial fishery is also regulated by time and area restrictions to focus harvest on hatchery coho while minimizing impacts on wild coho (see previous section on Fishing).

Hatchery fish produced for harvest can impact wild populations through:

- Overharvest in mixed populations,
- Incidental catch in selective fisheries targeting hatchery fish, and
- Post-release mortality in selective fisheries targeting hatchery fish.

Passage

Hatchery collection facilities use weirs, ladders, and screens to block fish passage, capture fish for the collection of broodstock, and regulate numbers, stocks, and species of fish entering and passing above hatchery facilities. All weirs cause some degree of migration delay. Most weirs cannot accommodate upstream passage of large fish unless they are staffed to provide passage. Weirs often cannot be operated as desired or according to protocol because of physical and biological constraints such as high water, cold or warm water temperatures, low flow, and/or staffing problems (Witty et al. 1995). Weirs operated to block fish passage for the purpose of collecting hatchery broodstock, or to implement supplementation programs, usually have specific operating criteria that vary facility-to-facility and year-to-year. Estimated production potential above weirs is usually known, and escapement may be allowed accordingly. Operating weirs to meet escapement and hatchery production goals is often a challenge (Witty et al. 1995).

Hatchery fish ladders have the potential to block or delay natural fish passage. These impacts can vary from very significant to insignificant depending on: numbers or proportion of the run affected, quantity and quality of habitat above the ladder, and impacts on life history characteristics (Witty et al. 1995).

Problems with inadequate screening at hatcheries can be divided into two categories: screen systems that fail to keep natural fish out of hatchery facilities and screen systems that fail to keep hatchery fish out of natural environments. The impacts of natural fish entering hatchery facilities are: 1) removing natural fish from their natural environment, 2) exposing natural fish to disease and predation in hatchery environments, 3) introducing disease from natural fish to the hatchery environment, 4) natural fish in environments unsuited for their survival, and 5) releasing natural fish in environments which will result in changing biological balance, changing genetics of endemic stocks, or otherwise upsetting management objectives.

Some possible impacts of hatchery fish escaping into natural environments are: 1) introduction of non-endemic species or stocks, 2) changing biological balance, changing genetics, or upsetting management objectives, 3) exposing natural fish to disease, competition or predation from hatchery fish, and 4) failing to meet hatchery program objectives.

The degree of impact may or may not be directly related to numbers of fish entering or leaving hatchery facilities, but potential impacts are related to fish numbers (i.e. when all hatchery fish escape as compared to a small number of hatchery fish escaping) (Witty et al. 1995).

Impacts to wild fish from blocked migratory access at hatcheries, and impacts to wild fish from hatchery fish access, include:

- Limitations to migratory access of wild spawners to upstream areas,

- Losses of wild fish into hatchery facilities, and
- Genetic, population, competition, or predation problems resulting from escape of hatchery fish.

Water Quality

General water quality effects resulting from the operation of hatchery facilities include potential impacts from water withdrawal and hatchery effluent. All hatcheries are required to comply with NPDES standards for clean water prescribed by WDOE. Many facilities have incorporated settling ponds that improve water quality discharges.

Many fish hatcheries and satellite facilities divert natural stream flows upstream of hatchery facilities and return the water downstream of the hatchery. The volume of water removed varies according to fish production profiles in the hatchery. Withdrawal of natural stream flows results in a stream channel with reduced flow, no flow, or unnatural flow patterns. When evaluating impacts of water withdrawal on natural fish and their environments, one should consider whether fish passage or homing is affected, and/or fish production is significantly affected.

Making these evaluations requires knowledge of life history characteristics and population dynamics of affected natural fish and comparing this information to measured area affected by water withdrawal, time of year when water is withdrawn, percent of flow withdrawn, and location where water is returned. The impact of hatchery water withdrawal requires an examination of past, present, and proposed operations at each hatchery (Witty et al. 1995).

Hatchery effluent may contain organic waste, chemicals, fish pathogens, and warmer or cooler water. The main forms of wastes in hatchery effluent are suspended solids and dissolved nutrients; especially nitrogen and phosphorus (Pillay 1992). Measuring the impacts of effluent one should consider (Witty et al. 1995) pounds of fish produced, effluent treatment facilities, rate of dilution in the recipient waters, quality of water entering the hatchery, and water quality standards set by state and federal regulations.

The nature and extent of chemical use in hatcheries depends on the locality, species of fish reared, nature and intensity of culture operations, and the frequency of disease occurrence (Pillay 1992). There is a potential for harmful effect of chemicals in natural environments. If chemicals used in hatcheries are deemed safe by the Food and Drug Administration, their dispersal into natural environments should be considered safe. The level of impact from discharged hatchery effluent on fish survival is unknown, but is presumed to be small and localized at outfall areas, as effluent is diluted downstream (NMFS 1995). Hatchery facilities that rear greater than 20,000 lbs annually must obtain state and federal pollution discharge (NPDES) permits that set limits on the release of effluent from the facilities.

Hatchery effluent may increase populations and virulence of indigenous pathogens. Virulent pathogens are usually associated with epizootics in natural populations, whereas facultative pathogens tend to emerge as causes of epizootics in cultured populations (Pillay 1992). Despite the absence of conclusive evidence of major infections of wild stocks from aquaculture, very little research has been done to define the role of aquaculture in the outbreak of diseases in natural fish (Pillay 1992). Agencies use guidelines outlined by the Pacific Northwest Fish Health Protection Committee (PNFHPC) to control fish pathogens in hatchery effluent.

Some hatcheries heat or cool water to control embryo development, although the amount of water treated usually is not great. If the water temperature in the natural environment is changed, adverse impacts on natural fish could occur (Witty et al. 1995).

Thus, hatchery operations can influence water quality and quantity to the detriment of wild fish through:

- Withdrawals of stream water, reducing available spawning and rearing habitat,
- Misdirected homing responses at hatchery outfalls, and
- Releases of water that is altered by organic loads, chemicals, pathogens, temperature,

3.6.3 Threats

The impact of hatchery fish on each wild population depends on the variety and extent of hatchery practices implemented in the watershed. The effects can range from simple exposure to a few planted fry mixed with wild fry in a natural stream, to overwhelming releases of millions of fry or smolts. In particular, hatchery programs based on hatchery broodstock lines, and which allow the hatchery products to interact intensively with natural populations, almost certainly impose a large cost on the affected natural populations. Many hatcheries have been founded with broodstock from other hatcheries and most hatchery populations have been affected to some degree by transfers between hatcheries to fill quotas in years of low adult returns. Hatchery or fish-management practices that increase straying of hatchery fish upon return continue to reduce diversity and fitness in locally adapted populations. Hatchery practices have been under scrutiny and study for decades. Many standard, detrimental practices have been curtailed, but others have not. The hatchery practices that continue to threaten the rebuilding, viability, and productivity of wild salmon are:

- Large releases of hatchery fish,
- High survival of less fit individuals (mass production in large hatcheries),
- Numerical predominance of inferior hatchery fish over wild in planned or *de facto* supplementation/augmentation programs,
- Population mixing (stock transfers),
- Broodstock collection (reducing the number of spawners in the wild),
- Artificial selection by hatchery personnel,
- Disease,
- Fishing effects on wild fish mixed with abundant hatchery fish, and
- Blocked habitat at hatchery facilities.

3.7 Ecological Interactions

3.7.1 Background

Ecological relationships describe species-species relationships and species-environment relationships; paramount to these relationships are the effects to the specific life stage of focal species, if known. Two general categories of interspecies relationships exist: native-native interactions and native-exotic interactions. Each of these categories are further segregated into predation or competition aspects of species interactions. Additionally, some exotic species interactions address full scale ecosystem alterations.

Effects of non-native species on salmon, effects of salmon on system productivity, and effects of native predators on salmon are difficult to quantify. Strong evidence exists in the scientific literature on the potential for significant interactions but the complex nature of relationships can make quantification difficult. Effects are often context- or case-specific. For instance, an introduced species might be a detriment in one area and have no impact in another area. This section includes consideration of ecological influences of other species and habitat changes on salmonids. The status of other related species, and the ecological interactions that influence them, is addressed in Section 4.8, below.

3.7.2 Limiting Factors

Ecological Interactions

Predation — Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation likely has always been a significant source of mortality but has been exacerbated by anthropogenic habitat changes. Piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of emigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary. Marine mammals prey on adult salmon, but the significance is unclear. Approximate predation rates can be estimated although interpretation can be complicated. In the lower Columbia River, northern pikeminnow, Caspian tern, and marine mammal predation on salmon has been estimated at approximately 5%, 10-30%, and 3-12%, respectively of total salmon numbers.

Caspian terns are native to the region but were not historically present in the lower Columbia River mainstem and estuary; they have recently made extensive use of dredge spoil habitat and are a major predator of juvenile salmonids in the estuary. The terns are a migratory species whose nesting season coincides with salmonid outmigration timing. Since 1900, the tern population has shifted from small colonies nesting in interior California and southern Oregon to large colonies nesting on dredge spoil islands in the Columbia River and elsewhere (NMFS 2000c). Many of these Columbia River dredge spoil islands were created as a result of dredging the navigational channel after the eruption of Mt. St. Helens in 1980 although Rice Island was initially constructed from dredge spoils around 1962 (Geoffrey Dorsey, USACE, personal communication). Caspian terns did not nest in the estuary until 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds (and others) moved to Rice Island in 1987 and the colony expanded to 10,000 pairs. Diet analysis has shown that juvenile salmonids make up 75% of food consumed by Caspian terns on Rice Island. Roby et al.

(1998) estimated Rice Island terns consumed between 6.6 and 24.7 million salmonid smolts in the estuary in 1997, and that avian predators consumed 10-30% of the total estuarine salmonid smolt population in that year. However, there are no data to compare historical and modern predation rates or predator populations. Further, current predation studies are limited because of the unknown effects hatchery rearing and release programs have had on salmon migration behavior and predator consumption. Nevertheless, evidence suggests that current predator populations could be a substantial limiting factor on juvenile salmon survival (Bottom et al. 2001). Ryan et al. (2003) estimated species-specific predation by Caspian terns from 1988-2000; predation by Caspian terns was consistently highest on steelhead (9.4-12.7%) and consistently lowest on yearling chinook salmon (1.6-2.9%) while predation on coho salmon was intermediate (3.6-4.1%).

Recent management actions have been successful in discouraging Caspian tern breeding on Rice Island while encouraging breeding on East Sand Island, which may decrease predation on juvenile salmonids. However, estimates of potential decreases in salmonid mortality from reduced tern predation assume that there is no compensatory mortality later in the life cycle (Fresh et al. 2003). This assumption may not be realistic; as Roby et al. (2003) hypothesized that tern predation was 50% additive. Thus, actual improvements in juvenile salmonid survival resulting from management actions that reduce tern predation would likely be lower than current estimates (Fresh et al. 2003).

Northern pikeminnow are also a significant predator on salmonid smolts in the lower Columbia River as discussed above in section 4.2.2.8. Pikeminnow predation is greatest downstream of mainstem dams. Pikeminnow abundance in the estuary is likely low because of salinity; thus, pikeminnow predation is not likely to be an important limiting factor on juvenile salmonids in the estuary.

***Competition* –** Competition among salmonids and between salmonids and other fish may occur in the subbasins, mainstem, or estuary. At present levels of natural production, density-dependent competition is not likely a limiting factor in the subbasins, although these relationships have not been clearly established. Large hatchery releases within each subbasin may trigger density-dependent competition, but the potential for this is minimized by releasing hatchery fish that are ready to emigrate.

American shad (*Alosa sapidissima*) populations have grown substantially since introduction into the Columbia River system in 1885 (Welander 1940, Lampman 1946). In recent years, 2-4 million adults have been counted annually at Bonneville Dam. The transition of the estuarine food web from a macrodetritus to microdetritus base (i.e. increased importation of plankton from upstream reservoirs) has benefited zooplanktivores, including American shad (Sherwood et al. 1990). Because of the abundance of American shad in the Columbia River system, studies have been launched to investigate species interactions between shad, salmonids, and other fish species such as northern pikeminnow, smallmouth bass, and walleye (Petersen et al. In press). A pattern is slowly emerging that suggests the existence of American shad is changing trophic relationships within the Columbia River. Because of their abundance, consumption rates, and consumption patterns, American shad may have modified the estuarine food web. One study found that in the Columbia River estuary and lower mainstem (up to RKm 62) shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Juvenile shad and subyearling salmonids also utilize similar heavily vegetated backwater habitats (McCabe et al. 1983). Another study examined shad abundance as prey contributing to faster growth rates of northern pikeminnow, which in turn are significant predators of juvenile salmonids (Petersen et al. In press). Commercial harvest has been considered as a means to reduce the abundance of American shad in the Columbia River, but harvest has been restricted because the shad spawning run coincides with the timing of depressed runs of summer and spring chinook, sockeye, and summer steelhead (WDFW and ODFW 2002).

The intensity and magnitude of competition in estuaries depends in part on the duration of residence of hatchery and natural juvenile salmonids. Estuaries may be "overgrazed" when large numbers of ocean-type juveniles enter the estuary *en masse* (Reimers 1973, Healey 1991). Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may also develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000). Reimer (1971) suggested that density-dependence affects growth rate and hypothesized that fall chinook growth in the Sixes River was poor from June to August because of greater juvenile densities in the estuary but that increased growth rate in the fall resulted from smaller population size and a better utilization of the whole estuary. Although research has demonstrated possible density-dependent competition mechanisms in other estuarine environments (Skagit River, WA, Sixes River, OR), the importance of density dependence in the lower Columbia River and estuary has not been determined.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type chinook salmon to overwhelm the production capacity of estuaries (Lichatowich and McIntyre 1987). However, Witty et al. (1995) could not find any papers or studies that evaluated specific competition factors between hatchery and wild fish in the Columbia River estuary. Simenstad and Wissmar (1984) cautioned that the estuary condition may limit rearing production of juvenile chinook, and many other studies have demonstrated the importance of the estuary to early marine survival and population fitness. However, rivers such as the Columbia, with well-developed estuaries, are able to sustain larger ocean-type populations than those without (Levy and Northcote 1982).

The ecological interactions of predation and competition limit salmon by:

- Juvenile losses to birds and fish,
- Adult losses to marine mammals,
- Reduced juvenile salmonid food base,
- Limitations on freshwater productivity,
- Competition for food in freshwater and the estuary,
- Decreased fitness, and
- Reduced survival.

Effects of Ecosystem Changes on Salmonids

Natural and anthropogenic factors have negatively altered habitat-forming processes, available habitat types, and the estuarine food web, resulting in decreased salmonid survival and production. The most significant habitat effects have resulted from modified river flow and channel manipulations. River flow changes have occurred as a result of hydrosystem operations, water withdrawals for agriculture and urban development, and decreased precipitation from climate changes. Channel manipulations encompass a suite of factors, but primarily refer to dikes that disconnect the river and floodplain or dredging that alters the river's bathymetry. Subsequently, estuary and lower mainstem habitat changes have facilitated the increase of important juvenile salmonid predators (specifically, Caspian terns and northern pikeminnow), thereby decreasing juvenile salmonid survival and abundance through the lower mainstem and estuary.

In a recent analysis of limiting factors, Fresh et al. (2003) evaluated the effects of river flow, habitat quality/availability, contaminant toxicity, and Caspian tern predation on juvenile salmonid abundance, life history diversity, and viable salmon population criteria. They concluded that the most important limiting factors are flow and habitat changes and the primary effects are on shallow water habitats and the salmonid life history strategies that depend on these habitats. Thus, habitat losses that have occurred in the estuary and lower mainstem (namely shallow water, peripheral habitats such as wetlands and side channels) are more limiting on subyearling life history strategies (commonly ocean-type life history) than yearling life history strategies (stream-type salmonids) that are not critically associated with these habitat types (Fresh et al. 2003). They further evaluated the effects of each limiting factor on viable salmon population criteria (abundance, population growth rate, spatial structure, and diversity; McElhany et al. 2000) and concluded that flow and habitat substantially limit all viability criteria for ocean-type salmonids.

Decreased Habitat Diversity and Productivity – Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon access to a wide expanse of low-velocity marshland and tidal channel habitats (Bottom et al. 2001). Flooding occurred frequently and was important to habitat diversity and complexity. Historical flooding also allowed more flow to off-channel habitats (i.e. side channels and bays) and deposited more large woody debris into the ecosystem. Historically, seasonal flooding increased the potential for salmonid feeding and resting areas in the estuary during the spring/summer freshet season by creating significant tidal marsh vegetation and wetland areas throughout the floodplain (Bottom et al. 2001). These conditions rarely exist today because of hydropower system water regulation.

Salmonid production in estuaries is supported by detrital food chains (Healey 1979, 1982). Therefore, habitats that produce and/or retain detritus, such as emergent vegetation, eelgrass beds, macro algae beds, and epibenthic algae beds, are particularly important (Sherwood et al. 1990). Diking and filling activities in the estuary have likely reduced the rearing capacity for juvenile salmonids by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore (Bottom et al. 2001, NMFS 2000c). Dikes throughout the lower Columbia River and estuary have disconnected the main channel from a significant portion of the wetland and floodplain habitats. Further, filling activities (i.e. for agriculture, development, or dredge material disposal) have eliminated many wetland and floodplain habitats. Thus, diking and filling activities have eliminated the emergent and forested wetlands and floodplain habitats that many juvenile salmonids rely on for food and refugia, as well as eliminating the primary recruitment source of large woody debris that served as the base of the historic food chain. The current estuary food web is microdetritus based, primarily in the form of imported phytoplankton production from upriver reservoirs that dies upon exposure to salinity in the estuary (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). The historic macrodetritus-based food web was distributed throughout the lower river and estuary, but the modern microdetritus-based food web is focused on the spatially confined ETM region of the estuary (Bottom et al. 2001). This current food web is primarily available to pelagic feeders and is a disadvantage to epibenthic feeders, such as salmonids (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001).

Columbia River mainstem reservoirs trap sediments and nutrients, as well as reduce sediment bedload movement, thereby reducing sediment and nutrient supply to the lower

Columbia River. The volume and type of sediment transported by the mainstem Columbia River has profound impacts on estuarine habitat formation, food webs, and species interactions. For example, organic matter associated with the fine sediment supply maintains the majority of estuarine secondary productivity (Simenstad et al. 1990, 1995 as cited in Bottom et al. 2001). Also, turbidity (as determined by suspended sediments) regulates light penetration needed for primary production and decreases predator efficiency on juvenile salmonids. Further, the type of sediment transported has profound effects on habitat formation. Sand and gravel substrates are important components of preferred salmonid habitat in the estuary, but sand and gravel transport has been reduced more (>70% reduction compared to predevelopment flow) than silt and clay transport (Bottom et al. 2001).

Additionally, the decreased habitat diversity and modified food web has decreased the ability of the lower Columbia River mainstem and estuary to support the historic diversity of salmonid life history types that used streams, rivers, the estuary, and perhaps the Columbia River plume as potential rearing areas. Bottom et al. (2001) identified several forms of ocean-type chinook life histories, based on the scale pattern, length, and time of capture data collected by Rich (1920). Wissmar and Simenstad (1998) and Bottom et al. (2001) suggest there may be as many as 35 potential ocean-type chinook salmon life history strategies. Bottom et al. (2001) suggested that human effects on the environment have caused chinook life history patterns to be more constrained and homogenized than historic data show. Most modern ocean-type chinook fit into one of three groups: subyearling migrants that rear in natal streams, subyearling migrants that rear in larger rivers and/or the estuary, or yearling migrants. Abundance patterns of juvenile chinook in the estuary may have shifted somewhat toward more yearling juveniles because of hatchery management practices.

Salmon are a single part to a complex ecosystem; they provide a food source for other species, contribute nutrients to freshwater ecosystems, and effect habitat forming processes in freshwater systems. Salmon abundance affects and is affected by significant salmon predators and scavengers, such as bull trout and eagles. Large numbers of salmon returning to spawning streams introduce significant amounts of marine-derived nutrients into nutrient-poor freshwater systems. These nutrients stimulate primary and secondary productivity that in turn increases food abundance in the entire stream system, particularly for juvenile salmon. Additionally, salmon can affect physical habitat conditions, such as fine sediment removal during digging of salmon redds.

Altered Migration Patterns — Hydrologic effects of the Columbia River dams include water level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. Altered flow regimes can affect the migratory behavior of juvenile and adult salmonids. For example, water level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and strand juveniles during the downstream migration. Reservoir drawdowns reduce available habitat which concentrates organisms, potentially increasing predation and disease transmission (Spence et al. 1996 as cited in NMFS 2000c).

Water regulation, as part of hydropower system operations, has drastically reduced historic spring freshet flows and altered juvenile salmon emigration behavior. Often, historic lower Columbia River spring freshet flows were approximately four times the winter low flow levels. Today, spring freshet flows are only about twice the winter low flow level, which is now generally increased during reservoir drawdown in winter. Spring freshets are very important to the emigration of juvenile salmonids; freshet flows stimulate salmon downstream migration and provide a mechanism for rapid migrations.

In summary, the effects of altered ecosystems on salmonid ecology include:

- Creation of habitat or structures that favor salmonid predators,
- Altered stream flow regimes,
- Loss of stream, off-channel, and estuarine rearing habitats,
- Change from macro- to micro-detritus base of the food web,
- Loss of juvenile life-history types, and
- Reduction of marine-derived nutrients delivered to freshwater ecosystems via salmon carcasses.

Non-native Species

The nature of exotic species introductions in the lower Columbia River are changing from the historical intentional introduction of game or food fish species to the unintentional introduction of species that have unknown or negative impacts on the ecosystem. Currently, there is an increasing rate of aquatic non-indigenous species introductions in the Columbia River; this increase has been attributed to the increased speed and range of world trade, which facilitates the volume, variety, and survival of intentionally or unintentionally transported species. Altered habitats in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have facilitated the successful establishment of aquatic non-indigenous species.

The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. All exotic species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites. Although the list of known exotic species in the lower Columbia River is currently greater than 70, limited information is available regarding the ecological interactions of many of these species.

The transition of the estuarine food web from a macrodetritus to microdetritus base (increased importation of plankton from upstream reservoirs) has benefited zooplanktivores, including American shad. Because of their abundance and consumption rates, American shad may have modified the estuarine food web. Also, shad and subyearling salmonid diets may overlap, suggesting potential competition effects.

Exotic and/or invasive plants, such as reed canary grass, scotch broom, Japanese knotweed and Himalayan blackberry can out-compete native plants in riparian and wetland areas and significantly alter habitat-forming processes.

There is often little that can be done to eradicate exotic species once a population has been established. Future prevention of exotic species introductions is vital to maintaining the current balance of ecological relationships in the Columbia River estuary and lower mainstem. These ecological interactions limit salmon by:

- Displacement of native prey species,
- Alteration of food web dynamics,
- Competition from non-native species, and
- Introduction of disease and parasites.

3.7.3 Threats

Predation

Human-induced habitat change has promoted the increase in native predator populations. For example, the Caspian tern breeding population in the estuary has expanded as a result of dredge material islands while northern pikeminnow abundance has increase because of favorable slackwater habitats created from the hydrosystem. At present, we lack the ability to determine how current levels of predation on salmonids compare to historical levels. Continued threats that affect predation on salmonids include:

- Operation of mainstem dams and other structures that encourage congregation of predators as a result of regulated water flow, and
- Creation of dredge material islands that increase habitat capacity for avian predators, such as Caspian tern.

Competition

Competition within and among species has been altered and exaggerated by ecological interactions, such as modified habitats and introduced species. Changes in food-webs that have resulted from the mainstem impoundments, or from introduced species, are also contributing to increased competition for food and space. Large hatchery releases may trigger density-dependent competition in streams, the mainstem, and/or the estuary.

Continued threats to salmonids from altered competition patterns include:

- Excessive hatchery releases,
- Altered streamflows that affect habitat,
- Mainstem impoundments that benefit competitive species,
- Increasing non-native fish populations
- Reduced juvenile salmonid food base,
- Limitations on freshwater productivity,

Food Web

Salmon serve as both predator and prey in a complex ecosystem. Additionally, decaying adult salmon carcasses provide significant nutrients to freshwater ecosystems. Hatchery practices, such as large releases of hatchery fish over short periods, may increase the likelihood of density-dependent competition among juvenile salmonids in subbasins, the mainstem, and estuary. The significance of density-dependent limitations in the lower Columbia River are not clear. Continuing threats from these ecosystem relationships include:

- Actions that contribute to depressed spawning escapements,
- Decreased fitness from reduced food availability, and
- Reduced survival.

Non-native Species

Increases in global trade, interstate recreation, and residential aquarium interests have all increased the predominance of aquatic non-indigenous species in lower Columbia River species assemblages. Introductions of aquatic non-indigenous species represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites. The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. Some species introductions have been intentional, while other have been unintentional. Additionally, habitat changes in the Columbia River estuary and lower mainstem as a result of hydrosystem development and water regulation may facilitate the successful establishment of aquatic non-indigenous species. Examples of actions that threaten salmonids are:

- Purposeful gamefish introduction for recreational purposes,
- Competition for food and space (American shad/juvenile salmonids), and
- Lack of regulatory control to prevent unintentional introductions via ballast water or other transportation mechanisms.

3.8 Other Fish and Wildlife Species

The other fish and wildlife species addressed in this Management Plan are affected by many of the same limiting factors and threats that affect salmonids. Regardless of their current abundance trend, implementation of an ecosystem-based approach to recovery of ESA-listed species indicates that an evaluation of effects of each recovery action on other species is warranted. Given the diversity of species comprising these other fish and wildlife species, population trends in response to current habitat conditions throughout the lower Columbia River ecosystem are quite variable. Some species are thriving in the altered lower Columbia River ecosystem, others have experienced precipitous declines, others appear unaffected by habitat changes that have occurred from historical to present times, while status of other species is unknown because data to assess population response to present habitat conditions are limited. The status and abundance trends of the non-salmonid focal species in the Columbia River estuary and lower mainstem are summarized below.

Four fish species are relatively abundant throughout the lower Columbia: cutthroat trout, white sturgeon, northern pikeminnow, and American shad. Two anadromous fish species (Pacific lamprey and eulachon) have experienced declining or variable trends in recent years; both are an integral part of the lower Columbia River ecosystem and are considered an important food source for sturgeon and pinnipeds. Other fish and wildlife species populations appear to be stable, but have low abundance compared to elsewhere in their range; species that fall into this category include green sturgeon, smallmouth bass, walleye, channel catfish, river otter, seals, and sea lions. The Columbia River seal and sea lion population appears stable or increasing. Aspian terns, native to the region but historically were not present in the lower Columbia River ecosystem, are now consistently found in the area because of human-induced habitat change. The sandhill crane and dusky Canada goose are other avian species that were not historically present in the lower Columbia River ecosystem. Agricultural lands in the lower Columbia floodplain have attracted cranes and geese to the region. Two avian species (bald eagle and osprey) have relatively stable populations trends but appear to be experiencing low reproductive success as a result of contaminant exposure. Two vastly different species (Columbian white-tailed deer and western pond turtle) have extremely low abundance levels in the lower Columbia River ecosystem. Data are sparse for a number of species, specifically yellow warbler and red-eyed vireo. Evidence suggest that abundance of both of these species is generally low in the lower Columbia River ecosystem; only possible breeding evidence exists for the area. Further details on all of these species are presented below.

3.8.1 Other Sensitive Species

Bald Eagle

Because of their presence in the mainstem and estuary, bald eagles may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section. In particular, floodplain development and presence of contaminants negatively affect bald eagles (Table 10). Bald eagles are strongly associated with large trees during nesting, perching, and roosting; thus, the loss of mature forest habitats in the Columbia River estuary and lower mainstem has likely decreased potential eagle territories. The lower Columbia River bald eagle population is one of only two regional populations in Washington that has exhibited low reproductive success representative of a decreasing population (the other regional population was in Hood Canal). Bald eagle populations in the estuary and lower mainstem have suffered from low reproductive success because of contaminants in the ecosystem that caused eggshell thinning. The populations have remained stable because of adult influx from nearby populations.

The Washington and Oregon bald eagle populations were listed as endangered under the ESA in 1978. In 1995, the USFWS reclassified the listing to threatened. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized.

Table 10. Suspected bald eagle limiting factors.

Life Stage	Limiting Factors
Reproductive Success	**BE.LF.1** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Uptake may be via prey consumption or direct contact. Contaminants are known to decrease eggshell thickness, which affects survival.
	BE.LF.2 Availability of nesting habitat. Eagles prefer mature forest habitats with adequate nest and roost trees in close proximity to abundant fish resources.

Sandhill Crane

The lower Columbia River mainstem and estuary is not a historic breeding or overwintering area for sandhill cranes. Sandhill cranes currently do not breed in the area, but agricultural development throughout the lower Columbia River floodplain has attracted overwintering sandhill cranes. Up to 1,000 sandhill cranes are estimated to winter in the lower Columbia River floodplain and an additional 2,000 to 3,000 sandhill cranes are estimated to use the lower Columbia River floodplain as a migratory stopover. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February 2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas (Ivey et al. in prep.). Because of their presence in the mainstem and estuary, sandhill cranes may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section. In particular, floodplain development and loss of riparian habitat in the lower mainstem and estuary limit the capacity for sandhill crane overwintering and use during migration (Table 11). Crane habitat on the lower Columbia bottomlands between Vancouver and Woodland is threatened with industrial development, conversion of agricultural lands to cottonwood plantations, tree nurseries, or other incompatible uses, and crane use is disturbed by hunters and other recreational users.Reclamation of agricultural land for habitat restoration projects may discourage overwintering by sandhill cranes, although future development of herbaceous wetlands may provide adequate winter habitat for sandhill cranes currently using the region.

Table 11. Sandhill crane and dusky Canada goose limiting factors.

Life Stage	Limiting Factors
Winter Population	**SC/DCG.LF.1** Availability of overwintering habitat. Urbanization and conversion of agricultural crops to non-preferred forage crops is reducing the acreage of goose and crane overwintering habitat. Continued habitat loss will decrease the number of overwintering birds the subbasins can support. Wildlife refuges within the subbasins provide a vital baseline of winter habitat.

Dusky Canada Goose

Approximately 16,000 dusky Canada geese currently winter in the Willamette Valley and SW Washington. The dusky Canada goose has been intensively managed since the 1950s with habitat preservation in the form of federal refuge creation and harvest regulations that reduced the harvest of dusky Canada geese. Beginning in the early 1970s and increasing to the present, tens of thousands of several Canada geese races began wintering in the same areas as the duskys. Harvest management that focuses on subspecies other than duskys became more complex and challenging in the face of this massive build-up of other races of geese, particularly given the duskys' declining productivity and relatively high vulnerability to hunting. Because of their presence in the mainstem and estuary, the dusky Canada goose may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section. In particular, floodplain development and loss of riparian habitat in the lower mainstem and estuary limit the capacity for dusky Canada goose overwintering (Table 11).

Columbian White-Tailed Deer

The conversion of much of its habitat to agricultural lands and unrestricted hunting reduced Columbian white-tailed deer numbers to a just a few hundred in the early 20th century. Columbian white-tailed deer are present in low-lying mainland areas and islands in the Columbia River upper estuary and along the river corridor in the vicinity of Cathlamet, WA, and Westport, OR. They are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; acreage of this habitat type has decreased substantially from historic to current conditions. Habitat conversion, losses, and isolation, coupled with low population productivity, are currently the most important threats to Columbian white-tailed deer population viability. The lower Columbia population, which has experienced a long-term decline, was significantly affected by flooding conditions in 1996.

Columbian white-tailed deer are a federal endangered species. In 1999, the USFWS proposed to delist the Columbian white-tailed deer throughout the entire range, but public concern over delisting motivated USFWS to withdraw the delisting proposal. Columbian white-tailed deer limiting factors are addressed more fully in the USFWS recovery plan. Restoration of contiguous preferred habitat is vital to population recovery.

Seals and Sea Lions

There are no large-scale limiting factors or threats to harbor seals, Steller sea lions, and California sea lions in the lower Columbia River estuary and mainstem. However, they are considered a threat to migrating adult salmonids, as was described in the Ecological Interactions section of this Management Plan.

The Columbia River seal and sea lion population appears stable or increasing. Harbor seals are the only pinniped considered a year-round resident in the Columbia River mainstem and estuary. Abundance is highest in winter and lowest in summer as a result of migratory behavior and the timing of the breeding season. Sea lions (both Steller and California) are considered seasonal residents of the Columbia River mainstem and estuary. Counts of Steller sea lions at the south jetty of the Columbia River typically peak during the winter months. Peak counts of 50-60 animals were reported in 1985. Recent surveys by WDFW and ODFW show an increase in Steller sea lions abundance at the south jetty with peak counts of 300-700 animals recorded.

Western Pond Turtle

The western pond turtle is a Washington state endangered species; they are limited to localized areas within Skamania and Klickitat counties. Their presence in Skamania and Klickitat counties suggests that they are affected by subbasin habitat limiting factors identified for those areas. Western pond turtles are limited by loss of riparian and wetland habitats, as well as predation by introduced bullfrogs and non-native fish. Wetland draining, filling, and development eliminated considerable habitat during the past century. Bullfrogs and warmwater fish are significant predators on hatchling and small juvenile western pond turtles. Raccoons are major predators on turtles and turtle eggs. Limiting factors are addressed more fully in the WDFW Western Pond Turtle Recovery Plan.

3.8.2 Species of Ecological Significance

Cutthroat Trout

Resident or fluvial cutthroat are regulated by local habitat conditions; sea-run populations encounter additional mainstem Columbia River and estuary effects. Because of their similar habitat requirements, cutthroat trout in the lower Columbia region are limited by the same subbasin and estuary/mainstem habitat limiting factors and threats identified above for other salmonids.

The USFWS found that cutthroat trout populations in the Washington part of the distinct population segment were widely distributed and remained at levels comparable to healthy-sized populations. Cutthroat trout are thought to be distributed throughout most areas where they were historically present.

White Sturgeon

The lower Columbia white sturgeon population is among the largest and most productive in the world. The deep water habitats in which sturgeon are commonly associated remain available throughout the lower mainstem and estuary. However, because of their mainstem and estuary residency, white sturgeon are limited by many of the same factors identified for salmonids in the estuary and mainstem habitat and the ecological interactions sections. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey in reservoirs upstream from Bonneville Dam. Sturgeon rarely use fish ladders which were engineered to pass the more surface-oriented salmon. On the other hand, hydrosystem development and operation has artificially created what functionally amounts to white sturgeon spawning channels downstream from Bonneville Dam, resulting in reliable annual recruitment (L. Beckman USGS (retired), G. McCabe Jr. NMFS (retired), M. Parsley, USGS, Cook Washington, personal communication). White sturgeon eggs and juveniles may be susceptible to direct mortality during Columbia River dredging operations (Table 12). Additionally, sturgeon are susceptible to fishery exploitation, but, current harvest levels and regulations appear to be maintaining sturgeon adult abundance in the lower Columbia river (Table 12). Columbia River white sturgeon were severely over-fished during the late 1800s prior to the adoption of significant fishery restrictions; recovery to present abundance levels required decades.

Green Sturgeon

Little is known about green sturgeon and considerable research effort is needed to establish green sturgeon habitat usage and preferences in the lower Columbia River ecosystem. Because of their presence in the mainstem and estuary, green sturgeon may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat and the ecological interactions sections; green sturgeon are believed to be limited by the same factors identified for adult white sturgeon (Table 12).

NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted but are a candiate species. Green sturgeon spend most of their life in nearshore marine and estuarine waters from Mexico to southeast Alaska (Houston 1988; Moyle et al. 1995). While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. These fish may be seeking warmer, summer river waters in the northern part of their range.

Table 12. Sturgeon limiting factors by life stage.

Life Stage	Limiting Factors
Egg Incubation	**WhS.LF.1** Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (deepwater, rocky substrates) results in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits.
	WhS.LF.2 Egg hypoxia. Hypoxia may have disproportionate negative effects on sturgeon compared to other fish because of their limited capacity to osmoregulate at low dissolved oxygen concentrations. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation.
	WhS.LF.3 Predation mortality. Demersal white sturgeon embryos are vulnerable to predation. Research on the upper Columbia indicated that 12% of naturally-spawned white sturgeon eggs were subject to predation, although the research suggests that predation was likely underestimated. If predation mortality is substantial, recruitment failure can result.
	WhS.LF.4 Direct dredging mortality. Although, white sturgeon prefer to spawn in rocky substrates with sufficient interstitial spaces, spawning has been observed in sands and fine sediments. Additionally, eggs broadcast among rocky substrates may disperse downstream and settle among sands or fine sediments. Dredging activities in areas where embryos are present results in direct mortality.
	WhS.LF.5 Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes.
Juvenile Rearing	**WhS.LF.6** Predation mortality. Juvenile white sturgeon losses to predation are probably low because of the protective scutes, benthic habitats, and fast growth.
	WhS.LF.7 Direct dredging mortality. White sturgeon association with benthic habitats make them susceptible to suction dredging mortality. There is speculation that dredging operations may attract white sturgeon, compounding potential losses.
	WhS.LF.8 Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on growth and physiological processes.
	WhS.LF.9 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon.
Adult Abundance	**WhS.LF.10** Fishing mortality. At present, size restrictions in the fishery are allowing for sturgeon survival to older ages, thus maintaining adequate abundance of spawning adults. Fishery regulations, fishing effort, harvest levels, and population response needs to be monitored closely to ensure adult spawning abundance is maintained.
	WhS.LF.11 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon.
	WhS.LF.12 Incidental mortality. Operations at Bonneville Dam, specifically dewatering of turbines, can strand white sturgeon and result in mortality. Significance of this mortality factor needs to be evaluated.

Eulachon (Smelt)

Because of their anadromous life history, eulachon are limited by many of the same factors and threats identified above for salmonids, particularly subbasin habitat, mainstem and estuary habitat, and ecological interactions limiting factors (Table 13). Eulachon (smelt) numbers and run patterns can be quite variable; low runs during the 1990s raised considerable concern by fishery agencies. Current patterns show a substantial increase in run size compared to the 1990s. The low returns in the 1990s are suspected to be primarily a result of low ocean productivity. Eulachon support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gill-net and small trawl fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Nevertheless, hydropower development on the Columbia River has decreased the available spawning habitat for eulachon. Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon (Smith and Saalfeld 1955). Additionally, dredging has the potential to impact adult and juvenile eulachon (Larson and Moehl 1990); dredging operations in the lower Columbia River have made local substrate unstable for the incubation of eulachon eggs. Thus, future dredging operations should be scheduled to avoid eulachon spawning areas during peak spawning times (Romano et al. 2002).

Table 13. Eulachon limiting factors by life stage.

Life Stage	Limiting Factors
Egg Incubation	**Eu.LF.1** Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (coarse sands) can result in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits.
	Eu.LF.2 Egg hypoxia. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation.
	Eu.LF.3 Predation mortality. Eulachon eggs may be vulnerable to predation. Eggs have been documented as an important food item of juvenile sturgeon in the lower mainstem. Eulachon eggs comprised up to 25% of stomach contents for sturgeon $\leq$350mm; the percentage increased to 51% for sturgeon 351-724mm.
	Eu.LF.4 Direct dredging mortality. Dredging activities in areas where eggs or developing larvae are present results in direct mortality. Also, evidence suggests that dredging activity in the vicinity of spawning areas makes the substrate too unstable for egg incubation.
	Eu.LF.5 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes.
Juvenile Migration	**Eu.LF.6** Predation mortality. Juvenile eulachon losses to predation are unknown and need to be evaluated. Predation could be substantial because juvenile eulachon have poor swimming ability and emigrate at the mercy of river currents.
	Eu.LF.7 Near ocean survival. Mortality upon ocean entry is unknown, but may be substantial.
Adult Abundance	**Eu.LF.8** Fishing mortality. At present, fishery regulations, fishing effort, and harvest levels appear to be at sustainable levels; population response needs to be monitored closely to ensure population viability.
	Eu.LF.9 Predation mortality. Eulachon are an important food item for many estuary and lower mainstem species. Large congregations of avian predators accompany eulachon runs into spawning areas. Pinnepeds prey on eulachon as they migrate through the estuary; pinnepeds may also follow eulachon runs to spawning areas.
	Eu.LF.10 Migration barriers. Eulachon do not navigate fish passage structures well, thus Bonneville Dam restricts access to historical spawning areas. Optimal water temperature for upstream migration is about 40 °F; below this temperature, migration will be delayed.
	Eu.LF.11 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on eulachon are unknown.

Pacific Lamprey

One non-salmonid focal species population currently experiencing a decreasing trend is Pacific lamprey. There are two available indicators of Columbia River Pacific lamprey population abundance; neither are robust. Fishery harvest levels have been low in recent years, although harvest levels are a function of regulatory limits and fishing effort, which have both been restricted in recent years because of a perceived decline in lamprey abundance. Recent (1997-2001) passage counts at Bonneville Dam were low compared to historical passage, but the 2002 passage count approached the historical average. Bonneville Dam passage counts are missing from 1970 to 1996, so it is difficult to determine if the low abundance during the late 1990s is part of a long-term trend or a short-term function of low ocean productivity during that period.

Because of their anadromous life history, lamprey are limited by many of the same factors and threats identified above for salmonids, particularly subbasin habitat, mainstem and estuary habitat, and ecological interactions limiting factors. More specifically, lamprey are negatively affected by increased flood frequency in the subbasins (premature dispersal of ammocoetes), decreased river flow in the mainstem resulting from hydropower water regulation (altered juvenile dispersal mechanisms), and mainstem dam passage (limited access to spawning areas and decreased juvenile survival) (Table 14). Other tributary habitat problems include low flow, degraded riparian conditions, and high water temperature (Close 2000). Although adult lamprey can negotiate waterfalls, evidence suggests that adult lamprey experience considerable difficulty migrating through mainstem dam fish passage structures, which has severely limited lamprey access to historical spawning tributaries thereby affecting population viability. Additionally, juvenile lamprey have difficulty in downstream dam passage and do not appear to benefit from juvenile salmonid passage systems; as a result, juvenile lamprey mortality is thought to be high.

Table 14. Pacific lamprey limiting factors by life stage.

Life Stage	Limiting Factors
Juvenile Rearing and Migration	**PL.LF.1** Flow alteration. Juvenile Pacific lamprey are poor swimmers and rely on flow to carry them toward the ocean. Flow alterations in the Columbia River basin (hydrosystem operations, water withdrawal) have decreased peak flows in the lower Columbia River mainstem, as well as created inundated habitats throughout the basin. Flow reductions may delay downstream migration, disrupting the synchrony of physiological development and downstream migration timing.
	PL.LF.2 Direct dredging mortality. Juvenile Pacific lamprey are closely associated with fine sediments where they burrow and filter feed. Dredging activities in areas where juveniles are present results in direct mortality; an estimated 3-26% of juvenile lamprey passed through a dredge survived.
	PL.LF.3 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on aquatic organisms. Juvenile Pacific lamprey are closely associated with fine sediments where contaminants commonly accumulate.
	PL.LF.4 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown.
	PL.LF.5 Predation mortality. Juvenile Pacific lamprey losses to predation are unknown and need to be evaluated.
Adult Migration	**PL.LF.6** Dam passage. Pacific lamprey are often unable or unwilling to migrate through fish ladders. Thus, Bonneville Dam, as well as many tributary or other mainstem dams, has limited upstream migration of Pacific lamprey to historical upriver spawning areas.

	PL.LF.7 Predation losses. Because of their high caloric value, Pacific lamprey are an important food source for marine mammals (pinnepeds) and sturgeon (and potentially others) in the lower Columbia River. The significance of predation on Pacific lamprey needs to be quantified.
	PL.LF.8 Harvest mortality. Historically, tribes harvested lamprey throughout the Columbia basin for food, ceremonial, medicinal, and trade purposes. Today, harvest is limited primarily to Willamette Falls and Sherars Falls (Deschutes River). Because of limitations on lamprey harvest (fishing effort, legal gear types, area closures, seasonal restrictions, diel restrictions), harvest may not be a major mortality factor.
	PL.LF.9 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown.

Northern Pikeminnow

The northern pikeminnow, a large (10-20 inches), long-lived (10-15 years), opportunisticly predaceous minnow has flourished with habitat changes in the mainstem Columbia River and its tributaries. Their abundance in the Columbia basin is highest from the estuary to The Dalles Dam. In the Lower Columbia, pikeminnow are concentrated around hydroprojects, particularly Bonneville Dam and multiple dams within the Cowlitz and Lewis subbasins.Larger individuals are considered a predation threat to migrating juvenile salmonids. As such, pikeminnow are thoroughly addressed in the Ecological Interactions sections of this Management Plan.

American Shad

The introduced American shad are also experiencing high productivity and abundance. Shad have recently increased to record abundance levels in the Columbia River; reasons for present abundance levels are thought to be mainstem dam passage improvements targeted toward salmon that have provided shad access to considerable amounts of spawning habitat, as well as abundant food sources for juvenile shad during their emigration. Also, hydrologic changes resulting from hydrosystem development appear to benefit American shad. There are no known threats to American shad in the lower Columbia River estuary and mainstem. However, shad are considered a threat to salmonids based on potential competition and food web effects as discussed in the Ecological Interactions sections of this Management Plan. Divergent trends in shad and salmon numbers occur primarily because the same habitat changes that favor shad are detrimental for salmon; interactions among these species are poorly understood.

Caspian Tern

Caspian terns are of conservation concern because of the concentration of breeding terns at relatively few sites. Currently two-thirds of the Pacific Coast and one-quarter of the North American population nests in the Columbia River estuary. In 1984, approximately 1,000 pairs of terns were observed breeding in the lower Columbia River; the breeding colony has since expanded to 10,000 pairs and represents the largest breeding colony in North America. Caspian terns nest on bare open ground of islands or beaches. They prefer newly formed, flat, sandy, unvegetated, mid-channel habitat. Dredging the navigational channel created several islands in the estuary that have been colonized. The U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA Fisheries are preparing an Environmental Impact Statement (EIS) for Caspian Tern management in the Columbia River estuary. The purpose of the EIS is to explore options to reduce the level of tern predation on Columbia River salmonids while insuring the protection and conservation of Caspian terns in the Pacific Coast/Western region (California, Oregon, Washington, Idaho, and Nevada). Threats to and from Caspian terns are expected to be part of the EIS, which is scheduled for release in the near future. Federal and State agencies and non-governmental organizations have agreed to explore options for restoring, creating, and enhancing nesting habitat for Caspian terns throughout portions of the Pacific Coast/Western region. The potential benefits of this proposed action would reduce the level of tern predation on migrating juvenile salmonids in the Columbia River, and lower the vulnerability of a significant portion of breeding Caspian terns in the Pacific Coast/Western region to catastrophic events.

Osprey

The osprey population along the lower Columbia River mainstem has increased slightly in recent years. Although forest habitats used for nesting have likely decreased, osprey have adapted to nesting on man-made structures. Osprey appear less selective of breeding sites than bald eagles, as they are often observed nesting on man-made structures such as channel markers or power poles. Because of their presence in the mainstem and estuary, osprey may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section. In particular, floodplain development and presence of contaminants negatively affect osprey (Table 15). Contaminant levels in osprey tissue are high enough to result in decreased egg thickness, but the increasing population in recent years suggests that young production is not a limiting factor.

Table 15. Suspected osprey limiting factors.

Life Stage	Limiting Factors
Reproductive Success	**Os.LF.1** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to decrease eggshell thickness, which affects survival. Uptake may be via prey consumption or direct contact. Columbia River osprey eggs contained the highest concentration of DDE reported in North America in the late 1980s and 1990s.
	Os.LF.2 Availability of nesting habitat. Osprey prefer mature forest habitats with adequate nest and roost trees in close proximity to abundant fish resources. Osprey appear to be adaptable and have been observed nesting on artificial structures such as channel markers or power poles.

Yellow Warbler

Within Washington, yellow warblers are apparently secure and are not of conservation concern. Yellow warblers are an indicator of riparian shrub habitat characterized by a dense deciduous shrub layer 1.5-4 m, with edge and with small patch size (heterogeneity). Habitat suitability for warblers is correlated with the percent of deciduous shrub canopy comprised of hydrophytic shrubs; warbler abundance is positively associated with deciduous tree basal area and negatively associated with closed canopy and cottonwood proximity.

Thus, loss of this specific habitat type limits yellow warblers in the lower Columbia River and estuary, although the extent of habitat loss is not clear. Yellow warblers are negatively affected by floodplain development and loss of riparian and wetland habitat.

Red-Eyed Vireo

the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The red-eyed vireo is an indicator of forested riparian habitat characterized by tall, closed canopy forests of deciduous trees (cottonwood, maple, or alder and ash), with a deciduous understory, forest stand sizes larger than 50 acres, and riparian corridor widths greater than 50 m. Thus, loss of this specific habitat type limits red-eyed vireos in the lower Columbia River and estuary, although the extent of habitat loss is not clear. Red-eyed vireos are negatively affected by floodplain development and loss of riparian and wetland habitat. Habitat alterations along the lower Columbia River corridor have likely been more damaging to the possible presence of red-eyed vireos as opposed to yellow warblers because dense riparian forests along the lower Columbia River are likely less abundant than shrub-dominated wetland habitat. However, there are no data to compared historic and current breeding populations in the Columbia River estuary and lower mainstem.

River Otter

The river otter is a year-round resident of the lower Columbia River mainstem and estuary. Field observations and trapper data indicate the river otter population abundance in the lower Columbia River mainstem and estuary was relatively low in the early 1980s (Howerton et al. 1984); low abundance may be the normal equilibrium level for river otters in this region. River otters are understudied and considerable research is needed to identify limiting factors or threats to the lower Columbia River mainstem and estuary population. However, because of their association with estuary riparian and floodplain habitat, river otters are assumed to be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section. In particular, floodplain development and loss of riparian habitat in the lower mainstem and estuary likely limit the capacity for river otter. River otters are concentrated in shallow water tidal sloughs and creeks associated with willow-dogwood and Sitka spruce habitats located primarily in the Cathlamet Bay area. Although dikes throughout the estuary have disconnected substantial amounts of side channel and floodplain habitats from the mainstem, the Cathlamet Bay area remains as one of the most intact and productive tidal marsh and swamp habitat throughout the entire estuary. Further, because river otters are capable of traveling over land, it is not understood how the loss of habitat connectivity of side channel and floodplain habitat has affected species' behaviors such as foraging, resting, mating, and rearing. Contaminants in river otter tissue may have adverse physiological effects, however, data suggests that the effects may be temporary (Tetra Tech 1996).

3.8.3 Species of Recreational Significance

For other species in this group (smallmouth bass, walleye, and channel catfish), abundance in the lower Columbia River is low compared to elsewhere in the Columbia River basin, Smallmouth bass, walleye, and channel catfish are all introduced species in the Columbia River basin and there is currently no basis for attempting to increase their productivity or abundance in the lower Columbia River ecosystem, particularly because of potential negative consequences on salmonid recovery.

Walleye

Walleye have benefited from hydrosystem development and they have successfully colonized reservoir habitats throughout the basin. Abundance in the free-flowing portion of the Columbia River below Bonneville Dam is generally recognized to be lower than elsewhere in the Columbia River basin primarily because these fish are adapted to lakes and impoundments. Walleye numbers appear to be regulated by variable year class strength which is affected by fluctuating environmental conditions. Walleye are considered predators of migrating juvenile salmonids, as described in the Ecological Interactions section of this Management Plan.

Smallmouth Bass

Smallmouth bass have benefited from hydrosystem development, successfully colonizing reservoir habitats throughout the basin. Abundance in the free-flowing portion of the Columbia River below Bonneville Dam is generally recognized to be lower than elsewhere in the Columbia

River basin. Smallmouth bass are considered predators of migrating juvenile salmonids; as as addressed in the Ecological Interactions section of this Management Plan.

Channel Catfish

Channel catfish have benefited from hydrosystem development; they are found in reservoir habitats throughout the basin. Small numbers of channel catfish can be found in some areas of the lower Columbia. Dams may provide increased suitable spawning habitat as well as more favorable water temperatures. There are no known threats to channel catfish in the lower Columbia River.

4 Scientific Foundation for Recovery

This chapter provides the biological and ecological basis for recovery planning. The problem of diminished fish runs, the recovery planning process, the species of interest, and the factors limiting those species, have been described in the preceding chapters and in the Technical Appendices. Now, the next step is to lay out the biological basis for establishing the subsequent recovery objectives, regional strategies and measures, subbasin restoration actions, and an implementation plan. This chapter addresses extinction processes, the principles for biological recovery, the salmonid life cycle as an integrating model for recovery, the role of science, and the issue of managing uncertainty.

4.1 Understanding Extinction and Recovery

To recover salmon, it is particularly helpful to understand what extinction is and why fish go extinct. *Extinction* typically refers to the irreversible disappearance of a species, subspecies, or, in the case of the Endangered Species Act, a "distinct population segment." For Pacific Salmon, a distinct population segment has been defined as an evolutionarily significant unit (ESU) (Waples 1991). Salmon ESU's may contain multiple "demographically independent" populations that return to different areas of the ESU (McElhany et al. 2000). Extinction of an ESU occurs when all of the component populations are extinct. The ESA defines extinction risk at two levels: *endangered* which is to be in danger of extinction, and *threatened* which is likley to become endangered within the foreseeable future. All listed lower Columbia salmon and steelhead ESUs are classified as threatened.

Extinction results from the interaction of fish population processes and external factors to reduce population size to critical low levels that are no longer self-sustaining. Small populations are subject to a variety of problems that may preclude recovery, such as inability to find mates, skewed sex ratios, increased predation effects, genetic inbreeding, and risks of extinction from natural downturns in survival conditions or catastrophes. Functional extinction typically occurs at population sizes greater than zero when numbers fall to critical low levels from which they cannot recover.

A species or ESU that has a low risk of extinction is typically referred to as *viable*. Viability is also equivalent to having a high likelihood of long-term persistence. With relation to the definitions in the ESA, a viable ESU is one that is not threatened or endangered with extinction. In this plan, "recovery" refers to the restoration of salmon and steelhead status to some level at or above viability represented by the gray area between V*iable* and *Capacity* in Figure 1.

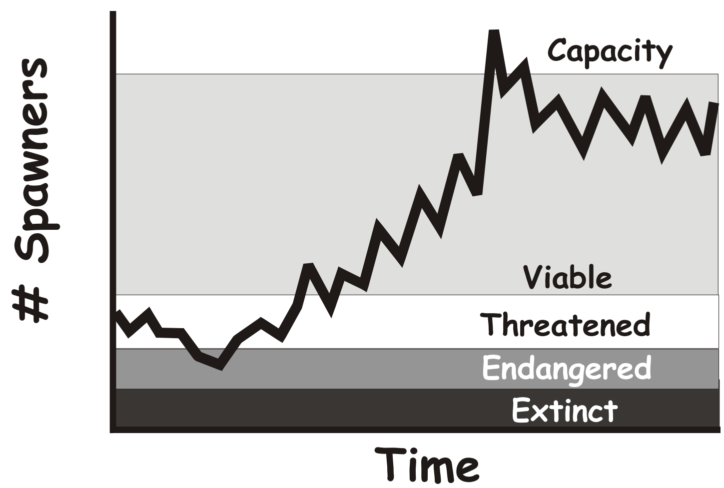


Figure 1. Continuum of abundance levels corresponding to potential fish recovery goals.

Capacity represents the maximum number of individuals that available habitat and resources can support, and is at the opposite end of the spectrum from extinction. Capacity is expressed through density-dependent population limits that reduce survival, growth, or reproduction via competition or other feedback mechanisms. Capacity may change as habitat quantity or quality increase. Current capacity of existing habitat conditions can be distinguished from potential capacity if conditions were improved. Average abundance may be less than the hypothetical habitat capacity as a result of mortality factors. Populations are typically viable at levels below the potential capacity of a system. Thus, viable species may often be recovered without restoring the ecosystem to its hypothetical capacity for salmon and steelhead as represented by pristine, historic conditions. However, a population may not be viable at the existing habitat capacity where numbers are constrained by low capacity of a small area with poor quality habitat.

Specific Recovery goals could be defined anywhere within the range between viable and the capacity of a fully restored habitat. Under the ESA, recovery of an ESU might be reached at the minimum viability threshold while the recovery vision in this plan of healthy, harvestable populations may require improvement to population levels greater than minimum viability.

4.2 Considering Biological and Social Values

Science can provide guidelines for the amount of risk that a species may be exposed to (i.e., extinction risk) but it is not the only factor in determining a vision for recovery. The development of recovery goals will require decisions by policy makers to balance both biological and social values. The vision may involve a description of an ESU's abundance and productivity, but it will also include choices about human-induced mortality and the cost to various sectors of society. Many combinations of actions could be chosen that would lead to recovery. Yet, the decision on which specific blend of actions to take will have substantial social, economic, and cultural costs and benefits.

The real pitfall occurs when the biological and social tradeoffs implicit in various standards are not clearly articulated and/or distinguished. These pitfalls can lead to unrecognized conflicts of interest, especially when social values are represented in purely biological terms. The line between biological and social considerations can sometimes be difficult to distinguish, especially because social values can often be expressed in biological terms. For instance, where the predominant social value derives from fishery benefits, a biological standard equivalent to maximum or optimum sustainable yield might be considered. Where the predominant social value derives from water use rather than fishery benefits, a biological standard equivalent to minimum population viability might be considered. Where ecological, intrinsic, or cultural fish values predominate, a biological standard equivalent to pre-development capacity might be considered. Considerations are also complicated by the broader role of salmon within a complex ecosystem. For instance, salmon provide food for wildlife and marine-derived nutrients that substantially affect plant and animal productivity, and even subsequent salmon production, in many watersheds.

4.3 Characteristics of Healthy Species

Fish go extinct when numbers fall to critically low levels from which they cannot recover. However, underlying population processes are the ultimate determinants of whether populations are viable. Key population parameters include abundance, productivity, diversity, and spatial structure. Each of these parameters is intimately interrelated. NOAA fisheries has incorporated these parameters into a Viable Salmonid Population (VSP) concept (McElhany et al. 2000) that provides useful guidelines for population viability. A Willamette/lower Columbia Technical Recovery Team proposed a series of viability criteria based on VSP guidelines (McElhany et al. 2003). These criteria are the basis for the viability recovery objectives described later in this plan.

4.3.1 Abundance

Abundance refers to the population sizes needed for recovery to levels that will ensure long-term persistence and viability. This population size depends on the buffer needed to avoid the risks of extinction in the face of normal environmental variation. Ideally, two determined fish of the opposite sex could forestall extinction but in practice, many more are needed to ensure population persistence and provide the raw material for recovery. Although there is little agreement on where functional extinction occurs and what population level is viable, NOAA

Fisheries generally assumes viability with at least 500 fish to ensure that critically low numbers do not result from normal environmental variation.

Small population sizes are subject to a variety of factors that affect viability (Lande and Barrowclough 1987, Nelson and Soulé 1987, Lynch 1996). Small numbers risk genetic bottlenecks that reduce diversity. The genetic diversity of salmon populations maximizes population persistence and productivity by allowing the salmon to capitalize on a wide range of habitats and environmental conditions. Small numbers also increase chances of inbreeding, possibly resulting in severe genetic side effects (e.g. expression of deleterious recessive genes). Small numbers increase demographic risks where scattered fish are unable to find mates, sex ratios are skewed by chance, or numbers are too few to escape predators (Hilborn and Walters 1992, Courchamp et al. 1999). Small numbers may also increase risks of extinction from natural downturns in survival conditions or catastrophes (e.g., poor ocean conditions, volcanoes, floods, chemical spills, dam failures, etc.) (Lawson 1993).

Reduced productivity at low densities is often referred to as depensation (also termed “Allee effects” or “inverse density dependence”) (Figure 2). McElhany et al. (2000) noted that depensation is a destabilizing influence at very low abundance and can result in a spiraling slide toward extinction. This downward spiral is sometimes referred to as an “extinction vortex.” The population size that can lead to this downward spiral is termed the “quasi-extinction” level. Because it is often unclear where this functional extinction level occurs, quasi-extinction is defined as a low abundance that does not guarantee extinction but from which recovery cannot be assured.

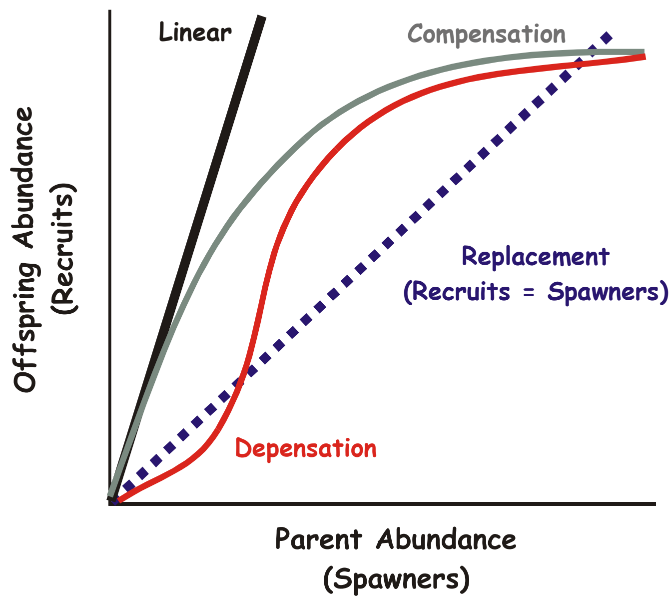


Figure 2. Reduced productivity (depensation) that results from small population processes and at high population sizes that results from competition for limited resources (compensation).

McElhany et al. (2000) identified key characteristics of viable and critical population abundance guidelines. Viable population size guidelines are reached when a population is large enough to: 1) survive normal environmental variation, 2) allow compensatory processes to provide resilience to perturbation, 3) maintain genetic diversity, 4) provide important ecological functions, and 5) not risk effects of uncertainty in status evaluations. Critical population size guidelines are reached if a population is low enough to be subject to risks from: 1) depensatory processes, 2) genetic effects of inbreeding depression or fixation of deleterious mutations, 3) demographic stochasticity, and 4) uncertainty in status evaluations.

Although biologists generally agree that extinction risks become increasingly acute as numbers decrease, there is little agreement on where functional extinction occurs and what population level is viable. Various viability and critical population size guidelines have been identified based on largely theoretical considerations for genetic and demographic risk. For instance, numbers needed to minimize genetic risks typically range from 30 to several thousand individuals based on theoretical models of genetic characteristics, effective spawner population sizes, and genetic diversity (Franklin 1980, Soule 1980, Allendorf and Ryman 1987, Lynch 1990, Waples 1990, Thompson 1991, Gabriel and Burger 1992, IUCN 1994, Lande 1995, NMFS 1995, Allendorf et al. 1997, McElhany et al. 2000). Thompson (1991) identified a 50/500 "rule of thumb" where 50 fish is a short term-effective population size which limits inbreeding and 500 is a long-term effective population size which maintains genetic variability. Recent viability analyses by NOAA Fisheries generally assume a 50-fish quasi-extinction threshold and produce minimum population viability levels of at least 500 fish to ensure that critically low numbers do not result from normal variation associated with environmental variation (McElhany et al. 2003). Uncertainties in actual minimum viable population sizes will require definition of recovery standards that incorporate appropriate safety factors.

4.3.2 Productivity

Productivity refers to a populations' ability to replace itself and reflects a populations' ability to rebound from a low level to the equilibrium population level. Productivity can also be defined in terms of intrinsic population growth rate independent of density dependent population regulating mechanisms. Highly productive populations produce larger numbers of juveniles or recruits per parent and can more readily rebound from low levels following perturbation. Less productive populations produce smaller numbers of offspring or recruits per parent and rebound more slowly or not at all. Highly productive populations generally sustain larger average numbers then unproductive populations. Productivity is directly related to density independent mortality or survival rates. Greater mortality rates (and lower survival rates) will proportionately reduce population productivity.

Extinction risks depend on the combination of abundance and productivity. While species go extinct when numbers fall to critical low levels, productivity is the engine that regulates risks associated with low numbers. Risks might be much less for a highly productive population even at low spawning escapements than for a larger population where productivity is low. Species can be predisposed to extinction by low population sizes that reduce population productivity and resilience well before extinction actually occurs. Cumulative effects of periodic poor spawning escapements may increase chances of future extinction even where numbers temporarily rebound (in good ocean years for instance) (Lawson 1993).

Productivity guidelines for viability are reached when a population's productivity is such that: 1) abundance can be maintained above the viable level, 2) viability is independent of hatchery subsidy, 3) viability is maintained even during extended sequences of poor environmental conditions, 4) declines in abundance are not sustained, 5) life history traits are not in flux, and 6) conclusions are independent of uncertainty in parameter estimates (McElhany et al. 2000).

4.3.3 Diversity

Diversity refers to individual and population variability in life history, behavior, and physiology. Diversity traits include some that are completely genetically based and others that vary as a result of a combination of genetic and environmental factors. Diversity is related to population viability because it allows a species to use a wider array of environments, protects species against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Correlations between diversity and population productivity have been observed in many populations (NRC 1996). In general, greater diversity, productivity, abundance, distribution, and viability all go hand in hand.

Once lost, the unique features of each population may be gone forever. Preservation of unique groups of salmon populations is a central tenet in the development of recovery standards. Salmon populations are often organized into groups for various management purposes. Populations within a species that have similar life histories are often referred to as “races” (e.g. winter steelhead, spring chinook, early run “tule” fall chinook). Populations within races that are grouped together for harvest management purposes are referred to as “stocks”. When salmon, steelhead or trout species are listed as threatened or endangered under the ESA, populations within a region are grouped into ESUs, which are the organizational groups to which recovery standards are applied.

Each salmon species is comprised of many related but different populations, each of which is specifically adapted to the unique local conditions of their natal watersheds and the other habitats they experience during their migratory life. Local adaptations have been naturally selected over hundreds of generations to optimize success under the prevailing conditions. Local populations are typically more productive in their native watersheds than populations introduced from other areas. Salmon that stray or are transplanted among widely separated watersheds do not fare as well as the native stock. Thus, a population of wild coho salmon from the lower Columbia River cannot be replaced with wild coho salmon transplanted from Puget Sound. Differences among populations in adjacent watersheds may be small where habitat conditions are similar but differences typically increase with distance (Riddell 1993).

Adaptations may be expressed in a variety of forms such as run timing that returns adults to streams exactly when spawning conditions are optimal or that allows smolts to arrive at the estuary during the critical physiological window for transition from fresh to salt water. Local adaptation is made possible by the homing of salmon across thousands of miles of ocean and river to spawn in the same river or stream where they were born. Recent studies have shown that homing may be so exact that many salmon even spawn in the same river bend or riffle where they originated. Local adaptation and homing go hand in hand to give each salmon the best chance for reproductive success by returning to the exact conditions to which they are best suited. The degree of difference among populations can often, but not always, be identified by genetic analysis.

According to McElhany et al. (2000), diversity guidelines for viable salmonid populations are reached when: 1) variation in life history, morphological, and genetic traits is maintained, 2) natural dispersal processes are maintained, 3) ecological variation is maintained, and 4) effects of uncertainty are considered.

4.3.4 Spatial Structure

Spatial structure refers to the amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Large habitat patches or a connected series of smaller patches are generally associated with a wider species distribution and increased population viability.

Spatial structure of a population is closely related to habitat quantity and quality. Salmonids typically use habitat patches of variable quality and salmon distribution may ebb and flow in response to normal environmental variation. In years of high ocean survival and high numbers, distribution may expand as fish fill the optimum habitats and spread out into other areas of suitable habitat. In years of low ocean survival and low numbers, distribution may contract into areas of high quality habitat. Marginal habitats may support fish under good ocean survival conditions but are not productive enough to sustain numbers under poor ocean survival conditions.

Spatial structure guidelines for viability are reached when: 1) the number of habitat patches is stable or increasing; 2) stray rates are stable; 3) marginally suitable habitat patches are preserved; 4) refuge source populations are preserved, and 5) uncertainty is taken into account (McElhany et al. 2000). The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be maintained sufficiently to support viable populations. The diversity of habitats for recovered populations should resemble historic conditions given expected natural disturbance regimes (e.g. wildfire, flood, volcanic eruptions, etc.). Historic conditions represent a reasonable template for a viable population; the closer the habitat resembles the historic diversity, the greater the confidence in its ability to support viable populations. At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability.

4.4 Natural Populations Spawning Naturally

Recovery ultimately depends on naturally-produced fish reproducing naturally. Natural habitats and wild populations are the only demonstrated alternative for guaranteeing long term sustainability. This biological fact is unchanged regardless of how current hatchery controversies play out or how NOAA classifies the significance of hatchery salmon stocks in salmon recovery. By both design and happenstance, fish produced in hatcheries sometimes spawn in the wild with naturally-produced fish. Numbers and effects of naturally-spawning hatchery fish vary widely among species and populations depending on hatchery proximity and practices. Some natural spawning populations include large fractions of hatchery fish. Other populations are largely free of hatchery influence. In the lower Columbia River, most tule fall chinook and coho have been heavily hatchery influenced, spring chinook populations rely on hatchery production, steelhead have been variously affected, and chum, bright fall chinook, and bull trout are largely free of hatchery effects.

Effects of natural spawning by hatchery fish have been extremely controversial (see Hatchery Section in Chapter 3). One issue has been the potential for reduced fitness and viability of some wild populations as a result of the introduction of domesticated or non-local hatchery fish that are ill-suited to local conditions. A second issue is the difficulty of accurately measuring numbers and productivity of wild populations where hatchery influence is significant. It can be especially difficult to distinguish situations where hatchery contributions to natural spawning reduce wild population productivity because of fitness effects or supplement wild population productivity because of high hatchery survival rates. The significance of each of these effects is in dispute but hatcheries clearly pose risks to population viability under certain situations.

Populations maintained through a continuing influx of hatchery fish are not sustainable if they might become extinct whenever the hatchery subsidy is removed. No hatchery has demonstrated the ability to preserve a full spectrum of wild population diversity and life history traits in the long term over multiple generations. This is not to say that hatcheries are incapable of long-term sustainability, but merely that significant uncertainty exists. Hatchery subsidies of wild populations also mask true status and can lead to a reduced imperative for protection and restoration of habitats critical to natural production. Gradual erosion of adaptive population diversity in the hatchery and coincident declines in natural population productivity are a formula for species extinction over the long term. Hatcheries depend on a continuing commitment of funding and other resources which places the long term viability of a hatchery-supported stock at the whims of political processes and competing funding priorities.

Hatcheries also provide significant fish population benefits in some circumstances and will be a critical tool for preservation, reintroduction, and supplementation over the short term. Many remnants of many lower Columbia River salmon currently exist only in hatcheries. Conservation values include preserving genetic stocks where habitat is gone, reintroducing fish in areas where habitat has been restored, and bolstering survival to offset survival bottlenecks.

This plan recognizes that current conditions and constraints on habitat restoration in some areas will require recovery using a combination of natural only and natural/hatchery populations. Hatcheries will continue to be operated for both conservation and fishery enhancement purposes and hatchery fish will continue to spawn naturally in some watersheds. Some populations will consist entirely of naturally-produced fish segregated from significant hatchery influences. Other populations will include natural and hatchery-produced fish from carefully integrated hatchery programs. Hatchery programs will need to be shaped to minimize risks while taking advantage of very real benefits. Integrated hatchery programs will be particularly important for preservation, reintroduction, and supplementation in the interim period until habitats that can sustain viable natural populations are restored. NOAA Fisheries hatchery policies will provide guidance on the role specific hatchery stocks may play in salmon recovery.

Hatcheries will continue to serve both production enhancement and fisheries enhancement purposes for the foreseeable future. Even after viable ESUs of salmon are recovered, hatcheries will be needed to provide fish for fisheries as mitigation for permanent loss of habitat and hydrosystem mortality. Fish populations in some areas will continue to include significant numbers of hatchery fish. It will not be necessary to exclude hatchery fish from every population in order to meet ESU recovery goals or to demonstrate individual population viability. Not every population needs to be restored to a high level of viability for ESU recovery. Viable populations capable of being naturally self-sustaining can also be restored in selected areas even when hatchery fish spawn in the wild. Natural fish population accounting practices will need to make the necessary adjustments to accurately represent the wild component independent of significant hatchery fish effects, thus providing an accurate assessment of the ability of the habitat conditions to support wild populations.

4.5 In-basin and Out-of-basin Influences

Effective recovery planning must consider in-basin and out-of-basin influences that affect salmon throughout their life cycle. Salmon numbers and population dynamics are affected by the interaction of a wide variety of human and natural factors operating over the salmon's far flung migration from freshwater streams, through the mainstem Columbia River and estuary, into the far reaches of the North Pacific ocean, and back again. Failure to consider all factors affecting the life cycle can overlook key limitations or changes in one area that potentially offset gains in other areas. For instance, it would be of little benefit to improve tributary habitat conditions and productivity if gains there were offset by increased mortality in the mainstem, estuary, and ocean. Conversely, improvements in multiple areas can provide compounding benefits over the course of the life cycle. For instance, benefits of tributary habitat improvements are enhanced where downstream improvements also improve survival such that the full effects of tributary improvements may be realized.

A comprehensive analysis of all factors limiting recovery helps ensure equitability in balancing the costs of salmon recovery among different stakeholders. Different combinations of stakeholders affect salmon in different areas. Without a systematic treatment for weighing impacts, discussions of site and action-specific recovery actions are easily confounded by counterproductive finger-pointing.

A fish life cycle focus provides a systematic means of effectively relating fish-specific recovery goals to factors limiting recovery and potential restoration actions (Figure 3). A life cycle focus identifies life stage-specific numbers, birth rates, and death rates that describe the biological processes regulating fish status. Stage-specific numbers and rates provide a consistent way to estimate fish effects from the impacts of a variety of stage-, time-, and area-specific factors that limit recovery. In addition, a life cycle approach provides the means of distinguishing wild and hatchery fish and explicitly evaluating the effects of their interactions. Finally, a life cycle focus incorporates the abundance and productivity elements of the NOAA Fisheries VSP approach.

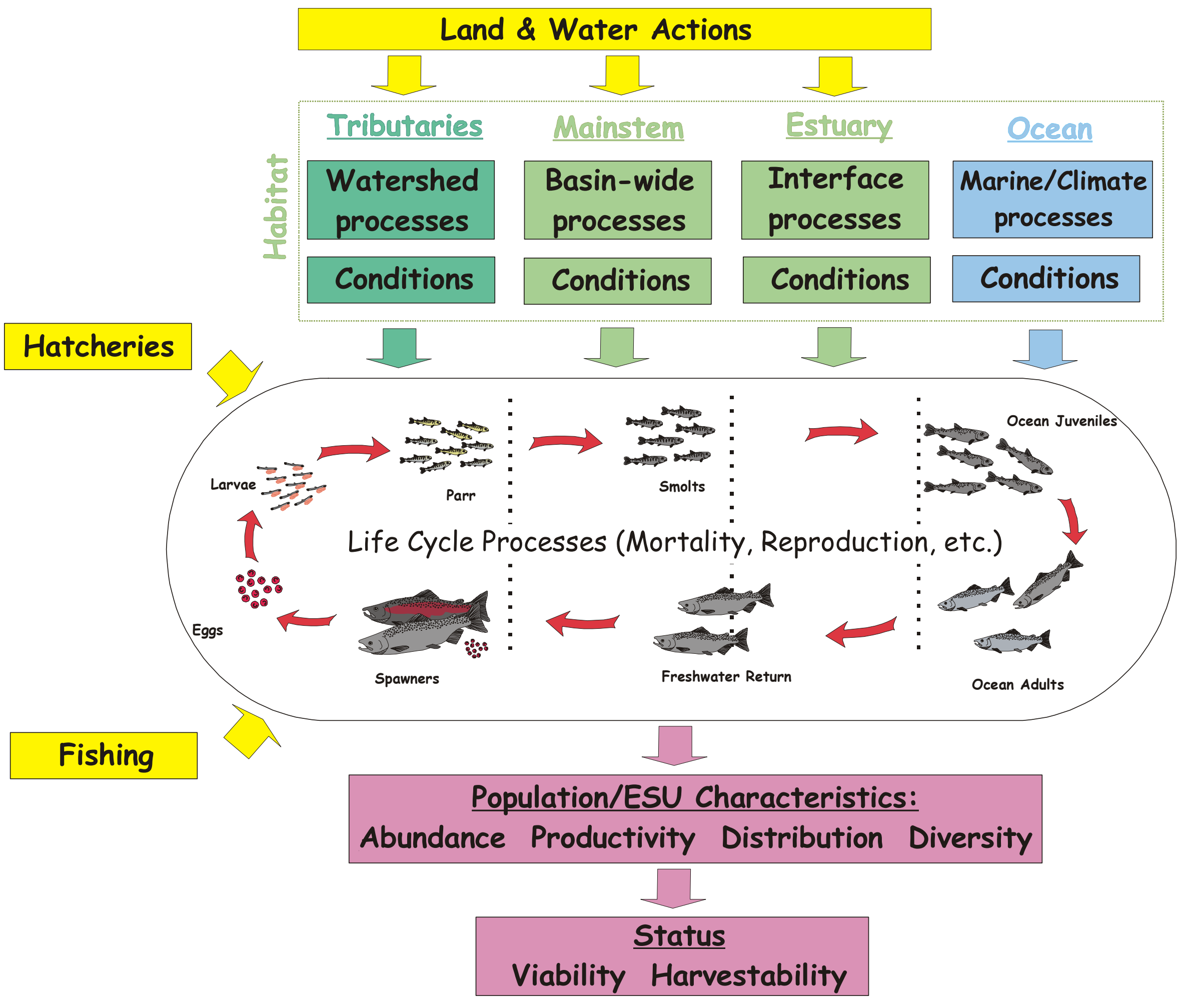


Figure 3. The basic salmonid life cycle, indicating how habitat, including dams, fishing, and hatcheries impinge on survival at various stages, and how this integrated process affects the viability and surplus production of the populations.

4.6 Ocean and Climate Variability

The comprehensive treatment of factors limiting fish recovery also warrants careful consideration of other influences that are beyond our control. These include environmental conditions such as ocean and climate cycles that can cause dramatic variation in natural mortality rates. The effects of human-caused mortality and restoration measures must be considered in the context of these significant and highly variable survival rates.

Large fluctuations in salmon numbers during the last few years have highlighted the importance of ocean conditions in regulating salmon survival, productivity, and abundance. Twenty years ago fish scientists generally regarded the ocean as a vast and consistently productive environment for salmonids. However, frequent El Niño circulation patterns over the last 20 years have demonstrated that environmental conditions are much more dynamic than previously thought. Ocean conditions are not randomly sorted – poor years tend to occur in groups as do good years. Transitions between good and poor regimes occur unpredictably and are obvious only in hindsight. Low salmon survival during El Niño years results in population declines and critically low numbers. Abnormally good salmon survival in cool, wet years following large El Niños results in temporary population increases and record returns like those seen in 2001–03.

Periodic poor ocean cycles are the stressor that bottoms out populations compromised by habitat degradation and overuse (Lawson 1993). Downturns challenge the persistence and health of impaired salmon populations and can precipitate irreversible consequences where fish have been heavily impacted by human-induced factors. Healthy populations are able to ride out the periodic declines without lingering effects. Large numbers, high inherent productivity, high diversity, wide distribution all help sustain viable populations in the face of normal environmental variability.

Recovery planning analyses must consider variable ocean conditions as an uncontrollable backdrop to the effects of human activities on salmon. Ocean conditions have always varied and always will. Just because salmon numbers decline during poor survival periods should not mean fish are threatened or endangered with extinction. Alternatively, high numbers returning in good ocean years does not mean that threatened or endangered fish are recovered. Recent large salmon runs suggest that we may have entered a period of better-than-average ocean survival conditions. Rather than relaxing the need for salmon recovery, this pattern provides an opportunity to implement substantive changes for population rebuilding needed to withstand the next down cycle. Habitat and demographic improvements require time to become effective and may come too late if the next period of decline is the one from which the population cannot recover.

4.7 Linking Actions to Limiting Factors and Threats

Species declines can be attributed to certain limiting factors and threats once they have been identified. Recovery actions can then be developed based on those limiting factors and threats. Once the factors that a species' decline have been adequately mitigated, it is likely that the species will recover.

Factors and threats include a wide spectrum of human-induced mortality factors that affect fish throughout their life cycles. These factors are sometimes referred to as the '4 Hs' (hatcheries, harvest, hydropower, and habitat), but also include ecological changes like predation and competition from introduced species. The '4-H' label oversimplifies the complex of direct and indirect relationships and the relative impacts of the different factors that affect fish. However, reference to this convenient characterization highlights the need to treat all factors limiting recovery in a similar and comprehensive fashion. Effective recovery planning must equitably address all human-induced mortality factors that limit fish status and have contributed to fish declines. This plan describes how harvest, hatchery, hydropower, habitat and ecological factors have influenced key fish species in the past, their current impacts, the anticipated trajectory of these influences, and actions to reduce corresponding threats.

The planning recovery planning process relates fish goals and status to specific actions, areas, and time periods. The plan weighs all the human-induced effects on mortality at the various life stages, identifies how mortality can be reduced overall, and determines how the distribution of mortality may be changed among life stages to meet delisting and other social goals. Analyses can identify the relative contributions of habitat, hatchery, and harvest impacts but should also relate necessary changes to specific activities that can produce the desired effect. Specific programs and activities need to be identified because that is the level at which changes will be implemented. Actions that are not specific will fail to provide a clear blueprint for recovery implementation and risk failure to ensure accountability. Additionally, specific management actions are required by the ESA for recovery plans.

Specificity of actions in time and space are important. Viability risks are extremely sensitive to implementation schedules, especially where small population numbers increase exposure to chance extinction events. Thus, fishing strategies that reduce impacts in low run years but increase catch in large run years might substantially reduce the risks of a fixed fishing rate strategy while optimizing use benefits. Similar suites of measures can also produce substantially different outcomes if implemented in different areas. For instance, concentrating aggressive habitat restoration actions in high quality habitats where fish production is already significant may provide relatively little benefit. These areas might be high priorities for protection but low priorities for restoration. Within marginal areas, systematic analyses can help distinguish smaller subareas for priority restoration where modest investments can restore significant fish production, from severely degraded sites where similar investments would be relatively ineffective.

4.8 The Role of Science: Guidance with limitations

Developing an effective recovery plan requires systematic analysis of questions related to goals, status, strategies, and proposed actions based on the best available scientific methods and data. Effective planning depends on our ability to answer five fundamental questions: 1) where are we now; 2) how did we get here; 3) where do we want to go; 4) how do we get to where we want to go; and 5) how do we know when we get there? While general planning questions can be simply stated, answers can be difficult and complicated. Fish are affected by a complex array of factors and our understanding of the relationships among these factors is highly indistinct. Efforts are complicated further by the need to consider multiple species, a large and diverse area, and a patchwork of overlapping jurisdictions and constituencies. Fundamental questions also need to be answered at several different levels in terms of fish populations and ESU status, fish life cycle parameters such as mortality rates, factors for decline, and programs by which actions may be affected.

Expectations for recovery must be tempered by our imperfect understanding of the complex interaction of fish, limiting factors, past and future human activities, both positive and negative, and the difficulties of collecting sufficient data. Analytical approaches that systematically relate fish status to underlying causal factors and actions can be extremely powerful tools for evaluating recovery goals and actions. Systematic analyses based on the scientific method facilitate the study, description, and prediction for complex systems and promote good decision-making (Grant 1986).

All scientific analyses and models are abstractions of reality subject to varying degrees of uncertainty. Systematic scientific analyses will help to reduce uncertainty, but cannot eliminate it. Clear paths for action will be provided by some analyses where relationships are well understood and data are substantial. Analyses in the gray areas may provide only partial answers and general compass directions. A gap will remain between what can be known and what cannot. Monitoring and evaluation will provide feedback for management adjustments, as well as identification of the most important data gaps and/or weaknesses, but the conundrum of decisions without full information will continue. Thus, science can continue to support recovery planning but will not supplant the need to make difficult policy decisions with less than complete information.

Science ultimately provides a prescription for recovery that includes a picture of what constitutes a viable population and ESU, an inventory of significant limiting factors and threats, a list of effective actions that address factors and threats, and some sense of the order of magnitude of improvements and actions needed to approach recovery. Science does not provide a cookbook recipe that details exactly how much of each action will be required to ensure recovery. It describes the cake and tells us the ingredients but does not always reveal the exact portions of each ingredient or how long ingredients need to bake. Science provides a direction for recovery, bounds the range of expectations, identifies critical first steps, and flags faulty logic and assumptions.

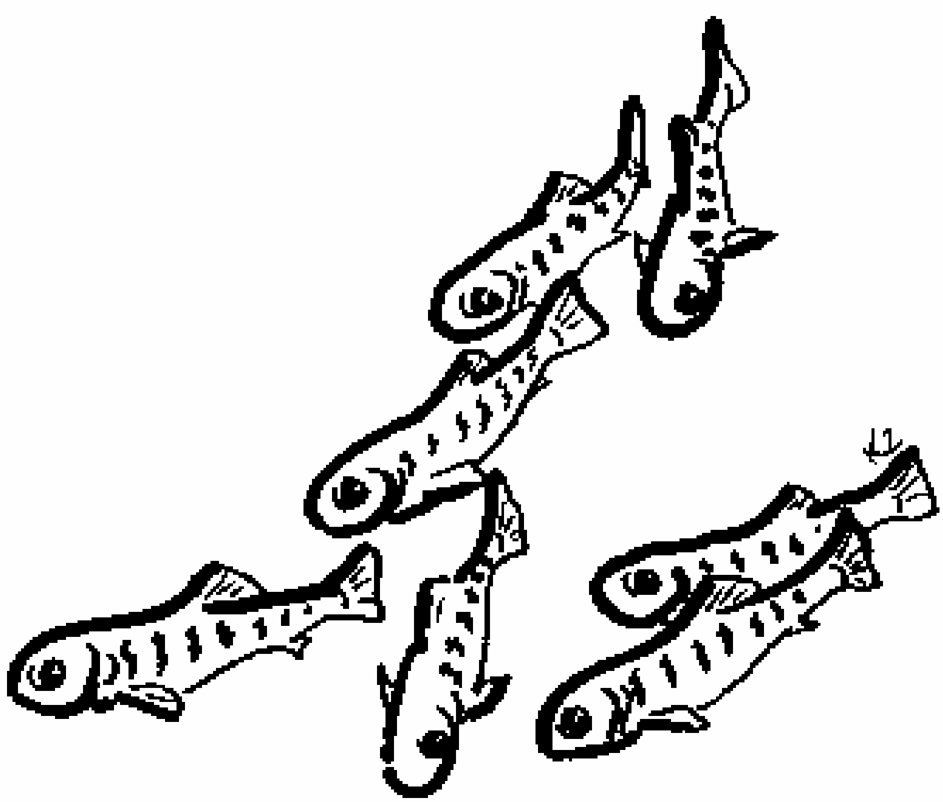
4.9 Dealing with Uncertainty

Incomplete human understanding of biological systems, and the effects of human activities and management practices on those systems, necessarily results in uncertainty about the outcomes of the Management Plan. These inherent uncertainties complicate the process of deriving, deducing, inferring, or interpolating estimates needed to characterize fish status and limiting factors, and to explicitly identify a level of effort and investment that will assure recovery. No amount of research or evaluation can be expected to entirely eliminate uncertainties. The key to effective analysis in an uncertain world is to frame an approach that recognizes that uncertainties will always remain in specific data, analyses, and assumptions. Uncertainties can be addressed by a variety of methods, all of which are incorporated into this plan:

- Explicitly identifying uncertainties and transparently communicating methods, strengths, and limitations of each analysis.
- Incorporating known uncertainties into the risk analyses. For instance, uncertain ocean survival can be incorporated as a random variable into a population viability modeling framework for integrated fish life cycle analysis to estimate extinction risks. Uncertainty in any population process or limiting factor can be captured similarly.
- Incorporating corroborative analyses to validate key conclusions independently.
- Using analyses to identify the risks associated with key uncertainties. Sensitivities of results to critical assumptions and uncertainties will be described for each analysis in the form of

testable hypotheses that may be addressed with future monitoring and evaluation through adaptive management.

- Identifying conclusions based on the weight of all evidence, rather than any specific analytical result, and with appropriate safety margins to buffer risks.
- Including substantive recovery strategies and measures that address every significant liiting factor and threat.
- Including safety factors into the plan to provide a buffer to offset the effects of uncertain or faulty assumptions. Safety factors may be included in biological objectives to target higher levels of recovery than minimum requirements in case efforts for some populations fall short.
- Incorporating a strong monitoring, research, and evaluation program that provides an information feedback loop for modifying prescribed actions. Future monitoring and analysis of lower Columbia salmon and steelhead populations is of utmost importance because, without sufficient data, it will be impossible to determine whether remedial actions are helping. Observed population trends, whether increasing or decreasing, may result from restoration activities, management changes, natural variation, or some combination of effects.



5 Recovery Goals

This chapter sets forth goals consistent with the healthy and harvestable vision for focal salmonid species addressed by this plan as well as management objectives for other significant fish and wildlife species. The section starts with a summary of draft viability criteria recommended by NOAA's Technical Recovery Team. A recovery scenario then describes target improvements for all populations within the ESU consistent with the viability criteria. These population improvements are described in terms of spawner abundance and productivity improvement increments needed to move from current to desired status. Benchmarks for spatial structure, diversity, juvenile abundance, and habitat are also identified to provide systematic standards for gauging future population status relative to all parameters identified by the WLC-TRT as related to viability. Long term harvestability goals are also discussed.

5.1 Overview

The vision of this plan is for all Lower Columbia salmon and steelhead to be recovered to "healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries, through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices." This vision for recovery encompasses ESA de-listing goals in the sense that ESA de-listing could be achieved while working toward this vision.

This recovery plan focuses on Washington subbasins. However, it also presents preliminary assumptions about the recovery of Oregon populations. Lower Columbia River salmon and steelhead ESUs include both Washington and Oregon populations. Assumptions for Oregon populations were used to ensure that Washington goals are consistent with achieving viability of the entire ESU. Assumptions about Oregon populations were developed in consultation with the Oregon Department of Fish and Wildlife, but do not necessarily represent Oregon's view of recovery. Final Oregon population goals will be developed separately and will ultimately be incorporated into a domain wide recovery plan.

Where our data and knowledge of a species permit, recovery goals provide measurable criteria which can be used to monitor progress in protection and recovery. Where our data and understanding are lacking, these goals are more qualitative. In either case, it should be noted that our existing data and knowledge for all species as well as our understanding of the complex ecosystems on which they depend is less than complete. For this reason, it should be expected that recovery criteria and goals may be refined over time as additional scientific analyses are completed and new information becomes available.

This chapter describes the recovery goals for salmon and steelhead as well as objectives for other fish and wildlife species affected by this plan. Salmon and steelhead recovery goals are described using: 1) interim viability criteria identified by the Willamette Lower Columbia Technical Recovery Team (TRT), 2) a recovery scenario that establishes priorities among populations and subbasins, 3) abundance and productivity objectives for each population consistent with the recovery scenario, 4) changes in human impacts and threats consistent with population objectives, 5) benchmarks for other viable salmonid population parameters that provide guidance for recovery strategies and progress evaluations, and 6) long term harvest goals. For other fish and wildlife species, goals are based on the current status of the species, their habitat needs, their role in the ecosystem, and, where applicable, social, cultural, and legal factors.

5.2 Salmon and Steelhead Recovery Criteria

The biological goals for salmon and steelhead in this plan are based on and explicitly incorporate the work of the Willamette/Lower Columbia Technical Recovery Team (TRT). The TRT was convened by NOAA Fisheries to provide technical guidance and recommendations relating to the recovery of salmon and steelhead in the Willamette/Lower Columbia Domain. The TRT has developed recommendations for biological criteria for population and ESU-level viability (criteria that would indicate when populations or ESUs had a high probability of persistence into the future). The TRT has submitted a series of recommendations to NOAA Fisheries (McElhany et. al. 2003).

The TRT described viability based on probability of persistence over a 100-year timeframe (Table 1) and developed an approach to recovery that included overall ESU viability criteria, and criteria based on smaller units of strata and populations (Figure 1). The TRT approach has five essential elements:

Stratified Approach: Every life history and ecological zone stratum that historically existed should have a high probability of persistence. Salmon ESUs in the lower Columbia River were stratified by the TRT into ecological zones (coast, cascade, and gorge) and life history types (spring run, fall run, etc.).

Viable Populations: Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence. The TRT defined high persistence probability based on the presence of at least two populations with a negligible risk of extinction and a strata average of a medium-low risk of extinction.

Representative Populations: Representative populations need to be preserved but not every historical population needs to be restored. Selected populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.

Non-deterioration: No population should be allowed to deteriorate until ESU recovery is assured. Currently productive populations and population segments must be preserved. Recovery measures will be needed in most areas to arrest declining status and offset the effects of future impacts.

Safety Factors: Higher levels of recovery should be attempted in more populations because not all attempts will be successful. Recovery efforts must target more than the minimum number of populations and more than the minimum population levels thought to ensure viability.

Table 1. Viability categories identified by the Willamette-Lower Columbia Technical Recovery Team.

Scale	Viability	Description	Persistence probability[1]
0	Very low (VL)	Either extinct or very high risk of extinction	0-40%
1	Low (L)	Relatively high risk of extinction	40-74%
2	Medium (M)	Medium risk of extinction	75-94%
3	High (H)	Low (negligible) risk of extinction (represents a "viable" level)	95-99%
4	Very High (VH)	Very low risk of extinction	>99%

[1] 100-year persistence probabilities.

Populations were delineated by the TRT based on a review of current and historical information (Myers et al. 2003). Strata were defined as groups of populations of an ESU with similar life history traits within the same ecological zone. Each ESU consists of two or more strata containing different life history and ecological zone combinations (Figure 2). Lower Columbia River ESUs generally include Washington and Oregon populations from the Columbia River mouth to the Big White Salmon River in Washington and the Hood River in Oregon. Distinct ecological zones in this range include Coast, Cascades, and Gorge watersheds. Chinook life history types include stream-type spring run, ocean-type fall run (tules), and ocean-type late fall run (brights). Thus, Chinook salmon strata include Coast fall, Cascade fall, Cascade late fall, Gorge spring, etc. Similar distinctions occur for listed steelhead and chum salmon.

The TRT's guidelines for ESU, strata, and population level criteria was drawn from previous work on the VSP concept (McElhany et. al. 2000). Recommendations for ESU and strata criteria address ESU diversity and risks (Box 1). Recommendations for population viability relate population status to adult abundance, adult productivity, juvenile abundance, spatial structure, diversity, and habitat (Box 2). Many of these parameters are interrelated and interactions are complex. Although the TRT pointed to all factors as being important, they developed specific population objectives only for abundance and productivity. For other population parameters, the TRT made general recommendations, which were used by the LCFRB to develop benchmarks that provide guidance for recovery strategies and evaluations of progress. Objectives for abundance and productivity, and benchmarks for spatial structure, diversity, juvenile abundance, and habitat will be refined in the future as outlined in the recovery actions of this plan.

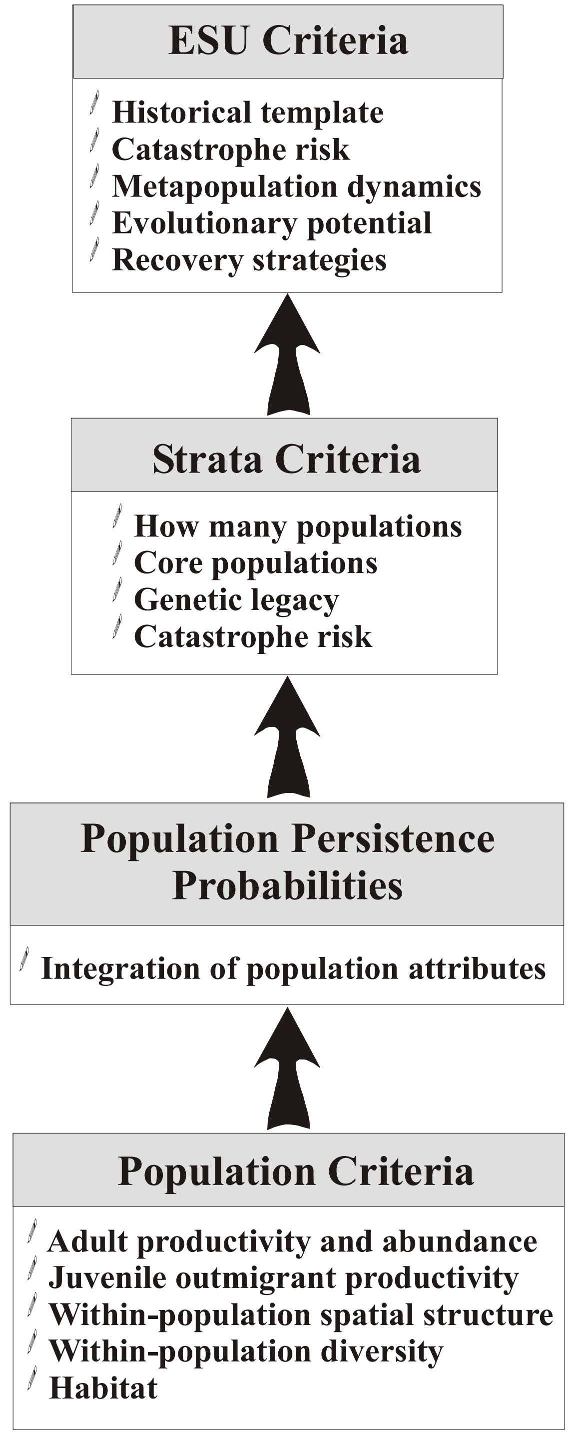


Figure 1. Willamette/Lower Columbia viability criteria (from McElhany et al. 2003). The bullets list key considerations involved in each criteria.

Figure 2. Ecological zones identified for recovery strata by the Willamette/Lower Columbia Technical Recovery Team for listed salmon and steelhead populations in lower Columbia River Evolutionarily Significant Units.

The TRT also provided a scoring system to evaluate population persistence probabilities (McElhany et al. 2003). Each population criteria is evaluated separately on a 0-4 scale, where 0 is either extinct or a very high risk of extinction, 1 is a relatively high risk, 2 is a medium risk, 3 is a low risk (viable), and 4 is at very low risk of extinction (Table 1). Criteria scores are then averaged to the overall population persistence level (based on all of the population viability criteria). This plan includes assessments of the current status of populations based on an average of scoring done by the TRT and the LCFRB. Since this is a plan for Washington populations, current status is not provided for Oregon populations. Additional details on the application of population scoring in this recovery plan can be found in Appendix E.

Box 1. ESU and strata viability criteria from the Willamette-Lower Columbia Technical Recovery Team.

ESU-Level Viability Criteria

1. Every stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence.
2. Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence.
3. High levels of recovery should be attempted in more populations than identified in the strata viability criteria because not all attempts will be successful.

Strata-Level Viability Criteria

1. Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence.
2. Within a stratum, the populations restored/maintained at viable status or above should be selected to:
   a. Allow for normative meta-population processes, including the viability of "core" populations, which are defined as the historically most productive populations.
   b. Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historic gene pools.
   c. Minimize susceptibility to catastrophic events.

Box 2. Population viability criteria from the Willamette-Lower Columbia Technical Recovery Team.

Adult Population Productivity and Abundance

1. In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable, but must meet reasonable standards of statistical rigor.
2. A population with non-negative growth rate and an average abundance approximately equivalent to estimated historic average abundance should be considered to be in the highest persistence category. The estimate of historic abundance should be credible, the estimate of current abundance should be averaged over several generations, and the growth rate should be estimated with adequate statistical confidence. This criterion takes precedence over criterion 1.

Juvenile Migrant Production

1. The abundance of naturally produced juvenile migrants should be stable or increasing as measured by observing a median annual growth rate or trend with an acceptable level of confidence.

Within-Population Spatial Structure

1. The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and benchmarks for evaluating the adequacy of a population's spatial structure should specifically address:
   a. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.
   b. Quality: Underlying habitat spatial structure should be within specified habitat quality limits for life-history activities (spawning, rearing, migration, or a combination) taking place within the patches.
   c. Connectivity: spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.
   d. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of flux should not exceed the rate of creation over time.
   e. Catastrophic Risk: the spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost because of a single catastrophic event, either anthropogenic or natural.

Within-Population Diversity

1. Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:
   a. Substantial proportion of the diversity of a life-history trait(s) that existed historically,
   b. Gene flow and genetic diversity should be similar to historic (natural) levels and origins,
   c. Successful utilization of habitats throughout the habitat, and
   d. Resilience and adaptation to environmental fluctuations.

General Habitat

1. The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be sufficient to maintain viable populations identified for recovery.
2. The diversity of habitats for recovered populations should resemble historic conditions given expected natural disturbance regimes (wildfire, flood, volcanic eruptions, etc.). Historic conditions represent a reasonable template for a viable population; the closer the habitat resembles the historic diversity, the greater the confidence in its ability to support viable populations.
3. At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability. Freshwater, estuarine, and marine habitat attributes should be maintained in a non-deteriorating state.

5.3 Salmon and Steelhead ESU Goals

5.3.1 The Recovery Scenario

ESU-level recovery goals are described in this plan by a recovery scenario that identifies a combination of populations and population status levels that meet TRT recovery criteria for a viable ESU. The scenario represents one of many possible combinations of populations and recovery goals that could meet the TRT's ESU- and strata-level viability criteria. Different scenarios may fulfill the biological requirements for recovery but can have unique implications for various stakeholders. Selection of a scenario for incorporation into the recovery plan is in part a policy decision based on scientific, biological, social, cultural, political, and economic considerations. This recovery scenario was developed through a collaborative process with a representative group of stakeholders.

The recovery scenario was developed with specific consideration of the biological significance and recovery feasibility of each population. Biological significance was based on current status, potential for improvement, historical significance, proximity to other selected populations with reference to catastrophic risks, and location relative to strata with reduced expectations. Feasibility of recovery was evaluated based on expected progress as a result of existing programs, absence of apparent impediments toward recovery, and other management considerations (e.g. fish trapping ability).

The recovery scenario designates individual population goals at three levels of contribution:

Primary populations are those that would be restored to high or "high+" viability. At least two populations per strata must be at high or better viability to meet recommended TRT criteria. Primary populations typically, but not always, include those of high significance and medium viability. In several instances, populations with low or very low current viability were designated as primary populations in order to achieve viable strata and ESU conditions. In addition, where factors suggest that a greater than high viability level can be achieved, populations have been designated as High+. $High^+$ indicates that the population is targeted to reach a viability level between High and Very High levels as defined by the TRT.

Contributing populations are those for which some restoration will be needed to achieve a stratum-wide average of medium viability. Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery.

Stabilizing populations are those that would be maintained at current levels (likely to be low viability). Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high.

The recovery scenario describes the target status (i.e. primary, contributing, or stabilizing) for each population within the lower Columbia ESUs (Table 2). The underlying population-level goals are described in Figure 5 through Figure 10. At least two populations are targeted for improvement to high or high+ levels of viability in every stratum except for strata within the Gorge ecological zone. Overall, the recovery scenario would restore each salmonid stratum to an average viability of medium or higher. Population and strata viability goals were higher than the minimum required to meet TRT criteria to provide a safety factor should goals for some populations not be achieved.

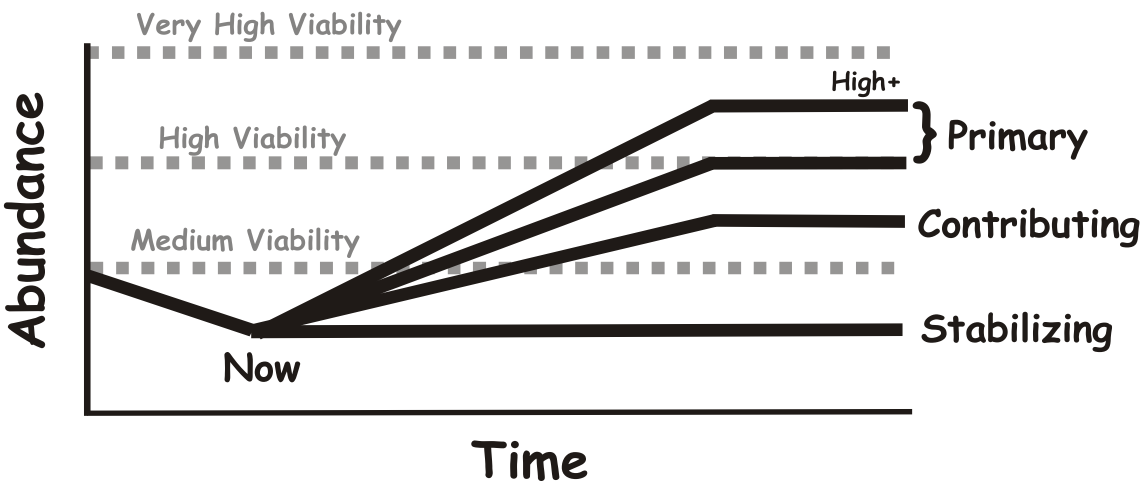


Figure 3. Example population trajectories corresponding to scenario designations.

Table 2. Primary (P), contributing (C), and stabilizing (S) population designations for the recovery scenario. Respective target viabilities are high or better, medium, and no lower than current levels. Primary populations identified for greater than high viability objectives are denoted with an '*'. X refers to subset of larger population. Dashes indicate species is not present.

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho[1]
COAST	Grays/Chinook	P	--	--	P*	P[1]	--	P
	Elochoman/Skamokawa	P	--	--	P	C	--	P
	Mill/Abernathy/Germany	C	--	--	P	P[1]	--	C
	Youngs Bay (OR)	S	--	--	P	na[1]	--	S
	Big Creek (OR)	S	--	--	C	na[1]	--	P
	Clatskanie (OR)	P	--	--	C	na[1]	--	S
	Scappoose (OR)	S	--	--	C	na[1]	--	P
CASCADE	Lower Cowlitz	C	--	--	C	C	--	P
	Upper Cowlitz	S	--	P*	--	C	--	C
	Cispus	--	--	P*	--	C	--	C
	Tilton	--	--	S	--	C	--	C
	SF Toutle	X	--	C	X	P*	--	P
	NF Toutle	S	--	X	X	P	--	P
	Coweeman	P*	--	--	X	P	--	P
	Kalama	P	--	P	C	P*	P	C
	Lewis (NF)	X	P*	P	X	C	S	C
	EF Lewis	P*	--	--	P	P	P	P
	Salmon	X	--	--	S	S	--	S
	Washougal	P	--	--	P*	C	P*	C
	Sandy (OR)	S	P	P	P	P	--	P*
	Clackamas (OR)	C	--	--	C	P	--	P*
GORGE	Lower Gorge	C	--	--	P*	P	--	P
	Upper Gorge	S	--	--	C	S	P*	P
	White Salmon	C	--	C	--	--	--	C
	Hood (OR)	S	--	P	--	P	P	C

It is assumed that one tule fall Chinook, one chum, and two coho populations in OR will be "primary" category and three chum populations will be in the "contributing" category. Assignments of specific populations shown are illustrative only. OR will identify specific assignments upon completing its population review.

Recovery opportunities in the Gorge are limited by the small numbers of populations and the high uncertainty of restoration feasibility because of Bonneville Dam. Recovery of gorge populations will be attempted but success will be highly uncertain given the continued existence of Bonneville Dam. The TRT's strata delineations between the gorge and Cascade strata populations are also uncertain and several chum and chinook populations downstream from Bonneville Dam may be quite similar to those upstream of Bonneville Dam. The recovery scenario identifies improvement in more than the minimum number of populations including several in the adjacent strata in order to provide a safety factor should not all attempts in the gorge prove successful. This approach mitigates some of the increased risk to the ESU that could occur as a result of not achieving the TRT's recommendations for strata within the gorge ecological zone. This is a more precautionary approach to gorge strata recovery uncertainties than merely assuming they can be effective given the fundamental changes to the gorge habitats. Monitoring and adaptive management in the course of plan implementation will provide more information on the feasibility of recovering chinook and chum populations above Bonneville Dam and can lead to adjustments in expectations and actions.

Recovery will require significant actions in most subbasins (Figure 4). Several Washington subbasins have been identified with the potential to provide substantial contributions to the viability of multiple species and populations. These include the Grays and Elochoman in the coast ecological zone; the Cowlitz, Kalama, Lewis, and Washougal in the Cascade ecological zone; and the lower Gorge in the Gorge ecological zone. Substantial improvements are not required in some severely degraded subbasins although recovery goals require additional protection and restoration efforts to prevent further declines until recovery of other populations is achieved. Examples include Salmon Creek.

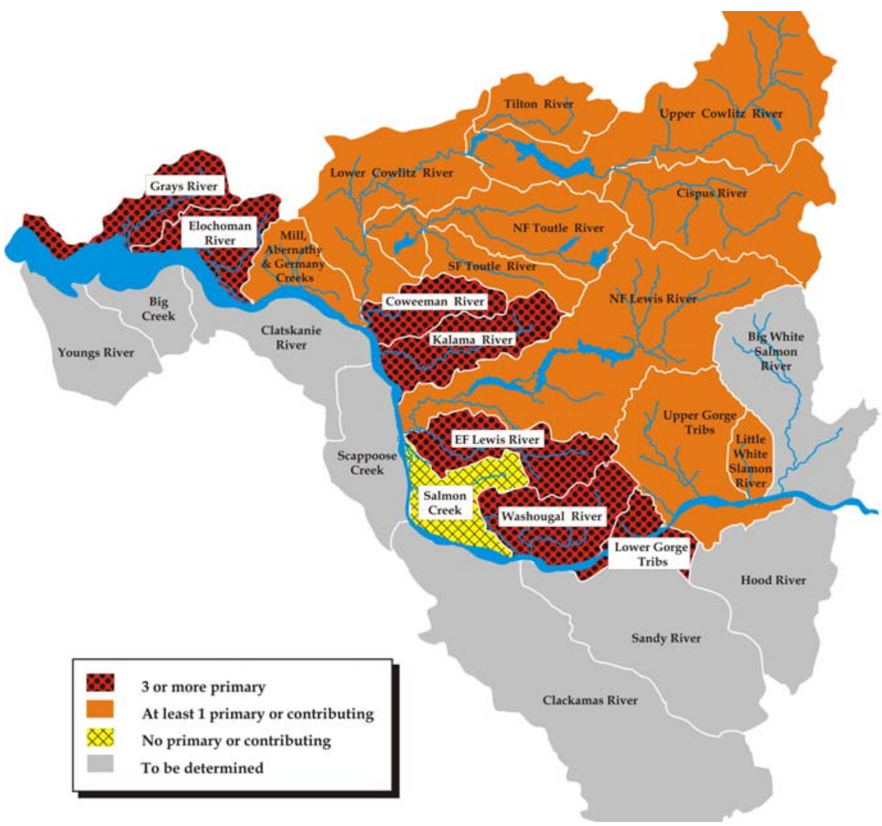


Figure 4. Numbers of primary, contributing, and stabilizing salmon and steelhead populations in each subbasin.

5.3.2 Population Priorities

Population priority rationales are brief descriptions of the basis for classification and selection for inclusion in recovery scenarios. Rationales summarize the biological significance, risk reduction, feasibility, and social/political considerations upon which designations were based. Rationales are presented for each species.

Fall Chinook

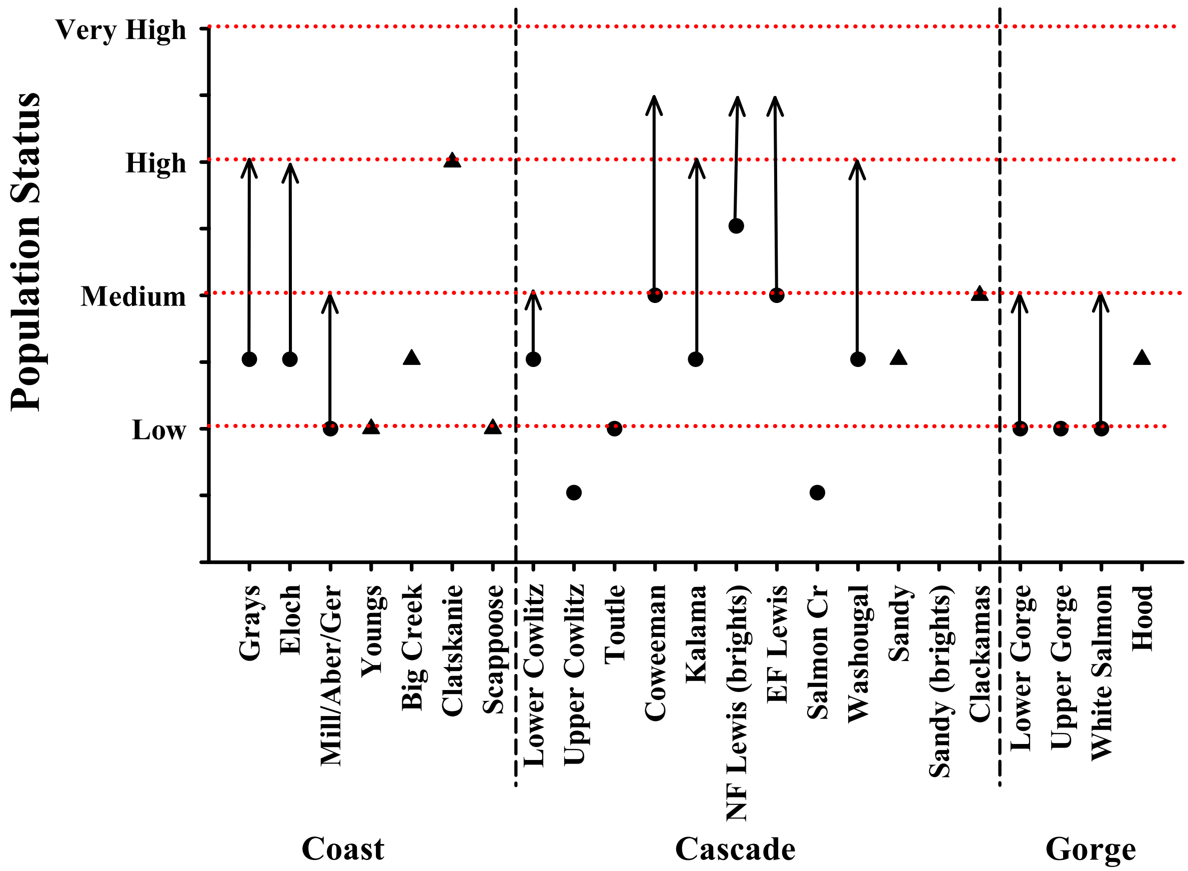


Figure 5. Improvements in population viability for fall Chinook corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

The scenario targets recovery of at least two tule fall Chinook populations to high levels of viability in both the Coast and Cascade strata. Recovery of at least two Gorge populations to high levels will be highly uncertain given current low numbers, limited habitat potential for the lower Gorge population, and Bonneville Dam impacts for the upper Gorge population. Medium levels of viability may be realistic for the lower Gorge, upper Gorge, and White Salmon populations. Kalama and Washougal population goals were targeted for high viability because of uncertain prospects of Gorge strata populations. Oregon populations may provide additional risk reduction options although Oregon populations are small and habitat potential is limited.

<u>*Grays (Primary, High)*</u> – The historical Grays River fall Chinook population was likely average in abundance for coastal tule fall Chinook populations. There was a hatchery fall Chinook program in the basin for almost 40 years, but it was recently eliminated. Current returns of natural produced fall Chinook are among the lowest in the ESU.

<u>*Elochoman (Primary, High)*</u> – Elochoman fall Chinook population were targeted for High status to address ESU and coast strata risks in meeting tule fall Chinook recovery criteria. Historical populations of fall chinook in coastal strata streams may have been small and constrained by low early fall flows but the TRT identified these populations based on a review of the available evidence. The Elochoman River likely contained the most significant historical coastal fall Chinook population, but does have a history of hatchery transfers from other lower Columbia basins. There is a weir operation at tidewater in the Elochoman that could be used to implement an integrated hatchery and wild program, although hatchery fall chinook would need to be marked before separation at he weir could be implemented. Additionally, the current habitat condition is better than many other watersheds for fall Chinook.

<u>*Mill/Abernathy/Germany (Contributing, Medium)*</u> – Mill/Abernathy/Germany tule fall Chinook population targeted for medium status in response to current adult spawning return information. The TRT identified this populations based on a review of the available evidence. However, the historical significance of the fall Chinook populations in these small tributaries is uncertain. They were largely represented by strays from Abernathy Hatchery until that program was eliminated. They currently support natural spawning populations, with the largest numbers typically in Mill Creek.

<u>*Lower Cowlitz-Below Mayfield Dam (Contributing, Medium)*</u> – This is likely the most significant historical lower fall Chinook Columbia population. There is a large hatchery program but few out of basin hatchery transfers have occurred. The hatchery and natural spawners are similar, although the natural population has consistent annual contributions from stray Lewis River wild spawners. An integrated hatchery and natural program may be difficult because of the feasibility of sorting fish prior to spawning.

<u>*Upper Cowlitz-Above Mayfield Dam (Stabilizing, Very Low)*</u> – Upper Cowlitz fall Chinook population is not targeted for improvements. Upper Cowlitz fall Chinook is not currently proposed for reintroduction above the dams on the Cowlitz because of conflicts with spring Chinook reintroduction efforts.

<u>*Toutle (Stabilizing, Low)*</u> – This was historically a large tule fall Chinook population and the current combined hatchery and wild returns are large. There is a significant history of hatchery transfers from other lower Columbia basins. The primary historical spawning areas of the North Fork and mainstem Toutle remain impacted by the eruption of Mt. St. Helens. There is also spawning that occurs in the lower SF Toutle and Green Rivers.

<u>*Coweeman (Primary, High^{+})*</u> – Coweeman fall Chinook were targeted for High+ status to address ESU risk in meeting tule fall Chinook recovery criteria. This population is one of two tule populations without a history of significant hatchery influence and is considered a genetic legacy population. The current population is small at about 300-900 adult spawners per year.

<u>*Kalama (Primary, High)*</u> – The hatchery program has maintained a local stock with negligible outside basin influence. Hatchery and wild fish are likely similar and the combined returns are one of the larger in lower Columbia tule populations. There is an existing weir operation in the lower river that could be used to manage an integrated hatchery and wild program. Kalama fall Chinook were targeted for high viability in part to compensate for lower goals for Gorge populations.

NF Lewis (Primary, High+) – North Fork Lewis bright fall Chinook were targeted above high viability to recognize favorable current status, existing program expectations, and risk reduction in meeting recovery criteria for fall Chinook bright populations. This is the healthiest fall Chinook population in the lower Columbia basin and one of only two late fall bright populations. There is no direct hatchery fall Chinook program influence and the FERC license includes flow enhancement and hatchery safeguards. Critical rearing habitat has been protected with the purchase of Eagle Island.

EF Lewis (Primary, High+) – The EF Lewis and Coweeman populations are the only tule populations without a history of significant hatchery influence and both are considered a genetic legacy population. The current population is small at about 200-800 adult spawners per year. Salmon Creek fall Chinook are considered part of the East Fork Lewis population although Salmon Creek fall Chinook are not targeted for improvements. EF Lewis and Coweeman fall Chinook populations were targeted for High+ status to address ESU risk in meeting tule fall Chinook recovery criteria.

Washougal (Primary, High) – This was a large tule fall Chinook population historically and current combined hatchery and wild returns are large. There is a significant history of hatchery transfers from other lower Columbia basins. This population has the potential to be managed as integrated hatchery and wild programs. There is no current weir operation but it would be feasible in the lower river. Chum enhancement may benefit natural spawning of fall Chinook. Washougal fall Chinook are targeted for high viability to partially compensate for lower goals for Gorge populations.

Lower Gorge-Below Bonneville Dam (Contributing, Medium) – The lower Gorge subbasin includes small Oregon and Washington streams between Washougal River and Bonneville Dam. On the Washington side, these include Hamilton, Hardy, and Duncan creeks. There are concerns with low flows in the early fall not providing adequate access for fall Chinook spawning in small tributaries and in the mainstem Columbia. There is competition in the mainstem Columbia with later spawning bright fall Chinook. Recovery to high levels of viability is uncertain because low flows in the late summer and fall restrict access of spawners to these small tributaries.

Upper Gorge-Above Bonneville Dam (Stabilizing, Low) – This includes small tule fall Chinook populations in the lower Wind and Hood rivers. There is consistent straying from returning Spring Creek Hatchery tule adults to the Wind River and competition from hatchery and naturally produced upriver bright fall Chinook. The Bonneville Reservoir has inundated significant portions of the historical habitat.

White Salmon (Contributing, Medium) – The historical tule fall Chinook population was large in the White Salmon. Currently, the population is impacted by Condit Dam, although fall Chinook habitat is available downstream of the dam, and upstream from Bonneville Reservoir inundation. The spring creek hatchery program, which originated from White Salmon fall Chinook stock, is located immediately downstream of the river mouth and straying of returning hatchery adults to the White Salmon River is consistent. A treaty Indian fishery targets Spring Creek Hatchery fish near the river mouth. The White Salmon population is targeted for medium viability to reflect concerns with hydro impacts (Bonneville and Condit Dam), and higher harvest rates associated with combined Indian and non-Indian fisheries.

Spring Chinook

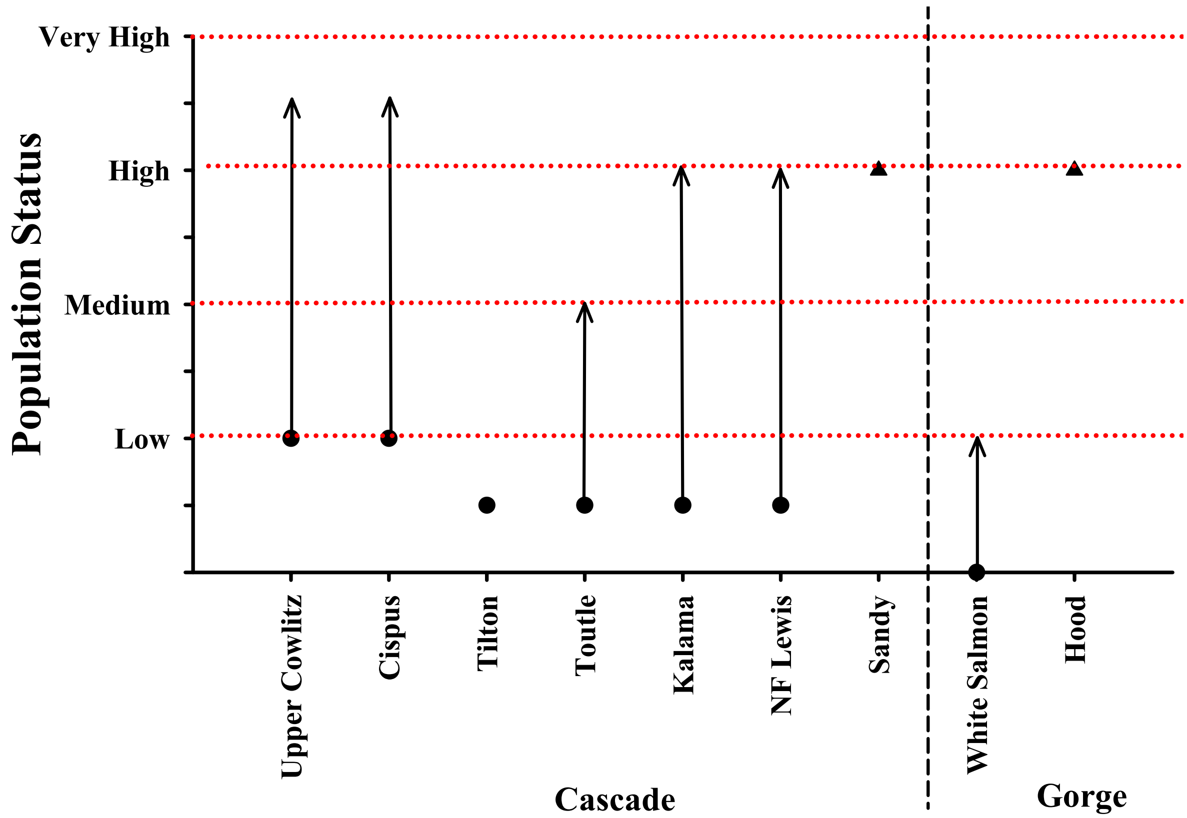


Figure 6. Improvements in population viability for spring Chinook corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

Four Cascade populations are targeted for high levels of viability. There is considerable uncertainty in prospects for recovery of the lower Columbia spring Chinook populations. Most Washington populations occurred historically in habitats upstream of current hydrosystems and recovery will rely on reintroduction success. Thus, multiple populations were targeted for aggressive recovery efforts to balance ESU risk. Oregon's Sandy River population will likely make substantial contributions to ESU viability. The historical Hood River population is extinct.

Upper Cowlitz (Primary) /Cispus (Primary), High+; Upper NF Lewis (Primary, High) – The vast majority of spring Chinook habitat in the lower Columbia is found in these three areas. Spring Chinook will not likely meet recovery criteria without sustaining viable populations in at least two of these three major historical production areas. Upper Cowlitz and Cispus population targets were targeted for High^{+} status. The upper Cowlitz and Cispus were the most significant production areas in the lower Columbia and current reintroduction efforts have shown the ability for the habitat to produce. There are problems with low collection rates for juvenile passage, but reintroduction efforts have progressed for several years while such efforts in the North Lewis have not yet begun. To date, collection of naturally produced spring Chinook juveniles at Cowlitz Falls Dam has been the most difficult of the three species reintroduced into the upper Cowlitz basin. However, to realize habitat potential, adequate passage through the Cowlitz and Lewis hydro systems must be achieved. Upper Cowlitz and Cispus spring chinook populations will be most effectively managed as a combined unit because of physical difficulties of maintaining separate populations.

Toutle (Contributing, Medium) – This population may have been historically small, but it is not affected by a hydrosystem in the watershed. The mainstem and NF Toutle are still recovering from the effects of the Mt. St. Helens eruption, but there may be some potential for spring Chinook production in the SF Toutle and NF Toutle tributaries. Toutle was targeted for medium viability to compensate for potential uncertainty in other areas. Spring chinook from the Cowlitz hatchery have been released into the NF Toutle in recent years with the last release in 2002.

Kalama (Primary, High) – The historical significance of this population is questionable and the best spring Chinook habitat was historically blocked by lower Kalama Falls. However, some natural spawning currently occurs and a hatchery program in the basin provides an opportunity for conservation-based efforts. In addition, Kalama spring Chinook are not limited by difficulties in dam passage that make upper Cowlitz and Lewis reintroduction efforts uncertain. The hatchery program in the Kalama River would need to incorporate naturally-produced spring chinook into the broodstock to meet this goal.

White Salmon (Contributing, Low) – This population was historically significant but is currently extinct. Reintroduction would include use of an outside stock and would require passage upstream of Condit Dam. The best source stock may be from the Klickitat, which is outside the lower Columbia ESU. The TRT would need to provide criteria for evaluating appropriate source stocks for reintroduction. The Big White Salmon target of low recognizes the long time frame required to restore a locally-adapted natural population from an out-of-basin stock.

Chum

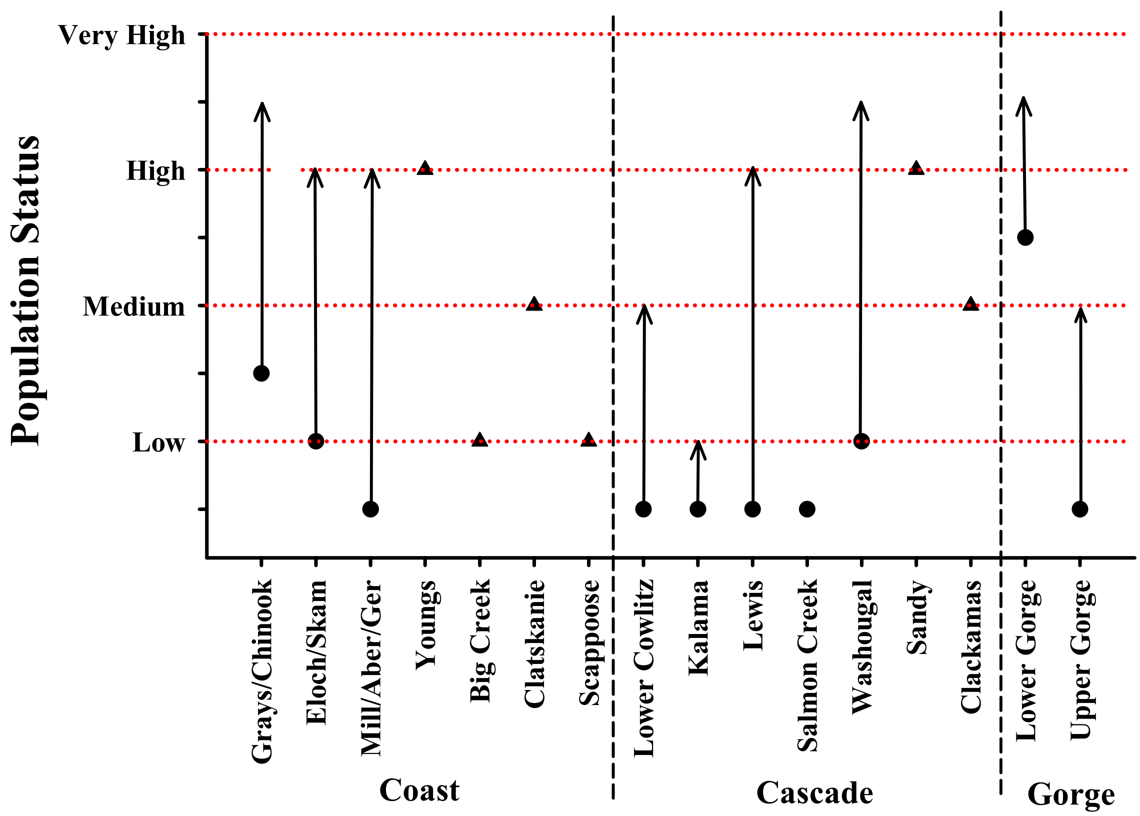


Figure 7. Improvements in population viability for chum corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

The TRT criteria specify that each stratum have two populations of each species at a high viability level (95% probability of persistence). The Gorge Stratum currently has one chum population located below Bonneville Dam. To meet the TRT criteria a second population of high viability would have to be re-established above Bonneville Dam. While it may be possible to re-establish a population above the dam, it is unlikely that the population could achieve a high viability level. Upper Gorge chum habitat has been inundated by Bonneville Pool and relative to other salmonid species, chum do not pass barriers effectively (Bonneville Dam passage). Accordingly, the scenario identifies a recovery goal for upper Gorge chum of medium. To compensate for this lower goal, the recovery goal for the lower Gorge population was established at High$^+$. Three coastal and three Cascade strata populations are targeted for High or High$^+$ levels to address ESU-wide uncertainties.

Grays/Chinook (Primary, High$^+$) – This population has remained stable at low to moderate levels over the past 50 years. The most recent year returns have been relatively large. Enhancement programs have been on going in the Grays Basin. The population was targeted for High$^+$ viability to address ESU recovery risk and to meet strata recovery criteria.

Elochoman/Skamokawa (Primary, High) – There have been fair numbers of spawning chum counted in Skamokawa Creek in the most recent years and the historical population was likely significant. The population was targeted for High$^+$ viability to address ESU recovery risk and to meet strata recovery criteria.

Mill/Abernathy/Germany (Primary, High) – Fair numbers of spawning chum have been counted in Germany and Abernathy creeks in the most recent years. There is potential for a protected habitat area in lower Germany Creek.

Lower Cowlitz-Below Mayfield Dam (Contributing, Medium) – This was likely the largest historical chum population in the Columbia Basin. However, critical habitat in the lower river has been significantly reduced by diking in the Longview/Kelso area. The lower Cowlitz population is targeted for medium status to reflect improvement difficulty associated with extensive diking in the Longview/Kelso area.

Kalama (Contributing, Low) – The historical significance of the Kalama chum population was likely below average for lower Columbia Basin. Few chum are currently found in the Kalama.

Lewis (Primary, High) – Significant population occurred historically in the mainstem Lewis and East Fork Lewis. There are currently low levels of production occurring. Some volunteer enhancement efforts are on-going in the lower East Fork Lewis.

Washougal (Primary, High$^+$) – Recent years have found chum spawning in several locations in and around the Washougal Basin, including tributaries of the Washougal and the mainstem Columbia near I-205 Bridge. Enhancement and protection efforts are underway for the near I-205 production areas. The population was targeted for High$^+$ viability to address ESU recovery risk and to meet strata recovery criteria.

Lower Gorge-Below Bonneville Dam (Primary, High$^+$) – Considered the healthiest Columbia River chum population, it includes several tributaries and the mainstem Columbia for spawning. Multi-agency enhancement efforts are on-going including use of the Washougal Hatchery for risk reduction and enhancement. The population was targeted for High$^+$ viability to address ESU recovery risk and to meet strata recovery criteria.

Upper Gorge-Above Bonneville Dam (Contributing, Medium) – The majority of the chum habitat is inundated by the Bonneville Reservoir and passage of adult chum over Bonneville Dam may be problematic. The upper Gorge chum population is targeted for medium viability to reflect uncertainty in resolving Bonneville Dam impacts.

Coho

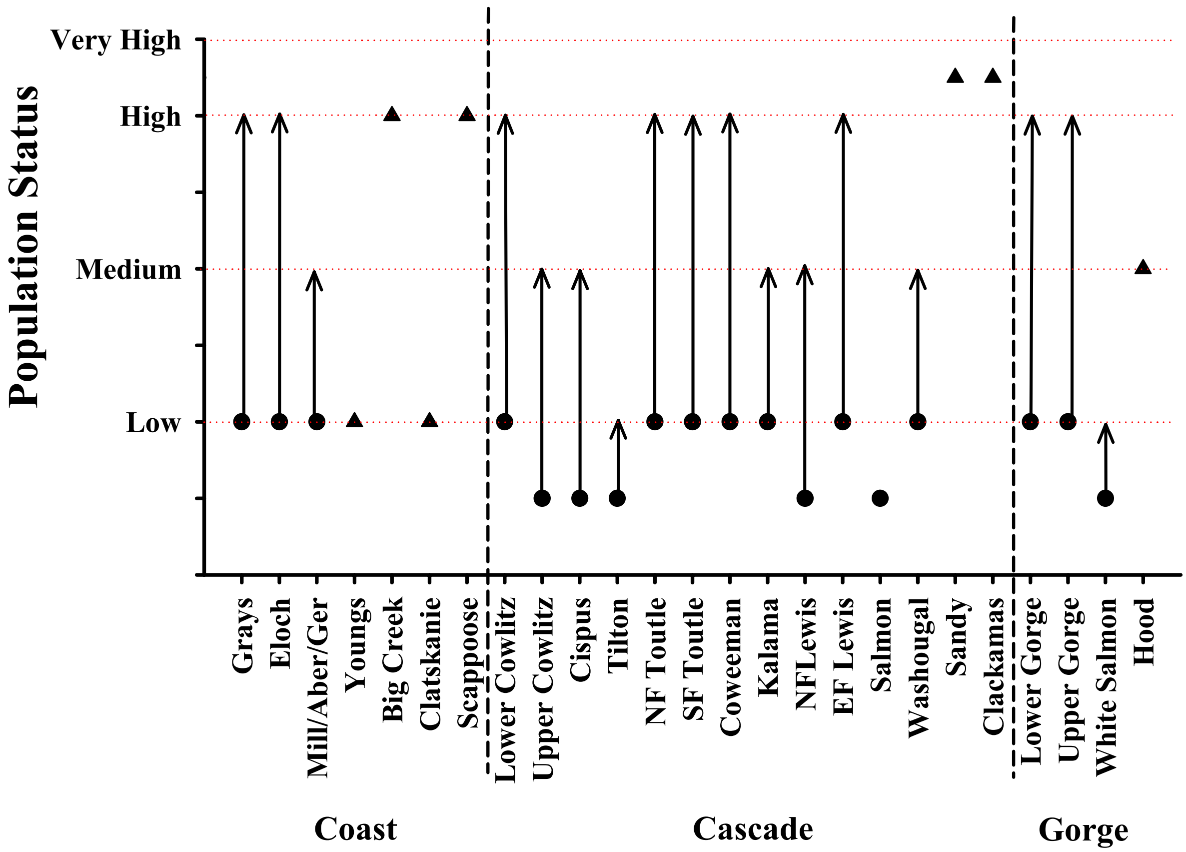


Figure 8. Improvements in population viability for coho corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

Meeting lower Columbia coho objectives may be difficult because of the current low status of Washington populations and the need for improvement in a significant number of those populations. Coho ESU viability will rely heavily on Oregon populations (Sandy and Clackamas). These populations are considered to be at medium current status and are listed under Oregon State ESA.

Grays (Primary, High) – Natural production occurs throughout the upper watershed and in lower river tributaries. The historical returns were predominately late-timed coho while the current hatchery program produces early-timed coho.

Elochoman (Primary, High) – Natural production occurs in the Elochoman River and Skamokawa Creek watersheds, as well as Jim Crow Creek, a direct Columbia River tributary just downstream of Skamokawa Creek. The historical returns to these streams were predominately late-timed coho. Elochoman Hatchery produces both early-timed and late-timed coho.

Mill/Abernathy/Germany (Contributing, Medium) – There is coho production in all three streams. There are no hatchery programs in these tributaries. The historical stock was principally late returning coho.

Lower Cowlitz-Below Mayfield Dam (Primary, High) – This population was likely one of the largest historical populations in the lower Columbia with production occurring in many tributary streams. These populations have been mixed with Cowlitz Hatchery production for years, however recent surveys have found areas (Olequa Creek) where the spawners were primarily unmarked naturally produced coho. The type-N coho program in the Cowlitz Salmon Hatchery is the archetype for all type-N coho programs in the lower Columbia River and has been maintained with no outside inputs. These hatchery fish are being used for reintroduction in the upper Cowlitz and Tilton rivers.

Upper Cowlitz/Cispus (Contributing, Medium) – Success is associated with reintroduction to habitats upstream of the dams in the Cowlitz Rivers which will be dependent on passage. Collection of juvenile coho reintroduced upstream of Cowlitz Falls Dam has been difficult, but better than spring Chinook juvenile collection efficiency.

Tilton (Contributing, Low) – Improvements to the Tilton coho population are linked to successful reintroduction and passage upstream of Mayfield Dam.

SF Toutle (Primary, High) – This population occurs in several tributary streams which were not significantly impacted by the Mt. St. Helens eruption. This watershed does not have a coho hatchery program, is not in urban areas, and is expected to benefit from forest management plans and fishery reductions. This population was designated for High viability to reduce risk to the ESU.

NF Toutle (Primary, High) – This population was more significant than the SF Toutle population historically, but was seriously effected by the Mt. St. Helens eruption. However, there are several tributary streams in the NF Toutle and in the Green River that still have productive coho habitat. Wild coho are trapped at the USACE Sediment Retention Structure and transported to upper NF Toutle tributaries. There is an early stock coho hatchery program at the Toutle Hatchery on the lower Green River.

Coweeman (Primary, High) – This population was likely modest to average in numbers historically. The current status rating is about average for lower Columbia populations. This sub-basin does not have a coho hatchery program, is not in urban areas, and is expected to benefit from forest management plans and fishery reductions. This population was designated for High viability to reduce risk to the ESU.

Kalama (Contributing, Medium) – This population was likely average or less historically, with production occurring in the lower basin tributaries downstream of Kalama Falls. There are both late and early stock hatchery programs in the Kalama and both types of coho were thought to be present historically.

NF Lewis (Contributing, Medium) – Success is associated with reintroduction to habitats upstream of the dams in the Lewis River, which will be dependent on successful passage measures. A naturally spawning population is being managed by WDFW in Cedar Creek and might be used to supplement other populations in the lower river.

EF Lewis (Primary, High) – This population was likely about average in numbers historically. There has not been a coho hatchery program in the basin for several years. A good portion of the natural production occurs in the lower basin tributaries. There are volunteer habitat enhancement efforts occurring in the lower East Fork.

Washougal (Contributing, Medium) – This population was likely average or less historically, with most production occurring in lower river tributaries. The Little Washougal is likely the most significant production area. There are volunteer habitat enhancement efforts in the Little

Washougal. There is a late stock hatchery program at the Washougal Salmon Hatchery, most of which is planted in the Klickitat River as part of a federal, state, and tribal production agreement.

Lower Gorge-Below Bonneville Dam (Primary, High) – These small tributary coho populations historically returned to Hamilton, Greenleaf, Hardy, Duncan, Gibbons and Lawton creeks. Both early-and late-timed coho were historically present. There are no hatchery programs in these tributaries.

Upper Gorge-Above Bonneville Dam (Primary High) – These populations include the Wind River and several small tributaries between Bonneville Dam and the Little White Salmon River. Most natural production occurs in the lower Wind and in Rock Creek. Historical returns were predominately early-timed coho.

White Salmon (Contributing, Low) – Current potential for coho production is limited by access to habitats upstream of Condit Dam. There may be some coho production occurring in the lower one mile of stream below Condit Dam.

Winter Steelhead

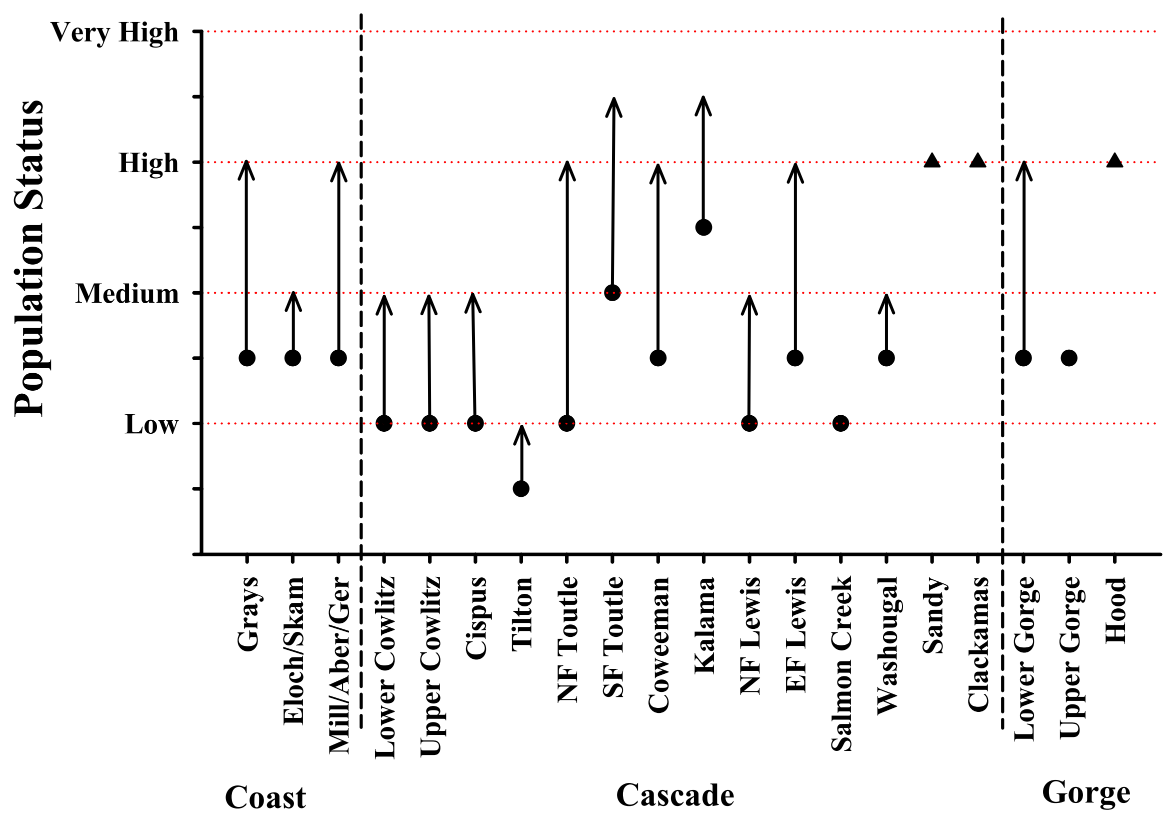


Figure 9. Improvements in population viability for winter steelhead corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

The scenario targets recovery of at least two winter steelhead populations for High levels of viability in both the Coast and Cascade strata. Recovery of at least two Gorge populations to High levels will be highly uncertain given current low numbers and limited habitat potential for lower Gorge populations. High levels of viability may be realistic for the lower Gorge but the upper Gorge was targeted for Medium. A total of four Cascade populations are targeted for High or High+ to address ESU-wide uncertainties. An Oregon population in Hood River may provide an additional risk reduction option.

Grays (Primary, High) – Current status may be above average for the lower Columbia. There is a steelhead hatchery program in the watershed.

Elochoman/Skamokawa (Contributing, Medium) – There is winter steelhead production in both Elochoman River and Skamokawa Creek. Non-local stock hatchery programs occur in the Elochoman. A local steelhead broodstock program at Elochoman Hatchery has recently been cut.

Mill/Abernathy/Germany (Primary, High) – There is winter steelhead production in all three streams with fair historical significance. There are no hatchery programs in these tributary streams.

Lower Cowlitz-Below Mayfield Dam (Contributing, Medium) – The lower Cowlitz winter steelhead historical population may have been one of the largest in the lower Columbia Basin. Natural production occurs in several lower Cowlitz tributaries. Both non-local stock (early-timed) and local stock (late-timed) hatchery winter steelhead programs exists in the lower Cowlitz.

Upper Cowlitz/Cispus (Contributing, Medium) – Success is associated with reintroduction to habitats upstream of the dams on the Cowlitz River, which is dependent on passage. Collection of juvenile steelhead reintroduced upstream of Cowlitz Falls Dam has been difficult but better than spring Chinook juvenile collection efficiency. There is uncertainty in even reaching medium status for reintroduced populations in the Upper Cowlitz and Cispus.

Tilton (Contributing, Low) – This population was likely about average historically prior to completion of Mayfield Dam. Contribution from this population would be subject to reintroduction and dam passage success.

SF Toutle (Primary, High$^+$) – Current status is one of the healthiest in the lower Columbia ESU. Impacts associated with the Mt. St. Helens eruption are less than the NF Toutle. There is a small Skamania summer steelhead hatchery program in the watershed. This population is targeted for High$^+$ to address ESU recovery risks.

NF Toutle (Primary, High) – This was a large historical population but near-term potential is limited by the effects of the Mt. St. Helens eruption. However, good habitat remains in many tributary streams and in the Green River watershed. Current returns are about average for lower Columbia streams in recent years. Wild steelhead are trapped and passed over the NF Toutle sediment retention structure to access tributaries in the upper NF Toutle. This population is targeted for High viability to compensate for uncertainty in reintroduction efforts above Lewis and Cowlitz basin dams. The population is not substantially affected by hydro systems and is within the same strata as the upper Cowlitz and upper Lewis populations.

Coweeman (Primary, High) – Current status is average for the lower Columbia. There is a small steelhead hatchery program in the basin.

Kalama (Primary, High$^+$) – This winter steelhead population has the highest current viability in the ESU and the largest current returns. Historical significance was likely about average. There are both local and non-local hatchery stock programs in the basin. This population is targeted for High$^+$ to address ESU recovery risks.

NF Lewis (Contributing, Medium) – The historical population was one of the larger in the lower Columbia basin and was predominately produced in the upper Lewis watershed above Swift Dam. Meeting the biological objective is dependent on successful reintroduction of winter steelhead into the habitats upstream of Swift Dam. The winter steelhead program at Merwin

Hatchery uses non-endemic early winter steelhead and the reintroduction efforts will require using natural origin late winter steelhead.

EF Lewis (Primary, High) – The historical population was average or above for the lower Columbia basin. Current status is about average for viability and abundance. There are Skamania stock hatchery steelhead released into the lower East Fork Lewis for harvest opportunity.

Salmon (Stabilizing, Low) – The historical Salmon Creek winter steelhead population was significant. Natural spawning occurred throughout the Salmon Creek watershed and in Burnt Bridge, Whipple, and Gee creeks. The current status is low with much of the watershed in heavily urbanized areas. Winter steelhead from Skamania hatchery are released into Klineline ponds.

Washougal (Contributing, Medium) – The historical population was likely about average for the lower Columbia. The current returns are about average for the recent years. There are winter and summer hatchery steelhead programs in the basin.

Lower Gorge-Below Bonneville Dam (Primary, High) – Includes populations in small tributaries such as Hamilton Creek. This is one of only three Gorge winter steelhead populations including the upper Gorge and Hood River.

Upper Gorge-Above Bonneville Dam (Stabilizing, Low) – Habitat potential is limited for very small populations near upstream limits of winter steelhead distribution in the Columbia. A small naturally-produced winter steelhead population occurs in the Wind River. No wild winter steelhead occur in most of these systems and populations are subject to Bonneville Dam passage concerns.

Summer Steelhead

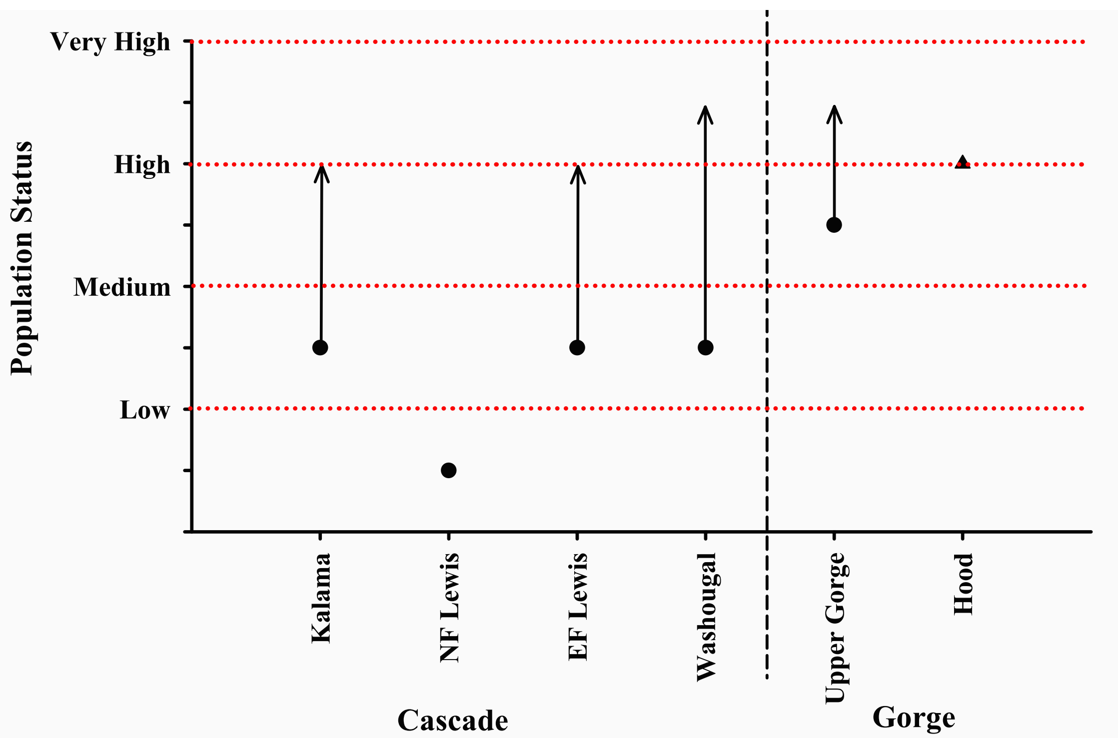


Figure 10. Improvements in population viability for summer steelhead corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

Wind River (Upper Gorge) and Washougal summer steelhead populations are targeted for High^{+} status for risk reduction. The Wind River population current status is near viable levels and has the highest current summer steelhead viability status rating. The Washougal population status is similar to the EF Lewis and Kalama populations, but there is more spatial separation between summer and winter steelhead in the Washougal basin than in the EF Lewis or Kalama basins.

Kalama (Primary, High) – This population was likely large historically. Current returns are about average for recent years in the lower Columbia streams. There are both local and non-local hatchery programs in the basin. Returns can be monitored at the Kalama Falls Trap.

NF Lewis (Stabilizing, Very Low) –The historical North Lewis summer steelhead population was likely less than average. Most spawning occurred in lower Merwin Reservoir tributaries and in Cedar Creek. Current status is very low with the majority of production occurring in Cedar Creek.

EF Lewis (Primary, High) – This population was likely large historically and is also considered a genetic legacy. Current returns are about average for recent years in lower Columbia streams. There is some concern with competition between wild summer and winter steelhead. There are hatchery steelhead programs in the East Fork Lewis.

Washougal (Primary, High^{+}) – This population was likely large historically and is considered a genetic legacy population. Current returns are about average for recent returns to lower Columbia streams. There is a hatchery program that supplies harvest production to several lower Columbia basins and to the lower Washougal.

Upper Gorge-Above Bonneville Dam (Wind) (Primary, High^{+}) – This is the highest rated population in the lower Columbia. Current adult returns are low and about average for recent years, but there is reasonable juvenile production in key reaches. There is no hatchery steelhead program in the basin.

5.4 Salmon and Steelhead Population Objectives

Previous sections in this chapter outlined a general approach to salmon and steelhead recovery that utilizes the TRT's interim viability criteria as the foundation. A recovery scenario was then described which integrates the TRT's ESU viability concept with goals for each population and how that effort at the population level will fit into the overall recovery effort for the ESU. Recovery will require improvements for a significant number of historical populations of each species and ESU as prescribed by TRT criteria and reflected in the recovery scenario. In this section, population recovery objectives are described using improvement increments that relate the prescribed changes in viability to specific changes in population parameters, particularly abundance and productivity.

5.4.1 Abundance

Population recovery objectives describe the numbers necessary to reach stabilizing, contributing, or primary population levels reflected in the recovery scenario. This plan identifies specific numerical objectives for population abundance and productivity. Abundance objectives are detailed in Table 3 through Table 6. Productivity objectives are described in Section 5.4.2.

Figure 11 is a schematic which describes the relationship between population abundance and productivity, viability levels identified in TRT interim criteria, and population improvements identified in the recovery scenario. In the example, the current population has low viability. As fish numbers or productivity increase, the population will eventually become viable as reflected by a 95% or greater persistence level over 100 years (see Table 1). Threatened or endangered salmon and steelhead typically include some populations where current abundance and productivity fall above the high viability mark, but a majority of populations fall below this level.

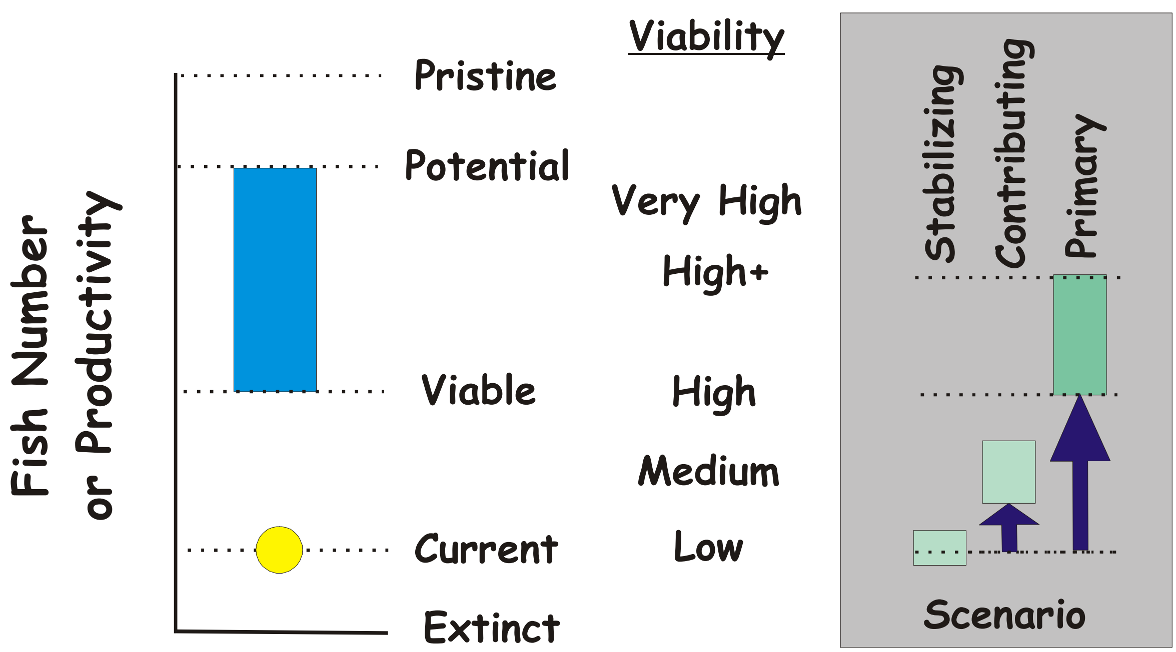


Figure 11. Schematic relating population abundance and productivity to viability levels identified by the Willamette/Lower Columbia Technical Recovery Team and population goals described by the recovery scenario.

The upper end of the recovery range is described as "potential" and represents the theoretical capacity if currently-accessible habitat was restored to "properly functioning conditions" (PFC's) identified by NOAA Fisheries. PFC's are benchmarks for habitat protection and restoration efforts that represent generally favorable conditions for salmonids. PFC conditions are assumed to be consistent with very high levels of viability. However, populations can also be assumed to reach high or very high levels of viability at numbers less than the potential represented by PFC.

Abundance and productivity provide simple quantitative metrics for describing population status and objectives. Abundance is the spawning population size averaged over a time period sufficient to account for year-to-year fluctuations due to natural environmental variation. Abundance objectives are reached when populations consistently exceed target numbers in most years. Productivity is the realized spawner to spawner replacement rate which provides a direct description of the dynamics that determine status and viability. Productivity objectives are reached when populations consistently exceed a 1:1 replacement rate by a margin sufficient to rebound quickly from periodic low numbers caused by natural environmental variation in survival conditions. Abundance and productivity objectives vary among individual populations as a result of subbasin differences in habitat quantity, habitat quality, fish distribution, juvenile production, spatial structure, and life history and genetic diversity. Additional work will be required during plan implementation to clarify time frames for measurement of these criteria (e.g. how many years of data are needed, what is an appropriate baseline for reference, and how are the effects of normal environmental variation considered).

Abundance and productivity objectives are intended to be used in close conjunction with these other viable salmonid population attributes (see section 5.4.4) to evaluate population status as recommended by the TRT. All VSP parameters are closely associated such that improvements in one parameter typically cause or are related to improvements in other parameters. For instance, productivity improvements might typically depend on increased diversity or habitat quality and be accompanied by increased abundance and distribution. Substantial improvements in population viability and reductions in extinction risk will require improvements in abundance and productivity. Abundance and productivity objectives assume related increases in other VSP parameters consistent with desired improvements.

Table 3. Recovery goals for lower Columbia River Chinook populations.

Population	Scenario Contrib.	Viability Current	Viability Goal	Abundance Current	Abundance Viable	Abundance Potential	Abundance Goal
Coast Fall							
Grays/Chinook	Primary	Low+	High	73	1,400	1,400	1,400
Eloch/Skam	Primary	Low+	High	140	1,400	4,500	1,400
Mill/Aber/Germ	Contributing	Low	Med	250	2,000	3,200	1,100
Youngs Bay (OR)	Stabilizing	na	Low	na	1,400	2,800	na
Big Creek (OR)	Stabilizing	na	Low+	na	1,400	2,800	na
Clatskanie (OR)	Primary	na	High	na	1,400	2,800	na
Scappoose (OR)	Stabilizing	na	Low	na	1,400	2,800	na
Cascade Fall							
Lower Cowlitz	Contributing	Low+	Med	602	3,900	33,200	2,300
Upper Cowlitz	Stabilizing	V Low	V Low	0	1,400	10,800	na
Toutle	Stabilizing	Low	Low	1,000	1,400	14,100	1,000
Coweeman	Primary	Med	High+	425	3,000	4,100	3,600
Kalama	Primary	Low+	High	1,192	1,300	3,200	1,300
Lewis/Salmon	Primary	Med	High+	235	1,900	3,900	2,900
Washougal	Primary	Low+	High	1,225	5,800	5,800	5,800
Clackamas (OR)	Contributing	na	Med	56	1,400	2,800	na
Sandy (OR)	Stabilizing	na	Low+	208	1,400	2,800	na
Cascade L Fall							
Lewis NF	Primary	Med+	High+	6,493	6,500	16,600	11,600
Sandy (OR)	Primary	na	Low+	445	5,100	10,200	na
Cascade Spring							
Upper Cowlitz	Primary	Low	High+	365	2,800	8,100	5,400
Cispus	Primary	Low	High+	150	1,400	2,300	1,800
Tilton	Stabilizing	V Low	V Low	150	1,400	2,800	150
Toutle	Contributing	V Low	Med	150	1,400	3,400	800
Kalama	Primary	V Low	High	105	1,400	900	1,400
Lewis NF	Primary	V Low	High	300	2,200	3,900	2,200
Sandy (OR)	Primary	na	High	2,649	2,600	5,200	na
Gorge Fall							
L. Gorge (Hamilton)	Contributing	Low	Med	na	1,400	2,800	700
U. Gorge (Wind)	Stabilizing	Low	Low	138	1,400	2,400	100
White Salmon	Contributing	Low	Med	174	1,600	3,200	900
Hood (OR)	Stabilizing	na	Low+	na	1,400	2,800	na
Gorge Spring							
White Salmon	Contributing	V Low	Low	0	1,400	2,800	400
Hood (OR)	Primary	na	High	0	1,400	2,800	na

Notes (for Table 3 through Table 6)

1. *Primary, contributing, and stabilizing designations are based on priorities identified in the recovery scenario.*
2. *Current viability is based on Technical Recovery Team viability rating approach.*
3. *Viability goal is related to the scenario contribution.*
4. *Recent average numbers are observed 4-year averages or assumed natural spawning escapements. Data typically is through year 2000.*
5. *Viable population size is defined by NOAA's Population Change Criteria. Minimum default values were used where population-specific data were lacking.*
6. *Potential abundance at PFC+ is defined by WDFW's Ecosystem Diagnosis and Treatment (EDT) assessments under properly functioning habitat and historical estuary conditions.*
7. *Abundance goals are interpolated from current, viable, and/or potential numbers based on viability goals.*
8. *These approximations are considered working hypotheses that provide benchmarks for scaling recovery strategies and a reference point for future monitoring, evaluation, and adaptation.*

Table 4. Recovery goals for lower Columbia River chum populations.

Population	Scenario contrib.	Viability		Abundance			
		Current	Goal	Current	Viable	Potential	Goal
Coast							
Grays/Chinook	Primary	Low+	High+	960	4,300	7,800	6,000
Eloch/Skam	Primary	Low	High	<150	1,100	8,200	1,100
Mill/Ab/Germ	Primary	V Low	High	<150	1,100	3,000	1,100
Youngs (OR)	Primary	na	High	na	1,100	2,200	na
Big Creek (OR)	Contributing	na	Low	na	1,100	2,200	na
Clatskanie (OR)	Contributing	na	Med	na	1,100	2,200	na
Scappoose (OR)	Contributing	na	Low	na	1,100	2,200	na
Cascade							
Cowlitz	Contributing	V Low	Med	<150	1,100	135,700	600
Kalama	Contributing	V Low	Low	<150	1,100	12,200	150
Lewis	Primary	V Low	High	<150	1,100	71,000	1,100
Salmon	Stabilizing	V Low	V Low	<150	1,100	4,200	75
Washougal	Primary	Low	High+	<150	1,100	9,400	5,200
Clackamas (OR)	Contributing	na	Med	na	1,100	2,200	na
Sandy (OR)	Primary	na	High	na	1,100	2,200	na
Gorge							
Lower Gorge	Primary	Med+	High+	542	2,600	3,100	2,800
Upper Gorge	Contributing	V Low	Med	<100	1,100	5,900	600

Table 5. Recovery goals for lower Columbia River steelhead populations.

	Scenario	Viability		Abundance			
Population	**contrib.**	**Current**	**Goal**	**Current**	**Viable**	**Potential**	**Goal**
Coast Winter							
Grays/Chinook	Primary[1]	Low+	High	150	600	2,300	600
Eloch/Skam	Contributing[1]	Low+	Med	150	600	1,000	400
Mill/Ab/Germ	Primary[1]	Low+	High	150	600	1,500	600
Cascade Winter							
Lower Cowlitz	Contributing	Low	Med	na	600	1,500	300
Coweeman	Primary	Low+	High	228	800	1,200	800
S.F. Toutle	Primary	Med	High+	453	1,400	1,900	1,600
N.F. Toutle	Primary	Low	High	176	700	3,500	700
Upper Cowlitz	Contributing	Low	Med	0	600	1,600	300
Cispus	Contributing	Low	Med	0	600	1,200	300
Tilton	Contributing	V Low	Low	0	600	1,300	150
Kalama	Primary	Med+	High+	541	600	700	650
N.F. Lewis	Contributing	Low	Med	na	600	3,400	300
E.F. Lewis	Primary	Low+	High	77	600	1,300	600
Salmon	Stabilizing	Low	Low	na	600	1,200	300
Washougal	Contributing	Low+	Med	421	600	1,000	500
Clackamas (OR)	Primary	na	High	277	1,000	2,000	na
Sandy (OR)	Primary	na	High	589	1,800	3,600	na
Cascade Summer							
Kalama	Primary	Low+	High	291	700	1,000	700
N.F. Lewis	Stabilizing	V Low	V Low	na	600	1,200	75
E.F. Lewis	Primary	Low+	High	463	200	400	200
Washougal	Primary	Low+	High+	136	500	900	700
Gorge Winter							
L. Gorge (HHD)	Primary	Low+	High	na	200	300	200
U. Gorge *(Wind)*	Stabilizing	Low+	Low+	na	100	100	50
Hood (OR)	Primary	na	High	436	1,400	2,800	na
Gorge Summer							
Wind	Primary	Med+	High+	391	1,200	1,900	1,600
Hood (OR)	Primary	na	High	154	600	1,200	na

[1] *Not listed under the U.S. Endangered Species Act*

Table 6. Recovery goals for lower Columbia River coho populations.

Population	Scenario contrib.	Viability		Abundance			
		Current	Goal	Current	Viable	Potential	Goal
Coast							
Grays/Chinook	Primary	Low	High	na	600	4,600	600
Eloch/Skam	Primary	Low	High	na	600	7,000	600
Mill/Ab/Germ	Contributing	Low	Med	na	600	3,700	300
Youngs (OR)	Stabilizing	na	Low	na	600	1,200	na
Big Creek (OR)	Primary	na	High	na	600	1,200	na
Clatskanie (OR)	Stabilizing	na	Low	na	600	1,200	na
Scappoose (OR)	Primary	na	High	na	600	1,200	na
Cascade							
Lower Cowlitz	Primary	Low	High	na	600	19,100	600
Coweeman	Primary	Low	High	na	600	7,600	600
S.F. Toutle	Primary	Low	High	na	600	32,900	600
N.F. Toutle	Primary	Low	High	na	600	1,200	600
Upper Cowlitz	Contributing	V Low	Med	na	600	28,800	300
Cispus	Contributing	V Low	Med	na	600	6,600	300
Tilton	Contributing	V Low	Low	na	600	4,000	150
Kalama	Contributing	Low	Med	na	600	1,300	300
NF Lewis	Contributing	Low	High	na	600	5,900	600
EF Lewis	Primary	Low	High	na	600	4,100	600
Salmon	Stabilizing	V Low	V Low	na	600	5,700	75
Washougal	Contributing	Low	Med	na	600	4,200	300
Clackamas (OR)	Primary	na	High+	1,684	600	1,200	na
Sandy (OR)	Primary	na	High+	587	600	1,200	na
Gorge							
L Gorge (Hamilton)	Primary	Low	High	na	600	1,200	600
U Gorge (Wind)	Primary	Low	High	na	600	1,100	600
White Salmon	Contributing	V Low	Low	na	600	1,200	150
Hood (OR)	Contributing	na	Med	na	600	1,200	na

5.4.2 Productivity

Productivity objectives are described in terms of relative improvement increments that identify increases needed to recover populations from current status to medium, high, and high+ levels of population viability consistent with the recovery scenario. Tables 7-10 identify the productivity improvements specified for each population consistent with meeting the overall productivity goal.

Productivity is defined as the inherent population replacement rate and is typically expressed as a median rate of population increase or a spawner recruit per spawner replacement rate. Increments defined in terms of productivity can be directly related to the impacts of specific limiting factors and threats. This provides a basis for systematic quantitative analysis of the effects of factors and threats on population status and viability. It translates the effects of different threats into common units that allow consideration of tradeoffs in strategies and measures among different factor and threat categories. These numbers also provide clear reference points for monitoring population performance as part of plan evaluation and implementation.

Productivity improvements are based on the needed increase relative to the current status. For instance, an improvement of 30% would be necessary to reach a median rate of population increase of 120% corresponding to high viability in a primary population if the current rate was 90% [(120-90)/90]. Equivalent calculations may also be based on Ln(recruits/spawner). Values are based on viable population productivity levels derived by NOAA Fisheries using their Population Change Criteria (PCC) analysis (McElhany et al. 2003) and on estimates of current and potential productivity derived by WDFW using an Ecosystem Diagnosis and Treatment (EDT) analysis (Appendix E of this plan).

Analyses highlight the need for substantial improvements in productivity of almost all populations to reach recovery goals. Net improvement increments for fall Chinook ranged from 0% for stabilizing populations to 200% for at least one population targeted for very high viability. Net productivity improvements for fall Chinook populations targeted for high viability averaged 30%. Improvement increments were undefined for spring Chinook either because access has been eliminated to all historical habitat or because data were inadequate to quantify current populations trends. Net productivity increments to reach high viability were 30-1000% for chum and 10-80% for steelhead. Data were insufficient for comparable estimates for coho but it can be assumed that improvement increments are similar to or greater than those of steelhead. For several populations, productivity improvements were undefined, for instance where dams have completely blocked access to potentially-productive habitats.

Improvement increments highlight order of magnitude improvements needed in each population to reach recovery goals. Population-specific objectives are subject to significant uncertainties in assessments but species averages and ranges provide a general idea of the scale of improvements that need to be addressed by recovery strategies, measures, and actions. This approximation approach is consistent with the scale in other uncertainties associated with all input parameters as well as the effects of specific recovery actions. Given the ultimate uncertainty in the effects of recovery actions and the need to implement an adaptive recovery program, this approximation should be adequate for developing order-of-magnitude estimates to which recovery actions can be scaled consistent with the current best available science and data.

5.4.3 Human Impacts and Threats

This plan also identifies objectives for reducing human impacts and threats that constrain population viability. These incremental improvements are identified as starting points to indicate the general level of effort that will be required from each sector to achieve recovery. Impact reduction objectives describe changes in potentially manageable factors consistent with abundance and productivity objectives. Changes are referenced to a baseline period corresponding to species listing dates. Tables 7-10 identify baseline impacts that quantify effects in each area of human impact (habitat, hydropower, harvest, etc.) and reduced impact levels consistent with meeting the overall productivity goal. Impact objectives address the subset of all threats that can be quantified with productivity impacts as reflected in the Appendix E. Recovery strategies, measures, and actions detailed elsewhere in this plan address both quantifiable and unquantifiable threats. Specific threat criteria are not explicitly identified in this plan but the plan does incorporate substantive strategies and measures to reduce threats in every category.

Impacts are estimates of the proportional reduction in population productivity associated with human-caused and other potentially manageable impacts including stream habitats, estuary/mainstem habitats, hydropower, harvest, hatcheries, and selected predators. Quantifiable impacts include:

- reductions in smolts produced per spawner caused by tributary habitat development relative to historical conditions,
- decreases in mainstem and estuary survival of migrants as a result of habitat changes,
- loss of habitat access and passage mortality due to tributary and mainstem dam construction and operation,
- predation rates by northern pikeminnow mortality, marine mammals, and terns,
- direct and indirect harvest rates from fishing, and
- reductions in natural population fitness and interspecific predation due to hatcheries.

Impact estimates are based on a simple salmon life cycle modeling approach (Adult Equivalent Impacts Occurring Unconditionally or 'AEIOU') developed by the LCFRB for this plan (see Appendix E for detailed methods). This approach has also been used in this plan to illustrate the relative significance of each factor with a series of pie diagrams (Figure 12) shown for each subbasin and population in Volume II of this plan.

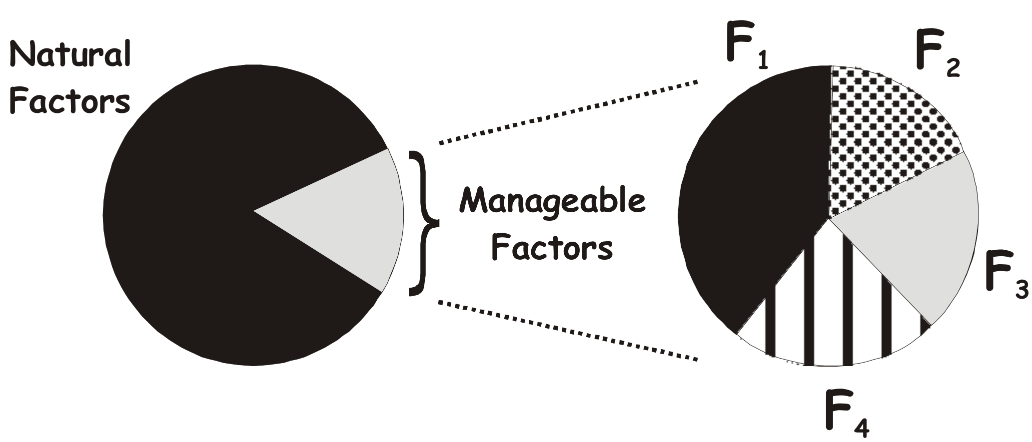


Figure 12. Manageable human factors affecting salmon mortality, productivity, and numbers represented as a portion of all factors and as their own pie.

Incremental improvements needed in each impact factor were estimated from the net productivity improvement needed to reach the population goal, the net effect of human and other potentially manageable impacts, and the distribution of impacts among the factors. The model simply assumes density-independent effects of all impacts but calculations are complicated by the need to translate back and forth between survival rates that can be directly related to productivity and mortality rates that can be directly related to human effects. For instance, a 33% increase in productivity needed to move from current to high viability would require a 33% improvement in net survival throughout the life cycle. Where the combined effects of all impacts produce a 90% reduction in survival [(1-Impact$_1$) (1-Impact$_2$)…(1-Impact$_n$)], the net impact from all factors would need to be reduced to 86.7% to produce an improvement in survival from 10% (100-90) to 13.3% [(10(1 + 0.33)].

Average reductions in each human impact (Δ) are less than the net change in productivity required for the population. Effects of impacts acting at various stages of the salmonid life cycle are multiplicative and compounded. For instance, a 60% habitat quality impact combined with a 60% fishery harvest rate will reduce population productivity by a net 84% {1-[(1-0.6)(1-0.6)}. As a result, improvements in multiple risk factors provide compounding benefits and the benefits of improvement in any given factor are multiplied by benefits in other factors. Incremental improvements in each of multiple impact factors are thus less than the net productivity improvement needed to reach the population objective. For instance, a required 33% improvement increment would require only a 8% improvement per impact where proportional impact reductions were required of six factors. This approach is a simple example of a life cycle analysis and is effective because density-dependent effects for salmon are largely concentrated in freshwater stream habitats and thus do not confound extrapolations of other impacts on net population productivity.

Population productivity improvement increments are ultimately translated into target values for each human impact. Thus to move our example population to high viability as specified by the recovery scenario, the 30% improvement in net productivity would require an 8% improvement for each impact factor. Thus, tributary habitat impacts might need to be reduced from 70% to 64% [(1-0.08)(70)], fishery impacts might need to be reduced from 5% to 4.6% [(1-0.08)(5)], and so on. These estimates assume net improvements for each human factor in proportion to the magnitude of the impact. Larger impacts would need to make larger net contributions than smaller impacts because X% of a large factor is greater than X% of a small factor. For instance, a net 6% reduction in habitat impacts (70%-64%) represents a greater change than a net 0.4% reduction in fishery impacts (5%-4.6%) in the example where habitat impacts represent a much larger share of the problem.

Analyses demonstrate the compounding benefits of improvements in multiple areas. This synergism of benefits means that recovery is imminently realistic if multiple impact factors can be affected. Analyses also confirm that recovery will require significant improvements in multiple risk factors. It is rarely feasible to reach recovery goals based solely on improvements in any single risk factor. Required improvement increments are primarily driven by the largest impacts among the various factors. The smaller impacts (<10%) generally have limited power to affect significant changes. Recovery flexibility is constrained by among-population and among-species requirements. Even where productivity improvements in any given population are modest, requirements in other populations or species typically demand more significant improvements in any given risk factor.

Desired future conditions consistent with these biological objectives are not identified by this plan because the available scientific information and methods is inadequate for making robust estimates of these values and because many different combinations of future conditions can be expected to meet the biological objectives. Definition of any given combination of desired future conditions for habitat for instance might artificially constrain flexibility in implementation and adaptive management efforts. Benchmark conditions such as an historical template or NOAA's properly functioning habitat (PFC) conditions provide useful indicators of the direction recovery strategies and actions should take to produce desired improvements in fish status toward the biological objectives. However, historical template and PFC conditions do not represent conditions that must be achieved to meet viability or use objectives. It is likely that many populations would be healthy and harvestable if historical template or PFC conditions were restored. However, it is also likely that healthy and harvestable objectives can be achieved at levels substantially less than historical template or PFC conditions.

Table 7. Productivity improvements and impact reduction objectives consistent with recovery of lower Columbia River Chinook populations.

	Prod.	Baseline impacts							Impacts at goal					
Population	**Incr.**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**	**Δ**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**
Coast Fall														
Grays/Chinook	30%	0.37	0.35	0.00	0.22	0.65	0.19	8%	0.34	0.32	0.00	0.20	0.59	0.18
Eloch/Skam	30%	0.30	0.35	0.00	0.23	0.65	0.40	8%	0.34	0.32	0.00	0.20	0.59	0.36
Mill/Aber/Germ	20%	0.56	0.35	0.00	0.23	0.65	0.24	4%	0.54	0.34	0.00	0.22	0.62	0.23
Youngs Bay (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Big Creek (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clatskanie (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scappoose (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Fall														
Lower Cowlitz	20%	0.64	0.37	0.00	0.23	0.65	0.47	4%	0.61	0.36	0.00	0.23	0.62	0.45
Upper Cowlitz	0%	0.71	0.38	1.00	0.23	0.65	0.20	--	--	--	--	--	--	--
Toutle	0%	0.56	0.36	0.00	0.23	0.65	0.31	0%	0.56	0.36	0.00	0.23	0.65	0.31
Coweeman	200%	0.44	0.30	0.00	0.23	0.65	0.00	40%	0.26	0.18	0.00	0.14	0.39	0.00
Kalama	30%	0.43	0.27	0.00	0.24	0.65	0.27	7%	0.40	0.25	0.00	0.22	0.61	0.25
Lewis/Salmon	230%	0.53	0.32	0.00	0.24	0.65	0.01	39%	0.32	0.20	0.00	0.14	0.39	0.00
Washougal	30%	0.47	0.29	0.00	0.24	0.65	0.20	7%	0.43	0.27	0.00	0.23	0.61	0.19
Clackamas (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sandy (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade L Fall														
Lewis NF	110%	0.16	0.39	0.07	0.24	0.50	0.17	35%	0.11	0.26	0.05	0.16	0.33	0.11
Sandy (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Spring														
Upper Cowlitz	--	0.82	0.20	0.90	0.31	0.53	0.27	--	--	--	--	--	--	--
Cispus	--	0.88	0.20	1.00	0.31	0.53	0.27	--	--	--	--	--	--	--
Tilton	--	--	0.20	1.00	0.31	0.53	0.27	--	--	--	--	--	--	--
Toutle	--	1.00	0.20	0.00	0.31	0.53	0.45	--	--	--	--	--	--	--
Kalama	--	0.92	0.20	0.00	0.31	0.53	0.45	--	--	--	--	--	--	--
Lewis NF	--	0.81	0.20	0.90	0.31	0.53	0.45	--	--	--	--	--	--	--
Sandy (OR)	--	0.63	0.20	0.92	0.34	0.53	0.70	--	--	--	--	--	--	--
Gorge Fall														
L. Gorge (Hamilton)	10%	0.45	0.29	0.20	0.25	0.65	0.29	3%	0.44	0.28	0.19	0.24	0.63	0.28
U. Gorge (Wind)	10%	0.63	0.30	0.60	0.27	0.65	0.19	0%	0.63	0.30	0.60	0.27	0.65	0.19
White Salmon			0.30	0.60	0.27	0.65	0.11	--	--	--	--	--	--	--
Hood (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gorge Spring														
White Salmon	--	--	0.20	0.92	0.34	0.53	0.70	--	--	--	--	--	--	--
Hood (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 8. Productivity improvements and impact reduction objectives consistent with recovery of lower Columbia River chum populations.

	Prod.	Baseline impacts							Impacts at goal					
Population	**Incr.**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**	**Δ**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**
Coast														
Grays/Chinook	90%	0.85	0.28	0.00	0.22	0.05	0.03	14%	0.73	0.24	0.00	0.19	0.04	0.02
Eloch/Skam	50%	0.86	0.28	0.00	0.23	0.05	0.03	7%	0.80	0.26	0.00	0.21	0.05	0.03
Mill/Ab/Germ	60%	0.88	0.28	0.00	0.23	0.05	0.03	7%	0.81	0.26	0.00	0.22	0.05	0.02
Youngs (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Big Creek (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clatskanie (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scappoose (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade														
Cowlitz	40%	0.96	0.59	0.00	0.23	0.05	0.11	2%	0.95	0.58	0.00	0.23	0.05	0.11
Kalama	30%	0.92	0.51	0.00	0.24	0.05	0.03	2%	0.90	0.50	0.00	0.23	0.05	0.03
Lewis	30%	0.93	0.58	0.00	0.24	0.05	0.04	2%	0.91	0.57	0.00	0.23	0.05	0.04
Salmon	0%	1.00	0.58	0.00	0.24	0.05	0.00	0%	1.00	0.58	0.00	0.24	0.05	0.00
Washougal	350%	0.96	0.58	0.00	0.24	0.05	0.01	11%	0.86	0.51	0.00	0.22	0.04	0.01
Clackamas (OR)	--	--	--	--	--	--	--							
Sandy (OR)	--	--	--	--	--	--	--							
Gorge														
Lower Gorge	90%	0.86	0.38	0.20	0.25	0.05	0.01	11%	0.77	0.33	0.18	0.22	0.04	0.00
Upper Gorge	960%	0.50	0.56	0.96	0.27	0.05	0.07	22%	0.39	0.44	0.75	0.21	0.04	0.06

Table 9. Productivity improvements and impact reduction objectives consistent with recovery of lower Columbia River steelhead populations.

	Prod.	Baseline impacts							Impacts at goal					
Population	Incr.	Trib	Est	Dams	Pred	Harv	Hat	Δ	Trib	Est	Dams	Pred	Harv	Hat
Coast Winter														
Grays/Chinook	20%	0.677	0.183	0.000	0.224	0.100	0.038	0.059	0.64	0.17	0.00	0.21	0.09	0.04
Eloch/Skam	10%	0.515	0.183	0.000	0.230	0.100	0.065	0.040	0.49	0.18	0.00	0.22	0.10	0.06
Mill/Ab/Germ	20%	0.441	0.183	0.000	0.233	0.100	0.040	0.108	0.39	0.16	0.00	0.21	0.09	0.04
Cascade Winter														
Lower Cowlitz	10%	0.885	0.109	0.000	0.235	0.100	0.276	0.010	0.88	0.11	0.00	0.23	0.10	0.27
Coweeman	30%	0.730	0.150	0.000	0.235	0.100	0.161	0.088	0.67	0.14	0.00	0.21	0.09	0.15
S.F. Toutle	80%	0.820	0.112	0.000	0.235	0.100	0.006	0.142	0.70	0.10	0.00	0.20	0.09	0.01
N.F. Toutle	10%	0.900	0.112	0.000	0.235	0.100	0.000	0.010	0.89	0.11	0.00	0.23	0.10	0.00
Upper Cowlitz	--	0.498	0.137	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Cispus	--	0.520	0.136	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Tilton	--	0.854	0.137	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Kalama	50%	0.497	0.127	0.000	0.236	0.100	0.031	0.281	0.36	0.09	0.00	0.17	0.07	0.02
N.F. Lewis	10%	0.586	0.104	0.952	0.239	0.100	0.231	0.005	0.58	0.10	0.95	0.24	0.10	0.23
E.F. Lewis	30%	0.749	0.132	0.000	0.239	0.100	0.357	0.067	0.70	0.12	0.00	0.22	0.09	0.33
Salmon	10%	0.869	0.132	0.000	0.243	0.100	0.357	0.010	0.86	0.13	0.00	0.24	0.10	0.35
Washougal	0%	0.743	0.124	0.000	0.243	0.100	0.350	0.010	0.74	0.12	0.00	0.24	0.10	0.35
Clackamas (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sandy (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Summer														
Kalama	10%	0.348	0.043	0.000	0.236	0.100	0.035	0.075	0.32	0.04	0.00	0.22	0.09	0.03
N.F. Lewis	--	0.586	0.586	0.500	0.239	0.100	0.651	0.000	0.59	0.59	0.50	0.24	0.10	0.65
E.F. Lewis	10%	0.790	0.043	0.000	0.239	0.100	0.189	0.020	0.77	0.04	0.00	0.23	0.10	0.19
Washougal	50%	0.707	0.049	0.000	0.243	0.100	0.175	0.135	0.61	0.04	0.00	0.21	0.09	0.15
Gorge Winter														
L. Gorge (HHD)	20%	0.561	0.134	0.000	0.246	0.100	0.007	0.085	0.51	0.12	0.00	0.23	0.09	0.01
U. Gorge *(Wind)*	10%	0.750	0.106	0.154	0.273	0.100	0.000	0.022	0.73	0.10	0.15	0.27	0.10	0.00
Hood (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gorge Summer														
Wind	50%	0.673	0.090	0.154	0.273	0.100	0.147	0.146	0.58	0.08	0.13	0.23	0.09	0.13
Hood (OR)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10. Productivity improvements and impact reduction objectives consistent with recovery of lower Columbia River coho populations.

Population	Prod. Incr.	Baseline impacts Trib	Est	Dams	Pred	Harv	Hat	Δ	Impacts at goal Trib	Est	Dams	Pred	Harv	Hat
Coast														
Grays/Chinook	na	0.715	0.287	0	0.224	0.510	0.477	na	na	na	na	na	na	na
Eloch/Skam	na	0.790	0.179	0	0.230	0.510	0.508	na	na	na	na	na	na	na
Mill/Ab/Germ	na	0.766	0.179	0	0.233	0.510	0.440	na	na	na	na	na	na	na
Youngs (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Big Creek (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Clatskanie (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Scappoose (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Cascade														
Lower Cowlitz	na	0.765	0.179	0	0.235	0.510	0.321	na	na	na	na	na	na	na
Coweeman	na	0.778	0.179	0	0.235	0.510	0.114	na	na	na	na	na	na	na
S.F. Toutle	na	0.888	0.179	0	0.235	0.510	0.258	na	na	na	na	na	na	na
N.F. Toutle	na	0.888	0.179	0	0.235	0.510	0.271	na	na	na	na	na	na	na
Upper Cowlitz	na	0.239	0.179	1.000	0.235	0.510	0.288	na	na	na	na	na	na	na
Cispus	na	0.423	0.191	1.000	0.235	0.510	0.288	na	na	na	na	na	na	na
Tilton	na	0.942	0.194	1.000	0.235	0.510	0.288	na	na	na	na	na	na	na
Kalama	na	0.629	0.194	0	0.236	0.510	0.311	na	na	na	na	na	na	na
NF Lewis	na	0.607	0.194	0.952	0.239	0.510	0.245	na	na	na	na	na	na	na
EF Lewis	na	0.751	0.194	0	0.239	0.510	0.235	na	na	na	na	na	na	na
Salmon	na	0.853	0.194	0	0.243	0.510	0.201	na	na	na	na	na	na	na
Washougal	na	0.790	0.194	0	0.243	0.510	0.463	na	na	na	na	na	na	na
Clackamas (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Sandy (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na
Gorge														
L Gorge (Hamilton)	na	0.798	0.194	0	0.246	0.510	0.455	na	na	na	na	na	na	na
U Gorge (Wind)	na	0.558	0.194	0.154	0.273	0.510	0.448	na	na	na	na	na	na	na
White Salmon	na	0.558	0.194	1.000	0.273	0.510	0.448	na	na	na	na	na	na	na
Hood (OR)	na	--	--	--	--	--	--	na	na	na	na	na	na	na

Notes (for Table 7 *through* Table 10*)*

1. *Productivity increment indicates needed improvements to reach population viability goal.*
2. *Improvement increments were inferred using existing analytical frameworks including PCC assessments conducted by NOAA Fisheries and EDT assessments conducted by WDFW.*
3. *Productivity improvements for contributing populations were based on half the distance between current productivity and productivity at viability.*
4. *Productivity reference points for populations targeted for High$^+$ viability were based on half the distance between viable and potential productivity. Potential productivity (the top end of the planning range) was based on EDT estimates under favorable habitat conditions in the subbasin, mainstem, and estuary (PFC+). This assumes that persistence probability will approach 100% in many populations under conditions well below historical population levels and properly functioning habitat conditions.*
5. *Species average increments were used for populations where component data were lacking.*
6. *Baseline impacts are effects on productivity at the time of ESA listing for tributary habitat conditions, estuary habitat conditions, hydropower dams, mainstem predation, harvest, and hatcheries.*
7. *Δ refers to proportional reduction in each impact needed to reach productivity improvement and viability goals. (Δ is less than the net productivity improvement because of compounding benefits of changes in each impact factor.)*
8. *Impacts at goal are values consistent with productivity and viability goals where reductions in each factor are evenly distributed in proportion to baseline impacts.*
9. *Uncertainties in the various parameters upon which this analysis is based sometimes produce inconsistent results for specific populations.*
10. *Missing values include: i) Oregon populations for which no EDT is available, ii) extirpated populations for which productivity improvements relative to a zero baseline are undefined, and iii) populations for which PCC and trend data are lacking for any representative (spring Chinook).*
11. *Average species and run type values for viability or incremental improvements needed to reach viability were used for populations where PCC and trend data were lacking. This assumes populations where data were present are representative where data are not. This assumption is probably optimistic because data is typically collected on the most significant populations. As a result, needed improvement increments are likely to be underestimates.*
12. *Improvement increments do not consider effects of measures implemented since listing.*
13. *Improvement increments do not explicitly include contingencies for large-scale risks such as regional or local trends in increasing development pressure, climate change, or exotic species invasions. (However, historic trends in abundance used to estimate productivity increments might capture continuing trends.)*
14. *Productivity improvements are approximations based on existing data and assessments. These approximations are considered working hypotheses that provide benchmarks for scaling recovery strategies and a reference point for future monitoring, evaluation, and adaptation.*

5.4.4 Other Viable Salmonid Population Parameters

The WLC-TRT developed guidelines based on a series of viable salmonid population (VSP) parameters including abundance, productivity, spatial structure, diversity, juvenile numbers, and habitat. This plan identifies specific quantitative abundance and productivity objectives for each listed population. Benchmarks values are also identified for other VSP parameters to provide a systematic basis for their consideration during plan implementation and evaluation (Table 11). All VSP parameters will be evaluated in future assessments of population status (using the TRT's scoring system).

Specific objectives were not identified for VSP parameters other than abundance and productivity because many different combinations of specific parameters can be expected to achieve the overarching population objectives. This approach allows for flexibility in tailoring recovery strategies to the threats and opportunities in each area without providing artificial constraints related to piecemeal representation of population parameter objectives. Definition of a series of specific subgoals for each other VSP parameter would unnecessarily burden plan implementers and evaluators with constraints that may not ultimately be related to overarching viability goals. Specific values of many VSP parameters associated with a given level of viability are also highly uncertain and it would be entirely possible to meet the overarching goals but fail some of the secondary goals.

Benchmark values for all VSP parameters were developed in this plan based on general guidance from the WLC-TRT and the VSP concept (McElhany et al. 2000). These benchmarks provide systematic standards for gauging future population status relative to all parameters identified by the WLC-TRT as related to viability. It is expected that specific benchmark values for other VSP parameters will be refined during plan implementation based on new information that addresses current uncertainties.

Benchmark values for all VSP parameters also provide a framework for designing strategies, measures, and actions necessary to substantively address limiting factors related to population viability. This plan identifies substantive measures to address all significant categories of threats including stream habitat, estuary/mainstem habitat, hydropower, harvest, hatcheries, and ecological interactions. This comprehensive treatment of threats can be expected to address the full suite of VSP parameters within populations. Improvements in all mortality factors and impacts will increase fish abundance and realized spawner:spawner productivity. Stream habitat improvements will directly address habitat criteria, increase freshwater production of juveniles, expand distribution, and enhance spatial structure. Improvements in abundance, productivity, and spatial structure will help restore normal evolutionary processes which will help preserve and begin rebuilding diversity. Hydropower actions, particularly related to reintroduction and passage will help restore spatial structure and diversity. Hatchery strategies, measures, and actions will also help protect existing diversity.

Table 11. Benchmarks for evaluating fish status relative to recovery criteria guidelines.

Category	Description	Values[1]
	Population Persistence	
0	Either extinct or very high risk of extinction	Very low (0-40%) probability of persistence for 100 years
1	Relatively high risk of extinction	Low (40-75%) probability of persistence for 100 years
2	Moderate risk of extinction	Medium (75-95%) probability of persistence for 100 years
3	Low (negligible) risk of extinction	High (95-99%) probability of persistence for 100 years
4	Very low risk of extinction	Very High (>99%) probability of persistence for 100 years
	Adult Abundance and Productivity	
0	Numbers and productivity consistent with either functional extinction or very high risk of extinction	Extinction risk analysis estimates 0-40% persistence probability.
1	Numbers and productivity consistent with relatively high risk of extinction	Extinction risk analysis estimates 40-75% persistence probability.
2	Numbers and productivity consistent with moderate risk of extinction	Extinction risk analysis estimates 75-95% persistence probability.
3	Numbers and productivity consistent with low (negligible) risk of extinction	Extinction risk analysis estimates 95-99% persistence probability.
4	Numbers and productivity consistent with very low risk of extinction	Extinction risk analysis estimates >99% persistence probability.
	Juvenile Out-Emigrants	Evaluated based on the *occurrence* of natural production, whether natural production was *self sustaining* or supplemented by hatchery fish*, trends* in numbers, and *variability* in numbers.
0	Consistent with either functional extinction or very high risk of extinction[3]	No significant juvenile production either because no natural spawning occurs or because natural spawning by wild or hatchery fish occurs but is unproductive.
1	Consistent with relatively high risk of extinction[3]	Long term trend in wild natural production is strongly negative. Also includes the case where significant natural production occurs in many years but originates primarily from hatchery fish.
2	Consistent with moderate risk of extinction[3]	Sample data indicates that significant natural production occurs in most years and originates primarily from naturally-produced fish. No trend in numbers may be apparent but numbers are highly variable with only a small portion of the variability related to spawning escapement.
3	Consistent with low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. No long term decreasing trend in numbers is apparent. Juvenile numbers may be variable but at least some of this variability is related to fluctuations in spawning escapement.
4	Consistent with very low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. Trend is stable or increasing over extended time period. Variability in juvenile production is low or a large share of the observed variability is correlated with spawning escapement.

Category	Description	Values[1]
	Within-Population Spatial Structure	
0	Spatial structure is inadequate in quantity, quality[2], and connectivity to support a population at all.	*Quantity* was based on whether all areas that were historically used remain accessible. *Connectivity* based on whether all accessible areas of historical use remain in use. *Catastrophic risk* based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.
1	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population far below viable size	The majority of the historical range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.
2	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population of moderate but less than viable size.	The majority of the historical range is accessible but fish are currently concentrated in a small portion of the accessible area.
3	Spatial structure is adequate in quantity, quality[2], and connectivity to support population of viable size, but subcriteria for dynamics and/or catastrophic risk are not met	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.
4	Spatial structure is adequate to quantity, quality, connectivity, dynamics, and catastrophic risk to support viable population.	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.
	Within-Population Diversity	
0	All four diversity elements (life history diversity, gene flow and genetic diversity, utilization of diverse habitats, and resilience and adaptation to environmental fluctuations) are well below predicted historical levels, extirpated populations, or remnant populations of unknown lineage	*Life history diversity* was based on comparison of adult and juvenile migration timing and age composition. *Genetic diversity* was based on the occurrence of small population bottlenecks in historical spawning escapement and degree of hatchery influence especially by non local stocks. *Resiliency* was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.
1	At least two diversity elements are well below historical levels. Population may not have adequate diversity to buffer the population against relatively minor environmental changes or utilize diverse habitats. Loss of major presumed life history phenotypes is evident; genetic estimates indicate major loss in genetic variation and/or small effective population size. Factors that severely limit the potential for local adaptation are present.	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.
2	At least one diversity element is well below predicted historical levels; population diversity may not be adequate to buffer strong environmental variation and/or utilize available diverse habitats. Loss of life history phenotypes, especially among important life history traits, and/or reduction in genetic variation is evident. Factors that limit the potential for local adaptation are present.	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.

Category	Description	Values[1]
3	Diversity elements are not at predicted historical levels, but are at levels able to maintain a population. Minor shifts in proportions of historical life-history variants, and/or genetic estimates, indicate some loss in variation (e.g. number of alleles and heterozygosity), and conditions for local adaptation processes are present.	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.
4	All four diversity elements are similar to predicted historical levels. A suite of life-history variants, appropriate levels of genetic variation, and conditions for local adaptation processes are present.	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.
	Habitat	
0	Habitat is incapable of supporting fish or is likely to be incapable of supporting fish in the foreseeable future	*Unsuitable habitat.* Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historical range are addressed by spatial structure criteria[2].
1	Habitat exhibits a combination of impairment and likely future conditions such that population is at high risk of extinction	*Highly impaired habitat.* Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur in only in favorable years.
2	Habitat exhibits a combination of current impairment and likely future condition such that the population is at moderate risk of extinction	*Moderately impaired habitat.* Significant degradation in habitat quality associated with reduced population productivity.
3	Habitat in unimpaired and likely future conditions will support a viable salmon population	*Intact habitat.* Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)
4	Habitat conditions and likely future conditions support a population with an extinction risk lower than that defined by a viable salmon population. Habitat conditions consistent with this category are likely comparable to those that historically existed.	*Favorable habitat.* Quality is near or at optimums for salmon. Includes properly functioning through pristine historical conditions.

[1] Rules were derived by the LCFRB and WDFW staff for attribute descriptions from McElhany et al. 2003. Application rules do not represent assessment by the Technical Recovery Team.

[2] Because recovery criteria are closely related, draft category descriptions developed by the Technical Recovery Team often incorporate similar metrics among multiple criteria. For instance, habitat-based factors have been defined for diversity, spatial structure, and habitat standards. To avoid double counting the same information, streamline the scoring process, and provide for a systematic and repeatable scoring system this application of the criteria used specific metrics only in the criteria where most applicable. This footnote denotes these items.

[3] This is a modification of the interim JOM criteria identified by the TRT. JOM scores consistent with persistence probabilities for other criteria. Consistent with an attempt to avoid double counting similar information in different criteria, data quality considerations were not included in the revised JOM criteria descriptions because they are scored separately for all criteria. This modification removes confounding effects of cases where no JOM data is available and provides

5.4.5 Harvestability Goals

The vision of this plan is for restoration of viable and harvestable naturally-producing salmon populations. This vision will be realized when:

1. The majority of natural populations have recovered to viable levels and are harvestable in the vast majority of years.
2. Natural populations are productive enough to produce fish at levels which will replace hatchery production and provide even more fishery opportunity, in terms of total catch, than currently is available with the hatchery production.

Harvestable species, ESUs and populations occur when adult production exceeds the population goal and viability level and can be directly harvested at levels that maintain spawning escapement at or above the biological objective. When adult production is less than the biological objective and less than viable, it is not considered harvestable and will only be subject to indirect harvest impacts associated with fisheries targeting other species and populations. These indirect rates will be controlled by ESA harvest impact limits. North Lewis and Hanford Reach natural produced fall chinook are good examples of harvestable naturally produced populations which consistently provide significant ocean and freshwater harvest opportunity.

Improvement increments described in the previous section describe reductions in current direct and indirect fishery impacts on wild populations needed to improve biological status to levels identified in the preferred recovery scenario. The long term vision involves increasing allowable fishing rates on natural populations as the benefits of other recovery measures are realized. For instance, fisheries on natural populations can be phased in as habitat restoration improves fish productivity to the point where natural populations again produce a harvestable surplus in addition to escapement needs for sustaining a viable population.

Increasing natural population productivity and numbers expected in response to implementation of this plan, can be expected to increase the numbers of harvestable wild fish over time and to increase the frequency of years where salmon and steelhead populations produce harvestable numbers. Increasing salmonid numbers can also be expected to provide a variety of other fishery benefits including more consistent seasons and fewer restrictions to access of harvestable numbers of fish of other stocks. Sustainable harvest rates will be based on realized improvements in population viability and productivity.

5.5 Bull Trout

Objectives: ***1) maintain current distribution within core areas and restore distribution in additional areas, 2) maintain stable or increasing trends in abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, and 4) conserve genetic diversity and provide opportunity for genetic exchange. (as per Draft Bull Trout Recovery Plan, USFWS 2002)***

Bull trout are listed as threatened under the ESA and are under the jurisdiction of the USFWS. Bull trout are subject of a draft recovery plan, although the USFWS recently decided to delay finishing the recovery plan in lieu of a 5-year review of the bull trout listing. The overarching goal of the bull trout recovery plan is to ensure the long-term persistence of self-sustaining, complex interacting groups (or multiple local populations that may have overlapping spawning and rearing areas) of bull trout distributed across the species' native range. In the lower Columbia, bull trout were believed to be historically distributed in the some large subbasins including the Lewis River and Columbia River upper Gorge tributaries. Of the subbasins addressed by this plan, bull trout currently occur only in the upper Lewis River. Bull trout were reported in the White Salmon River as recently as 1989 but have not been observed since despite focused sampling efforts. In the USFWS bull trout recovery plan, the Lewis, White Salmon, and Klickitat rivers have been identified as core bull trout habitats for the Lower Columbia Recovery Unit.

5.6 Other Fish and Wildlife Species

5.6.1 Other Sensitive Species

Bald Eagle

Objective: ***Increase the viability of the bald eagle breeding population in the lower Columbia River, particularly through increased reproductive success.***

Bald eagles are listed as threatened under the federal ESA; they are also culturally important throughout the Pacific Northwest. Bald eagles are an indicator of a large, mature treed, habitat and may be a good species to help monitor environmental contaminants. Reproductive success of the local population is low, presumably as a result of environmental contaminants and their effects on eggshell thinning. Adult abundance in the local population has remained relatively stable in recent years, but appears to be maintained by adult immigration from adjacent populations.

Sandhill Crane

Objective: ***Support and maintain the wintering population of sandhill cranes in the lower Columbia River, while limiting crop depredation.***

Sandhill cranes have ecological, recreational (wildlife viewing) and management significance, along with potentially negative economic (crop depredation) impact. They are a Washington state listed species. Because of their migratory life history, sandhill cranes are protected by the Migratory Bird Treaty Act. This objective involves protecting and expanding availability of winter habitat (particularly on public lands).

Dusky Canada Goose

Objective: Reverse the declining abundance trend and maintain a wintering population in the lower Columbia River, while limiting crop depredation.

The dusky Canada goose has ecological, management, and potentially negative economic (crop depredation) significance. The dusky Canada goose is classed as a migratory bird by federal regulation and thus protected by the Migratory Bird Treaty Act. It is considered a game bird by Washington rule. The Pacific Flyway and Washington Fish and Wildlife Commission regulate harvest. This objective involves protecting and expanding availability of winter habitat (particularly on public lands) and managing goose harvest to minimize impacts to duskys.

Columbian White-tailed Deer

Objective: Increase productivity and abundance, thereby creating a stable, viable population.

The Columbian white-tailed deer is listed as endangered under the federal ESA and is classified as endangered by Washington and Oregon. They are present in the upper estuary and along the river corridor; approximately 300-500 deer are present in this area. Habitat conversion to agricultural land, habitat loss, and low population productivity are currently the most important threats to the population. This objective involves protecting and restoring oak/Douglas fir forest within 200m of a stream/river, enforcing poaching regulations, minimizing negative human-interaction (auto collisions, fence entanglement, etc.), and protecting the population from flooding, particularly during times of fawning.

Fisher

Objective: Minimize risks to populations in the process of becoming established while increasing quantity and quality of habitat and minimizing incidental mortality.

The fisher is a Washington state endangered species and a federal species of concern. Scattered Within the Little White Salmon River subbasin, fishers may be found in multiple types of mixed conifer-hardwood forests. Limiting factors include loss of large tracts of low and mid elevation old growth or late seral forest, habitat fragmentation, stand replacement fires, incidental mortality from vehicle collisions or trapping for other species, and small population risks.

Western Gray Squirrel

Objective: Increase quantity and quality of habitat and reduce effects of nonnative species.

The western gray squirrel is a Washington state threatened species and a Federal species of concern. Within the Little White Salmon River subbasin, western gray squirrels may be found in mesic lowland conifer-hardwood forest in close proximity to westside white oak – dry Douglas fir forest. Limiting factors include loss of large tracts of old growth or late seral forest and increased disease or competition with introduced squirrel species.

Seals and Sea Lions

Objective: Maintain current seasonal population abundance while limiting predation risks to adult salmonids.

Harbor seals, California sea lions, and Steller sea lions are seasonal residents of the lower Columbia estuary and mainstem. Steller sea lions are listed as threatened under the federal ESA. All seals and sea lions are also protected by the Marine Mammal Protection Act. Seals and sea lions are ecologically important in the Columbia River estuary and lower mainstem and are a predator of adult salmonids.

Western Pond Turtle

***Objective:* Reverse the declining abundance trend in Washington and re-establish in the Puget Sound and Columbia Gorge regions at least 5 self-sustaining populations of >200 turtles composed of no more than 70% adults.**

The western pond turtle is listed in the state of Washington as endangered; there are an estimated 250-350 western pond turtles in Washington. The only remaining western pond turtles in the state are thought to consist of two small populations in Skamania and Klickitat counties, as well as a small pond complex in Pierce County where they were recently reintroduced from head-started juveniles from wild nests. This objective involves protection of the existing populations and their associated habitat, evaluation of introduced species (bullfrogs, warm-water fish, or opossum) effects on pond turtle population viability, and investigation of captive bred stock for reintroduction to additional wetland/ pond habitats. The core pond turtle sites should be wetland complexes that may be less susceptible to catastrophes than sites of a single water body.

The WDFW wrote a recovery plan for the species in Washington in 1999 (Hays et al. 1999). The recovery plan objectives are to have a total of 7 populations with more than 200 turtles each in two recovery areas – 3 in Puget Sound and 4 in the Columbia River Gorge. Achieving this recovery objective requires an ongoing program of captive breeding, head-starting wild-hatched turtles, and reintroduction until population numbers are increased to ensure the species' survival in the state.

The establishment of additional populations is needed to reduce the risk of potential loss of the species through catastrophic or other unforeseen circumstances. Threats to the pond turtle populations are predation by introduced predators such as bullfrogs, illegal shooting, mortality from vehicle collisions and disease. Increasing both the number of populations and population sizes can mitigate some of these threats.

Oregon Spotted Frog

***Objective:* Increase quantity and quality of habitat and reduce effects of nonnative species.**

The Oregon spotted frog is listed as endangered in the State of Washington and is a federal candidate for protection under the Endangered Species Act. Oregon spotted frogs are closely associated with open water habitat and may be present in any number of forested or wetland habitats that are intertwined with open water. Limiting factors include loss of wetlands, decreae in water quality, displacement of native plant communities by introduced species, and competition and predation by bullfrogs and introduced fish species.

Larch Mountain Salamander

***Objective:* Increase quantity and quality of habitat and minimize use of key habitats.**

Larch Mountain salamander distribution includes west-side habitats of the southern Cascades region in Washington and the Columbia Gorge area of Oregon and Washington. Larch Mountain salamanders depend on cool, moist environments; they require a suitable combination of slope, rock size, shade, and organic debris. Populations of Larch Mountain salamanders are small, isolated, and occur in a limited geographic area. This salamander is sedentary and its very specific habitat requirements may hinder dispersal.

5.6.2 Species of Ecological Significance

Coastal Cutthroat Trout

Objective: ***Reverse declining abundance trends and maintain life history diversity (resident, fluvial, and anadromous forms).***

The coastal cutthroat trout subspecies was a candidate for listing as threatened, but the USFWS determined that an ESA-listing was not warranted. However, in April 1999, NMFS and the USFWS issued a joint proposed rule for the listing of the anadromous form of coastal cutthroat in Southwest Washington and the Columbia River, including cutthroat trout in Columbia River tributaries downstream from the Klickitat River. At present, WDFW describes coastal cutthroat as depressed in many subbasins of the lower Columbia River because of long-term negative trends or short-term severe declines. This objective involves protecting existing functioning habitats, restoring other subbasin habitats toward historic conditions, and increasing research efforts to determine the abundance, distribution, migration patterns, and population viability of the various life forms

White Sturgeon

Objective: ***Continue management for a viable population that will maintain sufficient abundance to meet the continued cultural, economic, and ecological needs.***

White sturgeon are culturally, economically, and ecologically important in the lower Columbia River ecosystem; the lower Columbia population is among the largest and most productive in the world. Lower Columbia River white sturgeon support tribal and non-Indian commercial and recreational fisheries and serve as a top predator in the aquatic food web. This objective involves protecting large adult spawners; regulating harvest to sustainable levels; maintaining suitable spawning, incubation, and rearing habitats and flow conditions in the Columbia River Gorge and dam tailraces; monitoring ecological effects of non-indigenous species; and conducting future dredging operations in such a way as to minimize direct and indirect mortality of incubating eggs and juvenile sturgeon.

Green Sturgeon

Objective: ***Continue management for a viable population that will maintain sufficient abundance to meet the continued cultural, economic, and ecological needs.***

Green sturgeon are seasonal residents of the Columbia River estuary and originate from spawning populations in California and southern Oregon rivers. Considerably less is know about green sturgeon than white sturgeon. Lower Columbia River green sturgeon are incidentally harvested in commercial and recreational fisheries. This objective involves identifying the factors related to green sturgeon use of the estuary and lower mainstem (timing, habitat use, diet analysis, etc.); regulating harvest to sustainable levels; and monitoring ecological effects of non-indigenous species.

Eulachon (Smelt)

Objective: ***Maintain or increase annual population abundance to continue to provide forage value for other species and harvest opportunities for commercial and recreational fisheries.***

Eulachon are an anadromous species that use unique spawning habitat in the estuary, lower mainstem, and some tributaries. This objective involves managing the lower Columbia run as one population; increasing annual abundance to near historic levels, thus supporting an average annual commercial harvest of at least 2 million pounds; conducting research to reduce the uncertainty regarding all aspects of juvenile life history and ocean usage; avoiding disturbance of incubating eggs and juveniles, particularly by ceasing dredging or other activities in spawning areas during the January 1st to May 31st time period.

Pacific Lamprey

Objective: Reverse the decreasing abundance trend and manage for populations that can meet cultural and ecological needs.

Lamprey are culturally and ecologically important in the lower Columbia River ecosystem; they have served as an important food source for native peoples and for many Columbia River mainstem and estuary inhabitants (sturgeon, pinnipeds). The objective will require substantial increases in our understanding of the species. At present, research needs include: determining adult swimming and migratory capabilities and the degree of spawning site fidelity; quantifying the level of predation on migrating adults; identifying spawning locations, habitat characteristics, and incubation survival; determining habitat requirements and duration of freshwater residency of juvenile lamprey in the subbasins, mainstem, and estuary; and rectifying difficulties in abundance estimates because of repeated up and downstream movement.

Northern Pikeminnow

Objective: Decrease predation on juvenile salmonids by reducing the number of larger, predaceous pikeminnow in the population, while also maintaining pikeminnow population viability.

Pikeminnow are a native fish that has increased abundance as a result of habitat alteration in the lower mainstem and large tributary reservoirs. In unaltered systems, pikeminnow and salmonid interactions are limited by habitat preferences and behavior patterns. In altered systems including the Columbia River mainstem and large tributary reservoirs, pikeminnow can become significant predators of juvenile salmonids.

American Shad

Objective: Decrease abundance but maintain a viable population (range from 0.7 to 1.0 million, well below the recent record run sizes) while avoiding adverse impacts on other species, particularly the recovery of salmonids.

American shad are an introduced species with ecological, management, and minor economic importance. Because of their abundance, shad have become an important component of the lower mainstem and estuary ecosystem. For example, they have been identified as an important food source for sturgeon, a source of large quantities of marine-derived nutrients to freshwater, and may be an significant competitor of juvenile salmonids. Shad objectives involve proactive fishery management to reduce the population to the suggested viable level; thus, harvest is encouraged but is also challenged by the incidental catch of salmonids and other species. Additional research is needed to better understand the interrelationships between shad and salmonids.

Band-tailed Pigeon

Objective: Increase quantity and quality of habitat.

The band-tailed pigeon breeds throughout much of Western Washington. The band-tailed pigeon requires mineral springs as a source of calcium for egg-laying and the production of crop-milk for its young. The proximity of these mineral springs to suitable foraging habitats is an important factor for band-tailed pigeons.

Caspian Tern

Objective: Maintain population viability region-wide and decrease the population's vulnerability to catastrophic events while also managing predation on salmon.

Caspian terns are a colonial nesting species protected under the Federal Migratory Bird Treaty. They are perceived to be a significant predator of juvenile salmonids and have become a significant part of the estuarine ecosystem, based on their abundance and consumptive needs during the breeding season. This objective involves maintaining the regional breeding colony abundance near 10,000 pairs while minimizing predation effects on salmonids by encouraging breeding colony distribution among multiple breeding sites, particularly in locations where non-salmonid food sources are plentiful, consistent with direction emerging from the Caspian Tern Working Group and USFWS EIS process.

Osprey

Objective: Increase the viability of the osprey breeding population in the lower Columbia River, particularly through increased reproductive success.

Osprey can help monitor the presence of environmental contaminants, as well as large, mature trees (although less indicative of this habitat type than bald eagle). Reproductive success of the local population has remained relatively high, despite some of the highest observed DDE concentrations measured in North American osprey. Population productivity in 1997-98 was estimated at 1.64 young/active nest, which is higher than the recognized 0.80 young/active nest needed for a stable population.

Yellow Warbler

Objective: Protect critical preferred habitat including riparian zones characterized by a dense deciduous shrub layer (1.5-4 m) with edge and small patch size (heterogeneity).

Yellow warblers in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of dense riparian shrub habitat. The species is widely distributed and common.

Red-eyed Vireo

Objective: Protect critical preferred habitat including riparian gallery forest with tall, closed canopy forests of deciduous trees (cottonwood, maple, or alder and ash), with a deciduous understory, forest stand sizes larger than 50 acres, and riparian corridor widths greater than 50 m.

Red-eyed vireos in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of tall, closed canopy riparian habitat. The species is widely distributed and common.

River Otter

Objective: Maintain current population abundance.

River otters are ecologically important in the Columbia River estuary and lower mainstem and are thought to be an indicator of overall environmental health. Evidence suggests that abundance in the lower Columbia River has always been relatively low. River otter are concentrated in shallow, tidally influenced backwaters, sloughs, and streams throughout the estuary, particularly in the Cathlamet Bay area.

5.6.3 Species of Recreational Significance

Walleye

Objective: Adaptively manage the population to maintain or reduce current abundance levels while minimizing adverse impacts on salmonids and other native fishes.

Walleye are an introduced species that is widely distributed in the lower Columbia mainstem and common in some specific habitats. Walleye provide some recreational fishery benefits but eat primarily fish including significant numbers of juvenile salmonids. This objective involves an improved understanding of walleye habitat use, abundance, and distribution in the lower mainstem and estuary to evaluate and manage negative interactions between walleye and native species.

Smallmouth Bass

Objective: Adaptively manage the population to maintain or reduce current abundance levels while minimizing adverse impacts on salmonids and other native fishes.

Smallmouth bass are an introduced species that is widely distributed in the lower Columbia mainstem and common in some specific habitats. Smallmouth bass provide some recreational fishery benefits but are can also be significant salmonid predators in certain situations. This objective involves managing the population to limit or decrease the current level of abundance, evaluate and limit interactions between smallmouth bass and native species, and develop an understanding of smallmouth bass habitat use, abundance, and distribution in the lower mainstem and estuary.

Channel Catfish

Objective: Adaptively manage the population to limit adverse impacts on salmonids and other native fishes.

Channel catfish are an introduced species that provide fishery benefits in some altered lower Columbia habitats. Channel catfish are salmonid predators in certain situations and might also interact with juvenile sturgeon. This objective involves an improved understanding of channel catfish habitat use, abundance, and distribution in the lower mainstem and estuary to evaluate and manage negative interactions between with native species.

6 Regional Strategies and Measures

This chapter describes a comprehensive set of regional strategies and measures to address the range of threats as they are understood at this time. Working hypotheses are also included to explain the underlying rationales for strategies. Actions consistent with habitat, harvest, and hatchery measures are identified at the regional level. Actions are further detailed in subbasin volumes of the plan.

6.1 Overview

Regional strategies and measures identify general policies, approaches, mechanisms and categories of action needed to achieve the recovery of salmon and steelhead in the lower Columbia. Regional strategies describe the over-arching approaches for achieving the ESU-level biological objectives identified in this plan. Regional measures are more specific descriptions of the mechanisms or categories of actions needed to carry out these strategies. Actions are even more specific descriptions of efforts to be undertaken consistent with recovery. Descriptions of subbasin-specific actions corresponding to these strategies and measures are found in the subbasin chapter. Fishery and hatchery actions are also summarized in this chapter because many are regional in character albeit with specific applications in subbasins. Regional strategies and measures provide broad guidance for recovery efforts at a local level consistent with the regional vision.

Strategies and measures were identified to address all threats or factors limiting recovery. This chapter includes strategies for six threat or limiting categories of threat: subbasin stream habitat and watershed conditions; estuary and mainstem habitat; tributary and mainstem hydropower configuration and operation; in basin and out-of-basin harvest; mitigation and conservation hatcheries; and ecological interactions including non-native species, food web, and predation. This chapter also includes strategies and measures for integrating and scaling actions across and among each of the limiting factor/threat categories in order to balance demands and expectations among all affected parties while also achieving a complementary result.

While strategies are fundamentally intended to produce biological results, the strategies included in this plan were also based on economic, political, social, and cultural considerations. These considerations are critical to the prospects for developing and implementing an effective and equitable plan. Regional strategies and measures were developed in a series of meetings and workshops involving a working group of representatives from implementing and affected agencies. The strategies and measures included in this plan represent a draft list intended to provide a starting point for more widespread review and comment. It is expected that additions and revisions will be incorporated as part of the ongoing plan implementation process.This chapter includes explanations and rationales for each strategy and measure as well as descriptions of working hypotheses upon which strategies and measures were based. Working hypotheses are the series of assumptions and beliefs which underlie selection and definition of strategies and measures. Some hypotheses are well supported by evidence and might be considered to have graduated to the level of a fact. Other hypotheses are consistent with scientific information but should be considered assumptions until corroborated by further testing. Working hypotheses were based on descriptions and assessments detailed in the scientific and technical foundation of this plan. These descriptions and assessments are summarized for each limiting factor/threat in background subsections of this chapter and in a chapter dedicated to limiting factor and threats earlier in this plan. Many working hypotheses are conclusions based on extensive scientific evidence. However, some working hypotheses represent testable hypotheses needed to bridge gaps in existing information and provide direction for plan development.

Measures and/or actions are categorized based on whether they are existing or new and whether they primarily provide protection or restoration benefits. These categories will help inform priorities and schedules for specific actions addressing these measures which will be developed during plan implementation. Category A measures are currently being implemented and continued implementation will be critical to recovery. Category B measures expand protection of existing conditions and help ensure that species are not subjected to increased or new threats to viability. Category C measures restore degraded conditions or substantially reduce existing threats where improvement is feasible. Category C measures will help reverse current declining trends and establish a trajectory to future recovery.

6.2 Integrated Regional Strategy

The integrated strategy is intended to ensure that recovery efforts are developed and implemented in a scientifically sound and systematic approach. In other words, it strives to ensure that all recover actions effectively complement and support each other in achieving the recovery goal: healthy, harvestable populations of salmon and steelhead. It is also intended to ensure that the cost and consequences of achieving recovery are equitable across affected constituencies. Recovery can be achieved with different combinations of actions implemented at different intensities among and on varying timelines within each limiting factor/threat category. The integrated strategy defines expectations and requirements for affected parties who will implement this plan in a broader context of scientific, technical, economic, political, social, and cultural considerations. This recovery planning framework provides flexibility for implementing parties to select, scale, and adapt regional strategies and measures within each limiting/factor category to optimize effectiveness and efficiency in plan implementation while also ensuring an appropriate incremental improvement consistent with regional goals and objectives.

Salmon recovery is predicated on assumptions that: 1) remaining populations still retain the inherent characteristics needed to sustain healthy, harvestable levels when suitable conditions are provided, 2) declining trends can be reversed with appropriate actions, and 3) society is willing and able to implement appropriate actions. Biological objectives detailed in the recovery scenario and consistent with TRT recovery standards recognize that it may not be feasible to protect and restore every existing population. However, this plan assumes that a focused and broadly based effort will protect and restore sufficient number of populations to ensure long term viability and opportunities for harvest. The scale and scope of activities that threaten salmon or limit their recovery is extensive. The scope and scale of the actions needed to address these threats and limiting factors is equally extensive. Salmon recovery will not be easy, quick, or inexpensive. Recovery can only be achieved though concerted and substantive efforts by people throughout the region.

Comparisons of the impacts in each limiting factor/threat category indicate that recovery cannot be achieved solely by addressing any single category of limiting factors or threats. Spreading the responsibility among each category lessens the cost to any one group, increases the certainty of success, and compounds the benefits of moderate improvements in each factor. The plan has estimated the relative magnitude of potentially manageable impacts in six categories of limiting factors (tributary habitat, estuary/mainstem habitat, hydropower, harvest, hatcheries, and predation. Based on these estimates of relative magnitude of potentially manageable impacts and on population goals, the plan identifies the overall improvement in population productivity needed to achieve the target status for that population, and the proportional improvements needed in productivity from each category of limiting factor. These proportional improvements are identified as starting points to indicate the general level of effort that will be required from each sector to achieve recovery. Rather than demonstrating that proposed actions will achieve the allocation goals, in part because of high uncertainty regarding the magnitude of effect of any given action or suite of actions, the plan uses a directional approach which lays out actions that target threats and identifies who should implement those actions. Equity in contribution to recovery was initially defined in terms of biological impact. Future refinements in plan implementation will also incorporate other factors including economic and social burden. The Implementation Chapter of this plan identifies a transparent collaborative process for adapting biological targets and considering opportunities to shift the biological burden among different categories of limiting factors.

6.2.1 Working Hypotheses

R.H1. It is feasible to recover naturally-spawning salmon and steelhead to healthy and harvestable levels in the Washington lower Columbia Region.

Explanation: This hypothesis presumes that conditions are not irreversibly altered such that improvements cannot reverse declining trend in salmonid numbers. This plan assumes that recovery can realistically be achieved by marshalling a collective public will for fish and wildlife conservation and restoration.

R.H2. Substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required to achieve recovery.

Explanation: As the saying goes, 200 miles into the woods and 200 miles out. The current threatened status of many salmonid species results from widespread and pervasive changes in their ecosystem over the last two centuries. Many of these changes will require substantive measures to address. However, improvements in multiple limiting factors will have compounding benefits to fish status.

R.H3. No single limiting factor or threat is solely responsible for the current viability or health of salmon and steelhead nor can all recovery goals be achieved based solely on improvements in any one factor.

Explanation: Analyses detailed in technical appendices confirm that many different factors and threats have contributed to salmon declines and that significant improvements in multiple factors will be needed for recovery.

R.H4. Substantive recovery actions have already been implemented in many areas but existing program actions are not sufficient to reach recovery goals for all species.

Explanation: There has been a long history of fish protection and restoration activities. Significant actions have been taken before and prior to ESA listings. These actions have provided substantial benefits but many species and populations remain at significant risk.

R.H5. Recovery of salmon and steelhead cannot be achieved based solely on local actions. Human activities throughout the extensive range and life cycle of salmon and steelhead affect their health and the habitat upon which they depend. Recovery depends on local, state, regional, national, and in the case of harvest, international action.

Explanation: In-basin and out-of-basin actions are needed to address the full spectrum of factors and threats limiting anadromous salmonids.

R.H6. Many of the actions needed for salmon will have broader ecosystem benefits but additional actions will be needed to reach and balance goals among all fish and wildlife species of interest.

Explanation: Significant habitat improvements in tributary subbasins, the Columbia mainstem, and estuary will stabilize trends and restore some conditions more similar to a historical baseline. A wide variety of native fish and wildlife species will benefit from these habitat conditions.

R.H7. Strategies and measures likely to contribute to recovery can be identified based on limiting factors and threats but estimates of the incremental improvements resulting from each specific action are generally uncertain.

Explanation: Natural systems are complex. No amount of research can resolve all uncertainties and further delay in implementing substantive recovery actions places listed species at great risk.

6.2.2 Strategies

R.S1. Implement strategies and measures that address each limiting factor and risk category.

Explanation: Categories include stream habitat, estuary and mainstem habitat, hydropower, harvest, hatcheries, and ecological interactions. Recovery cannot be achieved without significant improvements in each category.

R.S2. Set improvement targets for each limiting factor/threat category that are proportionate to approximate magnitude of the impact of each on salmon and steelhead viability.

Explanation: The strategy allocates the responsibility for fish recovery among the various factor/threat categories in shares proportionate to their estimated contribution to the problem. Each potential recovery strategy and measure holds different costs and consequences for different combinations of stakeholders. Singling out any specific group for a greater or lesser share of responsibility would involve explicit or implicit consideration of specific tradeoffs and difficult economic, political, social, and cultural value judgments. Instead, this strategy identifies a proportional contribution in each factor/threat category scaled for the improvement needed to achieve the difference between current and desired population status. If population productivity must improve 50% to meet biological objectives identified in the recovery scenario, the net effect of each limiting factor/threat category must be reduced by 50%. Factor/threat categories with large impacts can expect large but proportional reductions. Factor/threat categories with small impacts can expect smaller but still proportional reductions. Improvement from very small impacts may be difficult to measure and may warrant cost-benefit consideration. Difficulties and costs of achieving proportional reductions vary among factor/threat categories but the recovery scenario identified in the previous chapter defined subbasin and population-specific biological objectives that recognized feasibility constraints as well as opportunities.

R.S3. Use the ESA listing date as a baseline reference for identifying the improvements needed to achieve fish recovery.

Explanation: A variety of recovery actions have already been implemented and others are planned. The ESA listing date provides a common reference point for measuring the improvements needed to achieve recovery. It provides a reference date consistent with NOAA Fisheries' review of population status and threats during the listing determination period. It also allows the recognition of progress that has been made over the past several years in addressing some threats and limiting factors. Many fish protection and restoration actions have been implemented prior to listing but identifying a common standard for consideration is problematic. Some beneficial actions date back decades (e.g. curtailment of splash dams and large scale commercial fishing). Contributing historical "credits" are much less important to fish recovery than the current scope for improvement.

R.S4. In evaluating the contributions of existing programs to recovery, both accrued and anticipated improvements will be considered.

Explanation: Both the accrued and expected recovery contributions of existing programs can be considered in evaluating the proportional improvements required for each factor/threat category. This will provide a more accurate indication of the additional improvements needed to achieve recovery. Existing actions are not expected to be sufficient to meet recovery goals consistent with working hypotheses described earlier.

R.S5. Identify a suite of factor-specific recovery strategies and measures scaled to meet biological objectives while also recognizing large uncertainty in the incremental contributions of individual actions.

Explanation: The suite of strategies and measures identified in this plan was designed consistent with the order of magnitude of needed improvements identified in the biological objectives. Considered collectively and within each category of limiting factors and threats, these strategies and measures were scaled to provide significant and measurable improvements in fish status and ecosystem health. Given substantial uncertainty in the effects of many limiting factors/threats and in the expected response to specific actions, this plan does not attempt to quantify the incremental contributions toward recovery of each individual strategy and measure. Some measures address threats and produce outcomes that can be confidently quantified. Other measures address threats or produce responses that are not easily estimated. These uncertainties were recognized with other contingencies incorporated into this plan including the biological objectives incorporated into the recovery scenario, requirements for substantive action and significant contributions for each limiting factor/threat category, and a strong monitoring, evaluation, and adaptive element.

R.S6. Identify an appropriate balance of recovery strategies and measures that address manageable limiting factors and threats throughout the range and life cycle of salmon and steelhead.

Explanation: Salmon recovery cannot be achieved in a vacuum that does not consider threats and limiting factors throughout the range and life cycle of fish. Identifying where other activities pose risks to local populations will provide a basis for pursuing appropriate changes. Conversely, the existence of out-of-region threats does not eliminate the need to undertake substantive local actions.

R.S7. Focus near term actions on species at risk of extinction while also ensuring a long term balance with other species of interest and the ecosystem.

Explanation: A fundamental strategy in this recovery plan is to avoid large-scale irreversible changes including species extinction. In the near term, protecting and stabilizing at-risk species can sometimes be prioritized over enhancement of healthier species as long as other species are protected from significant risk. In some cases, it may be most effective or efficient to manage other species for the benefit of at-risk species or to concentrate efforts and expenditures in favor of at-risk species. However, protection, management, and enhancement of all species and ecosystem components must be considered over the long term. A short-sighted focus only on at-risk species could inevitably doom other species that are currently healthy to a similar fate.

6.3 Habitat – Subbasin Streams and Watersheds

This section describes near-term and long-term strategies and measures to ensure that stream habitats support recovery of naturally-spawning fish. Stream and watershed habitat in Washington lower Columbia River tributary subbasins are included. Hydro, Columbia River mainstem, and estuary strategies and measures are addressed in other sections.

This section provides a regional overview of stream habitat restoration and preservation needs for recovery. More detailed information is available for each subbasin in Volume II of this plan. This recovery plan includes an extensive review of the available habitat information and analyses as well as extensive new analysis of stream condition, watershed conditions, and habitat forming processes. Modeling tools were applied that highlight a series of habitat perturbations in these watersheds that need to be addressed. Qualified local experts were convened to provide input to models where needed or where other data sources were lacking. Model outputs were also compared to other independent assessments of limiting factors to corroborate results. The outputs of these models identify reach scale issues that need to be addressed and provide a prioritization scheme that is linked to the input data and to expectations of the actions proposed. Entities with the authority to implement actions are identified in each subbasin and the Chapter 8 of this plan describes the process for implementation.

6.3.1 Working Hypotheses

S.H1. Healthy, harvestable salmon populations depend on favorable stream habitats for migration, spawning, and rearing.

Explanation: Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity that helps maintain adequate numbers. Even during poor ocean conditions, high quality habitat will allow populations to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication.

S.H2. Current stream habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable naturally-spawning salmon and steelhead populations.

Explanation: Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (a.k.a. the 4-H's). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins. Subbasin habitat declines have been compounded in the Lewis and Cowlitz subbasins by dam construction and operation that have blocked large areas of good habitat and virtually eliminated some populations.

S.H3. Recent changes in land and water use practices are improving salmon habitat conditions in some areas and will further improve salmon habitat over time. In other areas habitat conditions continue to decline, and substantial changes are needed to support the recovery of naturally-spawning populations.

Explanation: Land use practices vary substantially between regulatory jurisdictions on the lower Columbia River. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. Recent changes in land and water use practices are improving salmon habitat conditions in some areas and will further improve salmon habitat over time but additional changes are needed in many areas to support the recovery of naturally-spawning populations. Particularly damaging practices such as splash damming to transport logs and temporary dams to divert water have been relegated to the past. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced positive effects. Others are expected to pay future dividends. Still other changes will be needed to offset the cumulative effects of years of habitat degradation.

S.H4. Recovery can be achieved without restoration of pristine historical conditions and without restoration of optimum habitat conditions in every subbasin.

Explanation: Recovery guidelines identified by the Technical Recovery Team and status assessments detailed in the technical foundation indicate that viable populations can typically be restored at numbers substantially less than those corresponding to properly functioning conditions. Model estimates indicate that TRT viability goals for adult abundance and productivity — produced with population change criteria modeling — are generally lower than Ecosystem Diagnosis and Treatment model numbers under properly functioning conditions for habitat.

S.H5. Some level of increased habitat protection and restoration will be required in every subbasin to arrest declining trends and ensure that population status does not decline further.

Explanation: A significant increase in habitat protection and restoration will be required in every subbasin to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The magnitude of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the demands for increased habitat protection and restoration just to stabilize fish populations at current levels. Both regulatory and non-regulatory tools exist.

S.H6. Long-term improvements in stream habitat conditions will depend on restoration of functional watershed processes.

Explanation: Salmon depend on suitable stream habitat conditions which in turn are dependent upon conditions in tributary and upstream watersheds. Local habitat activities can provide short-term benefits but long-term improvements in stream habitat conditions will depend on restoration of functional watershed processes and access to existing quality habitat. Where watershed conditions have been degraded, stream habitat forming processes will progress toward a new less functional equilibrium with their surroundings. Where watershed conditions have been restored or allowed to improve naturally, stream habitat forming processes will progress toward a more fully-functional equilibrium. Access to quality habitat can achieve immediate and lasting benefits for fish. Restoring access can include the removal of culverts, providing fish passage at dams, and reconnecting isolated side channels and wetlands.

S.H7. Restoration of functional habitat-forming processes in watersheds is a large-scale undertaking with limited prospects for immediate relief of acute extinction risks for salmon.

Explanation: Habitat forming processes are driven by the cumulative effect of conditions across the landscape of a watershed. The areas affecting conditions increase with distance downstream. Thus, restoration of functional stream habitat-forming processes in watersheds is a large-scale undertaking. Moreover, the degradation of these processes occurred incrementally over a period of decades. Effective restoration processes, even in part, will also require decades. Even where changes are implemented immediately, it may take years for benefits to fully accrue. For instance riparian protection measures might require 30-80 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited immediate relief for acute extinction risks caused by current low salmon population numbers.

S.H8. It is more effective and less costly to restore access to quality habitat and to protect existing high quality habitat than to attempt restoration of degraded habitat, although restoring habitat access and protecting habitat will not be sufficient to achieve recovery.

Explanation: Widespread habitat improvements can be very costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation that precludes future changes in use but does not require a change to previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional impacts. Restoring natural, habitat forming processes can also be less costly than active restoration of stream conditions, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. Protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. For example, chum salmon occupy lower reaches of watersheds that have historically been highly urbanized and developed, or that will be in the next 50 years. Active restoration in previously disturbed areas may be necessary for this species in particular.

S.H9. Site-specific habitat improvements and access can help ameliorate acute extinction risks.

Explanation: Although effects may often be temporary, site-specific improvements in stream habitat conditions and access can help ameliorate immediate extinction risks in the interim until underlying causes of degraded stream habitat are addressed. Even where recent changes to land and water use patterns can be expected to restore population viability in the long term, more immediate actions may be required to make sure that the fish survive to reap those long term benefits. Moreover, in areas that have been extensively developed it may not be feasible or technically possible to restore habitat-forming process. In these areas, active on-going site-specific restoration actions may be the only means available to secure needed habitat conditions.

S.H.10. Salmonid populations require unimpeded access to stream habitats, at all life stages, during all migration periods. Fish passage at culverts is one of the most recurrent and correctable obstacles to healthy salmon stocks. In some cases, many miles of quality salmonid spawning and rearing habitat are blocked by single barriers.

Explanation: Barriers to migration can be particularly damaging to salmon and steelhead populations. Barriers range from large mainstem hydropower dams to inadequate culverts sprinkled among the myriad of small tributaries to which anadromous species return.

S.H11. Factors and activities affecting stream habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by fish and wildlife to any given action or set of actions.

Explanation: Factors and activities affecting stream habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given action or set of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

6.3.2 Strategies

S.S1. Provide habitats adequate to sustain healthy, harvestable salmon and steelhead runs in Washington lower Columbia River subbasins through access improvements, habitat protection, and restoration.

Explanation: Healthy and harvestable goals cannot be achieved without significant habitat improvements. Improvements may take the form of increased access to suitable habitats, protection of existing habitats, and restoration of suitable habitat quality for salmonids.

S.S2. Configure habitat protection and restoration activities among subbasins to support region-wide recovery goals.

Explanation: Salmon recovery will require high levels of habitat restoration in many subbasins but recovery can be achieved with a mixture of high levels of improvement in some basins and more limited activities in other subbasins. Recovery scenarios identify improvements in specific populations that vary among watersheds but ultimately add up to a viable group of populations (e.g. ESU or listing unit). Primary populations need to be restored to at least a high viability level. Contributing populations need to show significant improvement. Stabilizing populations need to be protected from further declines. Not every population needs to be subjected to the same level of recovery effort. Protection and restoration activities can be concentrated in specific areas so long as the net effect considered across the region ensures that a sufficient number of unique populations are restored to or maintained at specified levels. Opportunities exist to support recovery by clearly delineating priorities for habitat improvements among the regions subbasins and with subbasins. This is a substantial change from pre-recovery plan implementation of ESA that generally applied uniform habitat standards in all subbasins and portions of subbasins.

S.S3. Afford high levels of protection to stream and watershed habitats that currently support significant fish production for primary and contributing fish populations.

Explanation: As fish population and habitat productivity have declined, spatial distribution has contracted back to a limited amount of habitat that now supports a large fraction of naturally-spawning fish production. Current and future fish status depends on protection of these strongholds. A fundamental priority of fish recovery efforts will be to protect current core production areas to preserve significant remaining populations and provide the genetic material for fish restoration efforts.

S.S4. Address stream habitat conditions that limit fish as well as stream habitat forming processes in watersheds or subwatersheds that affect stream habitat in any given location.

Explanation: Stream habitat quality is often a symptom of conditions in tributary watersheds including those upstream. Sustainable long term improvements in stream habitat conditions for salmon will require restoration of functional watershed processes including those that affect water, wood, and sediment delivery to streams.

S.S5. Restore access of key populations to blocked habitats in historically accessible subbasins or portions of subbasins where necessary to support region-wide recovery goals and closely coordinate access improvements and habitat improvement activities.

Explanation: This strategy addresses local fish access issues in subbasins. Large scale loss of access due to dam construction is addressed separately in the Hydro strategy section. Lack of fish passage has eliminated access to many areas that historically supported significant fish production. Areas include upstream reaches of many subbasins where culvert construction or diversion structures impede or block passage. Habitat quality in many blocked areas continues to be suitable for salmon. Local passage improvements can restore access to significant amounts of favorable habitat. Restoring access may include removal of culverts, providing fish passage at dams, and reconnecting isolated side channels and wetlands. The amount and quality of habitat that can be opened for various populations varies considerably across the region. This strategy may involve a priority for restoring access to currently inaccessible high quality habitat for primary and contributing fish populations.

S.S6. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Explanation: Recovery criteria require some populations be restored to high levels of viability. All other things being equal, this is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will also require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

S.S7. Implement habitat restoration actions sufficient to offset projected future trends in conditions such that no net loss in habitat occurs.

Explanation: Recovery criteria identified by the TRT dictates that all populations be protected from further degradation until such time as recovery goals are achieved. Currently declining habitat trends in some areas and future development pressures result in a need for substantive habitat protection and improvement measures to maintain the current status.

S.S8. Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but only rarely provide lasting improvement unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures that protect and restore riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions). Habitats undergoing restoration through active and passive measures also require ongoing protection.

S.S9. Use existing procedures and programs wherever possible to take maximum advantage of opportunities for efficient implementation of habitat protection and restoration measures.

Explanation: A wide variety of regulatory and non-regulatory procedures and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region. However, in many jurisdictions, "Best Available Science" has not yet been used directly to determine appropriate habitat protection measures.

S.S10. Consider salmon recovery needs up-front in the comprehensive land use planning process, along with other social, infrastructure, and service needs.

Explanation: Implementation of salmon recovery efforts at the local government scale is driven largely by the existing land use planning and regulatory processes. However, critical areas (e.g., streams, wetlands, etc) protection has historically been addressed as an afterthought in the planning process. Infrastructure, housing, resource lands (e.g., agriculture, industrial, etc.), and service needs have been the primary drivers in determining how much, and where, growth occurs. Protection of critical areas has generally not been dealt with "up-front" in the comprehensive planning process. This approach has been inadequate in protecting existing salmonid populations from further declines. Direct consideration of salmon recovery needs in comprehensive land use planning would help steer growth to areas of the least impact, instead of the current approach of trying to mitigate impacts as an afterthought. Once a growth plan is prepared and development is proposed, critical areas are protected through regulatory means on a project-by-project, piece-meal basis.

6.3.3 Measures

Habitat measures represent the activities that are needed to address habitat limiting factors and threats. Habitat measures may already be underway or required under existing regulations or programs. Habitat measures may address individual threats or multiple threats. Habitat measures are often characterized as being passive restoration, active restoration, or preservation. Passive restoration refers to practices that remove the agent of degradation (stressor) and allow the system to recover naturally (e.g. levee removal). Active restoration refers to practices that are intended to accelerate the return to functioning conditions (e.g. re-establishing meander patterns, large woody debris supplementation). Preservation actions prevent degradation from occurring and protect areas and processes that have been restored (e.g. purchase of a conservation easement in a floodplain).

Protection can take many forms across many scales. It can be site-specific or watershed-wide and can involve regulatory and programmatic approaches. Addressing watershed-wide habitat forming processes requires a scientific, data-driven understanding of each watershed and subwatershed. In the absence of such understanding, site-specific protections may not be adequate to address cumulative effects. When analyzing the level of protection in place, it is necessary to determine if habitat-forming processes are protected across the watershed. If the watershed is not protected, tighter site-specific measures may be needed. Programmatic approaches should include opportunities for special purpose districts to evaluate their operations against the recovery plan and processes at work in their service area. The same holds true for entities such as BPA, hydro operators, and tribes conducting activities that impact processes. For example, BPA could evaluate its transmission line maintenance program against processes by watershed, and dam operators could ensure downstream processes such as large wood and gravel recruitment and transport are maintained. Protection actions must be described in terms of their scale across the watershed within which they are applied. Each watershed should then be evaluated to make sure there will be no degradation of habitat-forming processes. A listing of watershed-specific protection needs and measures is included in the subbasin chapters of this plan.

Habitat measures can be framed using any one of a number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration projects). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describe the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified below are framed as actions within categories of actions. These measures represent all of the potential measures throughout the lower Columbia region. Some measures apply in nearly all of the subbasins, whereas others are specific only to a subset of the basins. Subbasin-specific measures may be found in the subbasin chapters in Volume II of this plan.S.M1. Protect habitat conditions and watershed functions through land acquisition or easements where existing policy does not provide adequate protection. (Category A, B)

- Purchase properties outright through fee acquisition and manage for resource protection
- Purchase easements to protect critical areas and to limit potentially harmful uses
- Lease properties or rights to protect resources for a limited period
- Designate set-asides where no use or limited uses are allowed (e.g. metro greenspaces, wilderness areas)

Explanation: Establishing preservation areas is the most effective avenue to habitat protection. Preservation areas should ideally be located in properly functioning areas that support productive fish populations. Preservation areas can take the form of land designations (e.g. wilderness areas), private land acquisition, leases of properties or rights, or conservation easements. Land designations are established by land owners or managers and may require legislative approval in situations such as wilderness area designations. Land acquisition is conducted by public entities or private organizations (e.g. land trusts) with the purpose of preventing future degradation. Public and private entities can also purchase conservation easements or leases on critical properties, with the purpose of preventing detrimental land-uses for the contract period. Conservation easements do not purchase the land outright. Examples of conservation easement programs are the Conservation Reserve Enhancement Program (administered by the Natural Resources Conservation Service), the Riparian Open Space Program (administered by WDNR), and the Small Forest Landowner Riparian Easement Program (administered by WDNR).

S.M2. Protect habitat conditions and watershed functions through land-use planning that guides population growth and development. (Category A, B)

- Plan growth and development to avoid sensitive areas (e.g. wetlands, riparian zones, floodplains, unstable geology)
- Encourage the use of low-impact development methods and materials
- Apply mitigation measures to off-set potential impacts

Explanation: Comprehensive land-use planning and land use controls can provide important habitat protections by regulating growth and land use so that critical areas and watershed functions are preserved. Population growth forecasts for the region identify continued heavy growth, especially in Clark County. Other population centers and rural residential development will continue to expand, with much of the growth occurring in sensitive areas. Land-use planning that limits growth, concentrates new growth in non-sensitive areas, and protects critical areas will be necessary to prevent further ecosystem degradation. Critical areas protections, such as those called for under the WA State Growth Management Act (GMA), are administered by local jurisdictions, although not all jurisdictions have adopted adequate critical areas protections. Critical areas include stream channels, riparian areas, floodplains, wetlands, aquifer recharge areas, and geologically hazardous areas. Development or other potentially harmful activities in these areas are regulated as part of critical area protections. It is crucial that all jurisdictions in the region adopt adequate critical areas protections. As required by law, the GMA specifies that critical areas protections should be based on the ‘best available science’, which will be necessary for correctly defining critical areas and identifying potential threats. Only two of the 5 major counties that make up the study area (Clark and Lewis Counties) are currently fully planning under the (GMA), which involves comprehensive land-use planning that addresses natural resource impacts.

Throughout the study area, forest and crop land is being converted to urban and residential uses, which results in increased ecosystem disturbance. In these areas, preserving existing uses through zoning or other regulatory mechanisms will be necessary to prevent further habitat degradation. Limitations on land-use conversion and growth are often very politically and economically difficult to achieve, resulting in a low probability of success.

S.M3. Protect and restore instream flows. (Category B, C)

- Water rights closures
- Purchase or lease existing water rights
- Relinquishment of existing unused water rights
- Enforce water withdrawal regulations

- Implement water conservation, use efficiency, and water re-use measures to decrease consumption

<u>Explanation:</u> These instream flow measures relate to depleted stream flows resulting from water withdrawals, and not to alterations to stream flows due to changes in watershed runoff processes or hydro-regulation, which are covered under separate measures. Instream flow measures are aimed at retaining water in streams for protection of aquatic resources. Low flow concerns exist in most streams at certain times of the year, especially where surface and groundwater withdrawals contribute to depletion of stream flows. These measures include closures (administrative or formal rule closures) that restrict the allocation of new water rights, purchasing or leasing water rights, ensuring the relinquishment of unused water rights, enforcing withdrawal regulations, and implementing water conservation measures. These measures are often difficult to implement because of existing water rights and continual increases in demands. Some of these measures have a potential cost to land-users due to foregone use (e.g. loss in crop production) or costs associated with obtaining alternative water sources. If implemented, however, withdrawal reductions can begin to yield benefits immediately. Efforts are currently underway by the WRIA 25/26 and WRIA 27/28 Watershed Planning Units and the WDOE to identify streams that are currently closed to future withdrawals, identify other streams where closures are needed for fish protection, identify the impact of current withdrawals, and to identify the avenues by which flows can be restored in critical areas.

Many streams in the study area are currently closed to new water rights allocations through the administrative closures process conducted by WDOE. This relatively informal process is driven by somewhat random water rights requests. Closures based on these requests are then used to justify future request denials on the same stream system. There is increasing pressure for WDOE to improve this inefficient process and to systematically establish closures based on stream flow and aquatic habitat conditions. Establishing instream flow rules has not been used very extensively in the study area. Instream flow rules have variable success because of the lack of stream gauging data and lack of adequate enforcement.

Purchasing or leasing existing water rights can be an effective method for reducing existing use or preventing additional water withdrawals. This approach has the advantage of being conducted within the current legal framework with compensation provided to water rights holders. It has been used in portions of WA State but not to any significant degree in the study area.

Relinquishment of water rights refers to the “use it or lose it” policy that is common in Western water law. As the policy now stands in WA State, if a water right is not used for a consecutive 5-year period, the water right is relinquished back to the state. Municipal uses are exempt from this policy and water rights holders can apply for exemptions based on a number of criteria. The primary drawbacks to this policy include the difficulty with monitoring whether water rights are being exercised or not and the lack of enforcement.

Water rights regulations enforcement is lacking in most stream systems in the lower Columbia region and the actual extent of illegal withdrawals is unknown. In some stream systems, illegal withdrawals are believed to contribute to low flow problems at certain times of the year. Increased monitoring and enforcement will be necessary to prevent potentially detrimental illegal withdrawals.

Water conservation and water use efficiency are important aspects of addressing water withdrawal concerns. During critical times of the year or during drought conditions, water use can be curbed through community education or water use limits. Water conservation and water use efficiency can also be increased through upgrades to water delivery systems, water re-use, and development of alternative water sources.

S.M4. Protect and restore fish access to channel habitats. (Category B, C)

Explanation: Restoring access to critical spawning and rearing habitats can be one of the simplest and most effective restoration strategies. Restoration of habitat connectivity in streams typically involves correction of a passage obstruction that is restricting access to a portion of the stream channel. The most common passage barriers in stream channels include dams and culverts. Other types of barriers include tide gates, fish ladders, and diversion structures. In some cases, barriers may also be created by alterations to channel morphology or stream temperature.

The biological benefits of passage restoration are often realized within a couple of years, since re-colonization can occur relatively rapidly. Project success is often high, especially given the considerable amount of research that has been conducted on passage requirements for salmonids. The costs of culvert replacement are often relatively minor, although establishing passage at dams can be very expensive and politically challenging. Providing passage around dams will typically yield greater benefits than culvert replacements since relatively little useable habitat exists above problem culverts in most of the study area. There is considerable effort underway to inventory and upgrade culverts across the region. These efforts are being conducted by the USFS, WDOT, the LCFRB, and other cooperators. Passage has been provided around the Cowlitz River mainstem dams for years. Passage around the Lewis River hydro-system is currently being evaluated and is expected to occur within the next few years.

Protection of fish passage is generally provided for under existing regulations and agency policy. Construction standards for forest and non-forest roads on private, state, and federal lands prohibit the creation of passage obstructions.

S.M5. Manage regulated stream flows to provide for critical components of the natural flow regime. (Category B, C)

- Provide adequate flows for specific life stage requirements (e.g. migration, summer rearing)
- Address geomorphic effects of hydro-regulation (e.g. channel-forming flows, sediment transport)

Explanation: Addressing regulated flows will address the threats posed by hydropower operations. The annual hydrograph of the Lewis and Cowlitz Rivers has been altered from pre-dam conditions due to hydro-regulation. In general, spring flows have been reduced, summer base flows and fall flows have been increased, portions of some channels have been de-watered, and frequently occurring peak flows have been reduced. Some of these alterations may directly benefit certain life stages of fish (e.g. increased base flows benefit summer rearing), but may have indirect long-term negative consequences to fish due to impacts to channel form, sediment/substrate conditions, floodplain function, and riparian vegetation. Restoration emphasis should be placed on critical components of the natural flow regime, such as providing for occasional channel forming flows and providing for adequate flows for smolt migration. Sediment transport through dams should also be addressed where possible, with substrate enhancement below dams if necessary.

Many limiting factors are addressed through regulated flow restoration. These include primarily stream flow impacts (e.g. habitat dewatering), habitat diversity (e.g. channel-forming flows), and riparian function. Restoring stream flows has a relatively high probability of success, although power and recreation demands may out-compete natural resource needs in drought years. Re-establishing channel-forming flows may be difficult in some cases due to real or perceived flood impacts. Costs of flow restoration range from relatively low to quite high, especially if significant power generation is forgone. The benefits of regulated flow restoration accrue very quickly in some cases (e.g. flushing flows for smolt migration) and more slowly in other cases such as channel-forming flows, since a period of channel adjustment may be necessary before habitats become suitable.

S.M6. Protect and restore floodplain function and channel migration processes. (Category B, C)

- Set back, breach, or remove artificial channel confinement structures

Explanation: Floodplain degradation occurs as a result of a variety of land uses and can impact many limiting factors including stream flow, substrate and sediment, water quality, habitat diversity, and channel stability. The lower reaches of many lower Columbia streams have been straightened, channelized, and diked in order to create useable land, protect land-uses, and to increase flood conveyance. Restoration of a stream's access to its floodplain is achieved through partial or full removal of confining structures or through channel grade-control. Floodplain restoration addresses limiting factors related to stream flow, channel stability, habitat connectivity, and biological processes (e.g. nutrient exchange). These projects have a moderate-to-high probability of success and address important limiting factors, but they are typically expensive and politically challenging, especially if infrastructure is potentially at risk (e.g. risk to floodplain development if levees are breached). Floodplain reconnection projects have occurred infrequently in the study area and are typically only partially implemented (e.g. levee set-backs as opposed to levee removal). Nevertheless, some significant floodplain and estuarine reconnection / restoration projects have begun on the Chinook and Grays Rivers.

S.M7. Protect and restore off-channel and side-channel habitats. (Category B, C)

- Restore historical off-channel and side-channel habitats where they have been eliminated
- Provide access to blocked off-channel habitats
- Create new off-channel or side-channel habitats (e.g. spawning channels)

Explanation: Off-channel and side-channel habitats serve important roles for anadromous fish, resident fish, and wildlife. These habitat types provide important spawning areas, rearing sites, and refuges from disturbance. These habitats are dynamically created and maintained in unconfined alluvial channels. Examples of off-channel habitats include oxbow lakes, wetlands, and backwater sloughs. Off-channel and side-channel habitats are lost as a result of many of the same practices that reduce floodplain function, including channel straightening, floodplain filling, and artificial confinement. In some instances, off-channel habitats exist but access to them is blocked by barriers such as levees, roadways, or tide-gates. With the exception of barrier removal, restoration of off-channels and side-channels is best accomplished passively, through restoration of floodplain connections and channel migration zone processes. Active restoration approaches, such as excavating fill from historical off-channels, may be necessary in some cases where full function cannot be restored. Where populations have suffered from severe loss of critical off-channel habitats and where existing infrastructure limits restoration options, the creation of new habitats (e.g. spawning channels) may be necessary. This approach has been used in the creation of chum spawning channels in the Grays River and Bonneville Tributaries basins.

S.M8. Protect and restore instream habitat complexity. (Category B, C)

- Place stable woody debris in streams to enhance cover, pool formation, bank stability, and sediment sorting
- Structurally modify stream channels to create suitable habitat types

Explanation: In-stream habitat complexity is necessary to create the diversity of habitats and structural features utilized by fish at their various life stages. Important components of habitat complexity include large woody debris, boulders, spawning substrate, and a patchwork of habitat unit types (e.g. pools, riffles, glides). Habitat complexity is created and maintained by natural processes including channel migration, channel adjustment, sediment transport, and large woody debris recruitment. Restoration of habitat complexity is best accomplished through passive measures that restore watershed processes, riparian function, and floodplain connections. Active approaches to restoring habitat complexity include placement of in-stream structural components (i.e. large woody debris), substrate supplementation, and structurally modifying stream channels (e.g. re-meandering).

Many limiting factors are addressed by restoration of in-stream habitat complexity; however, active channel restoration often only addresses the symptoms and not the causes of limiting factors. To be successful, active channel restoration must be paired with restoration of the habitat-forming processes that served to create the limiting factors in the first place. Because habitat-forming processes are often not adequately addressed, active channel restoration varies widely in probability of success. It can also be very costly. An advantage to active channel restoration is that if implemented successfully, the benefits can be realized within a few years, an important consideration when faced with urgent risks to species.

Many active channel restoration projects have been conducted in the study area. The most common projects are large woody debris supplementation efforts. Changes to channel meander patterns and direct creation of habitat units have also occurred in some streams. The long-term benefits of many of these projects have not been fully evaluated because of their recent implementation.

S.M9. Protect and restore stream-bank stability. (Category B, C)

- Restore eroding stream banks
- Restore mass wasting (landslides, debris flows) within river corridors

Explanation: Projects that protect or restore stream-bank stability address habitat diversity, channel stability, and substrate and sediment limiting factors. Stream-bank erosion and mass wasting are natural processes that are necessary for habitat formation, large woody debris recruitment, and substrate delivery; however, land-use practices that artificially compromise bank stability can contribute to impaired channel adjustment and sediment delivery processes. Stream-bank instability occurs in two primary forms: 1) erosion of the bed and banks of stream channels, and 2) mass wasting within the river corridor. Bed and bank erosion occurs as bed scour or lateral bank erosion. Mass wasting occurs as landslides, gully formation, or debris flows. Stream-bank stability impairments are related to hillslope conditions (i.e. runoff, sediment supply) or to conditions within channels, riparian areas, and floodplains.

The most effective restoration measures include passive measures that restore the channel conditions or watershed processes that are contributing to the instability. Examples of passive measures include riparian reforestation, restoration of the natural runoff regime, and reductions in artificial confinement.

Active restoration measures include structural stabilization or vegetative plantings. The best approaches often utilize a combination of structural and vegetative measures known as bio-engineering techniques. To be successful, active channel restoration must be paired with restoration of the habitat-forming processes that served to create the limiting factors in the first place. Because habitat-forming processes are often not adequately addressed, active channel restoration varies widely in probability of success.

S.M10. Protect and restore riparian function. (Category B, C)

- Reforest riparian zones
- Allow for the passive restoration of riparian vegetation
- Livestock exclusion fencing
- Invasive species eradication
- Hardwood-to-conifer conversion

Explanation: Riparian degradation occurs as a result of a variety of land uses and can impact many limiting factors including stream flow, substrate and sediment, water quality, habitat diversity, and channel stability. Riparian restoration can take many forms. The most common type of riparian restoration is re-vegetation, which is a quasi-active restoration strategy, since plantings are initially conducted as a jump start, but the system is then left to recover on its own. Recovery of riparian vegetation is a critical step in system recovery as it addresses many of the habitat threats and in-stream limiting factors. As with other active restoration approaches, environmental stressors (e.g. livestock grazing) must be addressed for riparian plantings to be successful. Re-vegetation projects are very cheap and have a moderate-to-high probability of success. Benefits, however, take a long time to accrue. Stream shading, bank stability, and large woody debris improvements may not be realized for 30 to 80 years or more. These time lags should not deter the implementation of these projects, which can be a great investment in future watershed function. Due to the ease, cost, and community involvement potential, many re-vegetation projects have been conducted throughout the study area.

One of the most common restoration strategies on grazing lands is riparian exclusion fencing for livestock. This passive restoration strategy allows for trampled soils to stabilize, decreases animal waste delivery to streams, and allows the riparian plant community to recover. Riparian fencing is relatively inexpensive and has a high probability of success, if maintained properly. Some benefits, such as reductions in trampling and animal waste generation, accrue within the first few years. Other benefits, such as the benefits resulting from recovery of vegetation, may take many years to accrue. Riparian fencing has occurred along many streams in the study area, particularly through the efforts of the Natural Resources Conservation Service (NRCS) and local Conservation Districts (CDs).

Although significant riparian timber harvest occurred in the past, riparian areas currently receive protection from forest practices. Forest practices policies on private, state, and federal lands are geared towards riparian protections that maintain stream shade, wood recruitment, and stream bank stability.

S.M11. Protect and restore natural sediment supply processes. (Category B, C)

- Address forest road related sources
- Address timber harvest related sources

- Address agricultural sources
- Address developed land sources

Explanation: Restoration and protection of sediment supply processes addresses the substrate and sediment limiting factors. Sediment supply process restoration on forest lands includes road abandonment, road maintenance, ditch-line disconnect from stream channels, forest re-vegetation, and implementation of proper forest harvest practices. Protections of sediment supply processes are provided for in private, state, and federal forest practices policy. Road construction and maintenance standards are aimed at ensuring that no degradation to fish habitat occurs due to erosion or stream bank destabilization. Restrictions are placed on upland harvests that have a potentially adverse impact on unstable slopes and landforms.

In the last several years, the USFS has actively removed roads and upgraded problem roads on federal lands. On private lands, the new Forest Practices Rules (FPRs) contain strict standards for road construction and require timberland owners to submit road maintenance and abandonment plans. As these programs continue to be implemented, corresponding improvements to limiting factors are expected.

Road abandonment is very expensive and carries a risk of fill failure and continued erosion if not conducted and maintained properly. Proper maintenance and upgrades of existing roads can accomplish some of the same objectives as removal, but to a lesser degree. The social costs (e.g. limited human access) and economic costs of maintenance/upgrades are considerably less than abandonment, at least in the near term. The benefits from forest road restoration projects are likely to be realized in less than a decade.

Forest re-vegetation and wildfire risk reduction projects can help to protect and restore sediment supply processes. Re-vegetation of harvested areas is inexpensive and highly successful. Stabilization of harvest-related mass wasting sites is often less successful until a mature forest is re-established. Forest re-vegetation is standard practice on public and private lands and is required under the new FPRs for harvests greater than 50% of the timber volume.

Restoration of sediment supply processes on agricultural lands is accomplished through the application of agricultural Best Management Practices (BMPs) with respect to erosion control. These include activities such as conservation tillage and cover cropping. Tax incentives and cost-free technical assistance programs (e.g. through the Natural Resources Conservation Service) have resulted in many farmers implementing conservation measures on their lands.

S.M12. Protect and restore runoff processes. (Category B, C)

- Address forest road impacts
- Address timber harvest impacts
- Limit additional watershed imperviousness
- Manage storm water runoff
- Protect and restore wetlands

Explanation: Restoration and protection of runoff processes addresses stream flow, water quality, critical habitat, channel stability, and substrate and sediment limiting factors. Runoff impairment throughout the lower Columbia basin is related to forest practices, urban development, and channel / floodplain alterations. Land-use impacts have the greatest effect on frequent interval (2-10 year) floods and little effect on extreme flood events. Elevated peak flow volumes can increase the risk of redd scour and sedimentation.

Protections of runoff processes are provided for in private, state, and federal forest practices policy. Forest road construction and maintenance standards are aimed at ensuring that no degradation to fish habitat occurs due to ground water capture or surface water diversion. There are also restrictions placed on upland harvests in order to reduce the potential for increased snow accumulation and melt rates that can potentially increase runoff volumes during storm events. The adequacy of these restrictions has not been fully evaluated.

In the last several years, the USFS has actively removed roads and upgraded problem roads on federal lands. On private lands, the new FPRs contain strict standards for road construction and require timberland owners to submit road maintenance and abandonment plans. Road abandonment can reduce flow concentration and reduce conversion of stream flows from subsurface to surface flows (groundwater capture). Benefits and risks associated with road abandonment projects are discussed under the sediment supply measure. As these programs continue to be implemented, corresponding improvements to limiting factors are expected.

Forest re-vegetation and wildfire risk reduction projects can help to restore stream flow limiting factors. Re-vegetation of harvested areas is inexpensive and highly successful; however, hydrologic benefits of re-vegetation are not seen until after 25 years or more. Forest re-vegetation is standard practice on public and private lands and is required under the new FPRs for harvests greater than 50% of the timber volume.

Runoff preservation and restoration on developed lands includes storm water retention/infiltration measures, urban storm water BMPs (e.g. pervious pavement, on-sight runoff control, living roofs, etc), reductions in watershed imperviousness (e.g. fewer hard surfaces, more natural vegetation, less compacted soils), and changes to uniform building codes and development regulations (UBCs and the Fire Marshall often require excessive paving, wide roads and cul-de-sacs, and place restrictions on alternative low-impact building methods).

Due to the permanent infrastructure of developed lands, which is unlikely to be restored to pre-disturbance conditions, runoff restoration in these areas is more accurately classified as rehabilitation or mitigation as opposed to restoration. The existing infrastructure also makes for a low probability for success and great expense. For example, even though expensive storm water attenuation projects are required for most major developments, there is little evidence that they are sufficient enough to reduce harmful impacts to stream flows. Rehabilitation of watershed processes in developed lands will require aggressive measures at local (e.g. residential storm water infiltration) and municipal (e.g. storm water retention) scales. Efforts on developed lands in the study area should focus on the expanding Vancouver metropolitan area and on rural development that is encroaching on many of the lowland river valleys.

Wetlands are critical for attenuating stream flows, providing for nutrient exchange, and for creating complex habitats. Wetlands restoration can address several limiting factors, including habitat connectivity, stream flow, water quality, habitat diversity, and biological processes. Wetland areas have been reduced by a host of land-use practices, with agriculture and development having the greatest impacts. Wetlands restoration involves restoring historical wetlands or creating new wetlands to mitigate for loss of historical wetlands. Wetlands mitigation is often required by local jurisdictions when development results in irreversible wetlands loss. Restoring historical wetlands has a high probability of success if the agent of degradation is removed from the site. Mitigation wetlands have a much lower probability of success because natural conditions at the site may not be able to sustain wetland processes. Wetlands restoration can be very expensive, especially if an active approach is taken to create the appropriate structure and function. Passive approaches, such as letting an historical wetland recover on its own, are less expensive but may take decades. Wetland mitigation occurs frequently in developing areas in the study area, especially in the expanding urban areas within Clark County. Wetlands mitigation and restoration is especially important in these areas, which historically consisted of abundant wetlands throughout the broad Columbia River floodplain. Wetland restoration has also occurred in many other locations in the study area, often associated with riparian restoration efforts. Restoring wetlands in riparian and floodplain areas can yield important benefits to fish, including habitat creation and increased nutrient / food resources.

S.M13. Protect and restore water quality. (Category B, C)

- Restore the natural stream temperature regime
- Reduce fecal coliform bacteria levels
- Reduce turbidity sources
- Restore dissolved oxygen concentrations
- Reduce delivery of chemical contaminants to streams
- Reduce sub lethal effects of contaminants

Explanation: Water quality restoration and preservation measures address water quality limiting factors. Restoration can take many forms, including restoration of channel, riparian, and hillslope watershed processes that are discussed in other measures. These include riparian re-forestation, livestock exclusion fencing, recreation management, and restoration of sediment supply processes.

Water quality restoration and preservation on agricultural lands includes livestock exclusion fencing to reduce bacteria and erosion, on-sight manure management to prevent nutrient/bacteria loading, and application of agricultural BMPs with respect to pesticide, herbicide, and fertilizer use. These practices have a moderate probability of success and can be fairly expensive, especially for small-scale farmers. Tax incentives and cost-free technical assistance programs (e.g. through the NRCS) have resulted in many farmers implementing water quality related measures on their lands throughout the lower Columbia region.

Water quality restoration and preservation on forest lands involves sediment supply measures (turbidity), riparian measures (temperature, turbidity, dissolved oxygen, nutrients), and forestry BMPs that address pesticide, herbicide, and fertilizer use (chemical contaminants). Water quality protections on forest lands are generally covered under existing private, state, and federal forest practices policy.

Water quality restoration and preservation on developed lands involves managing industrial point sources of pollution, eliminating urban and rural sewage discharge to streams (e.g. urban sewage overflows, leaking septic systems), and treating storm runoff before it is discharged to streams. Chronic, sub lethal effects of contaminants are a source of particular concern.

S.M14. Restore channel and floodplain areas damaged as a result of streamside gravel mining and reduce risks of future impairment due to these activities. (Category C)

- Prevent potentially harmful mining wastes, high temperature water, and turbidity from entering streams
- Prevent fish stranding in processing areas
- Stabilize surface mining sites to prevent erosion

- Reduce the risk of gravel pond capture, while providing for natural channel migration processes
- Restore channel morphology where streams have avulsed into mining areas

Explanation: Mining site restoration includes stabilization of exposed substrate, re-vegetation, reduction in water quality impacts, reductions in channel avulsion risks, re-habilitation of degraded stream channels, and adequate fish screening. The primary limiting factors that are addressed include water quality, substrate and sediment, channel stability, riparian function, and floodplain function. Restoration aimed at decreasing erosion and sedimentation can occur through stabilizing dredge material and through measures that sever connections between processing areas and stream channels. Abatement of water quality impacts requires alterations to processing techniques, treatment of water prior to stream discharge, or effectively severing connections between processing areas and stream channels. On a few streams in the study area (e.g. East Fork Lewis River), restoration activities will need to focus on restoring the natural channel morphology where streams have avulsed into gravel mining/processing ponds. Future avulsion risk will also need to be addressed. In some instances, recovery of mining areas may provide an opportunity for floodplain, wetland, and channel migration zone restoration.

The success of mining site restoration will vary widely depending on the problems and techniques used to solve them. Efforts such as altering processing techniques or screening processing ponds can be very successful, whereas stabilizing dredge material or decreasing avulsion risk may prove very challenging, especially considering that many of these sites are located within the 100 year floodplain or geomorphic floodplain. There is also great variation associated with the time that is needed until benefits are realized. Water quality impacts could potentially be curbed within a few years, whereas channel migration zone recovery could take decades.

S.M15. Protect and restore sensitive areas through recreation management. (Category B)

- Limit intensive recreational use where there is harassment potential
- Actively rehabilitate areas damaged by intensive recreational use

Explanation: Recreation-related restoration efforts include rehabilitating damaged terrain, limiting use, and waste management. Rehabilitation efforts are sometimes necessary to reduce erosion and re-establish native vegetation, especially in areas where intensive motorized recreation occurs (e.g. all-terrain vehicles). Limiting recreation use will be necessary in some cases to allow the system to recover. Limiting use can also reduce direct harassment effects on aquatic biota. Such activities include swimming and boating in salmonid spawning, juvenile rearing, or adult holding areas during critical periods. Human waste management is a concern in areas of intensive use. Providing waste management or disposal facilities can reduce impacts.

The success of recreation management and restoration depends on the specific problems and the techniques applied. Success is often hampered by a user group's resistance to recreation limitations or by a lack of adequate enforcement. Recreation has been intensively managed on state and federal lands in the past, but funding cuts, combined with increasing population pressures, are making it increasingly difficult to manage recreation adequately.

S.M16. Maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of land and water use regulations for the protection and restoration of habitats significant to fish and wildlife resources. (Category B, C)

Explanation: Establish cooperative enforcement partnerships among agencies, public, land owners, and industry. Establish priorities to emphasize protection in key areas and facilities where recovery efforts are focused.

6.4 Habitat – Estuary & Lower Columbia Mainstem

The draft Columbia River Estuary and Lower Mainstem 4H Integration White Paper describes our current assumptions regarding the relationships between salmonid species, habitat conditions, and habitat-forming processes, as well as potential strategies and measures to address threats. Hypotheses, strategies, and measures in this chapter for the estuary are consistent with similar material in the Bi-State Estuary/Lower Mainstem Subbasin Plan and to the Lower Columbia River Estuary Partnership (LCREP) Comprehensive Conservation and Management Plan (CCMP). The LCREP will play a critical role in the development, implementation, and evaluation of estuary habitat protection and restoration actions.

In general, the complex relationships that exist between species and habitat conditions in the estuary and lower mainstem are poorly understood. However, a growing body of research is emerging that is contributing to our understanding of the physical habitat-forming processes and how the estuary and lower mainstem have changed over the past 100 years. These changes represent important indicators of the stresses imposed on various salmonid life histories. This is especially important to the entire Columbia River Basin because all salmonids in the Columbia River utilize the estuary and lower mainstem at least twice in their life cycle. Impacts (and benefits) to the various ocean- and stream-type salmonids occurring in the estuary and lower mainstem are multiplied by the numbers of migrating adults and juveniles throughout the basin (not withstanding those populations that spawn in the estuary and lower mainstem). Improvements in estuary conditions for salmonids can also be expected to benefit salmon in local lower Columbia River populations as well as other populations throughout the basin.

This plan addresses both historic and current factors limiting salmonid survival in the estuary of critical importance to all Columbia Basin ESU's. It does not apply the limiting factors at a level of detail sufficient to address specific life stages at the sale of populations as identified by the TRT, because our current knowledge and tools do not allow us to do so. Actions are linked to threats at a general level – for instance the plan does not provide detail on how much habitat and what type of habitat should be restored per river reach, again because the necessary information does not exist at this time..

6.4.1 Working Hypotheses

E.H1. Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.

Explanation: Habitat formation in the lower Columbia River mainstem and estuary is controlled by opposing hydrologic forces; ocean processes (tides) and river processes (discharge). Both hydrologic processes are affected by anthropogenic factors and climate cycles and variability. These processes control estuary bathymetry, water turbidity, salinity, nutrients, and woody debris, which in turn determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

E.H2. Human activities have altered how the natural processes interact, changing habitat conditions in the Columbia River estuary and lower mainstem.

Explanation: Anthropogenic factors have substantially influenced the current habitat conditions in the lower Columbia River mainstem and estuary. The primary anthropogenic factors that have determined estuary and lower mainstem habitat conditions include hydrosystem construction and operation (i.e., water regulation), channel confinement (primarily diking), channel manipulation (primarily dredging), and floodplain development and water withdrawal for urbanization and agriculture. Generally, these anthropogenic factors have influenced estuary and lower mainstem habitat conditions by altering hydrologic conditions, sediment transport mechanisms, and/or salinity and nutrient circulation processes. Projected population growth and land use conversion will continue to pressure habitat conditions and habitat-forming processes for salmon and steelhead in the estuary and lower mainstem.

E.H3. Changes in the Columbia River estuary and lower mainstem habitat are the result of local activities as well as activities throughout the Columbia and Snake river basins.

Explanation: This hypothesis exemplifies the idea that 'everything flows downstream'. Because of the location within the Columbia River basin, lower mainstem and estuary habitats are affected by both local and basin-scale activities.

E.H4. Rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years, current physical and biological processes are likely still changing such that habitat conditions represent a degraded state of equilibrium.

Explanation: The habitat alterations that have occurred since pre-development times have degraded the quality and quantity of habitat in the estuary and lower mainstem. Because this historical trend in habitat loss appears to have slowed recently, the estuary and lower mainstem habitat conditions are in a degraded state of equilibrium. This emphasizes the urgency of the current need to implement habitat restoration actions to reverse the trend of habitat loss.

E.H5. Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in decisions intended to benefit recovery and sustainability of natural resources.

Explanation: Our current understanding of causal relationships between salmonids, non-salmonid fishes, and wildlife and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem are unclear. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on known salmon and habitat relationships in non-tidal freshwater. Continued research is vital to the progress and success of restoration and recovery efforts in the Columbia River estuary and lower mainstem.

E.H6. Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.

Explanation: The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. All exotic species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites. Altered habitats in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have facilitated the successful establishment of aquatic non-indigenous species.

E.H7. Of all fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear to be one of the most distressed.

Explanation: Declining salmonid trends in the Columbia River basin are reflected in the prevalence of ESA-listings throughout the basin. The same trend does not hold true for many fish and wildlife species. Despite substantial changes to the Columbia River estuary and lower mainstem ecosystem, many species have stable or increasing abundance trends. This statement must be qualified by the lack of information on many fish and wildlife species. However, salmon are clearly among those at serious risk.

E.H8. The Columbia River estuary and lower mainstem ecosystem is critical to the expression of salmon life history diversity and spatial structure which support population resilience and production.

Explanation: Estuaries have important impacts on juvenile and subsequent adult salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean, as well as the olfactory cues needed for successful homing and migration. Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for high salmonid production in the estuary. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids.

E.H9. Changes in the Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem and contributed to the imperiled status of salmon and steelhead.

Explanation: Salmonid production in estuaries is supported by detrital food chains; habitats that produce and/or retain detritus are particularly important. Diking and filling activities have eliminated the emergent and forested wetlands and floodplain habitats that many juvenile salmonids rely on for food and refugia, as well as eliminating the primary recruitment source of large woody debris that served as the base of the historical macro detritus-based food web. The current estuary food web is micro detritus based, primarily in the form of imported phytoplankton production from upriver reservoirs. This current food web is primarily available to pelagic feeders and is a disadvantage to epibenthic feeders, such as salmonids. Additionally, the decreased habitat diversity and modified food web has decreased the ability of the lower Columbia River mainstem and estuary to support the historical diversity of salmonid life history types.

E.H10. Density dependent factors might affect salmonid productivity in the Columbia River estuary and lower mainstem under some conditions, but their significance is unclear.

Explanation: At our current level of understanding, the importance of density dependent mechanisms in the estuary, if they exist, are not clear. Research in other Pacific Northwest estuaries points toward density dependent mechanisms, although applicability to the Columbia River estuary is unknown. Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large numbers of salmonids (hatchery or natural) enter the estuary.

E.H11. Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

Explanation: Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. These important peripheral habitats could be returned to the lower Columbia River ecosystem via dike removal and restoration of historical flow regimes. Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids.

E.H12. Estuary and lower Columbia River mainstem habitat restoration efforts would provide substantial benefits for anadromous fish species throughout the Columbia and Snake river basins.

Explanation: All anadromous salmonids in the Columbia and Snake river basins must pass through the estuary twice to complete their life cycle. The estuary is critical to juvenile salmonid survival and smoltification, and it provides the necessary cues for successful return migrations. Improvements to lower mainstem and estuary habitat conditions will improve survival for all salmonids throughout the entire Columbia River basin.

6.4.2 Strategies

E.S1. Avoid large scale habitat changes where risks to salmon and steelhead are uncertain.

Explanation: This is similar to the physician's credo of first do no harm. Large scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

E.S2. Mitigate small-scale local habitat impacts such that no net loss occurs.

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site or off site efforts.

E.S3. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

E.S4. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes are due to natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

E.S5. Improve understanding of how salmonids utilize estuary and lower mainstem habitats and develop a scientific basis for estimating species responses to habitat quantity and quality.

Explanation: Emerging research and understanding about how physical processes affect habitat conditions for salmonids in the estuary and lower mainstem are promising tools potentially available in the foreseeable future. Just as critical is an increased understanding of how salmonid populations use and respond to the changing habitat conditions in the estuary and lower mainstem.

6.4.3 Measures

E.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River. (Category C)

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 62% and 94% loss of these habitat types since the 1800s. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements.

E.M2. Protect and restore riparian condition and function. (Category A)

Explanation: Riparian and upland zones are critical habitats for many naturally-spawning species. This includes are variety of tools including; local land use regulatory actions, acquisition, and restoration activities.

E.M3. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem. (Category A)

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species are largely understudied. Recent activities are beginning to fill in this gap, but our ability to identify and prioritize measures is difficult due to this knowledge gap.

E.M4. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations. (Category A)

Explanation: Use of the Columbia River estuary and lower mainstem by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

E.M5. Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and near shore ocean. (Category B)

Explanation: There is little understanding of the short- and long-term effects of contamination on salmonids, resident fish, or wildlife species.

E.M6. Mitigate channel dredge activities in the Columbia River estuary and lower mainstem that reduce salmon population resilience and inhibits recovery. (Category B)

Explanation: Channel dredge activities affect the quality of the various estuary and lower mainstem salmonid habitats through disturbance, sediment delivery, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and loss of tidal marsh and tidal swamp habitats.

E.M7. Restore connectedness between river and floodplain. (Category C)

Explanation: Restoring the access to the floodplain addresses the following juvenile rearing limiting factors: shallow water, low velocity, and peripheral habitats.

E.M8. Restore or mitigate for impaired sediment delivery processes and conditions affecting the Columbia River estuary and lower mainstem. (Category C)

Explanation: Sediment dynamics are a critical component of estuary and lower mainstem (and near shore) habitat forming processes. These dynamics have been altered by changes in mainstem transport due to upstream dam construction, flow regulation, channelization (e.g., pile dikes), deepening, maintenance dredging, and dredged material disposal activities.

6.5 Hydropower Operation and Configuration

This section describes near-term and long-term strategies and measures to ensure that hydropower dam configuration and operations in subbasins and the mainstem Columbia River support recovery of naturally-spawning lower Columbia River fish.

6.5.1 Working Hypotheses

D.H1. Tributary hydropower development and operation has eliminated access to large areas of productive habitat in some lower Columbia subbasins and has also affected habitat suitability downstream.

Explanation: Dam construction in the Cowlitz, Lewis, and White Salmon subbasins has eliminated access of anadromous fishes to large areas of habitat that historically supported productive populations and remains suitable for these species. In the Cowlitz basin, dam construction has blocked 90-100% of the available habitat for Upper Cowlitz, Cispus, and Tilton winter steelhead, coho, and spring Chinook habitat, as well as habitat for fall Chinook and chum. North Fork Lewis dams have similarly blocked 95% of winter steelhead, 50% of summer steelhead, 50% of Fall Chinook, 90% of spring Chinook, and 10% of chum habitat in that system. Inundation of habitats due to dam construction has also affected chum and fall chinook, particularly upstream of Bonneville Dam.

D.H2. Effects on migration and passage mortality of juvenile and adult salmon caused by the configuration and operation of Bonneville Dam has reduced population resilience and inhibits recovery.

Explanation: Upstream and downstream fish passage facilities are operated at Bonneville Dam in the mainstem Columbia River but significant mortality and migration delays continue to occur. No bypass system is 100% effective. Adults are typically delayed in the tailrace but most eventually find and use fish ladders. A varying percentage of adults do not pass successfully or pass but fall back over the spillway. Juvenile passage mortality results primarily from passage through dam turbine rather than spillway or fish bypass systems. For lower Columbia River salmon, passage is a concern only for upper Gorge populations. Most lower Columbia River salmon populations originate from areas downstream of Bonneville Dam and are not subject to passage concerns.

D.H3. Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions and habitat forming processes that have reduced salmonid population resilience and inhibits recovery.

Explanation: Construction and operation of the Columbia River hydropower system has drastically altered flow, temperature, and sediment transport patterns in the lower mainstem and estuary. Interactions of these changes and other local activities have substantially altered habitat conditions for lower Columbia fish and wildlife species. These include direct local effects such as dewatering of chum and fall Chinook redds in the mainstem downstream from Bonneville Dam. Also included are large-scale changes in habitat forming processes.

6.5.2 Strategies

D.S1. Restore access of key populations to blocked habitats in historically accessible subbasins or portions of subbasins where necessary to support region-wide recovery goals.

Explanation: Lack of fish passage has eliminated access to upper Cowlitz, Lewis, and White Salmon rivers where dams were constructed without adequate passage facilities. Habitat quality in many blocked areas continues to be suitable for salmon. Recovery of some salmon runs (e.g. spring Chinook) may not be feasible according to TRT criteria without restoration of effective passage upstream of some large tributary dams and downstream juvenile passage once populations are reestablished.

D.S2. Assure that the Columbia River and tributary hydropower systems are managed to contribute to recovery of lower river as well as upstream populations.

Explanation: The hydropower systems must be managed to complement and support the recovery of threatened lower Columbia River salmon and steelhead populations. Concerns with mainstem Columbia and tributary dams include passage efficiency, local effects of operations on tailrace habitats, and widespread ecosystem effects of changes in flow, temperature, and sediment transport patterns. Effects on watershed processes warrant must be considered (blockage of marine-derived nutrients to areas above dams, blocked movement of large wood and sediment, changes in historical hydrology and changes in hydro geomorphic processes).

6.5.3 Measures

D.M1. Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz, Lewis, and White Salmon dams and facilities as part of relicensing processes or requirements. (Category C)

Explanation: Reintroduction implementation and evaluations are already underway in the Cowlitz subbasin. Similar efforts are under consideration or planned as part of the Lewis and White Salmon relicensing processes. Uncertainty exists regarding the most effective way to restore passage through dam and reservoir complexes in the Cowlitz and Lewis systems. Dam heights and reservoir sizes make juvenile passage particularly problematic.

D.M2. Maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam and tributary dams when populations are reestablished. (Category B)

Explanation: Effective passage facilities are crucial for upper Gorge salmon populations as well as every other upstream anadromous fish population. Additionally, effective passage will be crucial in tributaries where populations are reestablished to historic spawning and rearing habitat located above tributary dams. Measure implementation will involve evaluations of proposed passage programs.

D.M3. Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods. (Category A, B)

Explanation: Prevents dewatering and decreased flows in redds during and incubation, as well as increasing the potential spawning sites available for adults. Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses.

D.M4. Operate the tributary hydro systems to provide appropriate flows for salmon spawning and rearing habitat in the areas downstream of the hydrosystem. (Category A,B)

Explanation: The quantity and quality of spawning and rearing habitat for salmon, in particular fall chinook and chum in the North Fork Lewis and Cowlitz, is affected by the water flow discharged at Merwin and Mayfield dams respectively. The operational plans for the Lewis and Cowlitz dams, in conjunction with fish management plans, should include flow regimes, including minimum flow and ramping rate requirements, which enhance the lower river habitat for fall Chinook and chum.

D.M5. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary. (Category C)

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes. Habitat for salmonids, other resident fish, and wildlife in the Columbia River estuary and lower mainstem would benefit from a more natural regime.

D.M6. Monitor and notify FERC of significant license violations, enforce terms and conditions of section 7 consultations on FERC licensing agreements, and encourage implementation of section 7 conservation recommendations on FERC Relicensing agreements. (Category C)

Explanation: This is a regulatory measure related to operations of facilities licensed by the Federal Energy Regulatory Commission, including tributary hydropower facilities.

6.6 Harvest

The harvest of salmon and steelhead can impact the viability of naturally-spawning fish populations. The strategies set forth in this paper are intended to ensure that future harvest management and practices will contribute to restoring lower Columbia salmon and steelhead populations to healthy, harvestable levels. The section describes a near-term strategy for limiting the harvest impacts and a long-term strategy for restoring naturally-spawning fish populations to harvestable levels. It includes a number of substantive measures that generally ensure that all fisheries are managed to contribute to recovery of naturally spawning populations and preserving fishery opportunities focused on hatchery fish and strong wild stocks in a manner that does not adversely affect recovery efforts.

The strategy includes a discussion of the impacts of harvest on naturally-spawning fish populations and an analysis of the various programs affecting harvest. Programs considered include the Pacific Fishery Management Council (PFMC), which manages Pacific Ocean fisheries in the U.S. south of Canada consistent with sustainable fishing requirements of the U.S. Magnuson-Stevens Act; the Pacific Salmon Commission (PSC) which oversees management by the domestic managers of fisheries subject to a treaty involving Alaskan, and Canadian fisheries; and Columbia River mainstem and tributary fisheries which are regulated by the Columbia River Compact (Oregon and Washington concurrent jurisdiction), The Columbia River treaty Indian tribes, and the Washington and Oregon Fish and Wildlife Commissions. All U.S. fisheries are managed to comply with the Endangered Species Act administered by NOAA Fisheries. Measures are included to integrate consideration of the LCFRB recovery goals into Pacific Salmon Treaty, PFMC, and US v. Oregon processes and to improve marking programs and monitoring of fishery catch.

6.6.1 Working Hypotheses

F.H1. Salmon recovery is predicated on restoration of healthy, harvestable naturally-spawning populations.

Explanation: Fishing is both part of the problem in protecting salmon populations from extinction and part of the goal of recovering naturally-spawning populations to harvestable levels. On the one hand, harvest of naturally-spawning fish reduces numbers of fish escaping to spawn. Significant harvest rates of naturally-spawning fish may thus increase risks of extinction. Reductions in fisheries may reduce the risk of extinction. On the other hand, the recovery goal has been defined to include sustainable harvest of naturally-spawning populations. As life cycle modeling indicates, recovery cannot be achieved merely by eliminating all fishing effects. The intent of this plan is to strike an appropriate balance between fishing and other land and water uses to recover lower Columbia salmon and steehead.

F.H2. Historic fishing rates in conjunction with other factors posed significant risks to the continued existence of many naturally-spawning populations and were not sustainable.

Explanation: Columbia River salmon are subject to harvest in the Canada/Alaska ocean, U.S. West Coast ocean, Lower Columbia River recreational, tributary recreational, and in-river treaty Indian (including commercial, ceremonial, and subsistence) fisheries. Historic harvest rates in combined fisheries ranged from species averages of 60% to 85% per year. These rates are sustainable by only the most robust salmon populations in the most productive habitats. Fishery restrictions have substantially reduced impacts to wild fish from historical levels (see hatchery limiting factors and threats chapter).

F.H3. Changes in fishery management to protect weak stocks have substantially reduced harvest risks to naturally-spawning populations.

Explanation: Fisheries from the Columbia Basin to Alaska have been widely restricted to limit impacts on listed and other weak stocks of fish. Salmon fisheries are currently managed in an attempt to protect weak, listed naturally-spawning populations. Listed populations are generally not targeted by fisheries but are caught incidental to the harvest of healthy hatchery and naturally-spawning populations (e.g. Hanford upriver bright fall Chinook). Changes have been made to ocean and in-river sport, commercial, and tribal fisheries to reduce risks to listed populations. Restrictions have been the most severe on in-basin fisheries.

Weak stock management (the practice of limiting fisheries based on annual abundance of particular stocks of concern) of Columbia River fisheries has evolved in response to decades of declining trends in naturally-spawning salmon viability that culminated in ESA listings of 26 species of for Pacific salmon and steelhead. Weak stock management became increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction. In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s. Fishery reductions were one of the first areas of focus following ESA listing and a wide variety of protective measures were quickly implemented by NOAA fisheries in the ESA section 7 process. These included elimination of some fisheries, reductions in allowable fishing impacts for naturally-spawning stocks, abundance-based management criteria to further reduce impacts in years of low abundance, and selective fisheries for marked hatchery fish.

F.H4. Additional fishery management opportunities exist for reducing near term population risks for some species such as fall Chinook but opportunities for others such as chum salmon and steelhead are limited.

Explanation: Current fishing impact rates on lower Columbia River naturally-spawning salmon populations average 45% for tule fall Chinook, 40% for bright fall Chinook, 22% for spring Chinook, 18% for coho, 8.5% for steelhead, and <2.5% for chum salmon. For those populations affected significantly by harvest and at risk due to low spawner abundance, fishery reductions can be used to reduce near-term viability risks until benefits of habitat improvements can be realized. Habitat improvements typically require many years to implement, whereas, fishery reductions can have a more immediate effect. For instance, changes in forestry practices adopted by Washington are expected to substantially improve watershed and stream habitat conditions in the future but many improvements based on current actions will require 50 to 150 years to accrue. This is the time it takes for forests to mature and reestablish functional watershed processes that create healthy stream habitat conditions for salmon. These habitat measures will restore conditions conducive to long term population viability but do not address the immediate problems of small populations and high extinction risks. Fisheries by contrast are subject to annual management decisions based on annual abundance and escapement needs. Fisheries can be restricted in years of low survival to ensure that escapement needs for population viability are met. The degree of necessary fishery restrictions may vary from year to year based on fish abundance. Restrictions may be less during large return years when numbers are greater than habitat and recovery needs.

F.H5. Additional fishery restrictions involve tradeoffs in foregone catch of healthy hatchery and naturally-spawning stocks in freshwater and ocean fisheries.

Explanation: Opportunities for additional fishery reductions exist but will increasingly depend on ocean fisheries where Columbia River fish comprise only a small portion of the catch and priorities are driven by a number of considerations in addition to the status of Columbia River fish. Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regulated by impact limits on weak populations mixed with the strong. Listed fish generally comprise a small percentage of the total fish caught by any fishery. Every listed fish may correspond to tens, hundreds, or even thousands of other stocks in the total catch. As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks and recreational trips to communities which provide access to fishing, with significant economic consequences.

F.H6. Reductions in fishing rates gradually reach a point of diminishing returns where further reductions do not significantly affect population risks.

Explanation: Reductions in fishing produce decreasing benefits as impact rates decline from high to medium to low. Risks are extremely sensitive to moderate to high fishing rates but further reductions eventually reach a point of diminishing returns. Not enough fish are saved at low fishing impact rates on small populations to make a significant biological difference. For instance, reducing a 50% harvest or exploitation rate by half on a run size of 100 fish would escape an additional 25 fish and increase the population size by one third (75 vs. 50 spawners). However, reducing a 10% harvest rate by half on the same run size would save only 5 fish and increase the population size by only 6%. Populations that remain at risk despite reductions in fisheries are constrained by other factors that will ultimately determine the population’s fate. This is not to argue that harvest no longer matters at a certain level, but merely to illustrate that substantial improvements in fish numbers and reductions in risks are no longer biologically feasible after fishing impacts have been reduced beyond a certain point.

F.H7. Restoration of healthy, harvestable naturally-spawning populations will ultimately depend on a combination of actions involving harvest management, hatchery operations, habitat protection and restoration, and ecological interactions.

Explanation: Effects of fisheries and habitat on fish population viability and harvest potential are intimately related. Sustainable fisheries ultimately depend on protection and restoration of significant amounts of high quality habitat. Population viability and the potential for sustainable harvests are ultimately determined by the inherent productivity of a population, which is a function of habitat quality and utilization. Productive populations in good habitat produce fish in excess of those needed for replacement. These additional fish provide resiliency that lets the population bounce back quickly following years of poor ocean survival. Additional fish disperse from core areas and help sustain adjacent or marginal populations. Additional fish are also available for harvest in many years. The viability of a productive population may remain high even where the habitat is not filled to capacity in every year. Thus, it is not necessary to regulate fisheries to achieve maximum seeding of productive habitats to ensure population viability. Unproductive populations in poor quality or over-utilized habitat operate at or below replacement where average numbers of offspring in subsequent generations are less than or equal to the spawners that produced them. Consequently, poor quality habitats may not support viable populations even when filled to capacity because fish replacement rates are low and populations lack the resiliency to rebound from the inevitable poor ocean cycles.

Long-term population viability depends on both spawning escapement as affected by fisheries and productivity as affected by habitat and hatcheries. To reap the benefits of habitat improvements, fisheries must be regulated to allow sufficient escapement to take advantage of the available habitat. Where currently lacking, weak stock management practices must be developed to support progress towards recovery of listed populations. Recovery will fail if fisheries are not properly managed to complement other recovery efforts and synchronized with increases in fish productivity due to habitat improvements.

6.6.2 Strategies

F.S1. Assure fishery impacts to lower Columbia naturally-spawning populations are managed to contribute to recovery.

Explanation: Fisheries must be managed to complement and support the recovery of threatened lower Columbia River salmon and steelhead populations. For those populations significantly affected by harvest, fishery limitations can provide immediate reduction in extinction risks, buying time until habitat improvement measures can become effective. Fisheries must be managed fundamentally to protect naturally-spawning escapement and ensure that incidental catches of naturally-spawning fish do not jeopardize near-term persistence probabilities or compromise long-term prospects for recovery. Further fisheries management must help ensure that sufficient fish return to take optimum advantage of the productivity of existing habitat and to sustain functional ecological processes.

F.S2. Preserve fishery opportunity focused on hatchery fish and strong naturally-spawning stocks in a manner that does not adversely affect recovery efforts.

Explanation: The long-term goal for salmon recovery is to restore harvestable populations but this goal will require substantial habitat improvements in tributaries, the mainstem, and estuary. Even if effective habitat measures are implemented immediately, benefits will accrue slowly. It took a long time to degrade the habitat to the current state and it will take a long time to restore it. In the interim, carefully controlled fishing opportunities can be provided for hatchery fish and strong naturally-spawning stocks.

6.6.3 Measures

F.M1. Revise or adjust ESA Fishery Management Plans for lower Columbia ESUs as needed to support the Lower Columbia Recovery goals and priorities.

Explanation: Integrate Lower Columbia Fish Recovery Plan and fishery management process. Modify ESA harvest limits, weak stock management regulations, and fishery conservation practices as needed to ensure consistency with Lower Columbia Recovery goals, objectives, and priorities.

F.M2. Consider recovery goals for lower Columbia salmon and steelhead populations as identified in the Lower Columbia Recovery Plan in annual fishery management processes.

Explanation: Lower Columbia populations (as directly represented or represented by appropriate index populations within the ESA based on the recovery scenario) will be considered in pre-season planning, technical review and assessments, in-season monitoring, and development of management strategies. Processes include PFMC, PSC, NOF, Compact, *U.S. v. Oregon*, F&W Commissions, and NOAA's ESA analysis of fishery actions. Specific index populations or stocks will be identified through these management processes.

F.M3. Ensure that scientific review of Lower Columbia Recovery Plan harvest objectives and current ESA management objectives occurs as part of the process in fishery management forums.

Explanation: Incorporate specific biological objectives for recovery of lower Columbia populations into processes established for PFMC, PSC, and *U.S. v. Oregon* technical committees to review, assess, and synthesize for regulatory decisions. Analysis will include effects of fisheries on listed species and how fisheries will impact recovery goals and objectives outlined in the plan. Goals and objectives will include consideration of the role of salmon in ecological interactions.

F.M4. Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries.

Explanation: Studies would be implemented to better estimate and control mortality of naturally-spawning fish released or encountered in selective fisheries as a function of gear types, environmental conditions, handling techniques, and revival methods.

F.M5. Seek to maintain and/or establish programs, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of fishery rules and regulations for the protection of fish and wildlife resources.

Explanation: Laws, rules, regulations, and agreements are most effective when they are consistently applied and enforced.

6.6.4 Actions

Fall Chinook

F.A1 Review NOAA Fisheries' recovery exploitation rate of fall Chinook tules and update risk assessment to consider including more tule populations. (Category B)

Explanation: Current tule fall Chinook fisheries limits are based on a Recovery Exploitation Rate (RER) analysis conducted by NOAA Fisheries in 2002 for Coweeman fall Chinook. The RER is the estimated exploitation rate that is consistent with an 80% probability of achieving and maintaining a Maximum Sustained Harvest (MSH) escapement goal over a 25 year period, with no greater than a 5% probability of falling below a minimum critical threshold over the same 25 year period. The RER is reviewed annually by NOAA fisheries with updated information, and was changed from 65% to 49% in 2002. The RER method includes conservative adjustments to account for variable marine survival, historical exploitation patterns, fishery management error, and current habitat conditions. The RER is intended to be a harvest strategy that promotes rebuilding of the population.

A review of the RER analysis would consider additional populations to include in the assessment (e.g., East Fork Lewis fall Chinook) to determine applicability of the Coweeman based RER to biological objectives for other populations. The RER should be determined for other populations as appropriate biological data becomes available and the amount and effects of hatchery strays are known and/or controlled. These stocks would become indicator stocks in which to gauge appropriate harvest rates for other lower Columbia tule fall Chinook populations. The role of hatchery fish would need to be considered if populations with mixed hatchery and natural production were included in the assessment.

Responsible Parties: NOAA, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.A2. Consider and expressly evaluate the potential for a sliding scale harvest plan based on annual abundance indicators for tule fall Chinook. (Category C)

Explanation: An abundance-based approach to annual fishery management has been implemented for many other stocks including upriver spring Chinook, Willamette spring Chinook, Oregon coast natural coho, and Oregon lower Columbia coho, but not for lower Columbia fall Chinook. An abundance based management approach reduces fishing rates in years of low abundance to decrease risks of low escapements. The following example is displayed as a conceptual illustration of how an abundance-based management plan with a sliding scale could be used. Specific harvest rates, population status, and survival indexes would need to be derived after thorough scientific analysis is conducted. This measure would include a comparison of the proposed sliding scale approach with the current abundance based approach utilized per the PST Agreement (as further limited by the RER) to determine if outcomes would be substantially different and if there were advantages of one approach over the other in respect to meeting recovery objectives. The abundance-based approach could also be considered in conjunction with the RER approach to account for variable abundance of hatchery fish.

Responsible Parties: NOAA, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

Box 1. Example of a sliding-scale abundance-based management approach for Coweeman fall Chinook.

Features

- ✓ *Harvest rates reduced from current levels in years of low returns to protect naturally-spawning spawning escapement in the Coweeman and reduce risks to population viability.*
- ✓ *Allowable impacts scaled to habitat capacity and marine survival.*
- ✓ *Provides access to other healthy salmon runs at variable rates dependent on condition of the Coweeman population and marine survival.*

		Marine survival index3			
		Very low	Low	Medium	High
	Cowee.	(<0.15%)	(0.15-0.25%)	(0.25-0.40%)	(>0.4%)
Parent spawner status[1]	Number2	Harvest Rate			
High (>75% of capacity	>1,270	Low	Med(-)	Med(+)	High
Medium (>50% of capacity)	850-1,270	Low	Med(-)	Med	Med(+)
Low (<50% of capacity)	170-849	Low	Low(+)	Med(-)	Med
Very Low (<10% of capacity)	<170	Low(-)	Low(-)	Low(-)	Low(-)
Total tule run size (1,000s)		<40	40-75	75-100	>100

1 Parent index = 3 year average of parent broods. (e.g., 2004 return based on 1999, 2000, 2001 parents)
2 Based on current EDT capacity estimate.
3 Survival based on LRH forecast adults vs. hatchery releases

F.A3. Conduct periodic reviews of fall Chinook harvest relative to habitat productivity and capacity to assure harvest objectives are synchronized with habitat changes. (Category C)

Explanation: The RER exploitation rate assumes a rate of improvement associated with current habitat conditions. As habitat conditions improve a greater rate of improvement will be achieved with the RER harvest plan. Conversely, the rate of improvement will be less if habitat degrades. An adaptive Management Plan would include a review of the relationship between a RER harvest plan and habitat conditions in basins that produce tule fall Chinook indicator populations. This review could be coordinated through NOAA Fisheries, WDFW, and the Technical Committees of the fishery management forums.

Responsible Parties: NOAA, WDFW

Programs: PFMC (Salmon Technical Team)

F.A4. Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbia naturally-spawning fall Chinook and to establish a collaborative U.S. policy position for the international table at the Pacific Salmon Commission. (Category B)

Explanation: Implementing a revised harvest management plan for lower Columbia fall Chinook would involve coordinated allocation of harvest impacts across ocean and freshwater fisheries. Lower Columbia tules are currently managed directly in PFMC and Columbia River fisheries and indirectly through the 1999 Abundance Based Management Agreement affecting PSC fisheries. This process would involve allocation agreements between Indian and non-Indian, commercial, and recreational interests, and in some years may require international management response if future harvest assessments conclude that refinement in the current 1999 Agreement is needed to meet the needs of lower Columbia Chinook. A collaborative U.S. approach would be necessary to negotiate with Canada. The 1999 Pacific Salmon Treaty Agreement expires after 2008.

Responsible Parties: NOAA, WDFW, ODFW, Col. Tribes, WA Tribes, USFWS

Programs: PFMC, N of Col. Compact

F.A5. Improve tools to monitor and evaluate fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits. (Category B)

Explanation: The pre-season fishery Chinook assessment models utilized in PFMC, PSC, and in *U.S. v. Oregon* should be evaluated to determine if they adequately represent harvest of lower Columbia tule fall Chinook. In-season methods for monitoring catch by species should be evaluated and improved where possible

Responsible Parties: NOAA, WDFW, ODFW, Col. Tribes, WA Tribes

Programs: PFMC, PSC, U.S. vs. Oregon (Tech Advisory Committee)

F.A6. Manage ocean, Columbia River, and tributary fisheries to meet the spawning escapement goal for lower Columbia bright fall Chinook. (Category A)

Explanation: The current escapement goal for Lower River bright fall Chinook is 5,700 natural adult fall Chinook returning to the North Fork Lewis River to spawn. Ocean and freshwater fisheries would continue to employ escapement goal management for Lewis River fall Chinook. The escapement goal may be reassessed as new data is acquired and Lower Columbia Recovery objectives are established for lower Columbia bright fall Chinook.

Responsible Parties: NOAA, WDFW, ODFW, ADFG, Canadian DFO

Programs: PFMC (STT), PSC, U.S. vs. Oregon (Tech Advisory Committee)

F.A7. Develop a more detailed process for in-season monitoring of stock specific harvest of fall Chinook in the Columbia River. (Category B)

Explanation: Evaluate process and resources used by management agencies to monitor in-season harvest of listed species. Assure monitoring and coded-wire tag analysis is adequate for accurate and timely estimates of stock specific impacts to enable in-season recovery and regulatory adjustments as necessary. Assure that investments into in-season monitoring programs are long term to match recovery timelines.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.A8. Develop a basin wide marking plan for hatchery tule fall Chinook that is adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish. (Category C)

Explanation: Assure that tule fall Chinook harvest and escapement monitoring are explicitly considered as part of an overall Columbia basin marking plan. A Columbia basin marking plan is being considered with development under the guidance of NOAA fisheries, however the Columbia basin marking plan development is currently on hold pending a broader coast wide review of the coded-wire tag programs. This measure would include adipose fin marking of hatchery tule fall Chinook in selected watersheds where the management plan includes the need to account for and/or control first generation hatchery fish in the natural spawning escapement. This measure would also provide the opportunity to implement selective tributary sport fishing regulations in the selected watershed. Recent legislation passed by Congress mandates marking of all Chinook, coho, and steelhead produced in federally-funded hatcheries that are intended for harvest. Details for implementation are currently under development by WDFW, ODFW, treaty Indian tribes, and Federal agencies.

Responsible Parties: NOAA, USFWS, WDFW, Col. Tribes

Programs: PFMC (STT), U.S. vs. Oregon (TAC), PSC (Chinook Tech Team), U.S. Congress, WA F&W Commission

F.A9. Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recoveries of fall Chinook in fisheries and escapement. (Category B)

Explanation: This measure addresses technical conflicts between the Chinook coded-wire tag stock identification program and mass marking of Columbia River hatchery fall Chinook. This measure would require assessment of those impacts associated with mass marking selected hatchery programs and would require technical and policy resolution in the fishery forums. Funding for marking and sampling would need to be addressed.

Responsible Parties: WDFW, ODFW, NOAA, USFWS, Col. Tribes, Canadian DFO, ADFG, WA Tribes

Programs: PFMC (STT), PSC (Chinook Tech Team), U.S. vs. Oregon (TAC)

Chum

F.A10. Columbia River Compact agencies will evaluate effectiveness of the current time and area management strategy for chum protection in the commercial fishery. (Category B)

Explanation: Late fall commercial fisheries target late stock hatchery coho and sturgeon. Chum impacts are limited by gear mesh size restrictions in sturgeon fisheries and by curtailing coho fisheries by November before significant numbers of chum are present. The Compact agencies would evaluate the effectiveness of this management strategy based on information acquired in recent years.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC)

F.A11. Develop more specific chum management details for pre-season and in-season management of the late fall commercial fishery. (Category B)

Explanation: The Compact agencies would develop specific criteria for in-season fishery adjustments (e.g. early closures, gear adjustments, area closures) based on chum encounter rates in the fishery. These criteria would be established as part of the chum management plan.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact

F.A12. Monitor chum handle rate in tributary winter steelhead and late coho sport fisheries. (Category B)

Explanation: State agencies would include chum incidental handle assessments as part of their annual tributary sport fishery sampling plan. The sampling effort would be focused in areas where chum rebuilding is a priority and there is significant sport fishing effort for other species occurring during November and December.

Responsible Parties: WDFW

Programs: WDFW Creel Program

Steelhead

F.A13. Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries. (Category A)

Explanation: Includes monitoring of naturally-spawning steelhead encounter rates in fisheries and refinement of long-term catch and release handling mortality estimates. Would include assessment of the current monitoring programs and determine their adequacy in formulating naturally-spawning steelhead incidental mortality estimates.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.A14. Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead. (Category B)

Explanation: The effectiveness of large-mesh commercial gear to target Chinook salmon and avoid steelhead is well documented, but recent live capture spring Chinook fisheries strategy includes a smaller mesh size to improve survival of released naturally-spawning spring Chinook. The smaller mesh size can increase encounters with winter steelhead. Regulatory agencies should continue to refine gear, handle and release methods, and seasonal options to minimize mortality of naturally-spawning steelhead in commercial and sport fisheries.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

FA15. Establish specific naturally-spawning steelhead encounter triggers for in-season Columbia River fishery adjustments needed to support lower Columbia recovery goals and strategies. (Category B)

Explanation: Encounter rates of naturally-spawning steelhead should be monitored in Columbia River fisheries with specific criteria established to trigger season adjustments, which could include delays, closures, gear requirement changes, or fishing area adjustments. This measure would require a long term monitoring program for Columbia River fisheries.

Responsible Parties: WDFW, ODFW

Programs: BPA F&W Program

F.A16. Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead. (Category B)

Explanation: Wind River summer steelhead are destined for above Bonneville Dam and therefore are subject to *U.S. v. Oregon* agreements regarding treaty Indian harvest. Wind River summer steelhead is a priority population for recovery. Discussions with the Columbia River treaty Indian tribes could include options to minimize harvest of Wind River steelhead in Zone 6 fisheries (e.g., expanded Wind River mouth sanctuary during early fall season treaty Indian fisheries).

Responsible Parties: WDFW, ODFW, NOAA, Col. Tribes, USFWS

Programs: U.S. vs. Oregon (Policy and TAC)

F.A17. Monitor naturally-spawning steelhead handle rate in tributary salmon and steelhead fisheries. (Category B)

Explanation: State agencies include naturally-spawning steelhead encounter rates as part of their future tributary sport fishery sampling plans. Efforts would be focused in areas with significant effort on hatchery steelhead and salmon, and prioritized in areas where priority populations are in the process of rebuilding. WDFW has modeled naturally-spawning steelhead encounter rates for Kalama winter and summer steelhead, and SF Toutle winter steelhead.

Responsible Parties: WDFW

Programs: WDFW Creel Surveys

F.A18 Manage Columbia River commercial fisheries by time, area and gear to target hatchery fish and minimize impacts to naturally spawning steelhead. (Category A)

Explanation: Commercial fisheries should utilize “Select Area” off-channel sites to harvest net pen-reared hatchery spring chinook. Continue to regulate mainstem commercial fisheries by mesh size, time, and area to reduce impacts to naturally-spawning steelhead.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC),

Coho

F.A19. Consider and expressly evaluate sliding scale harvest based on annual abundance indicators for naturally-spawning Columbia River coho. (Category C)

Explanation: Establish an abundance based Ocean/Columbia River harvest matrix for naturally-spawning lower Columbia coho. Consider harvest matrices established for Oregon Coastal Natural Coho and Oregon Lower Columbia coho and determine if a different harvest matrix is needed for lower Columbia coho.

Responsible Parties: WDFW, NOAA

Programs: Col. Compact, PFMC (STT)

F.A20. Maintain selective sport fisheries in ocean, Columbia River, and tributaries and monitor impacts on naturally-spawning coho stocks. (Category B)

Explanation: Mass marking of lower Columbia River coho has enabled successful ocean and freshwater selective fisheries to be implemented since 1998. Fin-marking programs should be continued and fisheries monitored to provide improved estimates of naturally-spawning coho release mortality.

Responsible Parties: WDFW, NOAA, ODFW, USFWS

Programs: PFMC, Col. Compact, BPA F&W Program, WDFW Creel Survey

F.A21. Manage Columbia River commercial fisheries by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning coho. (Category A)

Explanation: Commercial fisheries should utilize Select Area off-channel sites to harvest net pen reared hatchery coho. Continue to regulate mainstem commercial fisheries by mesh size, time, and area to reduce early naturally-spawning coho impacts and commercial fisheries targeting late hatchery coho by time and area to avoid impacts to the latest timed (Clackamas type) naturally-spawning coho.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact

F.A22. Review and evaluate the harvest management strategy developed to protect of naturally-spawning Clackamas late coho in terms of its ability to protect naturally-spawning Washington late coho. (Category B)

Explanation: If rebuilding strategies for late coho in Washington streams prioritize the November-January returning naturally-spawning fish, then separation from the October timed late coho produced in hatcheries for harvest will be achieved and the Clackamas late coho fishery management strategy may also protect Washington naturally-spawning coho. Technical review would include review of harvest impact rates and consider timing of Washington stocks.

Responsible Parties: WDFW, NOAA

Programs: U.S. vs. Oregon (TAC), PFMC (STT)

F.A23. Manage Columbia River commercial fisheries by time, area and gear to target hatchery fish and minimize impacts to naturally spawning coho. (Category A)

Explanation: Commercial fisheries should utilize “Select Area” off-channel sites to harvest net pen-reared hatchery spring chinook. Continue to regulate mainstem commercial fisheries by mesh size, time, and area to reduce impacts to naturally-spawning coho.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC),

Spring Chinook

F.A24. Continue to monitor Columbia River selective fisheries and provide estimates of impacts to naturally produced lower Columbia spring Chinook. (Category A)

Explanation: Current Columbia River management includes ESA harvest limits for upper Columbia, Snake River, and Willamette naturally-spawning spring Chinook. This measure would include specific estimates of impacts to lower Columbia naturally-spawning spring Chinook as part of the pre-season and in-season management process.

Responsible Parties: WDFW, ODFW, NOAA

Programs: Col. Compact, U.S. vs. Oregon (TAC)

F.A25. Monitor and evaluate handling mortality impacts to released naturally-spawning spring Chinook in Columbia River fisheries. (Category A)

Explanation: Columbia River selective fisheries for marked hatchery spring Chinook commenced in 2001. Studies should continue to increase precision of long-term mortality estimates of naturally-spawning spring Chinook captured and released in selective fisheries.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, U.S. vs. Oregon (TAC), BPA F&W Program

F.A26. Develop gear and handling techniques, as well as regulatory options in both commercial and sport fisheries, to minimize selective fishery impacts to naturally-spawning spring Chinook. (Category B)

Explanation: Continue alternative gear experiments in the commercial fishery to provide effective harvest of hatchery spring Chinook and high survival of released naturally-spawning spring Chinook. Also, experiment with methods to increase handling survival with improved revival methods and consider regulatory actions to reduce stress on released fish.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.A27. Develop a lower Columbia naturally-spawning spring Chinook harvest rate plan for management of Columbia River fisheries at such time as significant populations are re-established. (Category C)

Explanation: This measure would provide specific harvest limits for lower Columbia naturally-spawning spring Chinook. This harvest plan would consider existing populations and reintroduced populations as they are reestablished in historical habitats. This measure would includes an assessment of the current harvest constraints for other Columbia River spring Chinook stocks (Willamette, upper Columbia, and Snake River) and their adequacy for lower Columbia spring Chinook recovery.

Responsible Parties: WDFW, ODFW

Programs: WA F&W Commission, Col. Compact (TAC)

F.A28. Manage Columbia River commercial fisheries by time, area and gear to target hatchery fish and minimize impacts to naturally spawning spring Chinook. (Category A)

Explanation: Commercial fisheries should utilize "Select Area" off-channel sites to harvest net pen-reared hatchery spring chinook. Continue to regulate mainstem commercial fisheries by mesh size, time, and area to reduce impacts to naturally-spawning spring chinook.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC),

6.7 Hatchery

This hatchery strategy describes near-term and long-term strategies and measures to ensure that hatcheries support recovery of naturally-spawning fish. The evaluation of hatchery programs and implementation of hatchery reform in the Lower Columbia is occurring through several processes. These include: 1) the LCFRB recovery planning process; 2) Hatchery Genetic Management Plan (HGMP) preparation for ESA permitting; 3) FERC-related plans on the Cowlitz River and Lewis River; 4) the federally mandated Artificial Production Review and Evaluation (APRE) process, and an Environmental Impact Statement for funding and operation of Columbia River hatcheries authorized under the Mitchell Act.

The hatchery strategy included in this plan identifies some areas that will be free of hatchery influence and hatchery programs in other areas that are distributed to serve specific conservation and harvest purposes in specific watersheds, consistent with goals for populations using each watershed. This mosaic of programs is designed to ensure that overall each ESU will be naturally self-sustaining. Hatchery programs are divided into two types: production enhancement and fisheries enhancement (Table 1). Production enhancement programs are destined to enhance or protect production of a particular natural fish population through four strategies: 1) preserving or creating natural refuges for wild fish; 2) using hatchery supplementation to rebuild depressed natural runs as a temporary measure until habitat or passage improvements are completed; 3) physically separating hatchery fish from naturally-producing fish to avoid or minimize spawning interactions; and 4) addressing situations where natural and hatchery fish are principally one stock that includes the native genetic material for the basin.

Table 1. Distribution of hatchery purposes in subbasins consistent with proposed hatchery strategy.

	Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
Chinook	**S,B**	**--**	**--**	**S**	**--**	**--**	**S,F,B**
Grays	**R**	**--**	**--**	**S,B**	**F**	**--**	**S,F,B**
Elochoman	**C,F**	**--**	**--**	**S,B**	**I,F,B**	**F**	**S,F,B**
Skamokawa				**S**			
Mill/Abernathy/Germany	**R**	**--**	**--**	**S,B**	**R**	**--**	
Lower Cowlitz	**C**	**--**	**F**	**B**	**F,B**	**F**	**S,F**
Upper Cowlitz	**--**	**--**	**S,C**	**--**	**S,I**	**--**	**S**
SF Toutle	**--**	**--**	**--**	**--**	**R**	**F**	**S**
NF Toutle	**F**	**--**	**--**	**--**	**--**	**F**	**S,F**
Coweeman	**R**	**--**	**--**	**--**	**F**	**--**	**S**
Kalama	**C,F**	**--**	**S,F**	**--**	**I,B**	**I,F,B**	**F**
Lewis (Lower NF)	**--**	**R**	**F**	**S,B**	**F**	**F**	**F**
Lewis (Upper NF)	**--**	**--**	**S,C**	**--**	**S,I**	**--**	**S**
EF Lewis	**R**	**--**	**--**	**S**	**F**	**F**	**S**
Salmon	**--**	**--**	**--**	**S**	**--**	**--**	**--**
Washougal	**C,F**	**--**	**--**	**S,B**	**I,F**	**I,F**	**F**
Lower Gorge	**R**	**--**	**--**	**S**	**R**	**--**	**F**
Wind	**--**	**--**	**F**	**--**	**R**	**R**	**--**
Little White Salmon	**--**	**--**	**F**	**--**	**--**	**--**	**F**
Upper Gorge	**F**	**--**	**--**	**S**	**--**	**--**	**--**

Fishery Enhancement = F, Natural production enhancement: S = Supplementation/Reintroduction, C = Hatchery/natural conservation, I = Isolation, R = Refuge. B denotes cases where natural broodstock development will occur. These areas may be expanded to meet recovery goals. Undesignated subbasins provide opportunities for additional refuges, production enhancement, or fishery enhancement where appropriate.

The contribution of specific hatchery stocks to ESU viability and recovery will depend on the source of each stock, the history of hatchery practices which may have altered the genetic or life history characteristics relative to the native population, and the demands of recovery. In some cases, hatchery influences are minimal and wild fish may be used in a hatchery to jump start natural populations through supplementation in some areas where habitat restoration has been effective (e.g. Grays River and Duncan Creek chum). Some hatchery stocks are highly domesticated or from out-of-subbasin sources and are not appropriate for production enhancement but may continue to be used for fisheries enhancement where consistent with natural production goals. Several hatchery stocks represent the only significant native genetic material still existing in the ESU and will be critical for production enhancement. This is the case for Lewis and Cowlitz River hatchery stocks being used for reintroduction efforts above dams in the Cowlitz and Lewis rivers. Other hatchery stocks, including many tule fall chinook and coho, are practically the same as their naturally-spawning counterparts. This is common where natural stock productivity is no longer sufficient to support a self-sustaining natural population in the face of habitat degradation. These stocks will play a significant role in recovery as habitat is restored.

More detailed descriptions of specific actions consistent with hatchery strategies and measures may be found in subbasin managements plans contained in Volume II and further details will be developed during plan implementation. NOAA Fisheries is currently in the process of developing a hatchery fish policy which will provide additional guidance on appropriate uses of hatchery fish consistent with recovery. A variety of other ongoing hatchery review and reform efforts will also contribute to refinements in the hatchery strategy in the future.

6.7.1 Working Hypotheses

H.H1. Historic hatchery operations in conjunction with other factors posed significant risks to the continued existence of many naturally-spawning populations.

Explanation: Hatcheries have proven to be a powerful tool for producing salmon and steelhead but the benefits are accompanied by risks. On the one hand, high survival of eggs and juveniles in hatcheries enables large-scale production of fish. Dozens of hatcheries have been built throughout the Columbia Basin and especially in the lower Columbia, primarily to produce fish for harvest and to offset declines in natural salmon production. Harvest hatchery programs are located in the lower Columbia to mitigate for local watershed loss of fish access to habitat as well as to provide the means to fully mitigate for Columbia River dam construction. Hatcheries are also useful conservation tools for temporarily preserving populations where habitat has been lost, bolstering numbers through bottlenecks caused by poor ocean conditions, and supplementing naturally-spawning production where mortality factors are severe. On the other hand, hatcheries may also contribute to increased extinction risks by several mechanisms. Inadvertent hatchery selection can result in domesticated fish that do not reproduce or survive as well as naturally-spawning fish. Introduction or straying of significant numbers of naturally-spawning hatchery fish, that are genetically dissimilar from naturally-spawning fish, may reduce the productivity of the naturally-spawning population. Large numbers of hatchery fish can reduce naturally-spawning fish numbers through competition, predation, or disease. Large numbers of hatchery fish can also make it difficult to accurately estimate naturally-spawning fish numbers and productivity.

H.H2. Changes in hatchery operations have and will continue to contribute to reduced risks to naturally-spawning populations.

Explanation: Widespread hatchery reforms have been implemented over the last 20 years with the recognition of potential risks. Example reforms have included elimination of releases in priority wild production areas, elimination of inter-basin broodstock transfers, acclimation of smolts to reduce straying, lower basin releases to reduce inter-species predation, and differential management of fisheries for wild and hatchery fish. Additional refinements can be expected in the future. For instance, hatchery programs that are funded by the Mitchell Act will be going through a NEPA review process as part the development of an Environmental Impact Statement.

H.H3. Additional reductions in hatchery impacts are needed to support the recovery of naturally-spawning populations.

Explanation: Interim conservation measures and continued use of hatcheries to enhance fisheries requires fundamental changes in operations to reduce risk and protect naturally-spawning populations and ensure progress toward recovery. A series of comprehensive regional reviews have been completed that identify conservation hatchery strategies, hatchery reform principles, and recommendations for changes to Columbia River programs. Many changes are being implemented and are reflected in Hatchery Genetic Management Plans (HGMPs) prepared for every hatchery program as part of ESA compliance. The HGMPs are currently being developed and have not formally been submitted to NOAA Fisheries for authorization. This recovery plan identifies hatchery measures needed to support recovery of lower Columbia River salmon populations. These measures are expected to be integrated with the final lower Columbia hatchery program HGMPs.

H.H4. Conservation hatchery programs can contribute to recovery through the preservation, reintroduction, and supplementation of naturally-spawning populations.

Explanation: Because recovery ultimately depends on naturally-produced spawners spawning naturally, hatcheries by themselves are not the answer to salmon recovery. However, hatcheries can make near term contributions to the conservation and restoration of some naturally-spawning populations. For instance, the remnant native genetic material for lower Columbia River spring Chinook, coho, and some steelhead populations currently resides solely in the hatchery system. These hatchery fish may be building blocks for reintroduction and rebuilding of extirpated or weak populations. Hatcheries can also be used to jump start other populations and reduce use of naturally-spawning broodstock needed to seed extirpated populations (chum for example).

H.H5. Hatcheries can provide harvest opportunities consistent with measures to restore and maintain healthy, harvestable naturally-spawning populations.

Explanation: Hatcheries can help provide continuing fishing opportunity while habitat restoration measures are implemented. With few exceptions, current habitats are not able to produce sufficient numbers of fish to sustain meaningful fisheries. Current fisheries are focused almost entirely on hatchery fish. Abrupt closures of all existing hatchery programs would essentially terminate significant salmon and steelhead fisheries in large parts of the Columbia Basin and along Oregon and Washington coast. Analyses of hatchery risks detailed in the technical foundation also indicate that hatchery closures by themselves would not be sufficient to restore viable salmon or steelhead populations throughout the Washington lower Columbia recovery area. Naturally-spawning production levels foreseeable in the near future would fall far short of meeting mitigation responsibilities for eliminating anadromous access to habitat in large parts of the upper Columbia and Snake basins.

H.H6. Some hatchery programs have legal obligations to provide fish for mitigation purposes and those obligations will likely be offset to varying degrees by increases in natural production.

Explanation: Large-scale hatchery production exists primarily to mitigate for effects of habitat changes, particularly related to hydropower development and operation. For instance, programs in the Cowlitz and Lewis rivers are mitigation for dams which block access to historically productive areas in the lower basin. Other lower Columbia hatchery programs in Washington and Oregon help mitigate for the effects of Columbia and Snake river mainstem dam construction and operation. Hatchery production levels in many facilities are obligated by a series of inter-jurisdictional agreements, for instance, with Columbia River treaty Indian tribes, other states, and between the U.S. and Canada. Habitat improvements prescribed by this recovery plan are not likely to provide sufficient levels of natural production to meet other obligations within the foreseeable future.

H.H7. Returning adults from some hatchery programs currently sustain some natural populations.

In the lower Columbia, much of the native genetic material now exists only in the hatchery system. Upper Cowlitz and Lewis spring Chinook and winter steelhead were removed to hatcheries after dams blocked those rivers. Although some indigenous populations have been minimally influenced by hatchery programs, many hatchery and naturally-spawning populations of coho and fall Chinook are now indistinguishable. In these populations, domestication may have reduced the diversity and productivity of natural spawners. Conversely, returning adults from some hatchery programs currently supplement natural production in many marginal habitats that might no longer sustain a viable naturally-spawning population.

H.H8. Conservation and harvest benefits from hatchery programs can be realized with acceptable risks to naturally-spawning populations through effective integrated or segregated hatchery programs.

Hatchery programs can be evaluated and scored by the operating agencies and NOAA Fisheries based on levels of benefits provided and risks posed to naturally-spawning populations. Conservation programs would be expected to provide benefits to naturally-spawning population recovery while fishery mitigation programs would be expected to implement measures which neutralize or reduce risks to low levels. Each hatchery program would be considered in the context of affects on specific naturally-spawning populations in the watershed in which the program is implemented. The program would be evaluated and scored relative to the measures and strategies contained in this hatchery strategy as they apply to the needs of the naturally-spawning populations present in the subbasins.

H.H9. Restoration of healthy, harvestable naturally-spawning populations cannot be achieved solely by eliminating the effects of hatcheries either by closing all existing facilities or by replacing all production programs with conservation programs.

Widespread hatchery closures will not address the fundamental habitat problems that have placed wild salmon and steelhead populations at risk. Nor are hatcheries a long term solution for the loss of naturally-spawning populations. Hatcheries may not be sustainable in the long term if the natural biological diversity that supports the success of anadromous salmon and steelhead across the breadth of habitat and environmental conditions encountered throughout their life cycle is lost. Survival gradually declines and the cost of supplying benefits increases.

6.7.2 Strategies

H.S1. Expand use of hatchery reintroduction and supplementation programs to conserve and recover naturally-spawning fish when and where appropriate.

Explanation: Conservation hatchery programs will be a critical tool in salmon recovery throughout the lower Columbia River. Hatchery programs historically concentrated on production for harvest but recent experience has demonstrated that hatcheries can make substantial contributions to naturally-spawning salmon conservation. Conservation hatchery programs will be a key to reintroduction efforts in areas where access or suitable habitat is restored. Carefully designed supplementation programs can also be used to maintain viable naturally-spawning populations in the interim until adequate habitat improvements occur, or in cases where the appropriate brood stock is chronically under-seeding the habitat. Many conservation programs have already been initiated but additional modifications of existing hatchery programs and new programs will be needed.

H.S2. Reconfigure production-based hatchery programs for harvest to minimize detrimental impacts on naturally-spawning populations and to be complementary with recovery objectives.

Explanation: Every hatchery program should either benefit natural production or not adversely affect recovery. Detrimental hatchery effects can be reduced with integrated programs intended to minimize the divergence of the hatchery population from its natural counterpart and segregated programs where interactions (within species and inter-specific) between naturally-spawning and hatchery fish are minimized. Recovery scenarios identified in this plan provide the opportunity to operate different types of programs in different subbasins for different purposes. Programs will be evaluated and scored based on their ability to meet complementary hatchery and naturally-spawning fish objectives. This evaluation would be connected to and involve the parties associated with the HGMP process.

H.S3. Until harvestable naturally-spawning populations are restored, many lower Columbia River hatchery programs will continue to be operated to produce fish for harvest purposes in a manner consistent with restoring and maintaining healthy, harvestable naturally-spawning populations.

Explanation: Harvestable surpluses from naturally-spawning populations require high quality habitats that produce fish in excess of those needed for replacement. Habitat recovery is a long process, hence, harvestable surpluses for most naturally-spawning populations will not be available in the near future.. Fishing opportunity currently depends almost entirely on hatchery fish. Elimination of production hatchery programs in the lower Columbia River would essentially end significant sport and commercial salmon and steelhead fisheries in the lower Columbia and large portions of the ocean. Further, mitigation responsibilities for irreversible habitat losses to hydro development would be unfulfilled. Production scale hatchery programs and the need for hatchery fish for fisheries should decrease as naturally-spawning populations become healthy and can support fisheries. However, the need for hatchery programs at some level is not expected to be eliminated.

H.S4. Hatchery operations will be configured to support population and region-wide recovery goals and some areas will be independent of hatchery influence.

Explanation: Recovery scenarios identify improvements in specific populations that add up to a viable group of populations (e.g., ESU or listing unit). Priority populations need to be restored to a high level. Contributing populations need to show significant improvement. Stabilizing populations need to be protected from further declines. Thus, not every population needs to be subjected to the same level of recovery effort. Hatchery impacts will be considered in selecting recovery scenarios and hatchery programs should be assessed in terms of feasibility in meeting recovery goals under the current programs and identification of trade-offs and changes needed to meet recovery goals. Opportunities exist to support recovery by distributing hatchery programs to serve specific conservation and harvest purposes in specific watersheds, consistent with goals for the populations using each watershed. It is important to maintain representative areas independent of hatchery influences in order to determine population viability levels and the recovery status of naturally-spawning populations. Natural spawning by significant numbers of hatchery fish can mask true naturally-spawning population status, making it difficult to accurately assess the condition of naturally-spawning fish. This calls for a carefully-stratified approach where hatchery conservation measures are applied to some populations, protection measures are applied to other populations, and yet other populations are kept free of hatchery influences. This approach recognizes the inherent uncertainties in the relative risks and benefits of different hatchery approaches and optimizes opportunities for learning and future adaptive management.

6.7.3 Measures

H.M1. Promote region-wide recovery by using hatcheries as tools for supplementation and recovery in appropriate watersheds.

Explanation: Hatcheries will be utilized as a critical enhancement tool with programs developed and implemented to improve naturally-spawning fish numbers and productivity. Supplementation programs may be appropriate when habitat is under utilized. Reintroduction is appropriate when access to habitat is restored. Use of appropriate brood stock will assure fitness of fish for enhancement. Innovative rearing practices which simulate natural conditions can be used to maintain some of the naturally-spawning fish behavior attributes in hatchery reared fish. The efficacy of conservation hatchery programs remains unclear and additional research and experimentation will be required for refinement toward optimum application. Experimental conservation hatchery programs may require adaptation of existing facilities (e.g. Abernathy Hatchery) or the development of new facilities to conduct research that supports the recovery plan through an improved understanding of salmon genetics, life cycle diversity, habitat utilization, and effective management practices.

H.M2. Assess the risks and benefits posed by artificial production programs using WDFW's Benefit-Risk Assessment Procedure (BRAP)

Explanation: The BRAP procedure is intended to provide the framework to evaluate each artificial production program in the ecological context of each watershed. The procedure includes a policy framework and risk assessment. The policy framework assesses individual population status, develops risks tolerance profiles for specific stock conditions, and assigns tolerance profiles to each stock. The risk assessment evaluates each hatchery program for the risks it poses to any stock by means of a detailed Risk Assessment worksheet and identifies appropriate management actions to reduce risk. WDFW intends to conduct the BRAP procedure for each WDFW hatchery program in tandem with the Lower Columbia Recovery Plan development. Specific actions will be developed, evaluated and documented in the Hatchery and Genetic Management Plans (HGMPs) for NOAA Fisheries consideration.

H.M3. Operate hatcheries to promote region-wide recovery through the application of appropriate risk containment measures for: 1) hatchery origin adults returning to natural spawning areas, 2) release of hatchery juveniles, 3) handling of natural origin adults at hatchery facilities, 4) water quality and effective disease control, and 5) mixed stock fisheries.

Explanation: Programs which are not specifically designed for naturally-spawning fish enhancement will be operated in a manner that is consistent with achieving region-wide recovery through appropriate risk containment measures. Negative impacts from natural spawning hatchery fish are reduced by segregated programs or efficiency in removing hatchery adults. Juvenile releases may be modified by timing, area, or magnitude to reduce both intra-specific and inter-specific risks, Naturally-spawning adult handling impacts may be improved with modified collection or improved handling techniques. Brood stock guidelines may address genetic fitness risks. Water treatment methods can minimize disease. Marking programs enable catch and release of naturally-spawning fish in mixed stock fisheries.

H.M4. Assist in the design of hatchery programs to be consistent with recovery goals for lower Columbia ESUs and the ecological context of the watershed, including the characteristics of the habitat and the natural fish populations.

Explanation: Each hatchery program may be visualized as following a trajectory from the current operation to the expected operations at recovery. The speed and direction of the trajectory will depend on the current characteristics of the population, the current productivity of the habitat, and policy decisions that define region-wide recovery. Although watershed-specific considerations will ultimately shape each hatchery program, default hatchery programs for each of the four combinations of population and habitat conditions can be roughly characterized as follows: 1) High population integrity, low habitat productivity-Hatchery program used as egg bank, brood stock development source, or captive brood source to preserve the unique qualities of the stock until habitat restoration occurs; 2) High population integrity, high habitat productivity-Hatchery program operated to minimize impacts to naturally-spawning fish; no supplementation needed; 3) Low population integrity, low habitat productivity-Hatchery program provides mitigation for lost habitat without impeding achievement of region-wide recovery; and 4) Low population integrity, high habitat productivity-Hatchery program operated to improve stock integrity. The WDFW BRAP process will evaluate risks of hatchery programs relative to the characteristics of the natural populations and their risk tolerance profiles.

H.M5. Develop criteria for appropriate integration of hatchery and natural populations.

Explanation: WDFW has developed a model to estimate the effectiveness of a spawning population based on the mix of hatchery and natural produced fish in the spawning population. The appropriate proportions of wild and hatchery adult fish on the spawning grounds are determined based on the similarity between the hatchery and natural population, the size of the natural population, the condition of the habitat and access, and other attributes mentioned in H.M3. The WDFW integration model can be utilized to establish integrated programs in appropriate watersheds.

H.M6. Guide the configuration of hatchery programs with appropriate reform recommendations identified in the Northwest Power and Conservation Council's Artificial Production Review and Evaluation, WDFW's benefit-risk assessment procedure, and other tools.

Explanation: Explicit guidance has been developed for hatchery reforms in a variety of forums. This guidance should be considered when developing lower Columbia hatchery recovery measures.

H.M7. Develop marking programs to assure that hatchery-produced fish are identifiable for harvest management and escapement accounting.

Explanation: Marking of juvenile hatchery fish with an adipose fin-clip prior to release enables future identification of adult fish encountered in a fishery or in the escapement areas. Selective fisheries which allow the retention of hatchery fish and require the release of naturally-spawning fish are an effective tool for reducing fishery impacts of naturally-spawning stocks. Identifying individual fish as hatchery or naturally-spawning produced on the spawning grounds enables accurate enumeration of naturally-spawning production which is essential for monitoring recovery progress. In some cases, marks other than an adipose fin-clip (e.g., thermal or chemical marks) may be required when differentiation of natural and hatchery-origin adults is required for brood stock management but not to provide fishing opportunities.

H.M8. Use adaptive management to ensure that hatchery programs respond to new knowledge of how to further protect and enhance natural production and improve operational efficiencies.

Explanation: Innovative rearing methods, brood stock development, improved water quality, release strategies, improved rearing facilities, etc. will be researched and implemented where possible to improve survival and contribution of hatchery fish and to reduce impacts to natural fish in the watershed. Methods to improve efficiency of operations to enable attainment of complementary hatchery and natural objectives within funding constraints should be explored. Hatcheries programs will be reviewed for consistency with lower Columbia recovery objectives in the HGMP review process, including annual reports and 5-year comprehensive reviews.

H.M9. Promote public education concerning the role of hatcheries in the protection of natural populations.

Explanation: Hatcheries are often a first contact point for public exposure to fish management. Many hatcheries are organized with public education programs concerning hatchery operations. A new public education program would be developed for each hatchery to emphasize the importance of naturally-spawning fish populations in the watershed including information concerning recovery efforts and the role the hatchery is playing in the recovery mission. The intent of the public education programs would be to promote naturally-spawning fish stewardship and support for responsible hatchery programs. This measure is but one component of an comprehensive integrated education and outreach program that is described in further detail elsewhere in this plan.

H.M10. Document and formalize hatchery operations through the use of the existing Hatchery Genetic Management Plans (HGMPs).

Explanation: HGMPs provide a systematic means to step down from the population-scale hatchery strategies and measures to a detailed documentation of hatchery programs, including operations, performance standards, and performance indicators. Preparation and submittal of HGMPs by resource management agencies through the existing permitting process facilitates transparency, accountability, and regulatory certainty of program consistency with Lower Columbia Recovery Plan measures. Draft HGMPs currently under development will need to incorporate specific measures and actions identified in this recovery plan.

H.M11. Seek flexibility in current funding to assure hatcheries have the resources to achieve complementary harvest and natural production objectives.

Explanation: Current funding sources for lower Columbia hatchery operations are primarily the 1938 Mitchell Act, requiring federal mitigation for the development of the mainstem Columbia federal hydro system, and FERC Licenses, requiring private utilities to mitigate for operation of dams in lower Columbia tributaries. These funds are attached with specific production levels for specific hatcheries and in some cases with legal requirements to rear fish in the lower Columbia hatcheries for release into upper Columbia tributaries. There has been some limited investments in recent years by BPA to enhance naturally-spawning fish through hatchery programs and the re-license requirements for private utilities has included complementary investments for naturally-spawning enhancement as well as hatchery production. These investments will need to be significantly expanded to meet complementary naturally-spawning and production objectives in the hatchery programs. Additional funding sources or re-distribution of current funding will need to be considered. Mitchell Act fund flexibility may be limited because most of the funding is directed by congressional appropriations.

6.7.4 Actions

Fall Chinook

H.A1. Use hatchery releases of fall Chinook in watersheds without hatchery programs only if necessary for recovery of the natural population. (Category B)

Explanation: Current fall Chinook hatchery programs include on-site releases into the Elochoman, Cowlitz, Green (NF Toutle), Kalama, Washougal, Big Creek, Youngs Bay, Little White Salmon, and mainstem Columbia. Fall Chinook reared and released at Little White Salmon and Bonneville hatcheries are upriver bright stock and not part of the lower Columbia ESU. This measure would preclude off-site releases in other watersheds for harvest purposes. Fall Chinook hatchery releases into watersheds that currently have no fall Chinook hatchery programs may only be considered as part of a supplementation program or a brood stock risk reduction program when determined to be necessary to preserve and/or recover the population.

H.A2. Develop criteria for appropriate mix of first generation hatchery spawners and naturally-spawning spawners for each population with hatchery and naturally-spawning fall Chinook production, and reduce first generation spawners as appropriate. (Category B)

Explanation: In order to increase fitness of natural produced fall Chinook in watersheds which contain both hatchery programs and priority naturally-spawning populations, natural spawning of hatchery adults may be reduced by trapping and removing the majority from the stream. This approach may not encompass the entire watershed but could involve significant reduction of hatchery fish in the majority of the natural spawning area. For example, a trap site in the lower end of the stream near tidewater may be effective at removing 90 percent of the hatchery fish from 90 percent of the habitat. Monitoring and evaluation programs would evaluate the performance of natural fall Chinook with minimal hatchery spawning interaction. In some watersheds integrated hatchery and naturally-spawning programs may be developed with a matrix approach to guide the appropriate number of naturally-spawning brood stock in the hatchery program and the appropriate number of hatchery fish on the spawning grounds, based on the number of naturally produced adults returning each year. Adjustments to the initial strategies may be considered as an adaptive management measure in response to M&E results. The ability for natural fish to be sustained without hatchery supplementation should increase as habitat productivity improves. Implementation of this action will require marking of hatchery fall chinook production which could be expensive depending on how many programs were included. In addition to the marking, weirs and traps would need to be upgraded to meet NOAA adult handling criteria that will minimize adverse effects on natural origin adults. Disposition of surplus hatchery fish that are removed from the population will also need to be considered.

H.A3. Use only local watershed broodstock in fall Chinook hatchery programs. (Category A)

Explanation: Very limited outside watershed transfers have occurred in the Kalama and Cowlitz fall Chinook hatchery programs and, although domestication has occurred, the current hatchery and natural populations are similar and derived from the original natural runs produced in these watersheds. Fall Chinook transfer limits have included the remainder of the lower Columbia fall Chinook hatchery programs in recent years and are addressed in the draft “Fall Chinook Management Guidelines” developed by WDFW. Transfer limits would be upheld in the recovery plan to assure hatchery fall Chinook programs are consistent with development of natural and hatchery populations with attributes adapted to the unique characteristics of the watershed. Local broodstock in the hatcheries will reduce the risks associated with interactions between natural and hatchery fish.

H.A4. Use fall Chinook juvenile release strategies to minimize naturally-spawning fish interactions. (Category A)

Explanation: Hatchery fall Chinook are released in their first year as subyearlings and do not pose a major predation risk to rearing naturally-spawning fish in the same watershed. However, if hatchery fall Chinook spend significant resident time in the stream before migrating to the Columbia, they may compete for space with smaller naturally-spawning fall Chinook, displacing the naturally-produced fish to marginal habitat or influence premature migration, which will reduce naturally-spawning fish survival. Options to reduce these risks include; release fish at an optimum time when the majority have smolted and are prepared to leave the system quickly, release fish off-site and downstream of the majority of the naturally-spawning fish rearing area, or reduce numbers of hatchery juveniles released into the stream

H.A5. Use hatchery operation strategies to protect Lewis naturally-spawning fall Chinook. (Category A)

Explanation: Lewis River naturally-spawning (bright) fall Chinook are the healthiest Chinook population in the lower Columbia basin. The majority of the Lewis River naturally-spawning fall Chinook juveniles rear in the lower North Fork Lewis and utilize several miles of habitat located immediately downstream of the Lewis River Salmon Hatchery. Hatchery fall Chinook are not released into the North Lewis River and should not be considered in the future. Steelhead, coho, and spring Chinook yearling releases, either from the hatchery harvest program or from the upper Lewis natural reintroduction program, must include strategies to minimize impacts to rearing naturally-produced fall Chinook. Release options include; volitional releases to assure fish are smolted and migrate rapidly, release locations downstream of the majority of fall Chinook rearing area, rearing methods to reduce residual fish, and the inclusion of stress relief ponds for reintroduced smolts. Hatchery operations should include adequate water quality treatment methods to minimize chance of disease transmittal to natural fall Chinook. Monitoring of naturally-produced Lewis River fall Chinook status and evaluation of hatchery operation impacts should be included in an M&E plan.

H.A6. Mark hatchery fall Chinook in priority watersheds to promote fishery utilization, facilitate the utilization of natural-origin fish in integrated programs, and enumerate hatchery fish in natural spawning areas. (Category C)

Explanation: Hatchery produced fall Chinook are not mass marked with an adipose fin-clip in the Columbia River basin, while spring Chinook, steelhead, and lower Columbia released coho are mass marked. The reasons for not mass marking fall Chinook have included, funding, logistics of marking large numbers of fish, technical issues in estimating stock specific fisheries harvest, presence of healthy and harvestable naturally-spawning fall Chinook stocks, and lack of consensus in intergovernmental management arenas. This measure would result in mass marking of fall Chinook in certain hatchery programs, specifically in those watersheds which contain both fall Chinook hatchery programs and naturally-spawning populations designated as priority populations. This measure would enable a more accurate enumeration of naturally-spawning fall Chinook spawning escapement in the priority populations and provide the means to control the number of hatchery adults spawning naturally, integrate hatchery and naturally-spawning programs, and provide selective fishing options where appropriate. Identification of naturally-spawning fish in important areas with mixed hatchery and naturally-spawning returns will be an important element of a monitoring and evaluation program. It should be noted all fall chinook programs within the LCR Chinook ESU are proposed to be mass marked under current Federal legislation although a funding source has not been identified.

Spring Chinook

H.A7. Utilize facilities for spring Chinook reintroduction efforts. (Category A, C)

Explanation: The majority of the spring Chinook habitat in the lower Columbia basin is located upstream of the hydro dams in the Lewis and Cowlitz rivers. Facilities and operational strategies for hatchery programs in these basins must address space, brood stock development, rearing methods, transfer of fish, marking strategies, and monitoring and evaluation which adequately supports a spring Chinook reintroduction program. Successful reintroduction above these lower river tributary dams is critical to recovering lower Columbia spring Chinook, and hatchery support is a key element of the rebuilding program.

H.A8. Reintroduce of spring Chinook in upper Cowlitz and Lewis beginning with hatchery supplementation. (Category A, C)

Explanation: Supplementation of juvenile and adult hatchery spring Chinook above the dams represents the initial stage of reintroduction of spring Chinook into the upper Cowlitz and Lewis habitats. Broodstock choices for reintroduction are currently limited to the hatchery stocks. The Cowlitz hatchery brood stock has had negligible outside basin influence and is considered consistent with the original Cowlitz naturally-spawning stock. The Lewis hatchery spring Chinook program was developed from outside stocks, principally Cowlitz spring Chinook, but the Lewis program is currently sustained without transfers from other hatcheries.

H.A9. Develop plans for future hatchery programs relationship with reestablished natural-origin spring Chinook populations, including integrated and segregated options. (Category A, C)

Explanation: As natural production is established above the dams, natural brood stock may be incorporated into the hatchery program to reduce risks to reestablished natural populations, and to improve fitness of the hatchery stock in an integrated program. However, the future relationship of the hatchery and natural-origin spring Chinook in the FERC license basins of the lower Columbia may be dependent on the success of reintroduction and the final configuration of a dam passage system. Under some circumstances, a segregated hatchery program may be considered. An integrated program would first provide appropriate brood stock for natural supplementation as needed and, as a secondary priority, improve the fitness of the hatchery base program stock as well. The natural brood stock hatchery program would be initiated at variable levels based on criteria established for natural adult return levels and hatchery: naturally-spawning ratios on the spawning grounds and in the hatchery. A matrix approach would be developed to manage naturally-spawning fish in the brood stock, adult escapement to natural production areas and to the hatcheries, and hatchery fish on the spawning grounds

H.A10. Develop and apply hatchery brood stock watershed transfer policies for spring Chinook. (Category B)

Explanation: Cowlitz and Kalama hatcheries should maintain their current stock integrity and avoid outside watershed transfers. The Lewis program should use the current Cowlitz-type hatchery stock from the Lewis Hatchery to begin the reintroduction effort and establish an adaptive Lewis stock over time. Transfers would only be considered for the Lewis from the Cowlitz program in emergency situations where brood stock was not available to meet reintroduction and harvest mitigation objectives. However, under these circumstances, transfers would only be considered for the harvest program. As the Lewis stock is developed over time, transfers under any conditions would not be acceptable. Reintroduction of the extirpated spring Chinook stocks in the upper Gorge (Big White Salmon and Hood rivers) require supplementation from spring Chinook programs outside these watersheds (e.g. Klickitat, Deschutes). As reintroduced spring Chinook become sustainable in these upper Gorge watersheds, the supplementation programs would be phased out.

H.A11. Use spring Chinook juvenile release strategies to minimize impacts to naturally-spawning populations. (Category B)

Explanation: Hatchery produced spring Chinook are released as yearlings into the lower Cowlitz, Lewis, and Kalama rivers and pass through principal rearing areas for naturally-spawning fall Chinook and chum on their way to the Columbia River. To minimize potential predation on sub-yearling fall Chinook and chum, hatchery spring Chinook release strategies which encourage rapid migration through the lower Cowlitz and Lewis should be implemented; including volitional release, optimum release size, and release downstream of principal chum rearing areas. Rearing practices should avoid producing large numbers of immature mini-jacks which remain in the lower Columbia freshwater environment during the spring before returning in the summer. Rearing practice adjustments which increase smolt to adult survival rates would enable adult return mitigation requirements to be attained with less hatchery smolts released.

H.A12. Mark spring Chinook hatchery production for identification and harvest. (Category A)

Explanation: Spring Chinook which are reared as part of the hatchery base harvest program should continue to be adipose fin-clipped to enable selective fisheries and identification of hatchery fish in natural spawning areas and at collection facilities. Distinguishing the origin of returning adults will be necessary for the reintroduction of spring Chinook upstream of the hydro systems in the Lewis and Cowlitz, and will also provide the means to develop integrated broodstock programs in the hatcheries.

Chum

H.A13. Develop additional chum supplementation programs. (Category C)

Explanation: Hatcheries will play a key role in rebuilding lower Columbia chum populations. Recent year spawning surveys indicate remnant chum populations present in many tributary streams of the lower Columbia River. However, the majority of these populations are critically low in numbers. The unique attributes of the lower Columbia chum populations will be preserved and maintained with hatchery program support. Supplementation programs would be developed on a parallel track with habitat enhancement programs in the watersheds. This approach, however will not be needed in areas where chum demonstrate the ability to naturally colonize new access areas and respond quickly to improved habitat. Hatchery Genetic Management Plans will be need to be developed and broodstock sources identified for many of these proposed supplementation programs.

H.A14. Continue to enhance local chum populations using Grays and Chinook hatcheries. (Category A)

Explanation: Grays River chum stock is currently utilized to rebuild the chum population in the Chinook River and as a risk management tool for the Grays River population. The Grays River brood stock program may be expanded to include supplementation of other coastal stream populations, dependent on genetic similarities between Grays River and other chum populations. Expanding the Grays supplementation program should only be considered if sufficient Grays River brood stock were available to support the hatchery program without risking the Grays River natural population.

H.A15. Use hatcheries for chum enhancement and risk management in the lower Columbia River Gorge. (Category A,C)

Explanation: The Washougal Hatchery chum program supplements the Duncan Creek chum population and provides the facilities for risk management of the mainstem Columbia population at Ives Island and Hamilton and Hardy creek populations. Risk management options are assessed annually and implemented when low flow conditions compromise the ability of adult chum to access spawning areas. The Washougal Hatchery program is a good example of the role hatcheries should play in rebuilding lower Columbia chum populations. The Washougal Hatchery chum program concept could be expanded to include additional hatcheries and support additional populations.

H.A16. Use DNA data to select appropriate chum brood stock. (Category B)

Explanation: DNA samples from chum spawning in the mainstem lower Columbia and tributaries have been collected in recent years. Results from DNA analysis will inform strategies for developing specific hatchery programs which are consistent with specific traits of individual populations.

H.A17. Develop and apply hatchery brood stock watershed transfer policies for chum. (Category B)

Explanation: Chum releases into the Grays and Chinook rivers would only include Grays River stock, and chum releases into lower Gorge streams would include lower Gorge stocks. Transfer policies would be further developed based on DNA analysis results and would be adaptive over time as sustainable populations are established in more watersheds and more hatcheries are used for chum supplementation and risk management programs.

Steelhead

H.A18. Reintroduce winter steelhead in upper Cowlitz and Lewis rivers. (Category A,C)

Explanation: Re-license of Cowlitz and Lewis river dams will include provisions to reintroduce natural production of winter steelhead into the habitats upstream of the dams. Passage through these hydro systems will be critical to success of the programs, but hatchery facilities and operations must also be adapted to accommodate the reintroduction effort; including rearing space, brood stock development, marking programs, collection and sorting facilities, transfer equipment, and adequate monitoring and evaluation plans.

H.A19. Late winter steelhead brood stock development at Elochoman, Cowlitz, Kalama, and Lewis hatcheries. (Category C)

Explanation: The Cowlitz and Lewis hatcheries will develop late returning winter stocks for the purpose of supplementing winter steelhead reintroduction in the upper watersheds. The Kalama and Elochoman hatchery late winter steelhead programs would be developed to enhance recreational opportunity and as a risk management tool prepared to respond to a catastrophic event effecting the natural populations.

H.M20. Develop and apply hatchery brood stock watershed transfer policies for steelhead. (Category B)

Explanation: Brood stock transfer restrictions would be established for local naturally-spawning brood stock programs which are currently being developed or expected to be developed in the future. Hatchery harvest program transfers would continue subject to limitations and strategies represented in following measures (H.M. 30 and H. M. 31).

H.A21. Use steelhead juvenile release strategies to minimize impacts to naturally-spawning fish. (Category A)

Explanation: Hatchery steelhead are released as yearling smolts. Release strategies include; on-site hatchery releases, fish trucked away from the hatchery in the same watershed and released, fish acclimated in net-pen sites or acclimation ponds before release, and fish trucked to other watersheds and directly released. Potential for predation on naturally-spawning sub yearling fall Chinook, chum, or coho should be reduced through development of steelhead release strategies. Strategies would be developed for each watershed, with options including; release downstream of significant naturally-spawning fish rearing areas, volitional release methods, release fish when smolted and at optimum size for rapid movement out of the tributary, avoiding release of residual fish, and reduction in numbers of fish released into a particular watershed.

H.A22. Use complementary conservation/harvest programs with local steelhead stocks. (Category A,C)

Explanation: Natural steelhead populations in the lower Columbia are generally stable at low or moderate levels and utilizing much of the available habitat. With the exception of habitats upstream of tributary dams, and above Bonneville Dam, hatchery supplementation of winter steelhead would not be included as part of a hatchery program. However, development of local late winter stocks in the hatchery can be used as a naturally-spawning stock risk management tool as well as provide an expanded selective fishing opportunity on marked hatchery production.

H.A23. Mark steelhead harvest production. (Category A)

Explanation: Continue to provide resources to mass mark hatchery steelhead with an adipose fin-clip to enable selective fisheries and to distinguish hatchery fish and naturally-spawning fish at collection sites and other escapement sampling areas, Mass marking is also important for identifying and removing hatchery fish from the watershed prior to spawning.

H.A24. Maximize harvest and removal of non-local summer and early winter steelhead. (Category B)

Explanation: The summer and winter steelhead harvest programs include steelhead smolts released from hatcheries within the watersheds as well as fish transferred from Skamania or Merwin hatcheries and released into several watersheds. The winter steelhead hatchery stocks return as adults to the tributaries in late fall and early winter and spawn in mid-winter. Summer steelhead hatchery stocks return to the tributaries during spring and summer and also spawn in the winter. The local naturally-spawning winter steelhead arrive later then the hatchery fish and spawn in the spring. The naturally-spawning summer steelhead spawn in the spring also. The timing and spatial differences between the earlier spawning hatchery fish and the naturally-spawning fish minimize the opportunity for spawning interaction between the hatchery and naturally-spawning fish. However, because some overlap in spawning is possible, and surviving juveniles from natural spawning hatchery parents may compete with naturally-spawning juveniles, hatchery steelhead programs will improve methods to efficiently remove hatchery adults from the watershed prior to spawning. These methods would include efficient trapping, maximizing harvest of marked hatchery fish, limits on duration of adult recycling programs, and transfer of collected adults to lakes or ponds instead of return to the river.

Coho

H.A25. Develop hatchery supplementation programs for coho. (Category C)

Explanation: Hatcheries supplementation with appropriate stock will be an important part of rebuilding natural coho production in lower Columbia tributaries. The supplementation program sites and magnitude would be determined by assessing the status of individual populations relative to available habitat, as well as availability of appropriate brood stock. Hatchery supplementation levels would be reduced over time as sustainable natural populations are developed.

H.A26. Reintroduce coho in upper Cowlitz and upper Lewis rivers. (Category A,C)

Explanation: Re-license of Cowlitz and Lewis river dams will include provisions to reintroduce natural production of coho into the habitats upstream of the dams. Passage through these hydro systems will be critical to success of the programs, but hatchery facilities and operations must also be adjusted to accommodate the reintroduction effort; including rearing space, brood stock development, marking programs, collection and sorting facilities, transfer equipment, and adequate monitoring and evaluation plans.

H.A27. Develop local brood stocks for coho. (Category C)

Explanation: With the exceptions of Clackamas and Sandy river natural coho populations, it is believed there are little differences between the hatchery coho populations and the natural coho populations in the lower Columbia River. A significant number of the natural spawning coho are first generation hatchery fish. Re-establishing natural populations with attributes adapted to the local watershed will be connected to development of local brood stock in the hatchery programs. This measure will include development of brood stock with return and spawn timing characteristics which are similar to historical natural populations. Presently, Cowlitz and North Toutle hatchery coho are considered local broodstock with little outside basin influence. Late coho brood stock for naturally-spawning fish enhancement would include later spawning coho returning in December and January, which is consistent with the timing of the majority of the historical late coho populations. Late coho brood stock for the harvest program would continue to produce the earlier timed late stock (October-November) to separate programs similar to the hatchery steelhead strategy.

H.A28. Develop coho transfer policies as local brood stock is developed. (Category B)

Explanation: After local natural and hatchery coho populations are developed, brood stock transfer policies will be developed and implemented to assure the stock integrity of coho in a particular watershed is maintained. Transfer guidelines would not preclude meeting legal obligations to transfer lower Columbia coho to release areas in upper Columbia tributaries. Transfer exceptions may also include transfer of harvest program fish if appropriate measures are in place to protect the integrity of the locally developed natural stock.

H.A29. Use coho juvenile release strategies to minimize interaction with naturally-spawning fish. (Category A)

Explanation: Hatchery coho for the harvest program are released as yearling smolts. Release of yearling coho occur at the hatchery site, from net pens, and from acclimation ponds. Potential for predation on naturally-spawning subyearling fall Chinook, chum, coho, or steelhead should be reduced and addressed through development of coho release strategies. Strategies would be developed for each watershed, with options including; release downstream of significant naturally-spawning fish rearing areas, volitional release methods, release fish when smolted and at optimum size to assure rapid movement out of the tributary, and reduction in numbers of fish released in a particular watershed. Supplementation may occur with adult hatchery fish, yearling, or subyearling coho. The magnitude, life stage, and areas for supplementation releases would consider interactions and impacts to existing naturally-spawning populations.

H.A30. Mark coho hatchery harvest production. (Category A)

Explanation: Coho released as part of the hatchery base harvest program would continue to be adipose fin-clipped. Distinguishing the origin of returning adults will be a critical aspect of the reintroduction of coho upstream of the hydro systems in the Lewis and Cowlitz basins, and in monitoring natural production in other lower Columbia tributaries. This measure would enable a more accurate enumeration of naturally-spawning coho spawning escapement in the sub-basins, provide the means to control the number of hatchery adults spawning naturally, integrate hatchery and naturally-spawning programs, and provide selective fishing options where appropriate. Identification of naturally-spawning fish in important areas with mixed hatchery and naturally-spawning returns will be an important element of a monitoring and evaluation program.

H.A31. Establish naturally-spawning production sanctuary areas to be used for coho indicator stock programs. (Category B)

Explanation: Establishes key naturally-spawning coho production areas as sanctuaries where hatchery stray fish would be removed prior to spawning. These areas would be used to index natural production of naturally-spawning fish in the lower Columbia basins. Intensive monitoring and evaluation would occur in these indicator stock streams. This measure would provide the means for future estimates of annual naturally-spawning coho smolt production in the lower Columbia and also to compare coho production between streams with and without hatchery spawner influence.

6.8 Ecological Interactions

Ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. This section identifies strategies and measures pertaining to non-native species, effects of salmon on system productivity, and native predators of salmon. Ecological interactions of hatchery and natural fish populations are addressed in the hatchery strategy chapter.

6.8.1 Working Hypotheses

I.H1. Non-native, invasive, and exotic species often reduce or displace native species, particularly where habitats have been altered by human activities.

Explanation: Native species have co-evolved and typically experience some level of balance with each other. They are often co-adapted and depend on each other. Non-native and invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Altered habitats provide opportunities for introduced species to thrive and displace native species. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems.

I.H2. Salmon are but one element in a complex ecosystem where each part affects and is affected both directly and indirectly by all the other parts. Salmon have been a significant source of nutrients in freshwater systems and are both predator and prey.

Explanation: Salmon contribute a food source for other species, nutrients, and habitat forming processes in freshwater systems. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the abundance of salmon. Many significant salmon predators and scavengers including bull trout and eagles benefit from healthy salmon populations. Large numbers of salmon returning to spawning streams also introduce significant amounts of marine derived nutrients into nutrient-poor freshwater systems. These nutrients stimulate primary and secondary productivity that in turn increases food abundance in the entire stream system, and in particular for juvenile salmon. Finally, salmon affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

I.H3. Predation has always been a source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary, but habitat changes resulting from human activities have substantially increased predation by some species including Caspian terns and northern pikeminnow.

Explanation: Native predator species are an integral part of the naturally functioning system. Their abundance follows the abundance cycles of prey populations, and in healthy systems, prey numbers often limit predator numbers, rather than the reverse. At times predators can exploit altered habitats in ways that compromise the achievement of specific management goals, and may require management themselves to reduce prey mortality. These cases are rare and can require input of significant amounts of energy to maintain the system in a state that is essentially out of balance. Such management is only fruitful where it can be established that the predator management benefits are not offset by other limiting factors, predator population viability remains intact, effects of predator removal do not cause other unintended perturbations, and predation losses are not outweighed by benefits. (Predation benefits might include predation on competitors, stabilizing selective pressure, or prevention of habitat over-utilization.) Predator-prey interactions are also complex and difficult to understand or control.

6.8.2 Strategies

I.S1. Do not intentionally introduce new exotic species. Take aggressive measures to avoid inadvertent introductions of new species and to control or reduce the potential adverse effects of existing non-native species or their effects.

Explanation: The impacts of introduced or invasive species are unpredictable and may be severe. Once established, introduced or invasive species can be virtually impossible to control or eliminate.

I.S2. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Explanation: This recovery plan focuses on salmon but recovery measures must also consider the contribution of salmon to other parts of the ecosystem, as well as the balance among salmon-centric recovery measures and the health of other system components. Salmon recovery will likely benefit other parts of the native ecosystem. Salmon recovery cannot occur at the expense of the viability of other native species. Because of the complex nature of ecological relationships, attempts to recover salmon without consideration of their role in the ecosystem will inevitably fail.

I.S3. As an interim recovery strategy until more suitable habitat conditions are restored for salmon, manage predation by selected species while also maintaining a viable balance of predator populations.

Explanation: In selected cases it is possible to provide temporary benefits to selected species through management of predators or predation. Predation management need not rely on predator control. A variety of predation management alternatives exist, which can reduce the vulnerability of selected prey without jeopardizing predator or prey populations and compromising the health of the ecosystem.

6.8.3 Measures

Non native Species

I.M1. Implement regulatory, control, and education measures to prevent additional species invasions. (Category B)

Explanation: The lower Columbia ecosystem currently contains a variety of invasive, non-native species including fish, clams, shrimp, crabs, crayfish, clams, snails, plankton, and plants. Once established, it can be virtually impossible to control or eliminate these species. By far the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits. Recently adopted regulations for ballast water are one example of this measure.

I.M2. Establish a moratorium on intentional introductions of aquatic species and importation of high-risk species. (Category B)

Explanation: Intentional species introductions typically do not achieve intended benefits and cause more problems than they solve.

I.M3. Take proactive steps to control or reduce the impacts of introduced, invasive, or exotic species. (Category C)

Explanation: Once established, it can be difficult to eliminate introduced, invasive, or exotic species. However, a variety of direct or indirect methods can be employed to control or reduce their impacts. Local populations of introduced species can sometimes be removed prior to becoming firmly established. Vegetation control can be used to affect predator-prey interactions. Habitat modifications (coves, docks, levees, etc.) that favor introduced, invasive, or exotic species can also be designed to reduce impacts.

I.M4. Manage established populations of introduced gamefish to limit or reduce significant predation or competition risks to salmon, and to optimize fishery benefits within these constraints. (Category A)

Explanation: Significant populations of introduced gamefish including walleye, smallmouth bass, and channel catfish are firmly established and cannot be feasibly removed. In some cases, introduced gamefish populations might be managed to reduce risks to sensitive native species including salmon. Established populations can sometimes be managed to shape fishery benefits, as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. However, walleye fisheries might be managed with size regulations for trophy fishery benefits with no effect on salmonids.

I.M5. Evaluate positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures. (Category C)

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts from competition for habitat or food. Elimination or control of shad is not a panacea for salmon recovery but the potential significance of shad interactions with salmon, sturgeon or other species and options for management warrant closer consideration. Ill-considered attempts at intervention may produce unanticipated consequences.

Food Web

I.M6. Experimentally evaluate nutrient enrichment programs (LLT) and risks using fish from hatcheries or suitable analogs. (Category C)

Explanation: Under some circumstances, inputs of marine-derived nutrients from salmon carcasses have been shown to substantially increase system productivity. Additional research and experimentation is needed to determine where additional nutrient inputs can provide significant benefits and what alternatives for nutrient augmentation may be effective.

I.M7. Consider ecological functions of salmon, including nutrients in establishing escapement goals. (Category C)

Explanation: Nutrient benefits of large spawning escapements are theoretically already represented in escapement goals where based on spawner-recruit analyses. However, existing data may not effectively determine the incremental benefits of nutrients independent of other factors such as spawning density. This measure proposes more explicit consideration of nutrient benefits in establishing escapement goals based on results of other evaluations.

Predators

I.M8. Continue to manage the northern pikeminnow fishery to help offset increased predation on salmon that resulted from habitat alteration. (Category A)

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

I.M9. Continue to manage predation by avian predators, such as Caspian terns, to avoid large increases in salmon predation while also protecting the viability of predator populations. (Category A)

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where increased predation might pose added risks. Additional alternatives for management of predation by avian predators will be included in an Environmental Impact Statement currently being prepared by the U.S. Fish and Wildlife Service.

I.M10. Develop and implement a plan to manage predation by marine mammals such as seals and sea lions, where increased predation poses significant risks to salmon recovery and management is consistent predator population viability. (Category B)

Explanation: Following adoption of the U.S. Marine Mammal Protection Act, seals and sea lions have begun to recover from historically low population levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River. There is a need to permit resource agencies to use management options in prescribed situations where marine mammals are creating unnatural levels of predation.

6.9 Other Fish and Wildlife Species

Many of the fish and wildlife species addressed in this Management Plan are currently experiencing stable or increasing population trends; despite their current status, implementing an ecosystem-based approach to the recovery of ESA-listed species warrants evaluation of the effects of recovery actions on other fish and wildlife species. Because of the diversity of estuary and mainstem species of interest and their subsequent life history requirements, the potential for conflict exists among suggested strategies and measures among the focal species. If conflicts arise, planning and policy decisions will dictate which strategies and measures are implemented, based on species prioritization. However, the strategies and measures suggested within this management plan have been formulated to minimize conflict among species-specific strategies and measures. For example, lamprey and eulachon experience challenges with Columbia River mainstem migration and dam passage. Thus, strategies and measures promote lamprey and eulachon migration. However, because of the differential swimming capabilities between these two species and most salmonids, passage improvements for eulachon and lamprey are challenged by potential negative effects on salmonids.

As addressed in Chapter 3, Limiting Factors and Threats, the other fish and wildlife species addressed in this Management Plan are limited by many of the same factors as those identified for salmonids. Thus, it follows that many of the hypotheses, strategies, and measures developed for salmonids also apply to the other fish and wildlife species. In particular, regional strategies and measures for subbasin habitat, estuary and mainstem habitat, hydropower operation, and ecological interactions are most pertinent to the other fish and wildlife species. To avoid repetition, we have not included hypotheses, strategies, or measures from these particular sections. The following section includes only those hypotheses, strategies, and measures that are specific to these other fish and wildlife species.

OS.H1. Because of the broad range of fish and wildlife species habitat requirements, current habitat conditions have differentially affected each species.

Explanation: The group of fish and wildlife species addressed in this Management Plan are quite diverse; as such, no generalizations can be made regarding habitat effects on this group of species. In certain instances, habitat conditions may benefit one species while they negatively affect another species.

OS.H2. Anadromous fish species population viability is variable; annual abundance depends on existing habitat conditions, marine productivity, and harvest levels.

Explanation: Like salmonids, other anadromous fish species are affected by freshwater habitat conditions, ocean conditions, and harvest mortality (if applicable). The degree to which each factor affects species abundance depends of the life history characteristics of each species.

OS.H3. Permanent and seasonal resident fish species populations are stable and continue to support important commercial and sport fisheries.

Explanation: Resident fish species have been characterized as opportunistic feeders and diet items can vary widely depending on season, life stage, and location. Additionally, resident fish are not generally associated with peripheral habitats that have been substantially reduced over time. Many resident fish are associated with benthic habitats, which remain available today.

OS.H4. Semi-aquatic avian and mammal species populations are concentrated in the Columbia River estuary; current population trends are stable.

Explanation: The mosaic of tidal channels and terrestrial habitats in the lower Columbia River floodplain and estuary provide habitats for those species whose life history is inherently tied to both aquatic and terrestrial habitats. Semi-aquatic species addressed in this plan are concentrated in these habitats.

OS.H5. Important resident and breeding raptor species populations exist in the lower Columbia River; the populations are presently stable but may be sustained by colonization of individuals from adjacent populations.

Explanation: Mature forested habitats along the lower Columbia River and its tributaries provide habitat for bald eagle and osprey. Contaminant levels substantially influence reproductive. Bald eagle reproductive success is low while osprey reproductive success remains high, despite high contaminant concentrations detected in osprey. Abundance of the lower Columbia bald eagle population may be maintained through immigration of adults from other populations in the region.

OS.H6. Important over-wintering populations of sandhill cranes and dusky Canada geese exist in the lower Columbia River; the broad floodplain and agricultural lands maintain these populations.

Explanation: Extensive agricultural land in the lower Columbia floodplain attract sandhill cranes and dusky Canada geese. These species also use riparian and wetland habitat throughout the floodplain. Loss of agricultural lands to development or conversion of crops to less desirable forage affect the quantity and quality of crane and geese overwintering habitat.

OS.H7. Neotropical migratory avian species are important riparian habitat indicators; abundance in the lower Columbia River is generally low, although they are abundant elsewhere throughout their range. Causal relationships of population trends are complicated by the effects of habitat loss and fragmentation in overwintering areas.

Explanation: Yellow warblers and red-eyed vireos are abundant throughout their range and are not of conservation concern. They are both considered indicators of riparian habitats: yellow warblers are associated with riparian shrub habitats while red-eyed vireos are associated with forest riparian habitats. Little is known regarding their distribution and abundance in the lower Columbia region.

OS.H8. Sturgeon are susceptible to fishery overexploitation because of their longevity and slow growth.

Explanation: Fish species that take considerable time to replace themselves are generally susceptible to overfishing. Sturgeon can live to be 100 years old; age at first reproduction ranges from 10-20 years for males and 15-30 years for females. Lower Columbia River sturgeon population did not begin recovery from overfishing in the late 1800s until minimum size restrictions protected the broodstock fish beginning in 1950.

6.9.1 Strategies and Measures

Bald Eagle

Because bald eagles may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section (i.e. floodplain development and contaminants), bald eagles are addressed under the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Sandhill Crane

Because sandhill cranes may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section (i.e. floodplain development and loss of riparian habitat), sandhill cranes are addressed under the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Dusky Canada Goose

Because dusky Canada goose may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section (i.e. floodplain development and loss of riparian habitat), dusky Canada goose are addressed under the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Columbian White-tailed Deer

Because Columbian white-tailed deer may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section (i.e. floodplain development and loss of riparian habitat), Columbian white-tailed deer are addressed under the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Fisher

Because the fisher is limited by subbasin habitat and estuary and mainstem habitat limiting factors (loss and fragmentation of forested riparian habitat), they are addressed in the regional subbasin habitat and estuary and mainstem habitat strategies and measures developed for salmonids.

Western Gray Squirrel

Because the western gray squirrel is limited by subbasin habitat and estuary and mainstem habitat limiting factors (loss of forested habitat) and ecological interactions (competition with California ground squirrels), they are addressed in the regional subbasin habitat and ecological interactions strategies and measures developed for salmonids.

Seals and Sea lions

Because seals and sea lions are considered a threat to emigrating adult salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

Western Pond Turtle

Because western pond turtles are limited by subbasin habitat limiting factors (loss of riparian and wetland habitats) and ecological interactions (predation by introduced fish), they are addressed in the regional subbasin habitat and ecological interactions strategies and measures developed for salmonids.

Oregon Spotted Frog

Because the Oregon spotted frog is limited by subbasin habitat limiting factors (loss of wetland habitat) and ecological interactions (predation by introduced species [i.e. warmwater fish and the bullfrog]), they are addressed in the regional subbasin habitat and ecological interactions strategies and measures developed for salmonids.

Larch Mountain Salamander

Because the Larch Mountain salamander is limited by subbasin habitat limiting factors (loss of cool, moist forested habitat with adequate talus and organic debris), they are addressed in the regional subbasin habitat strategies and measures developed for salmonids.

Cutthroat Trout

Because cutthroat trout in the lower Columbia region are limited by the same subbasin and estuary/mainstem habitat limiting factors as other salmonids, they are addressed under the regional subbasin habitat and estuary and mainstem habitat strategies and measures developed for salmonids.

White Sturgeon

OS.M1. Protect preferred spawning habitat in extended tailrace zones downstream of Bonneville and The Dalles dams.

Explanation*:* White sturgeon spawn in deepwater, rocky habitats with sufficient interstitial spaces to provide adequate water flow and predator protection during embryonic development. This habitat is limited for the lower river population to the Columbia River Gorge downstream from Bonneville Dam and for the Bonneville Reservoir population to The Dalles Dam tailrace. Both areas currently appear adequate to provide consistent annual recruitment. The long term health of these sturgeon populations will depend on protection of these habitats.

OS.M2. Continue to monitor and manage Columbia River fisheries at sustainable levels, ensuring adequate spawner abundance through consistent recruitment to adulthood and protecting adult spawners from significant impacts.

Explanation*:* Longevity, slow growth, and delayed maturation make sturgeon susceptible to fishery overexploitation. Columbia River sturgeon fisheries should continue to be managed in such a way as to ensure sufficient abundance of fish attaining older ages, thus maintaining adequate spawner abundance.

OS.M3. Protect and restore all components of a healthy mainstem and estuary ecosystem that sustain sturgeon recruitment, survival, growth, and maturation.

Explanation*:* White sturgeon depend on a functional system that includes diverse and adequate seasonal food sources.

OS.M4. Continue as appropriate to trap and transport juvenile sturgeon from the lower Columbia into upstream reservoirs to utilize available habitats and offset recruitment failures in impoundments .

Explanation*:* Many upriver reservoirs no longer provide consistent conditions for white sturgeon recruitment but do contain significant amounts of habitat for juveniles and adults. Sturgeon rarely using existing fish ladders. Trap and transport is an effective method to maintain some level of upstream reservoir white sturgeon populations.

OS.M5. Avoid incidental mortality as a result of Bonneville Dam operations.

Explanation: Dewatering of turbines at Bonneville Dam has been documented to strand white sturgeon, resulting in mortality. Mortality can be avoided by blocking access by sturgeon to draft tubes prior to turbine shut down and dewatering. Salvage sturgeon trapped during emergency procedures.

Green Sturgeon

Green sturgeon make extensive use of the lower Columbia River estuary habitats and will likely benefit from regional estuary and mainstem habitat and ecological interactions strategies and measures developed for other species, as well as fishery regulations imposed for white sturgeon.

OS.M6. Regulate fisheries to avoid significant impacts on green sturgeon.

Explanation: Green sturgeon originate in other systems and are transitory seasonal residents of the Columbia River estuary. Data on abundance and productivity is limited. Columbia River salmon and white sturgeon fisheries should be managed to avoid increased impacts to green sturgeon.

Lamprey

OS.M7. Evaluate and improve passage conditions at mainstem and tributary dams, ensuring no negative effects on salmonid passage.

Explanation: Adult Pacific lamprey have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile salmonid passage systems. Bonneville Dam has blocked access to historical spawning and rearing areas. Potential improvements to lamprey passage need to be evaluated for potential negative effects on salmonids.

OS.M8. Allocate water within the annual water budget for the Columbia River Basin that simulates peak spring discharge.

Explanation: Flow affects from upstream dam construction and operation have significantly modified estuary and mainstem hydrologic conditions. Juvenile lamprey are poor swimmers and are at the mercy of currents to complete downstream migrations. Decreased spring flows in the lower Columbia River may have likely eliminated the synchrony between lamprey physiological development and emigration timing. Establishing flows in the Columbia River estuary and lower mainstem that emulate a more natural regime might help improve emigration conditions for juvenile Pacific lamprey.

Eulachon

OS.M9. Maintain eulachon preferred spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Spawning substrate used by eulachon is characterized by coarse sand substrate. At present, there is limited information as to the available acreage of preferred spawning habitat or as to whether acreage of this habitat type is increasing or decreasing. Because of our present lack of information regarding eulachon, an inventory of spawning locations, habitat characteristics, and habitat availability would be beneficial.

OS.S10. Avoid and/or mitigate incidental mortality of embryos and juveniles during dredging operations.

Explanation: Developing embryos or juvenile eulachon may be present among sand or fine substrates throughout the lower Columbia River. Suction dredging in these areas may result in direct mortality. Dredge operations should avoid areas of known embryo or juvenile presence. Dredging also can make eulachon spawning substrates unstable and therefore unsuitable for spawning.

OS.M11. Continue to monitor and regulate Columbia River fisheries for eulachon to inventory population status and protect spawning escapement.

Explanation: Harvest levels and fishery regulations should be closely monitored to ensure that population viability is maintained.

Northern Pikeminnow

Because northern pikeminnow are considered a predation threat to emigrating juvenile salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

American Shad

American shad are considered a potential threat to salmonids based on possible competition and food web effects, thus, shad are addressed in the regional ecological interactions strategies and measures developed for salmonids.

Band-tailed Pigeon

Because the band-tailed pigeon is limited by subbasin habitat limiting factors (loss of coniferous forests with associated mineral springs), they are addressed in the regional subbasin habitat strategies and measures developed for salmonids.

Caspian Tern

Management of Caspian terns will be addressed in a forthcoming EIS being completed by U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA Fisheries. Because Caspian terns are considered a predation threat to emigrating juvenile salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

Osprey

Because osprey may be limited by many of the same factors identified for salmonids in the estuary and mainstem habitat section (i.e., floodplain development and contaminants), they are addressed under the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Yellow Warbler

Because yellow warblers are limited by subbasin habitat and estuary and mainstem habitat limiting factors (i.e., loss of riparian and wetland habitats), they are addressed in the regional subbasin habitat and estuary and mainstem habitat strategies and measures developed for salmonids.

Red-eyed Vireo

Because red-eyed vireos are limited by subbasin habitat and estuary and mainstem habitat limiting factors (i.e., loss of riparian and wetland habitats), they are addressed in the regional subbasin habitat and estuary and mainstem habitat strategies and measures developed for salmonids.

Seals and Sea Lions

Because seals and sea lions are considered a threat to emigrating adult salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

River Otter

Because river otter are limited by estuary and mainstem habitat limiting factors (i.e., floodplain development and loss of riparian/wetland habitats), they are addressed in the regional estuary and mainstem habitat strategies and measures developed for salmonids.

Walleye

Because walleye are considered a predation threat to emigrating juvenile salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

Smallmouth Bass

Because smallmouth bass are considered a predation threat to emigrating juvenile salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

Channel Catfish

Because channel catfish are considered a predation threat to emigrating juvenile salmonids, they are addressed in the regional ecological interactions strategies and measures developed for salmonids.

7 MONITORING AND RESEARCH

7.1 Overview

As noted repeatedly in this plan, our knowledge and understanding of the biology, complex life histories, and ecosystem relationships varies considerably among the fish and wildlife species of interest. Some species, such as Chinook salmon, have been studied and researched extensively. Others, such as Pacific lamprey, have received relatively little attention. For no species is our knowledge and understanding complete, nor is it ever likely to be so. In short, this plan requests actions from fish managers, agency administrators, tribal leaders, elected officials, and the public based on imperfect and incomplete information. However, to delay all action until more studies and research can be completed risks further deterioration of the species and ecosystems upon which they depend. For some species, such a delay could substantially increase the risk of extinction.

This plan attempts to make the best use of our current knowledge of the fish and wildlife species and ecosystem processes and conditions to chart a course to recovery or viability that can be implemented now with reasonable confidence that it will achieve its stated goals and objectives. In this regard, a recovery program is fundamentally an experiment. Based on our acquired knowledge and understanding, the plan has constructed working hypotheses regarding focal species and their response to changes in ecosystem conditions or management practices.

While science can identify a reasonable course of action, it will never be able to predict with precise certainty whether a prescribed set of actions will be sufficient to meet objectives. Uncertainties exist and must be managed. Working hypotheses provide a sound basis for identifying and scaling a suite of appropriate recovery actions but substantial refinements in the scope and focus of measures will be needed as the recovery effort unfolds. Some measures may not produce the desired effects. Other measures will exceed expectations. Unexpected events will occur. A robust and adaptive monitoring, research, and evaluation framework will be critical for weighing progress toward recovery and making appropriate course adjustments along the way.

Monitoring, research, and evaluation elements of this plan were adapted from and are consistent with other regional strategies and plans developed by the ISAB (2003), SRFB (2002), NOAA (2003), and UCRIT (2004), and PNAMP (2004). The various programs describe monitoring in slightly different terms but generally address the same goal (UCRIT 2004). The ISAB described an integrated 3-tier monitoring program for assessing recovery of tributary habitat based on trend or routine monitoring, statistical monitoring, and experimental research monitoring. The SFRB program identified five purposes for monitoring including status and trend (extensive) monitoring, implementation monitoring, project effectiveness monitoring, validation monitoring, and compliance monitoring. NOAA working with the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, developed a detailed and intensive research, monitoring, and evaluation plan for implementing the 2000 Federal Columbia River Power System Biological Opinion (FCRPS). The FCRPS plan included six principle components; population and environmental status monitoring, action effectiveness research, critical uncertainty research, implementation/compliance monitoring, data management, regional coordination. UCRIT draws from existing strategies to develop a monitoring approach specific to the upper Columbia Basin. PNAMP developed guidance for subbasin planners based on a synthesis of existing strategies and plans. This guidance included a series of considerations regarding monitoring objectives, monitoring indicators, data and information archiving, coordination and implementation, and logic paths.

The measures in this plan are based on a series of strategies that provide overarching approaches for achieving plan objectives and working hypotheses or assumptions that underlie selection and definition of strategies. This plan identifies specific measures for monitoring of biological status, habitat status, action effectiveness, and implementation/compliance. Biological status monitoring describes progress toward ESU recovery objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Habitat status monitoring identifies the cumulative effect of human activity trends and recovery measures on critical limiting factors. Action effectiveness monitoring determines if specific habitat, hydropower, hatchery, harvest, and ecological interaction measures produce the specific intended effect. Implementation/compliance monitoring evaluates whether actions were implemented as planned or meet established laws, rules, or benchmarks.

This plan also identifies potential topics for critical uncertainty research that target specific issues that constrain effective recovery plan implementation. Critical uncertainty research includes evaluations of cause and effect relationships between fish, limiting factors, and actions that address specific threats related to limiting factors.

Evaluation measures describe a process for interpreting results of monitoring and research, assessing the deviation from particular target goals or anticipated results, and recommending appropriate modifications to strategies, measures, and actions identified in this recovery plan.

Coordination and data management measures are included to ensure efficient implementation of a comprehensive and complementary program as well as accessibility and effective application of the associated data.

Monitoring, research, and evaluation measures detailed in this plan provide the key elements of a coordinated regional program supporting the plan’s salmon recovery and fish and wildlife management efforts. Included are objectives, indicators, sampling approaches, and methods of analysis. Also included are an inventory of existing programs and new elements. This plan provides the framework for a systematic regional approach. It generally identifies what needs to be done and how to do it. It does not drill down into specific implementation details such as desired confidence levels, statistical power, data collection protocols, sample sizes, etc. These details will depend on additional refinements to the monitoring, research, and evaluation elements of this plan that will be developed as implementation planning proceeds. Refinements will be predicated on the availability of resources for conducting an integrated monitoring, research, and evaluation program.

7.2 Working Hypotheses

1. ***Successful implementation of this recovery/subbasin plan is predicated on an effective monitoring, research, and evaluation plan. Working hypotheses upon which this plan is based provide clear direction but many hypotheses are uncertain. Future course corrections will be required based on MR&E.***
2. ***Programmatic "top-down" and project "bottom up" monitoring, research, and evaluation approaches each provide useful guidance and an effective plan will incorporate elements of both approaches.***
3. ***Existing programs meet many but not all MR&E needs of this plan.***
4. ***There are direct tradeoffs in time and resource costs between MR&E and recovery actions that more directly affect species of interest.***
5. ***It is not feasible to fund and implement projects to monitor, research, or evaluate every focal fish population, uncertainty or action.***

7.3 Strategies

1. ***Develop a programmatic regional framework for monitoring, research and evaluation to address Ecosystem and ESU-wide concerns of fish recovery.***
2. ***Recognize different spatial and temporal scales appropriate to a variety of programmatic and project-specific applications of monitoring, research, and evaluation with a framework that incorporates routine and statistical status monitoring, action effectiveness monitoring, implementation monitoring, and critical uncertainty research.***
3. ***Optimize efficiencies by incorporating and adapting existing monitoring, research, and evaluation activities into the plan.***
4. ***Utilize other Columbia Basin ecosystem and oceanographic monitoring, research, and evaluation efforts.***
5. ***Identify information gaps that need to be addressed with new monitoring and evaluation activities while also balancing a recognition that the available resources limit implementation to the highest priorities and that tradeoffs exist between MR&E activities and measures that more directly contribute to fish recovery.***
6. ***Focus selected monitoring and research activities in intensively monitored watersheds (IWAs) to optimize opportunities for identifying cause and effect relationships while also providing cost efficiencies.***
7. ***Focus research on the effective implementation of recovery measures rather than detailed mechanistic studies of relationships between fish and limiting factors.***
8. ***Incorporate provisions for regional coordination and data distribution to maximize accessibility and applicability.***
9. ***Incorporate an adaptive evaluation framework with clear decisions points and direction to guide future actions.***

7.4 Biological Status Monitoring

Biological status monitoring describes progress toward ESU recovery objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Status monitoring involves routine and in-depth efforts. ISAB (2003) defines routine monitoring as repeated measurements of a selected series of units over a period of time to quantify and distinguish changes from background noise. For the purpose of this plan, in-depth monitoring is defined as an extension of routine monitoring with repeated measurements over a broader series of units with greater frequency and duration.

The following section presents an overview of routine and in-depth biological monitoring, followed by a graphical monitoring summary by species. Objectives, indicators, sampling strategies and analysis for each type of monitoring have been identified along with the logic trail used to select monitored populations. Rather than prescribing one monitoring strategy, three scenarios are proposed ranging in level of effort and cost from high to low (Level 1-3 respectively). Given the fact that routine monitoring is ongoing, only in-depth monitoring varies between each level. Preliminary cost estimates and funding considerations are included for relative points of comparison between the various monitoring levels.

7.4.1 Routine Monitoring

Routine monitoring for Washington lower Columbia basin consists of adult spawning escapement estimates collected annually as part of ongoing monitoring efforts. Table 1 provides a summary of current monitoring by species, basin and data type. Additional efforts will be required to achieve minimum goals for routine monitoring. The primary objective of routine monitoring can be summarized as follows:

1. ***Monitor trends and variation in annual adult spawning abundance and distribution of representative populations of Chinook, chum, coho, and steelhead in all watersheds.***

   Objective: Current population size and changes relative to objectives
   Indicator: Estimates of absolute or relative abundance from counts of live fish, carcasses, or redds
   Sampling: Representative long term index sites (dams, weirs, snorkel, ground or aerial surveys)
   Analysis: Annualized population growth rate and persistence probabilities

The goal of routine monitoring will be to produce annual adult abundance estimates for all populations included in Table 1 where those species are present. The purpose of the routine monitoring program would be to track abundance status of listed stocks for the purposes of determining if actions taken as a result of this plan are achieving their desired results and if abundance of listed stocks is progressing towards recovery. Routine monitoring is currently being conducted in a majority of watersheds for most species; however, current effort levels for coho are not adequate for the purposes of monitoring the status of an ESA listed stock. Additional adult coho surveys will be required in some streams, especially Washington tributaries. Additional sampling efforts will also be required to adequately monitor chum salmon populations for ESA recovery purposes. Many adult spawning surveys are currently funded with "soft funds" and continued funding will need to be solidified. Moreover, the current funding provides the minimum resources needed to count fish and redds and does not include monies to conduct a thorough investigation of the accuracy of the methods used to estimate total adult spawning escapement.

Table 1. Current biological status monitoring activities by subbasin and species.

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead[7]	Summer steelhead	Coho[11]
COAST[1]	Grays/Chinook	AA	--	--	AA/JM[5]	AA	--	PA
	Elochoman/Skamokawa	AA	--	--	AA	AA	--	PA
	Mill/Abernathy/Germany	AA	--	--	AA	AA/JI[8]	--	PA/JA
	Youngs Bay	AA	--	--	AA		--	AI
	Big Creek	AA	--	--	AA		--	AI
	Clatskanie	AA	--	--	AA		--	AI
	Scappoose	AA	--	--	AA		--	AI
CASCADE	Lower Cowlitz	AA	--	AA	AA	AA	--	PA
	Upper Cowlitz		--	AA/JA[3]		AA/JA	--	AA/JA
	Cispus		--	AA/JA[3]		AA/JA	--	AA/JA
	Tilton		--				--	AA/JA
	SF Toutle	AA	--	--		AA	--	PA
	NF Toutle	AA	--	--		AA/AI[9]	--	PA
	Coweeman	AA[1]	--	--	AI	AA	--	PA
	Kalama	AA	--	AA/JI	AI	AA/JA/BR	AA/JA/BR	PA
	Lewis NF		AA/JA/JT	AA[4]	AA	AI/JI[10]	AA	AI/JI[10]
	Lewis EF	AA[1]	AA	--	AA	AA	AA	PA
	Salmon		--	--	AI			PA
	Washougal	AA	--	--	AA	AA	AA	PA
	Sandy	AA	AA	AA		AA/JI	--	AI/JI
	Clackamas	PA	--	AA/JI		AA/JI	--	AI/JI
GORGE	Lower Gorge	AA	AA[2]	--	AA/JI			PA
	Upper Gorge	AA	AA[2]	AA	AA/JI[6]		AA/JI	PA
	White Salmon	AA	AA[2]	AA	AA	--		--
	Hood	AM	--	AA/JA/BR	--	AA/JA/BR	AA/JA/BR	--

AA = Annual adult abundance (weir counts or an estimate of absolute abundance based on the expansion of index counts) , AI = Annual adult index monitoring (a relative measure of species presence typically reported as redds/mile for the sample area), PA = Periodic adult abundance indices. JA = Annual juvenile abundance, JI = Juvenile index monitoring, JT = Juvenile coded-wire tagging. BR = Biological research, JM =Juvenile presence/absence

[1] Adult abundance estimates may not include entire spawning area.

[2] Not part of lower Columbia ESU.

[3] Juvenile accounting at Cowlitz Falls Dam. Does not separate Upper Cowlitz and Cispus production.

[4] Juvenile abundance monitoring will likely begin in new license period

[5] Juvenile migration timing only

[6] Juvenile abundance monitoring for Hamilton, Hardy, and Duncan Creeks. Juvenile index monitoring for mainstem Columbia near Ives Island.

[8] Adult monitoring does not include Mill Creek. Juveniles monitored in all three streams.

[9] Adult monitoring for NF Toutle. Adult index for Green River.

[10] Includes Cedar Creek only. Adult and juvenile monitoring will likely begin in new license period

[11] Coho adult monitoring is incidental to Chinook and chum monitoring.

Since adult spawning escapement is the bottom line currency in which to evaluate progress to recovery, we have proposed two steps to assuring the data is gathered annually for each population and the accuracy of the spawning escapement estimates are adequate to use as a measurement of recovery status.

1) Inventory current funding levels and solidify long-term commitment to provide adequate funding to survey adult spawning returns for all populations
2) Additional funding of $50,000 per year provided to investigate accuracy of spawning escapement estimates

7.4.2 In-depth Monitoring

In-depth monitoring for Washington lower Columbia basin consists of life-cycle population assessments, juvenile and adult abundance estimates and adult run-reconstruction. In-depth monitoring occurs in index watersheds and includes acquisition of juvenile and adult quantifiable data to provide life cycle analysis and enable productivity data to be generated. Such monitoring is critical to connecting habitat measures with fish productivity response and can be generally categorized as follows:

2. ***Monitor distribution/spatial structure of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.***

   Objective: Distribution and relative abundance of spawning and/or rearing by stream reach throughout potentially-accessible areas as an indicator of population viability and a basis for identifying or refining selection of routine monitoring sites.
   Indicator: Indices of relative abundance of adults from counts of live fish, carcasses or redds and/or juveniles based on snorkel, electrofishing, or seining surveys.
   Sampling: Replicate random samples stratified by time period and area in one or more years, repeated at periodic intervals.
   Analysis: Relative abundance, range, patchiness, used vs. available area, representativeness of index sites identified in routine sampling.

3. ***Monitoring trends and variation in annual juvenile production of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.***

   Objective: Current freshwater production and changes relative to objectives.
   Indicator: Juvenile migrant population estimates or indices of abundance, size, age, migration dates.
   Sampling: Collect outmigrating juveniles at representative index sites.
   Analysis: Annualized population growth rate, juveniles per spawner.

4. ***Monitoring trends and variation in productivity of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.***

   Objective: Estimate natural recruits per spawner and hatchery contributions.
   Indicator: Age structure, hatchery/wild origin, sex, biological condition.
   Sampling: Size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data.
   Analysis: Run reconstruction.

In-depth Monitoring will include annual monitoring of juveniles and adults in watersheds were annual monitoring is currently being conducted and funded through existing programs. This strategy minimizes cost by capitalizing on information being gathered as part of a FERC license agreement, BPA funds, Salmon Recovery funds, or Mitchell Act research funds. These projects are on-going for all species or are expected to be included in license agreements. These funded projects provide some level of representation for all species and are located in each stratum.

The existing annual projects provide opportunity for long-term assessments and some projects have long-term data bases that can be utilized to assess status trends (e.g. Kalama steelhead), however, these existing programs fall far short of covering sufficient numbers of key populations in watersheds to acquire the productivity data needed to connect and evaluate the adequacy of measures to achieve recovery objectives.

This Monitoring, Research and Evaluation strategy strives for efficiency in monitoring by intensively monitoring populations in watersheds with multiple key species and where information on more than one species can be gathered with the same equipment in the same area. For example, sampling steelhead and coho in upper watershed areas and Chinook and chum in the lower watershed areas. The watershed efficiency strategy is combined with focus on populations with higher biological objectives, as improvement in the populations which must become viable is the most critical and biggest challenge to achieving ESU scale recovery criteria.

In-depth monitoring is rotated between watersheds to provide more geographical coverage across strata, to include more critical watersheds, provide time for the populations to respond to recovery measures, and to save cost. The following criteria were used to select watersheds for in-depth monitoring:

1. Inventory existing monitoring
2. Identify gaps for basic monitoring
3. Develop criteria for In-depth monitoring
    - Indicator populations and watersheds
4. Prioritize In-depth monitoring areas
    - Build on existing programs, including habitat monitoring
    - Compare different biological strategies (hatchery vs. refuge areas)
    - Priority populations emphasized
    - Consider costs and logistics
    - Consider strata representation
5. Process for managing monitoring strategy
    - Funding
    - Coordination
    - Data management
    - Report mechanisms/distribution
    - Adaptive Management

7.4.3 Level of Effort

In-depth monitoring was prescribed according to three levels – Levels 1, 2, and 3. Level 1 reflects the highest level of effort and Level 3 reflects the lowest. Each level identifies the population to be sampled, the area to be sampled and an initial estimate of average annual cost. The following text and summary tables (Table 2 and Table 7) present level-specific sampling strategies and justification for monitoring particular populations and areas. The sampling activities described above do not vary between levels, simply the number of species and basins sampled.

Table 2. In-depth biological monitoring strategies by basin and level of effort.

BASIN	Level 1	Level 2	Level 3
Grays	F. Chinook Chum W. steelhead Coho	Chum*	Chum*
Skamokawa	Chum		
Elochoman	F. Chinook W. steelhead Coho	F. Chinook W. steelhead Coho	F. Chinook
MAG	Chum* W. steelhead* Coho*	Chum* W.steelhead* Coho*	Chum* W.steelhead* Coho*
L. Cowlitz	Coho	Coho	
U. Cowlitz	Spr. Chinook* W.steelhead* Coho*	Spr. Chinook* W.steelhead* Coho*	Spr. Chinook* W.steelhead* Coho*
SF Toutle	W. steelhead Coho	W. steelhead Coho	
NF Toutle	W. steelhead Coho		
Coweeman	F. Chinook W. steelhead Coho	F. Chinook	F. Chinook
Kalama	F. Chinook Spr. Chinook W. steelhead* S. steelhead*	W. steelhead* S. steelhead*	W. steelhead* S. steelhead*
NF Lewis	F. Chinook* W.steelhead* Coho*	F. Chinook* W.steelhead* Coho*	F. Chinook* W.Steelhead* Coho*
U. Lewis	Spr. Chinook* W.steelhead* Coho*	Spr. Chinook* W.steelhead* Coho*	Spr. Chinook* W. Steelhead* Coho*
EF Lewis	F. Chinook Chum W. steelhead S. steelhead Coho	F. Chinook Chum W. steelhead S. steelhead Coho	F. Chinook Chum W. steelhead S. steelhead Coho
Washougal	F. Chinook Chum S. Steelhead	Chum S.Steelhead	Chum
L. Gorge	Chum*	Chum*	Chum*
Wind	S. steelhead*	S.steelhead*	S.steelhead*
# populations/ # basins	42/16	32/16	25/16
Projected Cost/yr	$780,000	$610,000	$325,000

* annual in-depth monitoring program

Table 2 presents the basin-specific species considered at each of the three in-depth monitoring strategies. Included in the table is an initial cost estimate for the various monitoring levels. A breakdown by species for the monitoring costs are included in section 7.4.5. The annual cost was derived according to professional judgment and consists of personnel time, capital investments, data management, and an assessment of adult spawning ground survey accuracy. Given the preliminary nature of these costs estimates, they should only be relied upon for comparative ranking between the three levels.

Level 1 In-depth Monitoring

Level 1 provides the most in-depth in-depth monitoring and is summarized according to species in the following table:

Table 3. Level 1 in-depth biological monitoring by species.

Fall Chinook	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
Grays	U. Cowlitz*	Grays*	Grays	Kalama*	Grays
Elochoman	U. Lewis*	Skamokawa	Elochoman	EF Lewis	Elochoman
Coweeman	Kalama	MAG[3]	SF Toutle	Washougal	L. Cowlitz
Kalama		EF Lewis	NF Toutle	Wind*	SF Toutle
EF Lewis		Washougal	Coweeman		NF Toutle
Washougal		L. Gorge*	Kalama*		Coweeman
NF Lewis*			EF Lewis		EF Lewis
			NF Lewis* [1]		U. Lewis*
			MAG*[2]		U. Cowlitz*
			U. Lewis*		NF Lewis* [1]
			U.Cowlitz*		MAG*[2]

* annual in-depth monitoring program
1 Cedar Creek
2 Mill, Abernathy, Germany

Level 1 in-depth monitoring candidates include populations that are targeted for high viability recovery levels and/or have annual monitoring programs in place. Not all populations targeted for high viable levels are included in the Level 1 in-depth monitoring plan. A graphic representation of routine and in-depth monitoring by basins and species is presented in Figure 1.

All populations designated for annual in-depth monitoring have, or are expected to have in the future, annual monitoring programs with funding. (e.g. FERC Agreements, BPA, State Salmon Recovery, Mitchell Act). The one exception is Grays River chum which are targeted for annual in-depth monitoring because of the existing long-term adult abundance data base. There are a total of 15 populations that are expected to be funded for in-depth monitoring under current plans.

In-depth monitoring for remaining (not annually monitored) Level 1 populations would occur in three-year sampling periods and rotated to begin again every 9 years (Table 8).

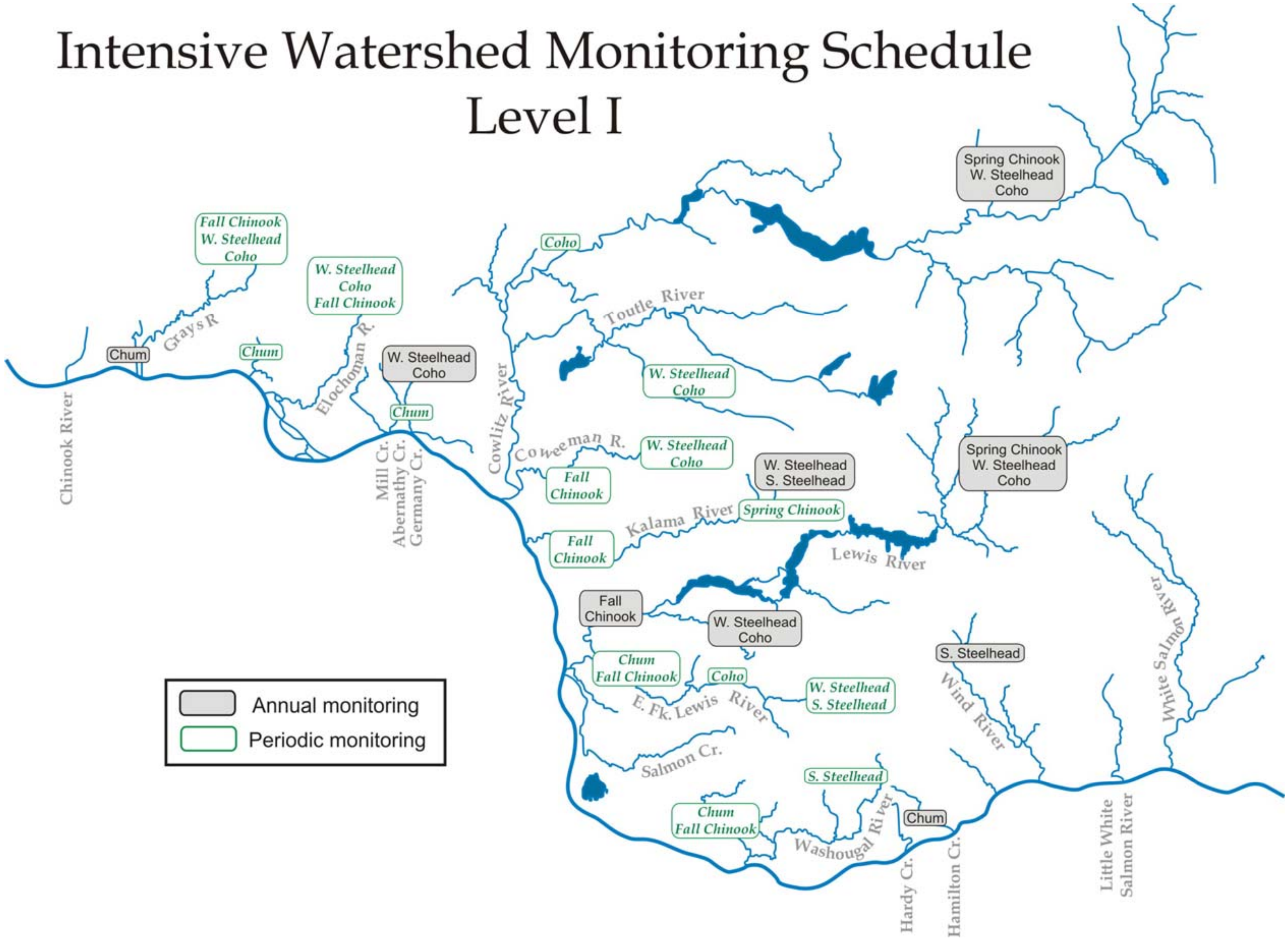


Figure 1. In-depth Biological Monitoring Level 1.

Level 2 In-depth Monitoring

Level 2 provides a moderate level of in-depth monitoring and is summarized according to species in the following table:

Table 4. Level 2 in-depth biological monitoring by species.

Fall Chinook	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
Coweeman NF Lewis* Kalama EF Lewis Elochoman	U. Cowlitz* U. Lewis*	Grays* L. Gorge* Washougal MAG[2] EF Lewis	Kalama* SF Toutle EF Lewis MAG*[2] Elochoman U. Lewis* U. Cowlitz* NF Lewis*[1]	Wind* Kalama* Washougal EF Lewis	Elochoman L. Cowitz SF Toutle EF Lewis NF Lewis*[1] U. Cowlitz* U. Lewis* MAG*[2]

* annual in-depth monitoring program
1 Cedar Creek
2 Mill, Abernathy, Germany

Table 5. Populations removed from Level 1 in order to establish Level 2

Species	Population removed	Justification
Fall Chinook	Grays	There is no weir in the mainstem Grays which would entail a costly investment. Given that expense and the retention of coastal sampling in the Elochoman, Grays Fall Chinook were removed from the Level 2 monitoring strategy
	Washougal	There is no lower river weir in the Washougal which would entail a costly investment. However the Kalama has an operating weir so the Washougal was removed from Level 2 sampling.
Spring Chinook	Kalama	The Upper Cowlitz and the Upper Lewis are the main focus for recovery, so the Kalama was removed from the Level 2 monitoring strategy
Chum	Skamokawa Cr	The Grays and MAG reflect Skamokawa population status
	Coweeman	The Kalama and Toutle represent Coweeman population status
	NF Toutle	The South Fork Toutle represent NF Toutle population status
Summer steelhead	No change	
Coho	Grays	Skamokawa and Elochoman represent Grays population status
	Coweeman	SF Toutle and Lower Cowlitz information remains in Cowlitz basin
	NF Toutle	SF Toutle info remains in Toutle basin
Other Cuts	Capital investments reduced by approximately 20%	

Level 3 In-depth Monitoring

Level 3 provides the lowest level in-depth monitoring and is summarized according to species in the following table:

Table 6. Level 3 in-depth biological monitoring by species.

Fall Chinook	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
Coweeman NF Lewis* Elochoman EF Lewis	U. Cowlitz* U. Lewis*	Grays* L. Gorge* Washougal MAG[2] EF Lewis	Kalama* U. Lewis* U. Cowlitz* EF Lewis* MAG*[2] NF Lewis*[1]	Wind* Kalama* EF Lewis*	EF Lewis* U. Cowlitz* U. Lewis* NF Lewis*[1] MAG*[2]

* annual in-depth monitoring program
[1] Cedar Creek
[2] Mill, Abernathy, Germany

Table 7. Populations removed from Level 2 in order to establish Level 3:

Species	Population removed	Justification
Fall Chinook	Kalama	Use Elochoman to represent hatchery/natural area. Retain Coweeman as the wild index stock for harvest and EF Lewis for long-term habitat monitoring
Spring Chinook	No change	No unfunded watershed remain
Chum	No change	MAG and EF Lewis selected for long-term habitat monitoring, Grays targeted for greater than high viability, and Washougal area chum critical for recovery. Chum are the least expensive species to monitor in-depth
Winter steelhead	SF Toutle	Cover with EF Lewis in Cascade
	Elochoman	Cover with MAG in Coast
Summer steelhead	Washougal	Cover with EF Lewis in Cascade
Coho	SF Toutle	Cover with EF Lewis in Cascade
	L. Cowlitz	Cover with EF Lewis in Cascade
	Elochoman	Cover with MAG
Other Cuts	Capital investments reduced by approximately 50 percent	
	Data management reduced by approximately 20 percent	
	Spawning survey accuracy investigations reduced by 50 percent	

7.4.4 Site Rotation Schedule for In-depth Monitoring

The following discussion presents the recommended monitoring by species. In-depth monitoring for a given population and level-of-effort occurs for 3 consecutive years, a sampling regime that is repeated every 9 years. The specific schedule is documented in Table 8.

Chum - Annual in-depth monitoring will occur in the Lower Gorge tributaries and Grays River. There is currently adult and juvenile accounting in the lower Gorge tributaries but only adult accounting in the Grays River. Periodic in-depth monitoring will occur for 3-year intervals on a rotation schedule in MAG creeks, Skamokawa Creek, EF Lewis, and the Washougal area. There are no juvenile monitoring programs in these sub-basins.

Fall Chinook Tule - All in-depth monitoring for fall Chinook tules would be conducted periodically in 3-year sampling intervals. Elochoman, Kalama, and Washougal basins would represent watersheds that have both natural and hatchery fall Chinook populations, Grays basin would represent an area where fall Chinook hatchery production occurred for many years, but was recently eliminated, and the East Fork Lewis and Coweeman would represent watersheds with only natural fall Chinook populations. There are no existing juvenile monitoring programs in these sub-basins

Winter Steelhead - In-depth monitoring would occur annually under existing programs with no additional cost in the Kalama, Upper Cowlitz, NF Lewis (Cedar creek), Upper Lewis and Cedar Creek), and MAG creeks. Periodic sampling would occur in 3-year intervals, with 2 tributaries annually, with a rotation schedule between Elochoman, Grays, EF Lewis, Coweeman, NF Toutle and SF Toutle. There are no existing juvenile programs in the tributaries included in the proposed rotation schedule.

Summer Steelhead - In-depth monitoring would occur annually with existing programs in the Wind and Kalama. Periodic sampling would occur in 3-year intervals in the EF Lewis and Washougal sub-basin on a rotation schedule and beginning every nine years. Annual cost is calculated as an addition to winter steelhead sampling in the East Fork Lewis and would occur in the same years. Annual cost is a new cost in the Washougal as there is no in-depth winter steelhead monitoring proposed in the Washougal sub-basin.

Coho - In-depth monitoring would occur annually with existing programs in the Upper Cowlitz, NF Lewis (Cedar Creek), upper Lewis and MAG creeks. Periodic monitoring would occur in 3-year intervals in the other basins, with a rotation between Elochoman, Grays, EF Lewis, Coweeman, SF Toutle, NF Toutle and Lower Cowlitz. This rotation schedule would be coordinated with the winter steelhead rotation schedule to enable sampling efficiency and reduced cost. Coho monitoring cost is represented at a reduced rate to represent the benefits of monitoring in the same watersheds as winter steelhead. Coho sampling will need to be extended in some watersheds, however, to include lower river tributaries as necessary.

Spring Chinook - In-depth monitoring would occur annually with existing programs in the Upper Cowlitz and NF Lewis. Periodic sampling would be included with steelhead sampling in the Kalama in 3-year intervals beginning every nine years. Big White Salmon In-depth spring Chinook monitoring would be implemented if passage is restored over Condit Dam or the dam is breached.

Fall Chinook Brights - NF Lewis Bright fall Chinook are intensively monitored with an existing WDFW/Pacificorp program. No additional costs are assumed for monitoring bright fall Chinook.

Table 8. Monitoring Rotation Schedule

Subbasin	Annual/Periodic Sampling	YR 1-3	YR 4-6	Yr 7-9
Grays	Annual Periodic	Chum Fall Chinook	Chum	Chum Winter steelhead Coho
Elochoman	Annual Periodic	 Fall Chinook		 Winter steelhead Coho
Skamokawa	Annual Periodic	 Chum		
MAG	Annual Periodic	Winter steelhead Coho Chum	Winter steelhead Coho	Winter steelhead Coho
L. Cowlitz	Annual Periodic		 W.Sthd Coho	
U. Cowlitz	Annual Periodic	Sp. Chinook Winter steelhead Coho	Sp. Chinook Winter steelhead Coho	Sp. Chinook Winter steelhead Coho
Toutle (SF&NF)	Annual Periodic		 Winter steelhead Coho	
Coweeman	Annual Periodic	 Winter steelhead Coho Fall Chinook		
Kalama	Annual Periodic	Winter steelhead Summer steelhead	Winter steelhead Summer steelhead Sp. Chinook	Winter steelhead Summer steelhead
L. Lewis	Annual Periodic	Fall Chinook Winter steelhead Coho	Fall Chinook Winter steelhead Coho	Fall Chinook Winter steelhead Coho
U. Lewis	Annual Periodic	Sp. Chinook Winter steelhead Coho	Sp. Chinook Winter steelhead Coho	Sp. Chinook Winter steelhead Coho
E.Fall Lewis	Annual Periodic	 Winter steelhead Summer steelhead Coho	 Fall Chinook Chum	
Washougal	Annual Periodic	 Summer steelhead	 Fall Chinook Chum	
L. Gorge	Annual Periodic	Chum	Chum	Chum
Wind	Annual Periodic	Summer steelhead	Summer steelhead	Summer steelhead

7.4.5 Cost

Whenever possible, sampling efficiencies were reflected in the site monitoring rationale. The following sections presents cost considerations for biological monitoring, capital investment, data management and adult spawning enumeration.

Biological monitoring - Costs for biological monitoring consist primarily of full time employees (FTE) and travel-related expenses. Monitoring for steelhead and coho is more costly than for fall Chinook or chum because of their extended freshwater life history. Annual base cost for a species is reduced if sampling occurs for another species at the same time

Projected annual cost of biological monitoring per population was estimated as follows:

- Winter steelhead- $100,000
- Summer steelhead-$100,000 (reduced to $25,000 if conducted with winter steelhead)
- Spring Chinook- $100,000 (reduced to $25,000 if conducted with steelhead)
- Coho- $100,000 (reduced to $50,000 if conducted with steelhead)
- Fall Chinook- $60,000
- Chum- $40,000 (reduced to $20,000 if conducted with fall Chinook/ except Washougal reduced to $30,000 because of vicinity chum areas)

Capital Investments (Weirs, Traps, vehicles, boats, sampling equipment) - Projected costs assume a one time purchase of traps and weirs to be rotated between watersheds every three years. The preliminary investment to cover watersheds sampled in years 1-3 will not need to be duplicated for other watersheds in the following years. Maintenance of equipment is projected as a $10,000 per year cost. Vehicles and water craft can be shared between watersheds in the same 3-year period and schedules were arranged geographically to minimize the number of vehicles, craft, and crew that would need to engage in a given day (e.g. sampling in the Elochoman and Grays rivers in the same three-year period). Estimated capital cost break down is:

- Fall Chinook/Chum sampling-$25,000 per watershed
- Steelhead/Coho sampling-$50,000 per watershed
- Vehicles- $90,000
- Water craft-$40,000

Data management - A significant amount of data will be collected and need to be entered, organized and summarized to fit the demands of evaluation. This cost estimates assumes 1 biologist and 1 technician FTE with benefits at a cost of $100,000 per year.

Adult spawning enumeration - This cost includes annual projects to verify the accuracy of spawning population estimates. Adult live and dead counts on spawning grounds would be supported with live adult tagging and recovery, or carcass tagging methods to determine if the count expansions used are appropriate. The studies may also involve confirmation of appropriate index count areas. The cost for adult spawning enumeration is estimated at $25,000 per population, with 2 projects conducted per year at a cost of $50,000 per year.

7.4.6 Funding Sources

Given the importance of funding, the following discussion outlines current annual coverage as well as options for alternative sources of funding. Currently the Bonneville Power Authority provides funding for adult spawning estimates, tag recovery, and biological data. In addition the Mitchell Act (16 USC 755-757; 52 Stat. 345) is responsible for funding in-depth monitoring of steelhead in the Kalama. Lastly, the Federal Energy Regulatory Commission supports spring Chinook, coho, winter steelhead monitoring as part of dam relicensing efforts in the Upper Lewis and Upper Cowlitz

Additional funds may be obtained from the following sources:

Bonneville Power Administration - expand coverage to include adult and juvenile monitoring. The proposed data could provide reference information for biological comparison to areas not impacted by impoundments. Furthermore it could be useful in estuary mitigation and as part of off-site verification under the Federal Hydro Biological Opinion (FCRPS 2000).

Salmon Recovery Federal funds - monitor salmon recovery investments.

State Dollars- Washington Department of Fish and Wildlife, Natural Resources, and Ecology. Each has a budget for monitoring

Mitchell Act- may provide additional monitoring below Bonneville to address harvest mitigation.

Federal Action agency funds- Army Corp. of Engineers, Forest Service, NOAA Fisheries

Local Funds- counties, cities, ports, private industry

Regional Enhancement Groups - work collaboratively with local, federal, and state governments to secure funding

7.5 Habitat Status Monitoring

Habitat monitoring provides a physical baseline upon which evaluate biological health. Habitat data ranges from watershed-scale characteristics such as road density to site-specific conditions such as channel substrate. The following table cites commonly considered habitat attributes useful in characterizing the overall condition of the ecosystem.

Table 9. Habitat attributes

Habitat Characteristics			
Watershed	**Stream Habitat**	**Water Quality**	**Water Quantity**
Geology Topography Road density • paved • unpaved Subwatershed Attributes • area • slope Mass Wasting Land cover Land Use Impervious Surfaces Stream and Wetland Mapping	Migration Barriers Channel Morphology • Stream classification • Habitat unit types • Substrate and sediment • Depth, width, gradient, confinement • Channel stability (incision/bank erosion) Instream structure • LWD • Boulders • Overhanging Banks Riparian Function • Vegetation • Riparian Disturbance (i.e. logging, roads) • Invasive species Floodplain Function • Connectivity • Hydrologic modifications	Temperature Turbidity/Suspended Sediments Dissolved Oxygen Conductivity Contaminants (point and nonpoint source) Nutrients (i.e. nitrogen, phosphorus) Additional Risk Factors (i.e. septic systems, grazing)	Stream gauging Stormwater management Withdrawls Instream Flow Assessment Groundwater / Surfacewater connectivity

Habitat status monitoring will occur in conjunction with biological status monitoring. The first step in establishing useful monitoring data is to develop an on-line, standardized database for the various basin attributes. With such a database, information can be input in a predetermined format and accessed by a wide audience. The next step is to analyze the available data and determine where and to what extend additional data would be useful. Cost estimates for the proposed habitat status monitoring require additional development and will be addressed in plan development.

7.5.1 Watershed Conditions

Of the categories cited in Table 9, watershed attributes are the slowest to change. Once baseline conditions are characterized, they require only need to be updated in the case of substantial land use change or natural events such as mass wasting. Each basin has been characterized in Volume II of this subbasin planning process and should be comprehensively updated every 10 years, unless conditions dictate otherwise. Annual sampling is not feasible for all locations and thus suite of possible statistical analyses are reduced. Nevertheless, the proposed sampling scale and strata is sufficient to reflect watershed changes on the instream habitat condition.

1. ***Conduct comprehensive survey of watershed conditions and processes across the Washington lower Columbia Region - completed.***

   Objective: Establish baseline conditions and use to stratify area for routine monitoring in a representative subset of areas. Also identifies priority areas for protection and restoration.
   Indicators: Geomorphology, land use, vegetation cover, riparian vegetative cover, road density, landslides, wetlands.
   Sampling: Primarily remote sensing and available GIS information.
   Analysis: Spatial and categorical summaries.

2. ***Monitor trends in watershed conditions and processes through periodic sampling of representative and indicator sites.***

   Objective: Detect broad changes in watershed conditions and processes that affect stream habitat forming processes. The changes can be small scale and extensive or large scale and intensive.
   Indicators: Geomorphology, land use, vegetation cover, road density, landslides, wetlands.
   Sampling: Remote sensing with ground validation. Long term index areas to identify temporal changes on a decadal scale; stratified selection of sample areas based on statistical surveys described above to identify sites representative of watershed types, stream types, and uses (forest, agriculture, urban); inclusion of non-randomly selected indicator sites expected to be most sensitive to trends in conditions. Sites should be sampled every 10 years unless changes to physical conditions warrant an increase in sampling frequency (i.e. mass wasting events, removal of impassible barriers).
   Analysis: Within and among site differences, changes over time. Although the frequency and extent of sampling will limit statistical inferences, the proposed monitoring will provide a quantitative as well as qualitative evaluation of watershed trends and processes.

The remaining categories require varying levels of monitoring. Existing monitoring data by basin are summarized in Table 10. The entities conducting ongoing monitoring and dates of sampling are included along with a coarse assessment of the depth of monitoring coverage.

7.5.2 Water Quality

As displayed in Table 10, water quality is extensively monitored by Washington's Department of Ecology, as well as the US Geological Survey. Data pertaining to each basin should be obtained from existing surveys and updated according to established monitoring schedules. Data gaps and regions prone to non-point source pollution may warrant additional monitoring. Furthermore refinement of the sampling plan will be implemented as needed:

1. ***Conduct comprehensive survey of water quality and quantity across the Washington lower Columbia Region.***

   Objective: Establish baseline conditions based on WDOE and USGS sampling. Identify priority areas for protection and restoration.
   Indicator: Stream flow, water temperature, turbidity, dissolved oxygen, conductivity, pH, nitrogen, phosphorous.
   Sampling: Stratified random sampling with replicates based on strata identified based on watershed and stream habitat assessments. Incorporate and supplement existing datasets.
   Analysis: Spatial and categorical summaries.

2. ***Monitor trends in water quantity and quality through periodic sampling of representative and indicator sites (includes USGS gauge sites and additional sites).***

   Objective: Detect changes in local stream conditions that affect the quantity and quantity of habitat provided for fish (i.e. the upstream extent of summer surface water).
   Indicator: Stream flow, water temperature, turbidity, dissolved oxygen, conductivity, pH, nitrogen, phosphorous
   Sampling: Long term index sites to factor out among-site variability and maximize statistical power to identify temporal changes; periodic sampling depending on indicator with replicates to distinguish temporal changes in conditions from inherent sampling variability and background noise; stratified selection of sample sites based on statistical surveys described above to identify sites representative of watershed types, stream types, and uses (forest, agriculture, urban); inclusion of non-randomly selected indicator sites expected to be most sensitive to trends in conditions.
   Analysis: Within and among site differences, changes over time.

Table 10. Existing monitoring data

		Stream / Riparian Habitat Surveys			WDOE[1] Water Quality		USGS[2] Water Quality		Continuous Temperature			USGS Stream Gaging			
Strata	Basin	Entity	Date	Level of coverage	Date	Level of coverage	Date	Level of coverage	Entity	Date	Level of coverage	Date	Real-time	Level of coverage	Entity
Coast	Grays/Grays Bay	WCD	1996	good	1973, 1976-7, 1998	moderate	1972-77	moderate	WCD/CCD	2002-present	good	1949-1975		moderate	WDOE
	Skamokawa	WCD, WDFW	1996-2003	moderate		poor	1980	poor	WCD/CCD	2002-present	good			poor	
	Elochoman	WCD, WDFW	1996-2003	moderate	1960, 1973, 1976-7, 1998	moderate	1972-77	moderate	WCD/CCD	2002-present	good	1940-1971		moderate	WDOE
	Mill	CCD, WDFW	1999-2003	poor		poor		poor	WCD/CCD	2002-present	good	1949-1956		poor	WDOE
	Abernathy	CCD, WDFW	1997-2003	moderate		poor		poor	WCD/CCD	2002-present	good	1949-1957		poor	WDOE
	Germany	CCD, WDFW	1997-2003	moderate		poor		poor	WCD/CCD	2002-present	good			poor	WDOE
Cascade	Lower Cowlitz	CCD, LCCD	1996-2001	poor	1960-present	good	1961-86	good	WCD/CCD	1999-present	poor	1926-present	✓	good	WDOE, PacifiCorp, Conservation Groups
	Coweeman	Weyerhaeuser, WDFW	1995-2000	poor		poor	1961-75	moderate	WCD/CCD	2002-present	poor	1950-1982		moderate	WDOE
	Toutle	USFS	1993	poor		poor	1960-2002	good			poor	1909-present	✓	good	
	Upper Cowlitz	USFS	1987-present	good		poor	1964-85, 2002	good	USFS	1996-present	good	1911-present	✓	good	WDOE
	Cispus	USFS	1987-present	good		poor	1971-72, 1980-81	moderate	USFS	1996-present	good	1910-present	✓	good	
	Tilton	USFS	1993	poor		poor	1968	poor			poor	1941-present	✓	good	
	Kalama	USFS, WDFW	1990, 2002-2003	poor	1972-present	good	1961-70, 1972-80	moderate	WDFW, USGS	1984-present	poor	1911-1982		good	WDOE
	Lower NF Lewis	PacifiCorp, WDFW	1999-2003	poor		poor	1962-73, 1976-86, 1994	good	PacifiCorps	1999-2000	poor	1909-present	✓	good	WDOE
	Upper Lewis	PacifiCorp, USFS	1989-present	good		poor	1970-71, 1976, 1980-2002	good	USFS, PacifiCorp	1994-present	moderate	1927-1970		moderate	WDOE
	EF Lewis	USFS, WDFW	1991-present	moderate	1977-present	good	1976-80, 1980	moderate	USFS	1996-present	moderate	1929-present	✓	good	WDOE
	Salmon	WDFW	2002-2003	poor	1973, 2004 (Burnt Br. Cr)	moderate	1968-73, 1978, 1980, 1997-98	moderate	Clark County	1998-present	good	1943-1990		good	WDOE
	Washougal	WDFW	2002-2003	poor		poor	1964-70, 1974-77, 1981	moderate	WDFW, CSF	unknown	good	1944-1981		moderate	WDOE
Gorge	Lower Gorge			poor	1992, 2002 (Campen & Gibbons Cr)	moderate	1981	poor	USFWS, WDFW	unknown	good			poor	WDOE
	Upper Gorge	USFS	1997	poor		poor		poor			poor			poor	WDOE
	Wind	USFS, WDFW	1988-present	good	1973, 1976-83, 1995	moderate	1972-1980	moderate	USFS, WDFW, USGS, UCD, WDOE	1998-present	good	1934-present		good	
	Little White Salmon	USFS	1991-present	moderate		poor		poor	USFS	1998-present	good	1944-1977		moderate	

Legend (shading): poor coverage; moderate coverage; good coverage

[1]WDOE collects data on fecal coliform bacteria, oxygen, pH, suspended solids, temperature, total persulf nitrogen, total phosphorous, turbidity

[2]USGS WQ collects some or all of the following: temperature, conductivity, oxygen, pH, hardness, acid neutralizing capacity, nitrogen, calcium, magnesium, sodium, potassium, chloride, sulfate, flouride, silica, arsenic, cadmium, chromium, copper, lead, zinc, selenium, mercury, organic carbon

IFIM - Instream Flow Incremental Methodology

RVA - Range of Variability Approach

7.5.3 Stream Habitat

Stream/riparian habitat data and water quantity records require focused attention to fully characterize the evolving health of the aquatic ecosystem. In parallel with the biological monitoring, there is ongoing routine monitoring (Table 10) which can be expanded with in-depth monitoring efforts. Table 11 shows three levels of proposed surveys by type and location – Level 1 reflecting the highest degree of monitoring and Level 3 reflecting the lowest. Unless otherwise noted, stream/riparian habitat surveys should be conducted every 3 years. The starting year should be coordinated with year 1 and year 9 biological monitoring for a given basin. Given the previously planned sampling effort, it is efficient and biologically beneficial to have sampling efforts overlap.

1. ***Conduct comprehensive survey of stream habitat conditions across the Washington lower Columbia Region.***

   Objective: Verify working hypotheses for stream habitat conditions based on previous surveys, fill in missing data, establish baseline conditions, use to stratify area for routine monitoring in a representative subset of areas, validate priority areas for protection and restoration, identify site-specific problems for habitat projects.
   Indicator: Channel morphology, depth, width, stream flow, substrate, woody debris, pools, riparian cover and condition, bank stability, etc.
   Sampling: Standardized wadeable and nonwadeable stream measurement protocols. Stratified random sampling with replicates in strata based on existing habitat assessments as summarized in WDFW EDT analyses. Strata include combinations of watershed, streams, and land use categories. Surveys include all strata – not just priority protection and restoration areas. Incorporate and supplement existing datasets.
   Analysis: Spatial and categorical summaries, estimated vs. observed conditions.

2. ***Monitor trends in stream habitat conditions through periodic sampling of representative and indicator sites.***

   Objective: Detect changes in local stream conditions that affect the quantity and quantity of habitat provided for fish.
   Indicator: Channel morphology, depth, width, stream flow, substrate, woody debris, pools, riparian cover and condition, bank stability, etc.
   Sampling: Standardized wadeable and nonwadeable stream measurement protocols. Long term index sites to factor out among-site variability and maximize statistical power to identify temporal changes; replicate but periodic sampling (e.g., 3 years of 10) to distinguish changes in conditions on a decadal scale from inherent sampling variability and background noise; stratified selection of sample sites based on statistical surveys described above to identify sites representative of watershed types, stream types, and uses (forest, agriculture, urban); inclusion of non-randomly selected indicator sites expected to be most sensitive to trends.
   Analysis: Within and among site differences, changes over time.

7.5.4 Intensively Monitored Subbasins

In an effort to monitor long-term changes to habitat conditions, a more aggressive schedule is proposed for the Mill, Abernathy, Germany cluster, EF Lewis and the Wind basins. These annually monitored basins can also be used to validate the broader scale comprehensive surveys. Water quantity should be continuously available for gauged systems and seasonally available for summer low flow "spot checks".

1. ***Validate comprehensive survey of watershed conditions and processes with site-specific assessments.***

    Objective: Test and calibrate remote sensing and GIS information used in comprehensive regional assessment.
    Indicators: Geomorphology, land use, vegetation cover, road density, landslides, wetlands.
    Sampling: Ground surveys at representative sites in strata identified through comprehensive survey.
    Analysis: Estimated vs. observed conditions.

Table 11. In-depth habitat monitoring strategies for stream habitat and water quantity by basin.

BASIN		Level 1	Level 2	Level 3
COAST	Grays	Complete Watershed[1]		
	Skamokawa			
	Elochoman	Low flow spot surveys	Low flow spot surveys	
	Mill/Abernathy/ Germany	Complete Watershed* (annual) Install stream gauges CIFA	Complete Watershed* Install stream gauges CIFA	Complete Watershed * CIFA
CASCADE	L. Cowlitz	Complete Watershed		
	Coweeman	Low flow spot surveys	Low flow spot surveys	
	Toutle			
	U. Cowlitz	Complete Watershed *		
	Cispus			
	Tilton			
	Kalama	Complete Watershed * Install stream gauge CIFA	Upper Watershed * Install stream gauge CIFA	Low flow spot surveys
	NF Lewis	Complete Watershed *		
	U. Lewis	Complete Watershed * Install stream gauge		
	EF Lewis	Complete Watershed (annual) CIFA	Complete Watershed CIFA	Complete Watershed CIFA
	Salmon	Install stream gauge		
	Washougal	Complete Watershed CIFA	Complete Watershed CIFA	Low flow spot surveys
GORGE	L. Gorge			
	U. Gorge			
	Wind	Complete Watershed[2] (annual) Update data access[3] CIFA	Upper Watershed * Update data access[3] CIFA	Upper Watershed * Update data access[3] CIFA
	Little White Salmon			

* routine adult abundance monitoring ongoing
1 routine adult abundance monitoring ongoing in the lower basin
2 routine adult abundance monitoring ongoing in the upper basin
3 data is not currently available on-line
4 CIFA = Comprehensive Instream Flow Assessment

7.6 Action Effectiveness Monitoring

Action effectiveness monitoring determines if specific habitat, hydropower, hatchery, harvest, and ecological interaction measures produce the specific intended effect. This is a key elements of the monitoring plan and aspects of this are currently being implemented by other regional entities (i.e. the SRFB's Project Effectiveness Program contained within the Comprehensive Monitoring Program). This type of monitoring helps determine whether some types of actions work better than others and what level of contribution toward recovery is contributed by an action or suite of actions.

Effects of actions may be estimated directly based on estimates of desired population attributes (e.g., abundance, productivity, spatial structure, diversity) or indirectly based on effects on limiting factors. Formal experiments and rigorous statistical analysis may be required, for instance involving test and control populations. Action effectiveness monitoring complements and sometimes depends on status monitoring for baseline conditions. It can be used to evaluate the effects of individual projects and/or suites of actions. However, fish response need not be monitored routinely unless we do not know what to expect from project scale restoration actions. If such situations arise, sufficient analysis will be conducted in order to establish a predictable pattern of response. Furthermore, attention will be paid to other ongoing effectiveness studies so as not to unnecessarily duplicate costly monitoring efforts.

7.6.1 Stream Habitat

1. ***Monitor effects of watershed and stream habitat protection and restoration actions on stream habitat conditions.***

   Objective: Determine whether actions produce desired improvements in habitat conditions.
   Indicator: Patterns of land use, vegetation, etc. at the landscape/watershed scale, site-specific riparian and stream habitat parameters.
   Sampling: Periodic sampling of a representative series of test and control watersheds and streams in close conjunction with routine habitat monitoring and intensively monitored watersheds.
   Analysis: Trend and multivariate analysis.

2. ***Monitor relative distribution, abundance, and condition of fish in relation to specific habitat improvements.***

   Objective: Determine degree to which habitat improvements translate into a fish response.
   Indicator: Adult and juvenile numbers and distribution.
   Sampling: Periodic sampling of a representative series of test and control sites in close conjunction with routine biological monitoring.
   Analysis: Trend and multivariate analysis.

3. ***Concentrate a portion of habitat status and action effectiveness monitoring in one or more intensively monitored watersheds to optimize opportunities for evaluating linkages between habitat and fish (e.g., Mill/Abernathy/Germany, Kalama, East Fork Lewis, Wind). Consider subbasins containing multiple high priority populations and other ongoing studies such as the SRFB-sponsored Intensively Monitored Watershed project in the Mill, Abernathy, Germany basins..***

   Objective: Identify and quantify relationships. Integrate efforts with any ongoing longterm studies.

Indicator: As described in biological and habitat monitoring.
Sampling: Combination of routine and statistical designs to build a long term dataset.
Analysis: Trend and multivariate analysis.

7.6.2 Mainstem/Estuary

1. ***Monitor effects of small scale and large scale activities (e.g., channel deepening) that affect habitat.***

Objective: Determine whether projects produce desired effects.
Indicator: Habitat quantity and quality.
Sampling: Periodic sampling of a representative series of test and control sites in close conjunction with routine biological monitoring.
Analysis: Trend and multivariate analysis.

7.6.3 Hydropower

1. ***Monitor adult and juvenile collection, passage, and survival rates at Bonneville Dam.***

Objective: Determine most effective means of passage to guide operations and construction.
Indicator: Fish numbers and rates.
Sampling: Statistical samples at passage upstream and downstream facilities, marking of representative groups.
Analysis: Numbers relative to prescribed performance standards.

2. ***Monitor the relative abundance, distribution and dewatering of chum and fall Chinook redds in the Bonneville Dam tailrace.***

Objective: Estimate impacts of hydropower operations.
Indicator: Redd and stranded fish numbers by site and elevation.
Sampling: Annual representative index areas.
Analysis: Numbers relative to operational patterns.

3. ***Monitor adult and juvenile collection, passage, and survival rates at Cowlitz, Lewis and Toutle Dams.***

Objective: Determine most effective means of passage to guide operations and construction.
Indicator: Fish numbers and rates.
Sampling: Statistical samples at passage upstream and downstream facilities, marking of representative groups.
Analysis: Numbers relative to prescribed performance standards.

4. ***Monitor the downstream channels of Mayfield, SRS and Merwin Dams for changes in substrate and flow***

Objective: Assess loss of substrate, spawning gravels and flow fluctuations.
Indicator: Changes in sediment and flow conditions over time or in relation to dam operations
Sampling: Sediment surveys and monitoring of existing flow gauges
Analysis: Substrate, spawning gravel and flow as a function of operational patterns

7.6.4 Harvest

1. ***Monitor annual harvest and harvest rates of representative index stocks in in-basin, Columbia River mainstem, and ocean fisheries.***

   Objective: Determine whether direct and incidental fishing impacts fall within intended limits for each fishery.
   Indicator: Numbers harvested and released, catch per effort.
   Sampling: Statistical angler surveys, catch sampling, coded-wire tag marking of representative stocks, natural production identification.
   Analysis: In-season and post-season estimates from run reconstructions, impact rates relative to benchmarks, observed vs. expected impact rates.

2. ***Monitor catch and release mortality of wild salmon and steelhead in selective fisheries.***

   Objective: determine wild fish mortality and develop methods to reduce mortality.
   Indicator: Interception rates, short-term mortality, long-term mortality.
   Sampling: Sport and commercial catch sampling and monitoring, marking released wild fish, recovery sampling at dams, weirs, natural spawning areas, and hatcheries.
   Analysis: Mortality rates and interception rates by gear type and fishery. Total impact to index stocks.

7.6.5 Hatchery

1. ***Monitor effects of fish culture practices within the hatchery.***

   Objective: Evaluate hatchery performance and identify best management practices.
   Indicator: Growth and survival rates
   Sampling: Pond inventories, treatment and control
   Analysis: Multivariate.

2. ***Monitor numbers and performance of hatchery fish returning to hatcheries.***

   Objective: Evaluate hatchery performance, hatchery rack operations, passage success above these racks and identify best management practices.
   Indicator: Release numbers, return numbers, survival rates
   Sampling: Pond inventories, adult traps, CWT tagging of representative hatchery release groups
   Analysis: Trend and multivariate.

3. ***Monitor in-basin and out-of-basin stray rates of hatchery fish in wild spawning areas relative to hatchery practices.***

   Objective: Determine the potential for negative and/or positive interactions between hatchery and wild fish.
   Indicator: Hatchery-wild proportions on spawning grounds, hatcheries of origin.
   Sampling: Routine biological monitoring of representative wild populations. Annual hatchery releases and returns, marking of hatchery fish, CWT tagging of representative hatchery release groups.
   Analysis: Run reconstructions.

7.6.6 Ecological Interactions

1. ***Monitor occurrences of new exotic aquatic fishes, invertebrates or plants based on incidental observations during other biological status monitoring, anecdotal reports, and follow-up sampling where appropriate.***

   Objective: Identify emerging threats.
   Indicator: Species types and numbers.
   Sampling: Opportunistic.
   Analysis: Reference to historical baselines.

2. ***Continue to monitor abundance of American shad based on Bonneville Dam counts.***

   Objective: Identify significant changes in numbers or population dynamics.
   Indicator: Annual fish counts and run timing.
   Sampling: Dam counts.
   Analysis: Annual trends.

3. ***Monitor annual angler participation, harvest, and exploitation rate in northern pikeminnow management program in Columbia River mainstem.***

   Objective: Determine whether program is achieving desired 10-20% annual exploitation rates intended to reduce pikeminnow predation on juvenile salmonids by 50%.
   Indicator: Anglers registered, numbers and sizes of fish caught, annual percentage of tagged fish caught.
   Sampling: Preseason tagging of pikeminnow, angler registration, catch sampling.
   Analysis: Annual differences relative to objectives.

4. ***Conduct periodic censuses of the abundance and distribution of nesting Caspian terns.***

   Objective: Determine if management measures continue to achieve desired redistribution of terns to areas of reduced salmonid predation.
   Indicator: Tern numbers by area.
   Sampling: Ground and/or aerial surveys.
   Analysis: Trends in population size and use of East Sand, Rice, and other islands.

5. ***Conduct periodic censuses of the abundance, distribution, and diet of marine mammals throughout the lower Columbia River mainstem and particularly near Bonneville Dam.***

   Objective: Identify emerging threats.
   Indicator: Numbers by area.
   Sampling: Boat or aerial surveys, behavioral monitoring near Bonneville Dam.
   Analysis: Trends in population size and increased numbers and predation near Bonneville Dam.

6. ***Monitor and evaluate the establishment of escapement rates through harvest management actions in relation to the nutrient and other ecological value of returning salmon***

   Objective: Evaluate the relation of returning adult salmon at or above planned escapement rates to the productivity of the habitat
   Indicator: Numbers of spawning adults
   Sampling: Ground and/or aerial surveys.
   Analysis Trends in spawner/recruit ratios in relation to planned escapement levels

7.7 Implementation/Compliance Monitoring

Implementation/compliance monitoring evaluates whether actions were implemented as planned or meet established laws, rules or benchmarks. Detailed elements of compliance monitoring are presented in Chapter 8 of this report (Plan Implementation) with the primary task as follows:

1. ***Maintain a coordinated database of federal, tribal, state, local, and non-governmental programs and projects implemented throughout the recovery region.***

    Objective: Track execution of management actions relative to this recovery plan.
    Indicator: Numbers and types of programs and projects by area.
    Sampling: Periodic polls and surveys.
    Analysis: Categorical summaries (implemented, partially implemented, not implemented).

7.8 Critical Uncertainty Research

Critical uncertainty research targets specific issues that constrain effective recovery plan implementation. Critical uncertainty research includes evaluations of cause and effect relationships between fish, limiting factors, and actions that address specific threats related to limiting factors.

7.8.1 Salmonid Status and Population Viability

1. ***Validate recovery goals and preliminary estimates of persistence probabilities based on life cycle analyses and long term data sets.***

7.8.2 Stream Habitat

1. ***Apply monitoring feedback loops to inform EDT analysis and improve estimates of fish productivity and capacity based on habitat and fish productivity data.***
2. ***Determine relative short term and long term tradeoffs in the benefits of site-specific and process based actions.***

7.8.3 Mainstem/Estuary

A research, monitoring, and evaluation (RME) plan for the Columbia River estuary and plume was recently developed (Johnson et al. 2003) for the purpose of fulfilling certain requirements of Reasonable and Prudent Alternatives of the 2000 Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000). Research needs were identified in that process at a 2003 workshop. The following research needs were identified at that workshop:

1. ***Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.***
2. ***Implement selected restoration projects as experiments, so that we can learn as we go.***
3. ***Implement pre- and post-restoration project monitoring programs, to increase the learning.***

4. ***"Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.***
5. ***Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.***
6. ***Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.***
7. ***Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.***
8. ***Identify and implement off-site mitigation projects in CRE tributaries.***
9. ***Establish a data and information sharing network so that all researchers have ready and up-to-date access.***
10. ***Increased genetic research to identify genotypic variations in habitat use.***
11. ***Understanding salmonid estuarine ecology, including food web dynamics.***
12. ***Understanding sediment transport and deposition processes in the estuary.***
13. ***Understanding juvenile and adult migration patterns.***
14. ***Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.***
15. ***Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.***
16. ***Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.***
17. ***Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.***
18. ***Improve our understanding of the role between micro- and macro-detritus al inputs, transport, and end-points.***
19. ***Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.***
20. ***Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.***
21. ***Increase our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.***

7.8.4 Hydropower

1. ***Determine feasibility of re-establishing self-sustaining anadromous populations upstream of hydropower facilities in the Lewis, Cowlitz and Tilton systems.***
2. ***Determine effects of flow on habitat in the estuary & lower mainstem.***
3. ***Identify delayed effects of passage on fish condition and survival.***

7.8.5 Harvest

1. ***Evaluate innovative techniques (e.g., terminal fisheries and tangle nets) to improve access to harvestable stocks and reduce undesirable direct and indirect impacts to wild populations.***
2. ***Evaluate appropriateness of stocks used in weak stock management.***

7.8.6 Hatchery

1. ***Develop a strategy for assessing the interactions between hatchery and wild fish***
2. ***Determine relative performance of hatchery and wild fish in wild in relation to broodstock divergence and hatchery practices.***
3. ***Experimentally determine net effects of positive and negative hatchery effects on wild populations.***
4. ***Experimentally evaluate the efficacy of hatchery program integration, segregation, and supplementation.***
5. ***Determine hatchery effects on disease and predation on wild fish.***

7.8.7 Ecological Interactions

1. ***Experimentally evaluate nutrient enrichment benefits and risks using fish from hatcheries or suitable analogs (same as measure I.M6).***
2. ***Determine the interactions and effects of shad on salmonids.***
3. ***Determine the significance of marine mammal predation on adult and juvenile salmonids and alternatives for management in the Columbia River mainstem and estuary.***

7.8.8 Bull Trout

The following research needs were identified in the draft bull trout recovery plan (USFWS 2002) for the Washington lower Columbia River Recovery Unit:

1. ***Distribution and abundance of bull trout consistent with recovery. The draft plan identifies interim criteria until uncertainty regarding appropriate numbers of populations, spatial distribution, and population sizes are identified.***
2. ***Guidelines for evaluating habitat elements necessary for bull trout and inventory of habitat inventory of streams that provide basic cold water habitat conditions necessary for bull trout.***
3. ***Productive capacity of each potential local bull trout population.***
4. ***Presence of bull trout and potential importance for recovery of Cowlitz and Kalama rivers.***
5. ***More thorough understanding of the current and future role that the mainstem Columbia should play in the recovery of bull trout.***
6. ***Effectiveness and feasibility of using artificial propagation in bull trout recovery.***
7. ***Describe the genetic makeup of bull trout in the mainstem Columbia and Klickitat rivers.***

7.8.9 Other Species of Interest

1. ***Identify status, limiting factors, and management alternatives for lamprey.***
2. ***Determine relative significance of mainstem and tributary spawning, environmental and habitat conditions related to population dynamics of smelt.***
3. ***Determine impacts of shad on salmonids and other ecosystem effects.***

7.9 Reporting, Data, and Coordination

Regional coordination and data management will ensure efficient implementation of a comprehensive and complementary program as well as accessibility and effective application of the associated data.

1. ***Conduct a data management needs assessment and use to develop a data management plan.***

   Explanation: Additional assessments are needed to coordinate with complementary data management activities throughout the region.

2. ***Maintain consistent regionally-standardized datasets and archive in regional data storage and management facilities (e.g., Pacific State Marine Fisheries Commission StreamNet, Washington Department of Fish and Wildlife SSHIAP, NOAA Fisheries biological datasets).***

   Explanation: Existing infrastructures will be used to archive relevant data and metadata generated through monitoring and research activities. Data will be compiled and subject to rigorous quality assurance/quality control protocols by the collecting agency. Collecting agencies will be responsible for maintaining databases and providing access upon request. Information will be also distributed to multiple archives to maximize accessibility.

3. ***Produce and distribute regular progress and completion reports for monitoring and research activities.***

   Explanation: Regular reporting is critical for making new information available to technical/scientific staff, decision-makers, stakeholders, and the public.

4. ***Closely coordinate Washington lower Columbia River monitoring, research, and evaluation efforts with similar efforts throughout the basin, including prioritization of activities and standardization of data methods.***

   Explanation: A variety of MR&E efforts are underway at local and regional scales across the Pacific Northwest. Coordination of Washington lower Columbia River efforts will provide synergistic benefits. For instance, many critical uncertainties are common among different areas and need not be addressed in each area. Standardization of data methods will greatly enhance comparative and interpretative power of monitoring and research activities.

8 Plan Implementation

This section of the plan discusses the means and organizational structure by which implementation of the plan's recommended actions will be coordinated, managed, and overseen. It melds implementation of programs and actions with the monitoring and evaluation process. It describes the mechanism that will be used track, evaluate, and report progress. It describes the process for revising the plan's strategies, measures, and actions. It identifies economic factors and an approach for weighing economic considerations in plan implementation. Finally, it identifies partners involved with specific actions.

8.1 Framework

This plan includes strategies, measures, and actions intended to: 1) reverse long term declining trends in salmon and steelhead numbers, 2) provide a trajectory leading to recovery of these species to healthy and harvestable levels within 25 years, and 3) periodically refine recovery efforts with checkpoints and course corrections throughout implementation (Figure 1). Lower Columbia salmon and steelhead populations have declined over decades due to a myriad of human activities. These activities have reduced the number of fish, their distribution, the quality and quantity of their habitat, and their adaptive population characteristics. Today they are threatened with extinction and listed under the federal Endangered Species Act (ESA). The immediate task we face is to halt the further decline of these populations in order to prevent extinction and to reverse the trend in the direction of recovery. The strategies, measures, and actions included in this plan represent the current best scientific estimates of the actions and efforts needed to meet recovery objectives within the prescribed time period. Strategies, measures, and actions will be refined based on new information and observed responses as the recovery effort unfolds.

Significant uncertainties remain with regard to the incremental benefits that can be expected from each specific action as well as the net effect of the prescribed suite of actions over time. At best, existing data, models, and theories can give only a qualified answer to the question of what it will take to recover these fish. The available information and current science is generally effective at identifying the right types of actions needed for recovery. For instance, this plan identifies the relative order of magnitude of impacts on each population from different threat categories and the actions needed to reduce those threats. However, the science is less certain on exactly how much effort will be required in each proposed action to achieve each incremental improvement. Many related actions also result in complex interactions among effects that are difficult to quantitatively predict with certainty.

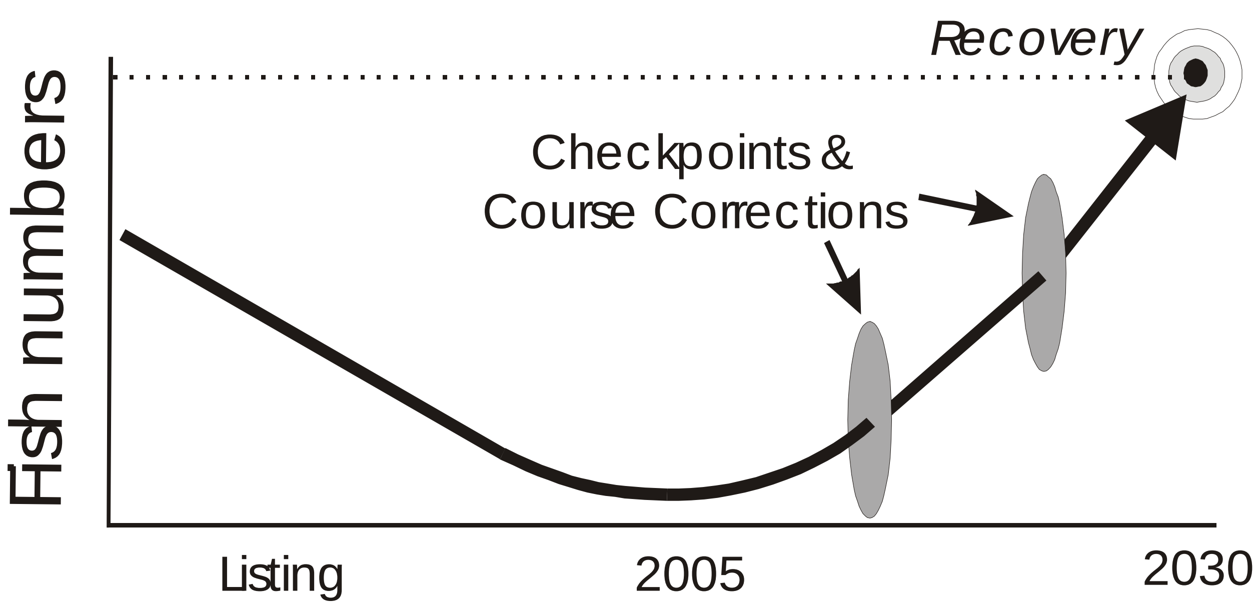


Figure 1. Hypothetical recovery trajectory including stabilization of current populations, reversal of declining trends and checkpoints for course corrections based on monitoring and evaluation.

The acute status of many listed salmon and steelhead populations means that it is not feasible to wait for more data, better models, or more certainty before embarking on a course toward recovery. Further delay is a recipe for irreversible consequences for the remaining lower Columbia salmon and steelhead populations. While current knowledge may not be adequate to categorically guarantee that recovery objectives will be met with the prescribed set of actions, existing information and analyses are adequate to identify the right things to do to set a recovery trajectory and a scale of effort than can reasonably be expected to achieve recovery objectives.

To address uncertainties in the magnitude of effect of any given action and the effort required to achieve a given improvement, this plan identifies recovery actions primarily in terms of directional rather than target outcomes. Directional actions identify the who, what, where, and when to address specific threats. Target outcome actions specify how much effort will be needed and how much improvement occurs as a result of each action. For instance, a directional action might be to use county land use regulations to protect and passively restore significantly areas of riparian zone in high value stream reaches. A target outcome action would further identify that X miles of riparian zone would need to be restored Y% of optimum. In the directional approach, objectives are clearly specified in terms of desired biological outcomes rather than a series of related conditions assumed to be consistent with biological objectives. In the target outcome approach, intermediate conditions provide more specific guidance on what it will take to accomplish the biological objectives. Target outcomes are similar to desired future conditions.

Target outcome and directional definitions of actions each have their limitations. The challenge with the target outcome approach is that existing information is inadequate to confidently identify and defend specific intermediate targets. Specific numbers are likely to be inaccurate and subject to considerable debate. The focus on specific values distracts attention from the activities needed to take substantive steps in the direction of recovery. An exact recipe for recovery also rapidly becomes obsolete or constraining during plan implementation as new information and opportunities come to light. The problem with the directional approach is that it leaves the question of exactly how much effort and improvement in each factor will be required to reach biological objectives unsatisfyingly open-ended. The reality is that directional action definitions must be the default when information is inadequate to accurately define magnitudes of effort and specific conditions that will achieve biological recovery objectives. Directional actions provide guidance on where we need to go from where we are now. We know where we need to go and how to start on the road to recovery. Monitoring and regular progress reviews during plan implementation will provide ample opportunity to refine exactly how much we have to do to get there after we demonstrate that we can take a substantive first step. This directional approach is consistent with other fish and wildlife recovery plans that have been adopted by NOAA Fisheries and the U.S. Fish and Wildlife Service.

Properly Functioning Conditions (PFC) identified by NOAA Fisheries for salmonid stream habitat are one example of a target outcome or desired future condition. In the directional action approach, PFC conditions are used as guidelines for desirable conditions rather than specific objectives. The objective is to make substantive improvements in current habitat conditions in the direction of PFC rather than restoring any given percentage of a subbasin to PFC. Existing information is inadequate to do much more than speculate on how much of a given subbasin would need to be restored to PFC conditions to restore a viable population. Fish population assessments suggest that viable populations can be restored with only a partial restoration of PFC conditions in portions of a subbasin or even habitat improvement that fall short of PFC in substantial portions of a subbasin.

Directional rather than target outcome actions provide maximum flexibility for plan implementers to determine the most effective means of meeting biological objectives rather than artificially constraining those efforts with inaccurate or incomplete intermediate targets.

Uncertainties are further addressed in this plan by: 1) corroborating analyses with the best available science; 2) strong monitoring, evaluation, and adaptive management elements, and 3) a recovery scenario that identifies more than the minimum populations and improvements needed to meet recovery goals. Corroborating analyses verify that strategies, measures, and actions can reasonably be projected to reduce threats to a level where recovery is realistic. Monitoring, evaluation, and adaptive management provides the means to make course corrections during plan implementation if initial assumptions prove to be too liberal or conservative. The recovery scenario includes contingencies that act as safety factors for failures for some populations.

Strategies, measures, and actions will be refined through adaptive management over the course of plan implementation based on the observed response to initial efforts. Initial hypotheses, actions, and efforts can be regarded as the first in a series of successive approximations regarding what it will take to get to recovery. As the plan is implemented, it is likely that uncertainty in initial assumptions will lead to surprises in both directions. Some actions will be more effective and some populations will respond more quickly than initially expected. Other actions or populations will prove less responsive than hoped. Monitoring, evaluation, and adaptive management will provide for capitalizing on successes and opportunities and compensating for disappointments and failures.

Effective adaptive management requires that initial actions are of a magnitude sufficient to produce a measurable response. It also requires monitoring sufficient to detect a response. The strength of the response provides a clear basis for tuning future effort. This truly adaptive management approach contrasts with an alternative approach that involves the successive addition of small scale increments of effort until a response is observed. The truly adaptive approach ensures a quick route to solutions and an effective means of addressing near-term extinction risks. The successive incremental approach postpones identification and implementation of effective recovery efforts and poses unacceptable near-term risks to salmon and steelhead threatened with extinction.

We know that recovery will ultimately be a long journey requiring substantive actions across all categories of limiting factors and threats affecting salmon and steelhead. We know the desired destination and the direction of travel. We are unsure of exactly how much mileage we will get from proposed actions, how much effort will ultimately be required to complete the journey, and the details of every twist and turn of the route. This plan lays out an initial direction, a scale of effort appropriate to the distance of the journey, and a framework for making course corrections along the way.

8.2 Implementation Mechanism

The scale of human activities that limit or threaten salmonids throughout the Washington lower Columbia region is broad and pervasive. Recovery can only be achieved through the combined and coordinated actions of federal and state agencies, tribes, and local governments with the participation of nonprofit organizations, the business sector, and citizens. Collectively, these parties are referred to as implementing partners.

This plan provides a blueprint for recovery. It includes specific actions needed to address all threats and identifies the partners with the authority, jurisdiction, or resources needed to implement each action. The plan does not obligate any party but does establish specific responsibilities for taking actions that have been identified as important to fish recovery. Obligation will come through the commitment of each implementing partner to undertake and complete the actions identified as their responsibility in a timely, sound, and thorough manner. Furthermore, implementation of recovery programs and actions is not a one-time or short-term initiative. Programs and actions put in place early will have to be sustained, evaluated, adjusted, and augmented over the 25-year recovery period.

The plan offers clear guidance for programs and actions that is consistent with achieving recovery. This guidance focuses the efforts of the implementing partners on actions and areas that offer the greatest potential for protecting and recovering salmon and steelhead.

While the ultimate goal of implementation is the recovery of the region's salmon and steelhead, implementation is also intended to afford the implementing partners and the people of the region greater regulatory certainty and efficiency under the ESA. This plan will provide improved context and certainty and a framework for streamlining and prioritizing ESA regulatory assurances. A range of ESA regulatory tools, including ESA section 4(d) limits, section 7 consultations, and section 10 Habitat Conservation Plans, is available to provide assurances, depending on the type of actions and implementing entities. NOAA Fisheries will work with entities interested in obtaining regulatory assurances for implementation of actions in this plan. This recovery plan will also supply technical assessment information that can be used as a shared foundation for some regulatory actions (e.g., as the basis for some Biological Assessments and Biological Opinions). The plan should be used as a collective organizing framework for federal and non-federal programs that are funding recovery actions and as a means to prioritize cost-effective actions and identify additional resources necessary to achieve recovery. In this way, the plan can be expected to serve as a vehicle in securing additional funds or other resources needed for recovery by highlighting priority actions and areas where gaps exist.

8.3 Institutional Structure

As noted above, effective implementation of this plan depends on the combined and coordinated action of federal and state agencies, tribal governments, and local governments with the participation of nonprofit organizations, the business sector, and citizens. Section 8.8 identifies the measures and actions for each implementing party. Six-year implementation plans described in section 8.5 will provide details on the how, when, where, and who of implementation. However, effective regional implementation also requires an institutional structure that effectively links all partners involved. Responsibilities can generally be categorized into three functions: oversight, facilitation/coordination, and implementation. In some cases a single party may fall into two or three function categories. Figure 2 summarizes the key relationships and partners involved with recovery plan implementation functions for the Washington lower Columbia River.

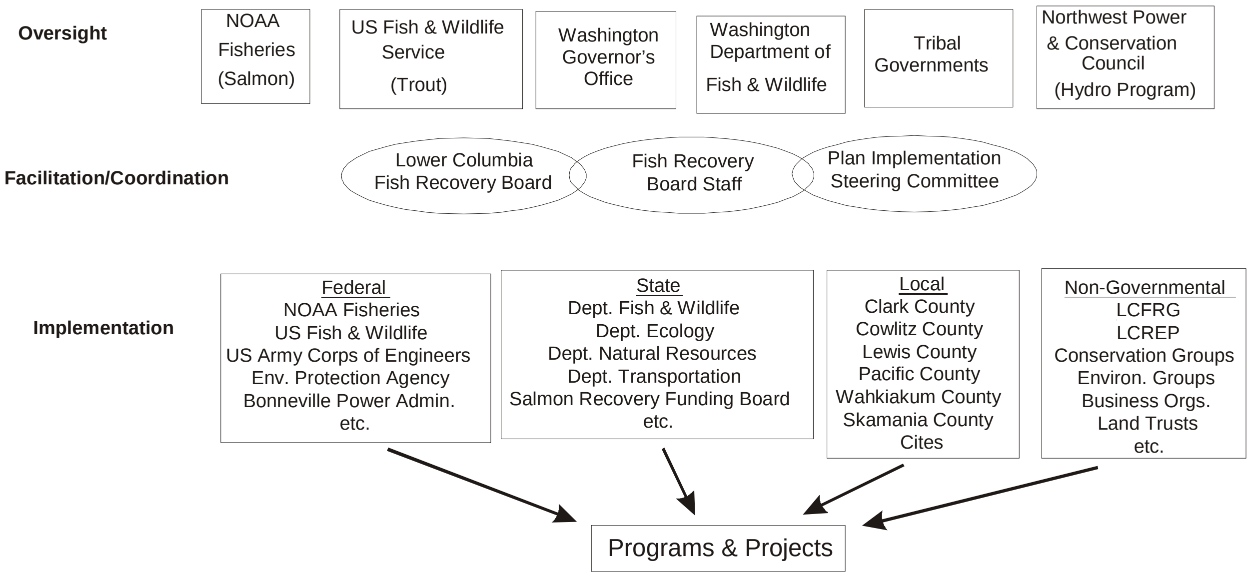


Figure 2. Institutional structure for implementing salmon recovery in Washington Lower Columbia River subbasins.

8.3.1 Oversight Bodies

Key oversight bodies are those entities with specific authority or responsibilities for managing the region's fish and wildlife resources. These include NOAA Fisheries, U.S. Fish and Wildlife Service, the State of Washington, the Cowlitz Tribe, the Yakama Nation, and the Northwest Power and Conservation Council.

- NOAA Fisheries has the primary Federal authority for Endangered Species Act and Sustainable Fisheries Act as they apply to salmon and steelhead.
- The U.S. Fish and Wildlife Service is responsible for Endangered Species Act implementation for bull trout.
- The Washington Governor's Office has the authority to direct and coordinate state agency actions in support of recovery. Washington Department of Fish and Wildlife has management authority for the state's fish and wildlife resources.
- The Cowlitz tribe and Yakama Nation are co-managers of fish resources with the state and federal agencies.
- The Northwest Power and Conservation Council oversees implementation of the program to address Federal Columbia River Power System effects on fish and wildlife.

Other federal, state, and local agencies have oversight responsibilities for water, natural resources, land management, and land use. These agencies are considered implementation partners, since their responsibilities are not specific to fish and wildlife management.

8.3.2 LCFRB Implementation Steering Committee

The Lower Columbia Fish Recovery Board working with a Plan Implementation Steering Committee will facilitate and coordinate efforts of the oversight and implementing partners. The Steering Committee will include representatives of the oversight and a cross-section of implementing partners. Working groups consisting of steering committee members and other implementing partners will be established as needed to address policy or technical issues or to coordinate implementation efforts.

Key functions of the Board and Steering Committee will include:

- Developing and revising a 6-year regional implementation plan;
- Assisting implementation partners develop and implement their individual 6-year implementation plans;
- Preparing and issuing clarifications or interpretations of recovery plan provisions when needed;
- Preparing and issuing revisions or updates to the recovery plan;
- Developing and implementing the regional public education and outreach program;
- Conducting implementation and biological evaluations in accordance with the adaptive management provisions and benchmarks set forth in section 8.4 of this plan.
- Tracking implementation of measures, actions, programs, and projects and issuing annual progress reports;
- Facilitating and assisting partners in resolving technical and policy issues that arise during implementation;
- Facilitating communications and the exchange of information and data among implementation and oversight partners;
- Coordinating the collection, management, synthesis, and evaluation of fish and habitat monitoring results collected by the partners; and
- Developing implementation partnerships and agreements.

8.3.3 Implementing Partners

Recovery actions will be implemented through the programs and projects of numerous federal, state, tribal, and local agencies and nongovernmental entities. Collectively these agencies and entities are referred to as implementing partners. The functions of the implementing partners are:

- Developing and implementing a 6-year plan for their recovery actions;
- Monitoring and reporting their implementation progress to the LCFRB/Steering Committee;
- Advising the LCFRB/Steering Committee of issues or developments affecting progress.

Each partner's specific responsibilities for recovery actions are provided in section 8.8. The 6-year Implementation Schedule submitted by each partner will set forth the tasks and schedule addressing assigned recovery actions and will document the partner's commitment to fulfilling its implementation responsibilities.

Success in achieving recovery of the region's salmon and steelhead and improving the status of other resident fish and wildlife is dependent on the effectiveness of the partners in undertaking and sustaining the identified recovery actions. The actions identified for each partner are based on the partner's mission, capabilities, responsibilities, authority, and jurisdiction. It is incumbent upon each partner to develop and fully implement programs to address its assigned actions. The programs must be technically sound and adequately funded and staffed. In the case of regulatory programs, agencies must be committed to taking enforcement actions when necessary to achieve the desired outcome. Enforcement authority provides an important incentive for compliance only if it is prudently exercised in pursuing and correcting instances of noncompliance.

In some instances an implementing partner may not have the full or exclusive authority to implement a recovery action. A case in point is the setting of harvest quotas pursuant international treaty provisions. NOAA Fisheries and the Washington Department of Fish and Wildlife are influential participants in this process, but do not control the outcome. In such instances, it is expected that implementing partners sharing an implementation responsibility will cooperate in working to achieve the desired outcome and will raise, support, advocate, and/or put in place those actions in appropriate fora, using whatever authorities or arguments we have available. In order to ensure needed coordination, the Implementation Steering Committee may designate a lead agency in carrying out an implementation action shared by two or more partners. Even where a single implementing partner possesses the authority to fully implement a recovery action, the action is likely to be more effectively implemented with the involvement, agreement, and support of other partners. To achieve this level of cooperation and coordination, implementing partners are requested to identify in their 6-year action schedule interrelationships with other partners that will facilitate, affect, or complement implementation of their recovery actions.

8.4 Implementation Coordination and Administration

8.4.1 Six-Year Action Schedules

To provide an effective basis for the recovery program, action schedules will be prepared showing the tasks, schedules, priorities, and responsibilities for implementation of the recovery actions identified in this plan. Since this recovery program relies on the combined action of federal and state agencies, tribal and local governments, and non-governmental entities, each of these partners will be requested to prepare an implementation schedule for their recovery actions. These individual action schedules will be melded into a regional implementation schedule. New implementation plans will be prepared on 6-year intervals. This cycle will coincide with the with the 6-year adaptive management checkpoints and allows the schedules to incorporate needed changes or modifications stemming from the adaptive management implementation and effectiveness evaluations. Six-year schedules may be revised every 2 years as necessary based on the adaptive management implementation evaluation checkpoint.

Implementing Partner Action Schedules and Commitment

Each implementing partner will be asked to submit a 6-year action schedule and commitment to the LCFRB and Implementation Steering Committee. The schedules prepared by the implementing partners will document their approach and commitment to implementing their recovery actions. Recovery actions are summarized for each implementing partner in section 8.8. The LCFRB in consultation with the Implementation Steering will develop a detailed template for 6-year schedules and will assist and advise partners, as necessary, in developing their schedule. The LCFRB and the Steering Committee will review the adequacy of the partners' implementation plans in achieving the desired outcome in a timely manner and may request revisions or additional information. In general, each schedule will identify:

- The tasks and schedule for implementing the recovery actions for which the partner is responsible;
- A public education and outreach program consistent with the guidance in section 8.7 of this plan;
- Technical, funding, legal, and/or other constraints or conditions affecting the timeliness or scope implementation;
- The mechanism for monitoring implementation progress;
- Estimated costs and funding sources; and
- Dependencies on or interrelationships with actions by other implementing partners.

Regional Action Schedule

Implementing schedules developed by the partners will be combined into a regional implementation schedule. The LCFRB/Steering Committee will prepare and adopt the regional schedule, in consultation with the implementing partners. In preparing the regional schedule the LCFRB/Steering Committee will review partner implementation schedules and ensure that the actions of the implementing partners are coordinated and/or complement each other and are consistent with the strategies, measures and actions set forth in the recovery plan. The LCFRB/Steering Committee may request revisions to an individual partner's implementation schedule or additional information in order to ensure that the regional schedule sets forth a sound course for recovery. The regional schedule will address regional implementation actions, including monitoring, evaluation, data management, and public education and outreach. Specifically, the schedule will:

- Provide a master list of tasks, schedules and responsible implementing partners;
- Address interdependencies among implementation actions and partners;
- Identify approaches, partnerships, and/or working groups needed to address implementation issues shared by multiple partners;
- Provide the means to facilitate information and data collection, management, and exchange among partners;
- Provide for a regional public education and outreach effort in accordance with the guidance of section 8.7 of this plan and in coordination with related efforts by individual implementing partners;
- Establish a coordinated implementation and biological monitoring program;
- Describe the process, procedures, and protocols for evaluating progress and, as necessary, revising recovery plan strategies, measures, and actions and corresponding implementing tasks and schedules in accordance with the adaptive management measures set forth in section 8.4 of this plan;

- Provide for coordinating implementation with Oregon; and
- Provide estimated costs, identify funding sources; and provide a regional funding strategy.

8.4.2 Interpretation of Recovery Plan

It is likely during the course of implementing the recovery plan that questions will arise that will require interpretation or clarification of the plan goals, objectives, strategies, measures, and actions. Implementing partners may request clarifications of the plan from the Implementation Steering Committee at any time. The Implementation Steering Committee shall be responsible for such interpretations or clarifications. In making interpretations or clarifications, the Committee may consult with federal state or local agencies or the NOAA Fisheries Technical Recovery Team (TRT) as deemed appropriate. The Committee may also establish a working group to advise on policy and/or technical issues that may require clarification.

8.4.3 Revisions to the Plan

The recovery plan will be routinely evaluated and revised as necessary based on the adaptive management process and intervals set forth in section 8.5. However, it may be desirable or necessary to revise the plan between these intervals in order to address issues or new information that may arise during implementation. Such revisions may be needed to clarify provisions of the plan as discussed in section 8.4.2 or to facilitate effective plan implementation. Interim revisions to address or incorporate new information or data may also be warranted in instances where the benefits to recovery efforts are deemed to be sufficiently significant.

The Implementation Steering Committee shall be responsible for coordinating and directing the development, evaluation, approval and issuance of all plan revisions as follows:

- Plan revisions that are editorial in nature and clarify the intent or provisions of the plan and do not materially alter the plan’s goals, objectives, strategies, measures, actions, or priorities shall be developed, approved and issued by the Implementation Steering Committee.
- Interim revisions to address or incorporate new information or data and result in substantive changes to the plan’s goals, objectives, strategies, measures, actions, or priorities, shall be developed and evaluated by the Implementation Steering Committee in consultation with affected implementing partners and with opportunities for the public participation. The proposed revision will be submitted to NOAA Fisheries and the U.S. Fish and Wildlife Service for concurrence prior to final adoption and issuance.
- Revisions to the plan’s goals, objectives, strategies, measures, actions, or priorities arising from the adaptive management process described in section 8.5 shall be developed and evaluated by the Implementation Steering Committee in consultation with affected implementing partners and with opportunities for the public participation. The proposed revision will be submitted to NOAA Fisheries and the U.S. Fish and Wildlife Service for concurrence prior to final adoption and issuance.

The Implementation Steering Committee or an implementing partner may propose plan revisions. The Implementation Steering Committee will establish the procedures necessary to ensure the timely consideration and action on proposed revisions. The Steering Committee may use working groups to assist in the evaluation of policy and technical issues associated with a proposed revision.

8.4.4 Monitoring, Research, and Evaluation

The LCFRB and the Implementation Steering Committee will direct and coordinate the implementation of the monitoring, research and evaluation provisions set forth in Chapter 7 of this plan. The program will also define the procedures and benchmarks for implementing the Adaptive Management Process set forth in section 8.5. The LCFRB and Implementation Steering Committee shall convene and work with a Monitoring, Research, and Evaluation Working Group to develop implementation measures and responsibilities. The Working Group will consist of representatives from federal, state, regional, and local programs engaged in biological and habitat status monitoring, effectiveness monitoring, implementation/compliance monitoring, and biological and habitat research. The working group will prepare and submit to the Implementation Steering Committee recommendations for a Monitoring, Research, and Evaluation Program. Based on Chapter 7 and section 8.5 of this plan, the program shall:

- Validate data needs;
- Develop benchmarks and procedures for evaluating action implementation, action effectiveness, and biological and habitat status as set forth in section 8.5;
- Establish procedures, methods, and protocols for monitoring and research, and data reporting;
- Develop the process, procedures and organizational responsibilities for data management and access;
- Set forth the necessary organizational structure and responsibilities;
- Provide a 6-year monitoring schedule and priorities for incorporation in the 6-year regional implementation plan;
- Identify and prioritize critical uncertainty research needs for the incorporation in the 6-year regional implementation schedule; and
- Identify unfunded monitoring and research needs and proposed or potential funding sources.

The program, when adopted by the Implementation Steering Committee, shall be included in the 6-year regional implementation schedule.

8.4.5 Economic and Cost Considerations

This plan identifies strategies, measures and actions for the recovery of fish populations. The actions have been designed and selected based on their anticipated contribution to the biological objectives set forth in Volume 1, chapter 6. They are heavily based on biological and technical factors, although consideration was also given social, cultural, and general economic factors. Additional consideration of cost and economic factors will play an important function in developing specific implementation mechanisms and actions that are both scientifically sound and politically and fiscally feasible.

To establish an estimate of implementation costs, implementing partners are requested to provide an estimate of the incremental costs associated with the implementation of their recovery actions. Incremental costs are the costs of recovery that will be incurred in addition to costs to their existing programs and activities. Partners are also requested to indicate how they will fund these costs and to identify fiscal constraints that would affect timely or full implementation of their actions. This information will be used along with biological, technical, social, and cultural considerations to help refine implementation priorities and to develop a regional funding strategy.

Economic analysis will be used to evaluate the positive and negative economic impacts of the overall regional recovery effort and will be compared to the impacts of not proceeding with a recovery effort. The comparison will identify the net cost/benefit to the region. The analysis will be used to assist in making decisions regarding implementation of this plan and, where, appropriate, to help realign recovery improvement increments across affected parties and sectors. Decisions regarding the specifics of plan implementation will take into account the economic and cost considerations but ultimately the overriding goal of this plan is to recover listed stocks. Appendix D explores possible approaches to conducting such an analysis. The specific approach to be used will be developed by the Implementation Steering Committee.

8.4.6 Enforcement of the Plan

This plan is not a regulatory document and is not enforceable. It relies largely on the cooperative efforts and support of federal and state agencies, tribal governments, local governments, businesses, non-profit organizations, and the people of the region. However, while this plan is not a regulatory document, federal, state, and local agencies do have regulatory authority and programs that will play critical role in the implementation of the plan. Enforcement action alone is not a sufficient or effective means to achieve recovery. The plan relies on a variety mechanisms in addition to enforcement to achieve progress toward recovery. These include encouraging voluntary public participation and providing incentives to implement necessary actions. Nevertheless, enforcement mechanisms are an important deterrent to actions detrimental to achieving recovery, if they are prudently and effectively applied. It is expected that agencies with such authority will exercise it as needed to ensure implementation of their recovery responsibilities. This includes enforcement of ESA regulations by NOAA Fisheries and the USFWS.

8.4.7 Schedule for Coordination and Administrative Measures

The schedule for instituting plan implementation coordination and administrative measures is provided in Table 1.

Table 1. Schedule for Coordination and Administrative Measures

COORDINATION/ADMINISTRATIVE MEASURE	TARGET COMPLETION DATE
Organize Implementation Steering Committee	**January 2005**
Complete 6-year Implementation Schedules • Template for Schedules • Implementing Partner Schedules • Regional Schedule	**July 2005** • February 2005 • June 2005 • July 2005
Procedures for Plan Interpretation and Revision	**February 2005**
Monitoring, Research, and Evaluation Program	**June 2005**
Public Education and Outreach Program	**July 2005**

8.5 Adaptive Management Process & Schedule

Adaptive management during plan implementation will be critical to effective implementation of this plan. The directional actions identified in this plan are the substantive steps needed to achieve a positive trajectory for recovery. They are consistent with initial estimates of incremental improvements needed to move populations from their current status to healthy and harvestable levels. Adjustments in direction and effort will be required if initial implementation efforts lag or if benefits are less than hoped. Adjustments will be needed to capitalize on new information, more specific objectives, new developments, and evolving opportunities.

The term "adaptive management" is in wide usage among subbasin planners and has come to denote two very different processes. A broad definition involves course correction during plan implementation based on observed progress and refinements in approach or objectives. An alternative definition involves a specific approach whereby substantive actions are implemented in order to invoke a significant response that provides clear direction for tuning. This contrasts with the sequential implementation of small incremental changes intended to steadily move progress toward the objectives. Substantive actions greatly expedite the process for identifying the sufficiency of plan actions but require significant effort by implementing parties. This plan treats adaptive management consistent with both definitions. It identifies substantive improvement increments in productivity consistent with recovery and specific actions intended to make corresponding reductions in threats. It also includes a process for monitoring and refinement as part of plan implementation.

The adaptive management process for this plan is based on a series of checkpoints, assessments, benchmarks, and decisions (Figure 3). Checkpoints are formal decision points where substantive changes in direction will be considered. Assessments are formal evaluations of progress and results. Benchmarks are standards or criteria that will drive decisions depending on observed progress in implementation effort and effectiveness. Decisions identify refinements in efforts or new directions based on progress relative benchmarks observed at checkpoints.

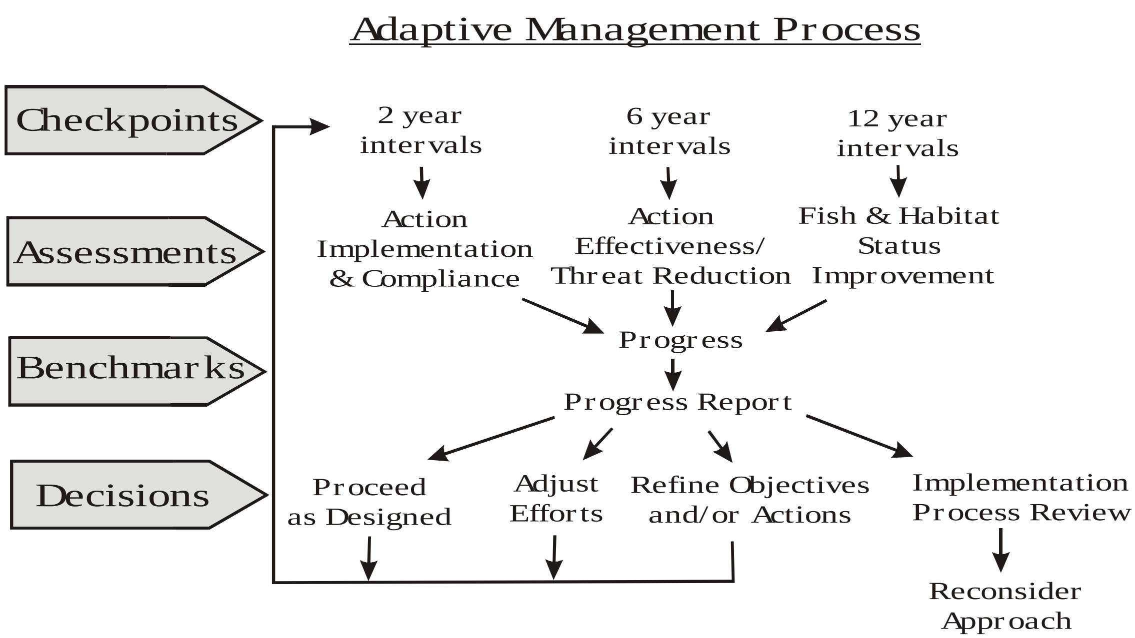


Figure 3. Elements and decision structure for adaptive management process for implementation of Washington lower Columbia River Fish Recovery Plan.

8.5.1 Checkpoints and Assessments

Checkpoints are prescribed at 2-year intervals for evaluation of progress in implementing plan actions, 6-year intervals for evaluation of effects of key actions, and 12-year intervals for evaluating biological and habitat status and response. Implementation progress will evaluated based 6-year implementation plans and the number of scheduled actions implemented and the degree of effort invested in implementation of each action. Action effectiveness will be evaluated based on whether specific habitat, hydropower, hatchery, harvest, and ecological measures and actions produce the desired reduction in threats relative to population productivity improvement targets. Biological status and response will be evaluated based on trends in fish numbers, population characteristics, and habitat conditions. More detail on implementation, action effectiveness, biological status, and habitat status monitoring activities may be found in Chapter 7 of this plan. Summary assessments will be completed at the prescribed intervals although these evaluations may require annual monitoring of key indicators to provide sufficient statistical power to separate trends from normal variability.

Assessments will take the form of written report cards prepared by the LCFRB/Steering Committee in cooperation with oversight and implementing partners (see section 8.3 for more detail on the institutional structure). Report cards at 2-year, 6-year, and 12-year intervals will focus on action implementation, action effectiveness, and fish/habitat status, respectively. When progress falls short of prescribed benchmarks, reports will document actions needed to adjust efforts or refine the approach. Technical and policy considerations and new information providing the basis for these adjustments will be described.

8.5.2 Benchmarks

Benchmarks for action implementation, action effectiveness, and biological and habitat status will provide tracking reference points by which progress toward recovery can be measured. Benchmarks for action implementation will be based on the tasks and schedules identified in the 6-year implementation plans. Since actions vary in the time needed to achieve their desired end result, benchmarks for action effectiveness will be the expected results of the action at the time of the review. Benchmarks for biological and habitat status reviews are based on an assumption of constant incremental annual progress toward achieving the recovery goals by the end of the 25-year planning period.

Implementation benchmarks will be based on the 6-year implementation schedules prepared by the implementing partners. The schedules will identify the tasks and milestones for implementing the actions identified in the plan. Action Implementation Reviews will be conducted every 2 years and will gauge the actual progress made against the milestones in the implementation schedules. Where benchmarks have not been achieved, the reasons will be evaluated and appropriate modifications or revisions to implementation plans will be made. Examples of the general types of questions that would be addressed during an Action Implementation Review are shown in Table 1. The LCFRB/Implementation Steering Committee working with the NOAA Fisheries TRT and the oversight and implementing partners will develop specific benchmarks.

Six-year Action Effectiveness Reviews will focus on determining if a specific action has achieved its objectives or desired outcomes. Since actions achieve their objectives or outcomes over varying timeframes, the review will evaluate whether an action as achieved the results expected during the period of review. Where actions have not achieved the expected results, the reasons will be evaluated. Plan strategies, measures, and actions and implementation schedules will be revised as necessary to address progress shortfalls. Examples of the general types of questions to be examined during an Action Effectiveness Review are shown in Table 3.

Table 2. Example Action Implementation Review Questions

Action Category	Example Action Implementation Review Questions
Habitat	• Have planned habitat restoration projects been completed on schedule? • Have watershed and habitat protection programs such as stormwater controls, forest and park management plans and road maintenance programs been implemented on schedule? • Have regulatory programs such has land use controls, forest practice rules, and stream flow rules been implemented on schedule?
Hydro	• Have tasks related fish passage been completed on schedule? • Have flow measures been implemented on schedule?
Harvest	• Have harvest management programs needed to protect wild populations been implemented on schedule?
Hatcheries	• Have planned hatchery operational modifications needed to protect wild fish populations been implemented on schedule? • Have tasks associated with planned hatchery operation and facility modifications needed to support reintroduction, supplementation, and augmentation needs been implemented on schedule?
Ecological Interactions	• Have predator control programs been developed, funded, and implemented on schedule?
Monitoring & Research	• Have tasks related to regional biological and habitat monitoring and data management been completed on schedule? • Have planned studies or assessments needed to address critical uncertainties been implemented on schedule?

Table 3. Example Action Effectiveness Review Questions

Action Category	Example Action Effectiveness Review Questions
Habitat	• Have habitat restoration projects achieved the expected improvements in conditions? • Have watershed and habitat protection programs such as storm water controls, forest and park management plans and road maintenance programs achieved the expected reduction in habitat loss or damage? • Have regulatory programs such has land use controls, forest practice rules, and stream flow rules achieved the expected reduction in habitat loss or damage?
Hydro	• Have performance standards for fish passage been achieved? • Have actual flows been within target ranges?
Harvest	• Have harvest impacts been equal to or less than those planned?
Hatcheries	• Have hatchery impacts been reduced to target levels? • Have hatchery operations achieved goals for reintroduction, supplementation, or augmentation?
Ecological Interactions	• Have predator control programs achieved target impact reductions?
Monitoring & Research	• Are needed data being collected and managed according to procedures and protocols? • Have studies adequately addressed targeted critical uncertainties?

Twelve-year biological and habitat status reviews focus the response of wild fish populations and habitat to the actions implemented. Evaluation of biological status will be made on both the individual population and ESU levels based on the NOAA Fisheries TRT recovery criteria. Abundance, productivity, spatial distribution, and diversity will be evaluated to determine if progress is consistent with the planned trajectory for recovery. Improvements in watershed functions and habitat attributes will be examined on a watershed, subwatershed, and reach basis to determine if habitat protection and restoration measures have achieved targeted levels.

8.5.3 Decisions

Decisions at each checkpoint depend on observed progress relative to benchmarks. The following sections show the type of actions that would result from the outcomes of action implementation, action effectiveness, and fish and habitat status reviews.

Table 4. Actions in response to implementation assessment findings.

Review Findings	Action	Review Type
Action Implementation Review		
Progress meets or exceeds benchmarks	Proceed as planned	Policy
Progress falls below benchmarks	Revise Implementation plan or approach	Policy
Action Effectiveness Review		
Effectiveness meets or exceeds benchmarks	Proceed as planned	Technical
Effectiveness falls below benchmarks	Evaluate action and revise strategy, measure and/or action(s). Revise implementation plan.	Technical/Policy
Fish Response & Habitat Status Review		
Fish response and habitat status meet or exceed benchmarks	Proceed as planned.	Technical
Fish response meets or exceeds and habitat status falls below benchmarks.	Evaluate and, as necessary, revise habitat and hydro strategies, measures and actions. Proceed as planned for other harvest and hatcheries. Revise implementation plans.	Technical/Policy
Fish response and habitat status fall below benchmarks	Evaluate and, as necessary, revise strategies, measures and actions for all H's. Revise implementation plans.	Technical/Policy
Fish response falls below and habitat status falls meet or exceed benchmarks	Evaluate and, as necessary, revise hatchery and harvest strategies, measures, and actions. Revise implementation plans.	Technical/Policy

8.6 Public Education and Outreach

The recovery of the region's salmon and steelhead is inherently dependent on the collective actions of the people of the region. Recovery cannot be accomplished through legislation, rules, or money. These are only tools for recovery. It depends on the cumulative efforts of people working as individuals and collectively through and with organizations and governmental entities to achieve a common goal. In this case, the goal is the recovery of salmon and steelhead to healthy, harvestable levels. It must provide for the equitable sharing of burdens and benefits across affected interests. It will require a sustainable balance between the needs of fish and the values and needs of the people. It will require fundamental changes in how we view, care for and manage our fish, steams and watersheds. In short a successful recovery program must work for people and fish. It must be sound biologically and technically feasible. It must also be sensitive and responsive to regional and local cultural, social, and economic values.

In developing this recovery plan, efforts were made to meld biological and technical factors with social values and interests. The planning process was open to the public. Public participation was sought through workshops, meetings, working groups, and public review and comment periods. Copies of working papers and plan drafts were made available. Attempts were made to present technical information and analysis in a clear, understandable, and transparent manner. A careful record was maintained of all comments received and the disposition of each comment was logged and made available to the public.

While these public outreach efforts have helped assure a more balanced and equitable plan, successful implementation of the plan will require broader public awareness, understanding, support, and participation. The public will be an active partner in the implementation of the plan. This section set forth the approach for engaging the public as a partner in recovery efforts.

8.6.1 Goal

It is a goal of public education and outreach to engage the public as an active partner in implementing and sustaining recovery efforts. This goal will be achieved by building public awareness, understanding, and support; and by providing opportunities for participation in all aspects of recovery implementation. The term "public" in intended to be inclusive of individuals, community groups, environmental and conservation organizations, businesses, fishing interests and others with a stake or role in achieving recovery.

<u>Awareness</u>: The public will be made aware of the recovery efforts and informed of the opportunities to become involved.

<u>Understanding</u>: Members of the public will be provided the tools and information needed to effectively support and participate in recovery. Public education and outreach will help people understand why we are attempting to recover salmon and steelhead populations and what actions are required to do so. It will help the public understand the program's goals, objectives, strategies, measures, and actions and supporting the science and policy decisions. It will promote the understanding that recovery is shared responsibility, requiring coordinated and complementary participation at the federal, state, local, and citizen levels. It will assist the public in understanding their role and those of others. It will help members of the public understand how their collective efforts contribute to restoring salmon and steelhead populations to healthy, harvestable levels. Information needs will vary based on location and interests. For

many, a concise overview and summary of the recovery plan will likely suffice. However, some may wish examine the recovery program and its underlying technical basis in more detail. All will want to know how recovery will affect them.

Support and Participation: Support and participation will be achieved by providing the public with opportunities to become involved in recovery efforts. This includes helping to shape implementation efforts. Agencies and governments can do this by engaging the public in developing their implementation plans and actions. Doing so will engender public support and ownership of recovery actions, while also helping to ensure that these actions take into consideration public interests and concerns. Engaging the public in performing specific recovery actions such as habitat restoration projects and monitoring habitat conditions will also further participation and support. Schools and non-profit organizations can further the understanding of recovery concepts and participation in recovery actions through watershed and habitat studies and restoration efforts.

8.6.2 Principles

A) Public Education And Outreach Is A Shared Responsibility. All agencies, governments, and organizations involved in recovery efforts will actively engage in public education and outreach to achieve the needed levels of public awareness, understanding, support, and participation. These efforts will be coordinated to ensure consistency across the entire recovery region.

B) The Public Is A Key Partner In Recovery. Public education and outreach is an ongoing and integrated process that makes the public a key partner in all aspects of recovery, including designing measures and actions, implementing those measures and actions, reviewing the outcome, and, if necessary, adjusting course.

C) Public Education And Outreach Is A Continuing Process. Public education and outreach is not a short-term activity. While it is critical to the initial implementation of recovery strategies, measures and actions, public involvement is equally important to sustaining recovery efforts over the many years needed to achieve healthy harvestable salmon and steelhead populations.

D) Public Information Must Be Timely, Accurate, Relevant, And Consistent. Information is critical to effective public understanding and participation. The public must have access to needed information in time to apply or act on it. To be credible, it must be complete, accurate, and understandable. It must also be relevant to the issue or action being considered and responsive to the public interests involved. Finally, given the numerous parties engaged in the implementation of recovery actions, it must be consistent. Conflicting or inconsistent information will damage public confidence.

E) The Public Will Have Meaningful Opportunities To Participate. The public should be involved from the outset of planning and implementing recovery actions, not after decisions have been made. Public input on or involvement in implementation actions should be encouraged and actively solicited. The public should be advised of how its input shaped the decision made.

F) Public Contributions Should Be Recognized. Public contributions to recovery should be recognized and celebrated within their community and throughout the region. Doing so builds support and encourages broader participation.

8.6.3 Approach

As noted above, public education and outreach is a responsibility shared by all implementing partners. Each implementing partner will have an effective public education and outreach effort tailored to its recovery responsibilities and the needs of its constituency. Each implementing partner will also be able represent the regional recovery effort accurately and consistently and to put its actions in the broader context of the regional effort. While the purpose of these programs is to build awareness, understanding, support and participation, multiple public education and outreach efforts also have the potential to overwhelm and confuse the public and to be needlessly repetitive and wasteful.

The implementation approach relies largely on the individual implementing partners. It also identifies measures and actions to coordinate and integrate these individual efforts into an effective regional public education and outreach effort that will help ensure consistency, avoid redundancy, and leverage efforts and resources.

A regional education and outreach program will be established to support, assist and coordinate the efforts by individual implementing partners. The LCFRB and the Implementation Steering Committee in consultation with the implementing partners will develop the regional program. The program will be incorporated in the 6-year regional implementation plan discussed in section 8.5 of this plan. The program will be consistent with the principles discussed above and will:

- Develop and distribute informational and educational materials explaining the reasons for the recovery effort and the recovery plan's goals, strategies, measures, actions, and priorities.
- Coordinate and facilitate communications and information sharing among agencies, governments, and organizations and with the public. This will include a regional communications network, information clearinghouse, and identification of informational contacts for implementing partners.
- Identify opportunities for and assist implementing partners in integrating or consolidating similar, duplicative, or complementary education and outreach efforts.
- Provide the public with information on implementation actions throughout the region, including notice of opportunities to participate and information sources.
- Provide the public with information on the progress, status, and achievements of recovery actions throughout the region.
- Encourage and assist schools and educational organizations such as conservation districts and WSU cooperative extension to integrate salmon recovery into their environmental, agricultural, watershed, water quality curriculum, and classes. Also support agency, local government, and utility educational programs promoting actions by individuals to protect and conserve water resources.
- Coordinate briefings and presentations to civic, business, trade, environmental, conservation, and fishing organizations on the regional recovery program, actions and progress.
- Establish regional measures to acknowledge and celebrate the contributions of organizations, businesses, and individuals.
- Publicize incentive programs for the protection and restoration of water resources and habitat and encourage landowner participation.

- Encourage business and professional organizations to adopt and promote implementation of best management practices for the protection and restoration of fish and habitat.
- Encourage and assist local or community organizations interested or involved in watershed and habitat protection and restoration.

In concert with the development of the regional recovery public education and outreach plan, the implementing partners will be requested to prepare an education and outreach plan for their implement ting activities. These plans would be an element of the 6-year implementation plan to be prepared by each partner. While public entities are already required by law or rule to have some form of public education and outreach, these plans would help to ensure efforts by the implementing partners are consistent with the principles and regional program discussed above and coordinated with the efforts of other implementing partners.

8.7 Evaluating Plan Sufficiency

Evaluation of the sufficiency of this plan is based on: 1) substantive strategies, measures, an actions that address all current threats to the viability and harvestability of Washington lower Columbia salmon and steelhead populations, 2) incorporation of effective monitoring, evaluation, and adaptive management measures and actions as well as an institutional framework for plan implementation, and 3) assessments confirming that reductions in threats are of an order of magnitude consistent with recovery.

Threats to viability and harvestability include all categories of human activities that impact fish numbers, adaptive population characteristics, and habitats. This plan has treated threats grouped by category including stream habitat, estuary and mainstem habitat, hydropower, harvest, hatcheries, and ecological interactions. These threats are cataloged at length and related to fish limiting factors in Chapter 3 of this plan. Impacts of key factors in each threat category were quantified based on the best available information and in Chapter 5 were related to improvement increments needed to achieve biological objectives. These impacts estimates also provide baseline values for modeled assessments of threats. Detailed strategies, measures, and actions that address each category of threat are described in Chapter 6. Actions for addressing threats are further detailed in subbasin volumes I.A-II.L. All recovery measures are cross-referenced with the threats they address.

Monitoring, evaluation, and adaptive management components of the plan consider whether actions were implemented as designed, actions produce the expected immediate effect, and the net effects of multiple actions produce the desired improvement in fish populations. The recovery actions detailed for each threat provide a checklist for evaluating the scope of plan implementation. Quantitative estimates of the impacts of key threat factors and expected responses projected from fish life cycle and habitat models provide testable hypotheses for the monitoring, evaluation, and adaptive management effort. Monitoring, research, and evaluations measures are described in Chapter 7 and the adaptive management framework for implementation is detailed in Chapter 8.

The immediate test of plan sufficiency is whether current working hypotheses, strategies, measures, and actions provide a plausible scientific basis for reversing decline fish trends and providing a significant trajectory toward recovery. The complex dynamics of biological systems introduce large uncertainty into fine-scale, long-term predictions of response to recovery actions. Existing data, models, and theories are not adequate to categorically prove that a given set of actions will guarantee recovery. No amount of additional research, modeling, and theorizing is likely to provide an iron-clad projection. Existing information and tools are adequate to evaluate whether proposed actions are of an order of magnitude to significantly reduce threats to the a level where a response in fish populations can feasibly be measured and a trajectory for recovery can be detected.

These assessments will be completed as part of the plan development and implementation process. Assessments will determine whether prescribed actions are sufficient to reverse declining trends in fish numbers and provide a significant trajectory to recovery. Expected responses to recovery actions will be based on: 1) composite effects of target reductions in human impacts in each threat category on fish population trends and extinction risks, and 2) net effects of habitat improvements in subbasins on fish productivity and capacity. Probability life cycle modeling of composite effects will determine whether the combined reduction in impacts in all threat categories can reasonably be expected provide the desired trajectory toward recovery objectives. Habitat modeling will determine whether projected improvements in habitat conditions associated with recovery actions are of the scale necessary to make substantive contributions to the overall recovery effort.

8.8 Measures

Coordination

P.M1. ***Establish an oversight group for plan implementation (NOAA, USFWS, WDFW, NPCC) and an implementation facilitation and coordination function to be carried out by the LCFRB, LCFRB staff, and a plan implementation steering committee (Section 8.3).***

P.M2. ***Regularly review and revise this plan in a collaborative agency, stakeholder, and public process. Responsible Party: LCFRB/Steering Committee (Sections 8.4.3 and 8.5)***

P.M3. ***Refine draft benchmarks for assessing implementation progress, implementation effectiveness and biological and habitat status. Responsible Party: LCFRB/Steering Committee (Section 8.5)***

P.M4. ***Develop and implement cost and economic analysis methods to assist in decision-making and meet ESA needs. Responsible Parties: LCFRB/Steering Committee and NOAA Fisheries.***

P.M5. ***Develop ESA threats criteria and prioritization for incorporation into the Lower Columbia and domain recovery plans. Relate actions, strategies, and measures to threats. Responsible Parties: LCFRB/Steering Committee and NOAA Fisheries***

P.M6. ***Conduct qualitative evaluation of program sufficiency. Responsible Party: LCFRB/Steering Committee (Sections 8.5 and 8.7)***

Explanation: This measure will involve close coordination of work by NOAA Fisheries' science center and the LCFRB staff to develop a systematic approach to modeling effects of actions on fish habitat and watershed processes and use this approach to evaluate alternative restoration scenarios.

P.M7. ***Coordinate the development of a regional monitoring, research, and evaluation program. Responsible Parties: LCFRB/Steering Committee (Section 8.4.4)***

P.M8. Coordinate the development of a regional public education and outreach program. Responsible Parties: LCFRB/Steering Committee. (Section 8.6)

Implementation

P.M9. Develop and periodically update 6-year implementation schedules. Responsible Parties: LCFRB/Steering Committee and implementing partners. (Section 8.4.1)

P.M10. Evaluate whether recovery strategies, measures, and actions are being implemented as planned. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: This recovery plan describes an ambitious series of strategies, measures, and actions based on the gap between where we are now and where we want to go. The plan will fail at its most fundamental level if these strategies, measures, and actions are not implemented.

P.M11. Refine and reprioritize plan implementation at the programmatic level based on evaluations of implementation and compliance. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: Plan implementation at the program and project level will be a dynamic process requiring continual adaptation by implementing parties. Plan implementation will also be formally evaluated at intervals as prescribed in the implementation chapter.

P.M12. Prepare written plan implementation progress reports to participating agencies, stakeholders, and the public at 2-year intervals. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: These include descriptions of refinements based on findings.

Action Effectiveness

P.M13. Evaluate whether specific strategies, measures, and actions are producing the desired effects in each limiting factor/threat category (stream habitat, mainstem/estuary habitat, hydropower, harvest, hatcheries, ecological interactions). Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: Factor-specific responses are based on action effectiveness monitoring. A series of monitoring activities have been identified specific to each limiting factor/threat category to occur at different scales and periods. Evaluations will be ongoing and also incorporated into regular plan-wide reviews.

P.M14. Refine and reprioritize existing recovery strategies, measures, and actions for each limiting factor/threat category based on results of action-effectiveness evaluations. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: Adjustments in the implementation of related measures can be made as new information is gained on the effects of specific measures and actions. Large-scale adjustments and compensation among measures across limiting factor/threat categories will be considered.

P.M15. Prepare written action effectiveness progress reports to participating agencies, stakeholders, and the public at 6-year intervals. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: These include descriptions of refinements based on findings.

Fish and Habitat Response

P.M16. Periodically evaluate biological status relative to population and ESU objectives to determine whether necessary improvements are being achieved. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: The success of the recovery plan will ultimately be determined based on observed response in fish populations across the ESU as well as trends in other fish and wildlife species of interest. Trends will be evaluated on an annual basis with more comprehensive assessments prescribed at 12-year intervals. Evaluations will also consider and correct for confounding effects of regional climate patterns.

P.M17. Periodically evaluate habitat status relative to baseline conditions and benchmarks to determine whether appropriate progress is being made toward desired future conditions. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: Desired conditions are based on specific objectives identified in subbasin sections of Volume II. The baseline corresponds to conditions at the time of listing and is intended only as a reference point for measuring significant trends. Desired conditions may be similar to the baseline in areas targeted for preservation. Desired conditions will be more suitable for objective species in areas targeted for recovery. Trends will be evaluated on an annual basis with more comprehensive assessments prescribed at 12-year intervals. Evaluations will also consider and correct for confounding effects of regional climate patterns.

P.M18. Refine and reprioritize existing recovery strategies, measures, and actions for each limiting factor/threat category based on results of biological and habitat status evaluations. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: Adjustments in the implementation of related measures can be made as new information is gained on the observed response. Large-scale adjustments and compensation among measures across limiting factor/threat categories may be considered.

P.M19. Prepare written fish and habitat status reports to participating agencies, stakeholders, and the public at 12-year intervals. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: The interval coincides with the action effectiveness and implementation reporting requirements. Reports will include descriptions of refinements based on findings.

Adaptive Management

P.M20. Use results of critical uncertainty research to identify new or refine and reprioritize existing recovery strategies, measures, and actions. Responsible Party: LCFRB/Steering Committee (Sections 8.4.4 and 8.5)

Explanation: Adjustments in the implementation of related measures can be made as critical uncertainty research provides new insights. Large-scale adjustments and compensation among measures across limiting factor/threat categories will be considered at intervals as prescribed in the Implementation Chapter.

P.M21. Refine analytical tools and methods to better support adaptive management process. Responsible Parties: LCFRB/Steering Committee, W/LC TRT, NOAA Fisheries (Section 8.5)

Explanation: Evaluations of limiting factors and threats as well as recovery objectives are based on a series of analyses and models. All of these evaluations will be subject to refinements and testing. Considerations related to uncertainties in the various models will be incorporated into the monitoring, evaluation, and adaptive management framework for this plan.

P.M22. Refine biological objectives consistent with recovery as new information becomes available on status and viable population or ESU characteristics. Responsible Party: LCFRB/Steering Committee (Sections 8.4.3 and 8.5)

Explanation: The biological objectives identified in this plan are working hypotheses based on incomplete data and a series of assumptions regarding what constitutes a viable population or ESU. These assumptions were identified as subjects for further evaluation and it is anticipated that substantial advances in understanding will occur as a result of efforts in the lower Columbia recovery domain as well as in other domains across the Pacific Northwest. These advances will inevitably lead to refinements in recovery criteria which will need to be incorporated into the biological objectives of this plan.

P.M23. Periodically evaluate strengths and weaknesses of the available monitoring and research to determine adequacy for assessing progress and identifying appropriate course corrections. Responsible Party: LCFRB/Steering Committee (Section 8.5)

Explanation: The monitoring, research, and evaluations program itself will be subject to regular review and refinement, for instance, in response to available resources for implementation.

P.M24. Identify appropriate alternative approaches and revise priorities for monitoring and research based on results of evaluations. Responsible Party: LCFRB/Steering Committee (Sections 8.4.4 and 8.5)

Explanation: Adjustments in the implementation of related measures can be made as new information is available. Large-scale revisions will be considered at intervals as prescribed in the Implementation Chapter.

8.9 Implementation Actions

The following table organizes by entity the actions for which that entity would be involved in implementation. Because multiple entities are involved in the implementation of certain actions, some actions appear under more than one entity. In some cases, no single entity has full authority to implement an action, and successful implementation will depend on the coordination and cooperation of a number of agencies. In other cases, while one entity may have lead authority and implementation responsibility, effective implementation will depend on the involvement, support, and agreement of a number of agencies. In the process of developing implementation plans, as discussed earlier in this chapter, lead entities will be identified where appropriate for each action.

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Battleground	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)													X	X					
Battleground	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach													X	X					
Battleground	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations													X	X					
Battleground	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces within urban growth boundaries													X	X					
Battleground	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices													X	X					
Battleground	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management													X	X					
BPA	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status							X												

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
BPA	Habitat	Initiate habitat restoration and protection projects to mitigate impacts hydroelectric facilities operations							X												
BPA	Habitat	Restore access through the hydropower system for anadromous and resident fish, unless proven to be infeasible or biologically unnecessary							X												
BPA	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz dam and facilities as part of relicensing processes or requirements							X												
BPA/NPCC	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BPA/NPCC	Habitat	Increase funding levels for habitat restoration, preservation, and research projects to help achieve recovery goals	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Camas	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality															X				
Camas	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)															X				
Camas	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or															X				

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		otherwise) and enhancing program marketing and outreach																			
Camas	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations; Initiate the development and implementation of a regional water source in the Stiegerwald Refuge vicinity															X				
Camas	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces within urban growth boundaries															X				
Camas	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices															X				
Camas	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management															X				
Castle Rock	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)						X													
Castle Rock	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach						X													

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Castle Rock	Habitat	Manage existing and future water supplies consistent with WRIA 25/26 Watershed Management Plan recommendations						**X**													
Castle Rock	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces within city growth areas						**X**													
Castle Rock	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management						**X**													
Cathlamet	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)				**X**															
Cathlamet	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach				**X**															
Cathlamet	Habitat	Manage existing and future water supplies consistent with WRIA 25/26 Watershed Management Plan recommendations				**X**															
Cathlamet	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces				**X**															

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Cathlamet	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices				X															
Cathlamet	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management				X															
Chinook	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X		X																
Chinook	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach	X		X																
Chinook	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X		X																
Chinook	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X		X																
Clark CD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status											X	X	X	X	X				
Clark CD	Habitat	Assess the impact of fish passage barriers throughout the county and											X	X	X	X	X				

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		restore access to potentially productive habitats																			
Clark CD	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids											X	X	X	X	X				
Clark CD	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach											X	X	X	X	X				
Clark CD	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding											X	X	X	X	X				
Clark CD	Habitat	Participate in floodplain restoration projects where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives											X	X	X	X	X				
Clark CD	Habitat	Protect and restore native plant communities from the effects of invasive species											X	X	X	X	X				
Clark Co	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status.	X										X	X	X	X	X	X			
Clark Co	Habitat	Assess and require upgrade or replacement of on-site sewage systems	X										X	X	X	X	X	X			

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		that may be contributing to water quality impairment																			
Clark Co	Habitat	Assess the impact of fish passage barriers throughout the County's jurisdiction and restore access to potentially productive habitats	X										X	X	X	X	X	X			
Clark Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X										X	X	X	X	X	X			
Clark Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach	X										X	X	X	X	X	X			
Clark Co	Habitat	Limit intensive recreational use of priority stream reaches during critical fish use periods											X	X	X	X	X	X			
Clark Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives											X	X	X	X	X	X			
Clark Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X										X	X	X	X	X	X			
Clark Co	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads,											X	X	X	X	X	X			

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		parks, and weed management																			
Clark PU	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations; Initiate the development and implementation of a regional water source for Clark County, including Ridgefield and Battleground													X	X	X				
Conservation Commission	Habitat	Assist in the development and promote the implementation of Best Agricultural Practices for the protection and restoration of watershed functions, riparian conditions, habitat and water quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
County Noxious Weed Control Boards	Habitat	Increase education, enforcement, and if necessary, control activities related to tributary noxious instream and riparian plant species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cowlitz Co	Estuary	Protect and restore riparian condition and function	X																		
Cowlitz Co	Estuary	Restore connectedness between river and floodplain	X																		
Cowlitz Co	Estuary	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River	X																		
Cowlitz Co	Habitat	Assess and require upgrade or replacement of on-site sewage systems that may be contributing to water quality impairment	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Assess the impact of fish passage barriers throughout County and restore access to potentially productive habitats	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Conduct floodplain restoration where feasible along the mainstem and in	X				X	X		X	X	X	X	X							

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives																			
Cowlitz Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Limit intensive recreational use of priority stream reaches during critical fish use periods					X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X				X	X		X	X	X	X	X							
Cowlitz Co	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X				X	X	X	X	X	X	X	X							

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Cowlitz PUD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status											X	X							
Cowlitz PUD	Habitat	Initiate habitat restoration and protection projects to mitigate impacts of hydroelectric facilities												X							
Cowlitz PUD	Habitat	Restore volitional access through the hydropower system for anadromous fish; restore habitat											X	X							
Cowlitz PUD	Hatchery	Reintroduce coho in upper Lewis rivers												X							
Cowlitz PUD	Hatchery	Reintroduce spring Chinook in the Lewis beginning with hatchery supplementation												X							
Cowlitz PUD	Hatchery	Reintroduce winter steelhead in Lewis rivers												X							
Cowlitz PUD	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream Lewis River dams as part of relicensing processes or requirements												X							
Cowlitz Tribe	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives						X	X			X	X	X							
Cowlitz Tribe	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach						X	X			X	X	X							

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Cowlitz Tribe	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding						X	X			X	X	X							
Cowlitz/ Wahkiakum CD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status			X	X	X	X		X	X	X	X								
Cowlitz/ Wahkiakum CD	Estuary	Protect and restore riparian condition and function	X																		
Cowlitz/ Wahkiakum CD	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives		X	X	X	X	X		X	X	X	X	X							
Cowlitz/ Wahkiakum CD	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids		X	X	X	X	X		X	X	X	X	X							
Cowlitz/ Wahkiakum CD	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach		X	X	X	X	X		X	X	X	X	X							
Cowlitz/ Wahkiakum CD	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and		X	X	X	X	X		X	X	X	X	X							

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		increasing funding																			
Cowlitz/ Wahkiakum CD	Habitat	Protect and restore native plant communities from the effects of invasive species		X	X	X	X	X		X	X	X	X	X							
CREST	Estuary	Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and near shore ocean	X																		
EPA	Estuary	Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and near shore ocean	X																		
FERC	Habitat	Ensure stream flows in hydro-regulated streams are managed to provide maximum fish habitat use						X					X								
FERC	Habitat	Ensure the terms of relicensing are met over the licensing period						X	X				X	X							
FERC	Habitat	Ensure volitional passage for salmonids and Bull Trout is attained through hydrorelicensing unless shown to be infeasible or biologically unnecessary						X	X				X	X							
FERC	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz and Lewis dams and facilities as part of relicensing processes or requirements							X					X							
Implementing Partners	Monitoring	Closely coordinate Washington lower Columbia River monitoring, research, and evaluation efforts with similar efforts throughout the basin, including prioritization of activities and standardization of data methods.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Concentrate a portion of habitat status and action effectiveness monitoring in	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		one or more intensively monitored watersheds to optimize opportunities for evaluating linkages between habitat and fish (e.g., Mill/Abernathy/Germany, Kalama, East Fork Lewis, Wind). Consider subbasins containing multiple high priority populations and other ongoing studies such as the SRFB-sponsored Intensively Monitored Watershed project in the Mill, Abernathy, Germany basins..																			
Implementing Partners	Monitoring	Conduct a data management needs assessment and use to develop a data management plan.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Conduct comprehensive survey of stream habitat conditions across the Washington lower Columbia Region.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Conduct comprehensive survey of water quality and quantity across the Washington lower Columbia Region.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Conduct comprehensive survey of watershed conditions and processes across the Washington lower Columbia Region - completed.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Conduct periodic censuses of the abundance and distribution of nesting Caspian terns.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Conduct periodic censuses of the abundance, distribution, and diet of marine mammals throughout the lower Columbia River mainstem and particularly near Bonneville Dam.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Continue to monitor abundance of American shad based on Bonneville Dam counts.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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Implementing Partners	Monitoring	Maintain a coordinated database of federal, tribal, state, local, and non-governmental programs and projects implemented throughout the recovery region.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Maintain consistent regionally-standardized datasets and archive in regional data storage and management facilities (e.g., Pacific State Marine Fisheries Commission StreamNet, Washington Department of Fish and Wildlife SSHIAP, NOAA Fisheries biological datasets).	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor adult and juvenile collection, passage, and survival rates at Bonneville Dam.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor adult and juvenile collection, passage, and survival rates at Cowlitz, Lewis and Toutle Dams.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor and evaluate the establishment of escapement rates through harvest management actions in relation to the nutrient and other ecological value of returning salmon	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor annual angler participation, harvest, and exploitation rate in northern pikeminnow management program in Columbia River mainstem.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor annual harvest and harvest rates of representative index stocks in in-basin, Columbia River mainstem, and ocean fisheries.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor catch and release mortality of wild salmon and steelhead in selective fisheries.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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Implementing Partners	Monitoring	Monitor distribution/spatial structure of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor effects of fish culture practices within the hatchery.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor effects of small scale and large scale activities (e.g., channel deepening) that affect habitat.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor effects of watershed and stream habitat protection and restoration actions on stream habitat conditions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor in-basin and out-of-basin stray rates of hatchery fish in wild spawning areas relative to hatchery practices.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor numbers and performance of hatchery fish returning to hatcheries.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor occurrences of new exotic aquatic fishes, invertebrates or plants based on incidental observations during other biological status monitoring, anecdotal reports, and follow-up sampling where appropriate.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor relative distribution, abundance, and condition of fish in relation to specific habitat improvements.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor the downstream channels of Mayfield, SRS and Merwin Dams for changes in substrate and flow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor the relative abundance, distribution and dewatering of chum and fall Chinook redds in the Bonneville Dam tailrace.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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Implementing Partners	Monitoring	Monitor trends and variation in annual adult spawning abundance and distribution of representative populations of Chinook, chum, coho, and steelhead in all watersheds.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor trends and variation in annual juvenile production of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor trends and variation in productivity of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor trends in stream habitat conditions through periodic sampling of representative and indicator sites.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor trends in water quantity and quality through periodic sampling of representative and indicator sites (includes USGS gauge sites and additional sites).	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Monitor trends in watershed conditions and processes through periodic sampling of representative and indicator sites.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Produce and distribute regular progress and completion reports for monitoring and research activities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implementing Partners	Monitoring	Validate comprehensive survey of watershed conditions and processes with site-specific assessments.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kalama	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality										X									

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Kalama	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)										X									
Kalama	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach										X									
Kalama	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations										X									
Kalama	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces										X									
Kalama	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices										X									
Kalama	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management										X									
Kelso	Habitat	Assess the impact of fish passage barriers throughout the City's jurisdiction and restore access to potentially productive habitats						X			X										
Kelso	Habitat	Conduct floodplain restoration where feasible along the mainstem and in						X			X										

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		major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives																			
Kelso	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality						X			X										
Kelso	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)						X			X										
Kelso	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and enhancing program marketing and outreach						X			X										
Kelso	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces						X			X										
Kelso	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices						X			X										
Kelso	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management						X			X										
LCFEG	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness,	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

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		and biological and habitat status																			
LCFEG	Habitat	Assess the impact of fish passage barriers throughout the region and restore access to potentially productive habitats	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Proactively conduct floodplain restoration on lands being phased out of agricultural production. Survey landowners, build partnerships, and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFEG	Habitat	Protect and restore native plant communities from the effects of	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

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		invasive species																			
LCFRB	Habitat	Build partnerships with landowners and agencies and provide financial incentives to restore floodplain function	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFRB	Habitat	Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing regulatory programs are inadequate	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFRB	Habitat	Increase implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships with landowners and agencies and increasing funding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LCFRB	Implementation	Establish an oversight group for plan implementation (NOAA, USFWS, WDFW, NPCC) and an implementation facilitation and coordination function to be carried out by the LCFRB, LCFRB staff, and a plan implementation oversight committee.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Conduct qualitative evaluation of program sufficiency.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Coordinate the development of a regional monitoring, research, and evaluation program.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Coordinate the development of a regional public education and outreach program. Committee.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Develop and implement cost and economic analysis methods to assist in decision-making and meet ESA needs.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Develop and periodically update 6-year	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		implementation schedules.																			
LCFRB/RPOC	Implementation	Develop ESA threats criteria and prioritization for incorporation into the Lower Columbia and domain recovery plans. Relate actions, strategies, and measures to threats.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Evaluate whether recovery strategies, measures, and actions are being implemented as planned.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Evaluate whether specific strategies, measures, and actions are producing the desired effects in each limiting factor/threat category (stream habitat, mainstem/estuary habitat, hydropower, harvest, hatcheries, ecological interactions).	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Identify appropriate alternative approaches and revise priorities for monitoring and research based on results of evaluations.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Periodically evaluate biological status relative to population and ESU objectives to determine whether necessary improvements are being achieved.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Periodically evaluate habitat status relative to baseline conditions and benchmarks to determine whether appropriate progress is being made toward desired future conditions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Periodically evaluate strengths and weaknesses of the available monitoring and research to determine adequacy for assessing progress and identifying appropriate course corrections.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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LCFRB/RPOC	Implementation	Prepare written action effectiveness progress reports to participating agencies, stakeholders, and the public at 6-year intervals.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Prepare written fish and habitat status reports to participating agencies, stakeholders, and the public at 12-year intervals.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Prepare written plan implementation progress reports to participating agencies, stakeholders, and the public at 2-year intervals.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine analytical tools and methods to better support adaptive management process.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine and reprioritize existing recovery strategies, measures, and actions for each limiting factor/threat category based on results of action-effectiveness evaluations.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine and reprioritize existing recovery strategies, measures, and actions for each limiting factor/threat category based on results of biological and habitat status evaluations.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine and reprioritize plan implementation at the programmatic level based on evaluations of implementation and compliance.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine biological objectives consistent with recovery as new information becomes available on status and viable population or ESU characteristics.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Refine draft benchmarks for assessing implementation progress,	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		implementation effectiveness and biological and habitat status.																			
LCFRB/RPOC	Implementation	Regularly review and revise this plan in a collaborative agency, stakeholder, and public process. Responsible Party: LCFRB and Recovery Plan Oversight Committee (RPOC)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCFRB/RPOC	Implementation	Use results of critical uncertainty research to identify new or refine and reprioritize existing recovery strategies, measures, and actions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LCREP	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X																	
LCREP	Estuary	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem	X																		
Lewis CD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status						X	X												
Lewis CD	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives						X	X												
Lewis CD	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids						X	X												
Lewis CD	Habitat	Increase technical assistance to						X	X												

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach																			
Lewis CD	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding						X	X												
Lewis CD	Habitat	Protect and restore native plant communities from the effects of invasive species						X	X												
Lewis Co	Habitat	Assess the impact of fish passage barriers throughout the County jurisdiction and restore access to potentially productive habitats						X	X												
Lewis Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)						X	X												
Lewis Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach						X	X												
Lewis Co	Habitat	Manage existing and future water supplies consistent with WRIA 25/26						X	X												

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		Watershed Management Plan recommendations																			
Lewis Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives						X	X												
Lewis Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices						X	X												
Lewis Co	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management						X	X												
Lewis Health Districts	Habitat	Assess and require upgrade or replacement of on-site sewage systems that may be contributing to water quality impairment						X	X												
Longview	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X					X													
Longview	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X					X													
Longview	Habitat	Implement the recommendations of the WRIA 25/26 Watershed Planning Unit regarding water quality						X													
Longview	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs	X					X													

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		that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach																			
Longview	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces	X					X													
Longview	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X					X													
Longview	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X					X													
Morton	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)							X												
Morton	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach							X												
Morton	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces							X												
Morton	Habitat	Review and adjust operations to ensure compliance with the Endangered							X												

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		Species Act; examples include roads, parks, and weed management																			
Mossyrock	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)							X												
Mossyrock	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach							X												
Mossyrock	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces							X												
Mossyrock	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management							X												
NOAA	All	Develop appropriate ESA assurances for entities implementing actions of the Lower Columbia Fish Recovery Plan	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	All	Utilize the Lower Columbia Fish Recovery Plan as a basis for enforcement actions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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NOAA	All	Utilize the Lower Columbia Fish Recovery Plan as a basis for its section 7 consultations and its section 4 and 10 permits	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Ecol	Coordinate with the LCFRB and other relevant agencies on the development and implementation of a plan to manage predation by marine mammals such as seals and sea lions, where increased predation poses significant risks to salmon recovery and management is consistent predator population viability	X																		
NOAA	Ecol	Evaluate positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures	X																		
NOAA	Estuary	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem	X																		
NOAA	Estuary	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations	X																		
NOAA	Habitat	Monitor, evaluate, and enforce the Stordahl Habitat Conservation Plan													X						
NOAA	Harvest	Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recovery of fall Chinook in fisheries and escapement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Conduct periodic reviews of fall Chinook harvest relative to habitat productivity and capacity to assure		X	X	X	X	X		X	X	X			X	X	X	X	X	X	

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		harvest objectives are synchronized with habitat changes																			
NOAA	Harvest	Consider and expressely evaluate sliding scale harvest based on annual abundance indicators for naturally-spawning Columbia River coho		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Consider and expressly evaluate the potential for a sliding scale harvest plan based on annual abundance indicators for tule fall Chinook		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
NOAA	Harvest	Consider recovery goals for lower Columbia salmon and steelhead populations as identified in the Lower Columbia Recovery Plan in annual fishery management processes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Continue to monitor Columbia River selective fisheries and provide estimates of impacts to naturally produced lower Columbia spring Chinook							X			X		X							
NOAA	Harvest	Develop a basin wide fish marking plan for hatchery tule fall Chinook that is adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
NOAA	Harvest	Develop a mass marking plan for hatchery tule Chinook for tributary harvest management and for naturally-spawning escapement monitoring		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
NOAA	Harvest	Ensure that scientific review of Lower Columbia Recovery Plan harvest objectives and current ESA management objectives will occur as part of the process in the above fishery forums	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Improve tools to monitor and evaluate		X	X	X	X	X		X	X	X			X	X	X	X	X	X	

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		fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits																			
NOAA	Harvest	Maintain selective sport fisheries in Ocean, Columbia River, and tributaries and monitor naturally-spawning coho stock impacts	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Manage Columbia River commercial fisheries by time, area, and gear to target hatchery fish and minimize impacts to naturally spawning spring chinook							X			X		X							
NOAA	Harvest	Manage Columbia River commercial fisheries managed by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Manage Columbia River commercial fisheries managed by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning steelhead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Manage ocean, Columbia River, and tributary fisheries to meet the spawning escapement goal for lower Columbia bright fall Chinook							X			X		X							
NOAA	Harvest	Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Review and evaluate the harvest management strategy developed for protection of naturally-spawning Clackamas late coho to also protect naturally-spawning Washington late coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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NOAA	Harvest	Review of NOAA Fisheries' recovery exploitation rate of fall Chinook tules and update risk assessment to include more tule populations		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
NOAA	Harvest	Revise or adjust ESA Fishery Management Plans for lower Columbia ESUs as needed to support the Lower Columbia Recovery goals and priorities	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbia naturally-spawning tule fall Chinook and to establish a collaborative US policy position for the international table at the Pacific Salmon Commission		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
NOAA	Harvest	Seek to maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of fishery rules and regulations for the protection of fish and wildlife resources	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Harvest	Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead																	X		
NOAA	Hatchery	Assist in the design hatchery programs to be consistent with region-wide recovery and the ecological context of the watershed, including the characteristics of the habitat and the natural fish populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Develop criteria for appropriate integration of hatchery and natural	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		populations																			
NOAA	Hatchery	Develop marking programs to assure that hatchery-produced fish to assure they are identifiable for harvest management and escapement accounting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Document and formalize hatchery operations through the use of the existing Hatchery Genetic Management Planning (HGMP) process	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Guide the configuration of hatchery programs with appropriate reform recommendations identified in the Northwest Power and Planning Council's Artificial Production Review and Evaluation (APRE), the Benefit-Risk procedure developed by WDFW, and other tools	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Promote public education concerning the role of hatcheries in the protection of natural populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Promote region-wide recovery by using hatcheries as tools for supplementation and recovery in appropriate watersheds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Seek flexibility in current funding to assure hatcheries have the resources to achieve complementary harvest and natural production objectives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hatchery	Use adaptive management to ensure that hatchery programs to respond to new knowledge of how to further protect and enhance natural production and improve operational efficiencies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Hydro	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary																			
NOAA	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz and Lewis dams and facilities as part of relicensing processes or requirements							X					X							
NOAA	Hydro	Monitor and notify FERC of significant license violations, enforce terms and conditions of section 7 consultations on FERC relicensing agreements, and encourage implementation of section 7 conservation recommendations on FERC relicensing agreements						X	X				X	X							
NOAA	Implementation	Develop and implement cost and economic analysis methods to assist in decision-making and meet ESA needs.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Implementation	Develop ESA threats criteria and prioritization for incorporation into the Lower Columbia and domain recovery plans. Relate actions, strategies, and measures to threats.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOAA	Implementation	Refine analytical tools and methods to better support adaptive management process.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Non Government Organizations	Estuary	Restore connectedness between river and floodplain	X																		
Non Government Organizations	Estuary	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River	X																		
Non Government Organizations	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		channel confinement. Build partnerships with landowners and agencies and provide financial incentives																			
Non Government Organizations	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Non Government Organizations	Habitat	Develop partnerships to help increase funding for purchase easements or property in sensitive areas to protect watershed function where existing regulatory programs are inadequate	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Non Government Organizations	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Non Government Organizations	Habitat	Proactively conduct floodplain restoration on lands being phased out of agricultural production. Survey landowners, build partnerships, and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Non Government Organizations	Hatchery	Continue to enhance Chum enhancement at Grays and Chinook hatcheries			X																
NPCC/BPA	Ecol	Continue to manage the northern pikeminnow fishery to help offset increased predation on salmon that resulted from habitat alteration	X																		
NPCC/BPA	Ecol	Evaluate positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures	X																		
NPCC/BPA	Estuary	Improve understanding of	X																		

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem																			
NPCC/BPA	Estuary	Protect and restore riparian condition and function	X																		
NPCC/BPA	Estuary	Restore or mitigate for impaired sediment delivery processes and conditions affecting the Columbia River estuary and lower mainstem	X																		
NPCC/BPA	Hydro	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
NPCC/BPA	Hydro	Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NPCC/BPA	Hydro	Maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam and tributary dams when populations are reestablished	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NRCS	Estuary	Protect and restore riparian condition and function	X																		
NRCS	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing incentives (financial or otherwise) and increasing program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		marketing and outreach																			
NRCS	Habitat	Maintain and expand agriculture protection and restoration programs implemented through conservation districts in the region	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pacific CD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status		X	X	X															
Pacific CD	Estuary	Protect and restore riparian condition and function	X																		
Pacific CD	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids		X	X	X															
Pacific CD	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach		X	X	X															
Pacific CD	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding		X	X	X															
Pacific CD	Habitat	Protect and restore native plant communities from the effects of invasive species		X	X	X															
Pacific Co	Estuary	Protect and restore riparian condition and function	X																		

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Pacific Co	Estuary	Restore connectedness between river and floodplain	X																		
Pacific Co	Estuary	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River	X																		
Pacific Co	Habitat	Assess the impact of fish passage barriers throughout the county and restore access to potentially productive habitats		X	X	X															
Pacific Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X	X	X	X															
Pacific Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach		X	X	X			X												
Pacific Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives		X	X	X															
Pacific Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices		X	X	X															
Pacific Co	Habitat	Review and adjust operations to ensure compliance with the Endangered		X	X	X															

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		Species Act; examples include roads, parks, and weed management																			
Pacific Co Health Districts	Habitat	Assess and require upgrade or replacement of on-site sewage systems that may be contributing to water quality impairment		**X**	**X**	**X**															
PacifiCorp	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status											**X**	**X**							
PacifiCorp	Habitat	Initiate habitat restoration and protection projects to mitigate impacts of hydroelectric facilities											**X**	**X**							
PacifiCorp	Habitat	Manage regulated stream flows in the NF Lewis to maximize fish habitat use											**X**								
PacifiCorp	Habitat	Restore volitional access through the hydropower system for anadromous and resident fish, unless proven to be infeasible or biologically unnecessary											**X**	**X**							
PacifiCorp	Hatchery	Reintroduce coho in upper Lewis river												**X**							
PacifiCorp	Hatchery	Reintroduce spring Chinook in the Lewis beginning with hatchery supplementation												**X**							
PacifiCorp	Hatchery	Reintroduce winter steelhead in Lewis river												**X**							
PacifiCorp	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of the Lewis dams and facilities as part of relicensing processes or requirements												**X**							
PacifiCorp	Hydro	Operate the tributary hydro systems to provide appropriate flows for salmon spawning and rearing habitat in the											**X**								

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		areas downstream of the hydrosystem																			
Port of Camas/Washougal	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X														X				
Port of Kalama	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	X									X									
Port of Kalama	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X									X									
Port of Longview	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X					X													
Port of Vancouver	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement	X													X					
Port of Vancouver	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X													X					
Port of Vancouver	Habitat	Work with federal, state, and local agencies to equitably resolve groundwater quality issues in the Vancouver Lake Lowlands related to a regional water source for Clark County														X					
PSMFC	Ecol	Continue to manage the northern pikeminnow fishery to help offset increased predation on salmon that resulted from habitat alteration	X																		
Skamania Co	Habitat	Assess the impact of fish passage barriers throughout the county and												X			X	X	X	X	X

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		restore access to potentially productive habitats																			
Skamania Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)												X			X	X	X	X	X
Skamania Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach												X			X	X	X	X	X
Skamania Co	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations												X			X	X			
Skamania Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives												X			X	X	X	X	X
Skamania Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X											X			X	X	X	X	X
Skamania Co	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management												X			X	X	X	X	X
Skamania Health	Habitat	Assess and require upgrade or replacement of on-site sewage systems												X			X	X	X	X	

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Districts		that may be contributing to water quality impairment																			
SRFB	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
SRFB	Habitat	Increase funding levels for habitat restoration, preservation, and research projects to help achieve recovery goals. Evaluate the use block grants to LCFRB to fund projects consistent with recovery plan and the Salmon Recovery Act	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
State Noxious Weed Control Board	Habitat	Increase funding and technical assistance to county noxious weed control boards for improve their effectiveness	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
State Parks	Habitat	Limit intensive recreational use of priority stream reaches during critical fish use periods													X			X			
Tacoma Power	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status						X	X												
Tacoma Power	Habitat	Initiate habitat restoration and protection projects to mitigate impacts of hydroelectric facilities						X	X												
Tacoma Power	Habitat	Manage regulated stream flows in the Cowlitz Subbasin to maximize fish habitat use						X													
Tacoma Power	Habitat	Restore volitional access through the hydropower system for anadromous fish; restore habitat						X	X												

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Tacoma Power	Hatchery	Reintroduce coho in upper Cowlitz							X												
Tacoma Power	Hatchery	Reintroduce spring Chinook in upper Cowlitz							X												
Tacoma Power	Hatchery	Reintroduce winter steelhead in upper Cowlitz							X												
Tacoma Power	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz dam and facilities as part of relicensing processes or requirements							X												
Tacoma Power	Hydro	Operate the tributary hydro systems to provide appropriate flows for salmon spawning and rearing habitat in the areas downstream of the hydrosystem						X													
Tribes	Harvest	Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recovery of fall Chinook in fisheries and escapement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tribes	Harvest	Develop a basin wide fish marking plan for hatchery tule fall Chinook that is adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
Tribes	Harvest	Improve tools to monitor and evaluate fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
Tribes	Harvest	Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbi naturally-spawning tule		X	X	X	X	X		X	X	X			X	X	X	X	X	X	

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		fall Chinook and to establish a collaborative US policy position for the international table at the Pacific Salmon Commission																			
Tribes	Harvest	Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead																	X		
Underwood CD	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status															X	X	X	X	X
Underwood CD	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives															X	X	X	X	X
Underwood CD	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids															X	X	X	X	X
Underwood CD	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach															X	X	X	X	X
Underwood CD	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding															X	X	X	X	X

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Underwood CD	Habitat	Protect and restore native plant communities from the effects of invasive species															X	X	X	X	X
USACE	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USACE	Estuary	Mitigate channel dredge activities in the Columbia River estuary and lower mainstem that reduce salmon population resilience and inhibits recovery	X																		
USACE	Estuary	Restore or mitigate for impaired sediment delivery processes and conditions affecting the Columbia River estuary and lower mainstem	X																		
USACE	Estuary	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River	X																		
USACE	Habitat	Address fish passage and sediment issues at the Sediment Retention Structure on the NF Toutle								X											
USACE	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USACE	Habitat	Proactively conduct floodplain restoration on lands being phased out of agricultural production. Survey landowners, build partnerships, and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USACE	Hydro	Establish an allocation of water within the annual water budget for the	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary																			
USACE	Hydro	Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USACE	Hydro	Maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam to support chum reestablishment																X			
USFS	Habitat	Assess the impact of fish passage barriers throughout the Gifford Pinchot NF and restore access to potentially productive habitats							X	X	X	X	X	X	X	X	X	X	X	X	X
USFS	Habitat	Manage federal forest lands to protect and restore watershed processes and habitat conditions							X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Ecol	Continue to manage predation by avian predators, such as Caspian Terns, to avoid large increases in salmon predation while also protecting the viability of predator populations	X																		
USFWS	Ecol	Establish a moratorium on intentional introductions of aquatic species and importation of high-risk species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Ecol	Evaluate positive and negative impacts	X																		

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		of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures																			
USFWS	Ecol	Implement regulatory, control, and education measures to prevent additional species invasions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Ecol	Take proactive steps to control or reduce the impacts of introduced, invasive, or exotic species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Estuary	Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and near shore ocean	X																		
USFWS	Habitat	Identify and initiate habitat restoration projects in Stiegerwald and other wildlife refuges consistent with goals in the salmon recovery plan															X	X			
USFWS	Habitat	Implement existing restoration, protection, and education USFWS programs in the lower Columbia region	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Habitat	Monitor and enforce NF Lewis relicensing agreements relative to passage for Bull Trout and habitat restoration requirements											X	X							
USFWS	Habitat	Monitor, evaluate, and enforce the Stordahl Habitat Conservation Plan													X						
USFWS	Harvest	Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recovery of fall Chinook in fisheries and escapement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Harvest	Develop a basin wide fish marking plan for hatchery tule fall Chinook that is		X	X	X	X	X		X	X	X			X	X	X	X	X	X	

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		adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish																			
USFWS	Harvest	Maintain selective sport fisheries in Ocean, Columbia River, and tributaries and monitor naturally-spawning coho stock impacts	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Harvest	Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbi naturally-spawning tule fall Chinook and to establish a collaborative US policy position for the international table at the Pacific Salmon Commission		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
USFWS	Harvest	Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead																	X		
USFWS	Hatchery	Assess the risks and benefits posed by artificial production programs using WDFW's Benefit-Risk Assessment Procedure (BRAP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Assist in the design hatchery programs to be consistent with region-wide recovery and the ecological context of the watershed, including the characteristics of the habitat and the natural fish populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop additional supplementation programs for chum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop and apply hatchery brood stock	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		watershed transfer policies for chum																			
USFWS	Hatchery	Develop and apply hatchery brood stock watershed transfer policies for spring Chinook							X			X		X							
USFWS	Hatchery	Develop and apply hatchery brood stock watershed transfer policies for steelhead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop coho transfer policies as local brood stock is developed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop criteria for appropriate integration of hatchery and natural populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop criteria for appropriate mix of first generation hatchery spawners and naturally-spawning spawners for each population with hatchery and naturally-spawning fall Chinook production, and reduce first generation spawners as appropriate		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
USFWS	Hatchery	Develop hatchery supplementation programs for coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop local brood stocks for coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop marking programs to assure that hatchery-produced fish to assure they are identifiable for harvest management and escapement accounting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Develop plans for future hatchery programs relationship with reestablished natural-origin spring Chinook populations, including integrated and segregated options.							X			X		X							
USFWS	Hatchery	Document and formalize hatchery operations through the use of the existing Hatchery Genetic Management Planning (HGMP) process	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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USFWS	Hatchery	Establish naturally-spawning production sanctuary areas to be used for coho indicator stock programs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Guide the configuration of hatchery programs with appropriate reform recommendations identified in the Northwest Power and Planning Council's Artificial Production Review and Evaluation (APRE), the Benefit-Risk procedure developed by WDFW, and other tools	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Hatchery brood stock watershed transfer policies for chum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Mark coho hatchery harvest production	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Mark hatchery fall Chinook fish in priority watersheds to promote fishery utilization, facilitate the utilization of natural-origin fish in integrated programs, and enumerate hatchery fish in natural spawning areas		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
USFWS	Hatchery	Mark spring chinook hatchery production for identification and harvest							X			X		X							
USFWS	Hatchery	Operate hatcheries to promote region-wide recovery through the application of appropriate risk containment measures for: 1) hatchery origin adults returning to natural spawning areas, 2) release of hatchery juveniles, 3) handling of natural origin adults at hatchery facilities, 4) water quality and effective disease control, and 5) mixed stock fisheries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Promote public education concerning the role of hatcheries in the protection of natural populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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USFWS	Hatchery	Promote region-wide recovery by using hatcheries as tools for supplementation and recovery in appropriate watersheds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Seek flexibility in current funding to assure hatcheries have the resources to achieve complementary harvest and natural production objectives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Use adaptive management to ensure that hatchery programs to respond to new knowledge of how to further protect and enhance natural production and improve operational efficiencies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Use DNA data to select appropriate brood stock for chum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Use fall chinook juvenile release strategies to minimize naturally-spawning fish interactions		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
USFWS	Hatchery	Use hatcheries for chum enhancement and risk management in the lower Columbia River Gorge																	X	X	X
USFWS	Hatchery	Use hatchery operation strategies to protect Lewis naturally-spawning fall Chinook											X								
USFWS	Hatchery	Use hatchery releases of fall Chinook in watersheds without hatchery programs only occur if necessary for recovery of the natural population		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
USFWS	Hatchery	Use juvenile release strategies of spring Chinook to minimize impacts to naturally-spawning populations							X			X		X							
USFWS	Hatchery	Use juvenile release strategies to minimize interaction with naturally-spawning coho.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
USFWS	Hatchery	Use of hatcheries for chum enhancement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		and risk management																			
USFWS	Hatchery	Use only local watershed fall Chinook broodstock only in hatchery programs		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
USFWS	Hatchery	Utilize facilities for spring Chinook reintroduction efforts							X			X		X							
USGS	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vancouver	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality	X													X	X				
Vancouver	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X													X	X				
Vancouver	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	X													X	X				
Vancouver	Habitat	Limit intensive recreational use of priority stream reaches during critical fish use periods														X	X				
Vancouver	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations; Participate in the development and implementation of a														X	X				

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		regional water source for residents, businesses, and industries within its Urban Growth Boundary																			
Vancouver	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces within urban growth boundaries	X													X	X				
Vancouver	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X													X	X				
Vancouver	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X													X	X				
WADA	Habitat	Assist in the development and promote the implementation of Best Agricultural Practices for the protection and restoration of watershed functions, riparian conditions, habitat and water quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WADA	Habitat	Build upon existing efforts to implement regulatory controls relating to Best Management Practices for agriculture	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wahkiakum Co	Estuary	Protect and restore riparian condition and function	X																		
Wahkiakum Co	Estuary	Restore connectedness between river and floodplain	X																		
Wahkiakum Co	Estuary	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River	X																		
Wahkiakum Co	Habitat	Assess the impact of fish passage barriers throughout the County and restore access to potentially productive			X	X	X														

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		habitats																			
Wahkiakum Co	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X		X	X	X														
Wahkiakum Co	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	X	X	X	X	X														
Wahkiakum Co	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces and limiting the conversion of resource lands to developed uses through land use controls and incentives	X		X	X	X														
Wahkiakum Co	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X		X	X	X														
Wahkiakum Co	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X		X	X	X										X	X			
Wahkiakum Health Districts	Habitat	Assess and require upgrade or replacement of on-site sewage systems that may be contributing to water quality impairment	X		X	X	X														
Washougal	Habitat	Develop and implement stormwater management practices needed to protect	X														X				

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		stream flows and water quality																			
Washougal	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	X														X				
Washougal	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	X														X				
Washougal	Habitat	Manage existing and future water supplies consistent with WRIA 27/28 Watershed Management Plan recommendations															X				
Washougal	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces	X														X				
Washougal	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices	X														X				
Washougal	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	X														X				
WDFW	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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WDFW	Ecol	Consider ecological functions of salmon, including nutrients in establishing escapement goals		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Ecol	Continue to manage predation by avian predators, such as Caspian Terns, to avoid large increases in salmon predation while also protecting the viability of predator populations	X																		
WDFW	Ecol	Continue to manage the northern pikeminnow fishery to help offset increased predation on salmon that resulted from habitat alteration	X																		
WDFW	Ecol	Establish a moratorium on intentional introductions of aquatic species and importation of high-risk species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Ecol	Evaluate positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures	X																		
WDFW	Ecol	Experimentally evaluate nutrient enrichment programs (LLT) and risks using fish from hatcheries or suitable analogs.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Ecol	Implement regulatory, control, and education measures to prevent additional species invasions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Ecol	Manage established populations of introduced gamefish to limit or reduce significant predation or competition risks to salmon, and to optimize fishery benefits within these constraints	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Ecol	Take proactive steps to control or reduce the impacts of introduced, invasive, or exotic species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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WDFW	Estuary	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem	X																		
WDFW	Estuary	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations	X																		
WDFW	Habitat	Assess the impact of fish passage barriers throughout the region and restore access to potentially productive habitats on WDFW lands. Track the location of barriers on SalmonScape	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Assist in evaluation and solution of fish passage and sediment issues at the Sediment Retention Structure on the NF Toutle								X											
WDFW	Habitat	Conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Create and/or restore lost side-channel/off-channel habitat for salmonids	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		increasing incentives (financial or otherwise) and increasing program marketing and outreach																			
WDFW	Habitat	Increase the level of implementation of habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Monitor and enforce fish harrassment laws throughout the region	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Monitor and evaluate hydroelectric licensing for volitional passage, hatchery, and habitat milestones to ensure compliance						X	X				X	X							
WDFW	Habitat	Monitor and evaluate hydro-regulated stream flows in the NF Lewis and Cowlitz Subbasins						X					X								
WDFW	Habitat	Proactively conduct floodplain restoration on lands being phased out of agricultural production. Survey landowners, build partnerships, and provide financial incentives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Habitat	Provide techical assistance to Ecology relative to instream flow rule-making consistent with recommendations of the WRIA 25/26 and WRIA 27/28 Planning Units		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
WDFW	Harvest	Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recovery of fall Chinook in fisheries and escapement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Columbia River Compact agencies will evaluate effectiveness of the current	X	X	X	X	X	X			X	X	X		X	X	X	X			

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		time and area management strategy for chum salmon protection in the commercial fishery																			
WDFW	Harvest	Conduct periodic reviews of fall Chinook harvest relative to habitat productivity and capacity to assure harvest objectives are synchronized with habitat changes		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Harvest	Consider and expressely evaluate sliding scale harvest based on annual abundance indicators for naturally-spawning Columbia River coho		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Consider and expressly evaluate the potential for a sliding scale harvest plan based on annual abundance indicators for tule fall Chinook		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
WDFW	Harvest	Consider recovery goals for lower Columbia salmon and steelhead populations as identified in the Lower Columbia Recovery Plan in annual fishery management processes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Continue to monitor Columbia River selective fisheries and provide estimates of impacts to naturally produced lower Columbia spring Chinook							X			X		X							
WDFW	Harvest	Develop a basin wide fish marking plan for hatchery tule fall Chinook that is adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
WDFW	Harvest	Develop a lower Columbia naturally-							X			X		X							

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		spawning spring Chinook harvest rate plan for management of Columbia River fisheries at such time as significant populations are re-established																			
WDFW	Harvest	Develop a mass marking plan for hatchery tule Chinook for tributary harvest management and for naturally-spawning escapement monitoring		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
WDFW	Harvest	Develop a more detailed process for in-season monitoring of stock specific harvest of fall Chinook in the Columbia River		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Harvest	Develop gear and handling techniques, as well as regulatory options in both commercial and sport fisheries, to minimize selective fishery impacts to naturally-spawning spring Chinook.							X			X		X							
WDFW	Harvest	Develop more specific chum management details for pre-season and in-season management of the late fall commercial fishery	X	X	X	X	X	X			X	X	X		X	X	X	X			
WDFW	Harvest	Ensure that scientific review of Lower Columbia Recovery Plan harvest objectives and current ESA management objectives will occur as part of the process in the above fishery forums	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Establish specific naturally-spawning steelhead encounter triggers for in-season Columbia River fishery adjustments needed to support lower Columbia recovery goals and strategies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Improve tools to monitor and evaluate fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	

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WDFW	Harvest	Maintain selective sport fisheries in ocean, Columbia River, and tributaries and monitor naturally-spawning stock impacts	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Manage Columbia River commercial fisheries by time, area, and gear to target hatchery fish and minimize impacts to naturally spawning spring chinook							X			X		X							
WDFW	Harvest	Manage Columbia River commercial fisheries managed by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Manage Columbia River commercial fisheries managed by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning steelhead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Manage ocean, Columbia River, and tributary fisheries to meet the spawning escapement goal for lower Columbia bright fall Chinook											X								
WDFW	Harvest	Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Monitor and evaluate handling mortality impacts to released naturally-spawning spring Chinook in Columbia River fisheries							X			X		X							
WDFW	Harvest	Monitor chum handle rate in tributary winter steelhead and late coho sport fisheries	X	X	X	X	X	X			X	X	X		X	X	X	X			
WDFW	Harvest	Monitor naturally-spawning steelhead handle rate in tributary salmon and	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		steelhead fisheries																			
WDFW	Harvest	Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Review and evaluate the harvest management strategy developed for protection of naturally-spawning Clackamas late coho to also protect naturally-spawning Washington late coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Review of NOAA Fisheries' recovery exploitation rate of fall Chinook tules and update risk assessment to include more tule populations		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
WDFW	Harvest	Revise or adjust ESA Fishery Management Plans for lower Columbia ESUs as needed to support the Lower Columbia Recovery goals and priorities	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Harvest	Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbi naturally-spawning tule fall Chinook and to establish a collaborative US policy position for the international table at the Pacific Salmon Commission		X	X	X	X	X		X	X	X			X	X	X	X	X	X	
WDFW	Harvest	Seek to maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of fishery rules and regulations for the protection of fish and wildlife resources	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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WDFW	Harvest	Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead																	X		
WDFW	Hatchery	Assess the risks and benefits posed by artificial production programs using WDFW's Benefit-Risk Assessment Procedure (BRAP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Assist in the design hatchery programs to be consistent with region-wide recovery and the ecological context of the watershed, including the characteristics of the habitat and the natural fish populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Continue to enhance Chum enhancement at Grays and Chinook hatcheries			X																
WDFW	Hatchery	Develop additional supplementation programs for chum	X	X	X	X	X	X			X	X	X		X	X	X	X	X	X	X
WDFW	Hatchery	Develop and apply hatchery brood stock watershed transfer policies for chum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop and apply hatchery brood stock watershed transfer policies for spring Chinook							X			X		X							
WDFW	Hatchery	Develop and apply hatchery brood stock watershed transfer policies for steelhead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop coho transfer policies as local brood stock is developed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop criteria for appropriate integration of hatchery and natural populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop criteria for appropriate mix of first generation hatchery spawners and naturally-spawning spawners for each		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	

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		population with hatchery and naturally-spawning fall Chinook production, and reduce first generation spawners as appropriate																			
WDFW	Hatchery	Develop hatchery supplementation programs for coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop local brood stocks for coho	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop marking programs to assure that hatchery-produced fish to assure they are identifiable for harvest management and escapement accounting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Develop plans for future hatchery programs relationship with reestablished natural-origin spring Chinook populations, including integrated and segregated options							X			X		X							
WDFW	Hatchery	Document and formalize hatchery operations through the use of the existing Hatchery Genetic Management Planning (HGMP) process	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Establish naturally-spawning production sanctuary areas to be used for coho indicator stock programs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Guide the configuration of hatchery programs with appropriate reform recommendations identified in the Northwest Power and Planning Council's Artificial Production Review and Evaluation (APRE), the Benefit-Risk procedure developed by WDFW, and other tools	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Hatchery brood stock watershed transfer policies for chum	X	X	X	X	X	X			X	X	X		X	X	X	X	X	X	X
WDFW	Hatchery	Hatchery brood stock watershed transfer	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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		policies for steelhead																			
WDFW	Hatchery	Late winter steelhead brood stock development at Elochoman, Cowlitz, Kalama, and Lewis hatcheries				X		X				X	X								
WDFW	Hatchery	Mark coho hatchery harvest production	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Mark hatchery fall Chinook fish in priority watersheds to promote fishery utilization, facilitate the utilization of natural-origin fish in integrated programs, and enumerate hatchery fish in natural spawning areas		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Hatchery	Mark spring chinook hatchery production for identification and harvest							X			X		X							
WDFW	Hatchery	Mark steelhead harvest production	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Maximize harvest and removal of non-local summer and early winter steelhead						X	X								X				
WDFW	Hatchery	Operate hatcheries to promote region-wide recovery through the application of appropriate risk containment measures for: 1) hatchery origin adults returning to natural spawning areas, 2) release of hatchery juveniles, 3) handling of natural origin adults at hatchery facilities, 4) water quality and effective disease control, and 5) mixed stock fisheries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Promote public education concerning the role of hatcheries in the protection of natural populations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Promote region-wide recovery by using hatcheries as tools for supplementation and recovery in appropriate watersheds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Reintroduce coho in upper Cowlitz and upper Lewis rivers							X					X							

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
WDFW	Hatchery	Reintroduce spring Chinook in upper Cowlitz and Lewis beginning with hatchery supplementation							X					X							
WDFW	Hatchery	Reintroduce winter steelhead in upper Cowlitz and Lewis rivers							X					X							
WDFW	Hatchery	Seek flexibility in current funding to assure hatcheries have the resources to achieve complementary harvest and natural production objectives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Use adaptive management to ensure that hatchery programs to respond to new knowledge of how to further protect and enhance natural production and improve operational efficiencies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Use complementary conservation/harvest programs with local steelhead stocks	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Use DNA data to select appropriate brood stock for chum	X	X	X	X	X	X			X	X	X		X	X	X	X	X	X	X
WDFW	Hatchery	Use fall chinook juvenile release strategies to minimize naturally-spawning fish interactions		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Hatchery	Use hatcheries for chum enhancement and risk management in the lower Columbia River Gorge																	X	X	X
WDFW	Hatchery	Use hatchery operation strategies to protect Lewis naturally-spawning fall Chinook											X	X							
WDFW	Hatchery	Use hatchery releases of fall Chinook in watersheds without hatchery programs only occur if necessary for recovery of the natural population		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Hatchery	Use juvenile release strategies of spring Chinook to minimize impacts to							X			X		X							

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		naturally-spawning populations																			
WDFW	Hatchery	Use juvenile release strategies to minimize impacts to naturally-spawning for steelhead.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Use juvenile release strategies to minimize interaction with naturally-spawning coho.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDFW	Hatchery	Use of hatcheries for chum enhancement and risk management		X	X	X	X	X			X	X	X		X	X	X	X	X	X	X
WDFW	Hatchery	Use only local watershed fall Chinook broodstock only in hatchery programs		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
WDFW	Hatchery	Utilize facilities for spring Chinook reintroduction efforts							X			X		X							
WDFW	Hydro	Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz and Lewis dams and facilities as part of relicensing processes or requirements						X	X				X	X							
WDNR	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDNR	Habitat	Assess the impact of fish passage barriers throughout the region and restore access to potentially productive habitats		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDNR	Habitat	Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDNR	Habitat	Fully implement and enforce the Forest		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats																			
WDNR	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing incentives (financial or otherwise) and increasing program marketing and outreach		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDNR	Habitat	Increase technical support and funding to small forest landowners faced with implementation of Forest Practices Rules to ensure full and timely compliance with regulations		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDOE	All	Participate in the development and implementation of a coordinated regional monitoring program for action implementation, action effectiveness, and biological and habitat status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDOE	Estuary	Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and near shore ocean	X																		
WDOE	Habitat	Assist in the development and promote the implementation of Best Agricultural Practices for the protection and restoration of watershed functions, riparian conditions, habitat and water quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDOE	Habitat	Assist local governments in protecting floodplains from future development through development of Best	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		Management Practices guidelines																			
WDOE	Habitat	Implement priorities of the Watershed Planning Unit regarding TMDLs			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
WDOE	Habitat	Initiate instream flow rule-making in the lower Columbia region consistent with recommendations from the WRIA 25/26 and WRIA 27/28 Planning Units		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WDOE	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)						X								X	X	X			
WDOE	Habitat	Monitor and enforce stream flows in hydro-regulated streams to ensure critical components of natural flow regimes						X					X								
Winlock	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)						X													
Winlock	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach						X													
Winlock	Habitat	Manage existing and future water supplies consistent with WRIA 25/26 Watershed Management Plan recommendations						X													

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Winlock	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces						X													
Winlock	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices						X													
Winlock	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management						X													
Woodland	Habitat	Assess the impact of fish passage barriers within the City's jurisdiction and restore access to potentially productive habitats											X								
Woodland	Habitat	Develop and implement stormwater management practices needed to protect stream flows and water quality											X								
Woodland	Habitat	Expand standards in local land use plans and controls to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)											X								
Woodland	Habitat	Implement the recommendations of the Watershed Planning Unit regarding water quality											X								
Woodland	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach											X								

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
Woodland	Habitat	Manage future growth and development patterns to ensure the protection of watershed processes. This includes reducing effective impervious surfaces											X								
Woodland	Habitat	Prevent floodplain impacts from new development through land use controls and Best Management Practices											X								
Woodland	Habitat	Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management											X								
WRIA 25/26 Planning Unit	Habitat	Implement recommendations of the WRIA 25/26 Planning Unit through identification of funding, coordination, and monitoring of progress			X	X	X	X	X	X											
WRIA 27/28 Planning Unit	Habitat	Implement recommendations of the WRIA 27/28 Planning Units through identification of funding, coordination, and monitoring of progress									X	X	X	X	X	X	X	X			
WSDOT	Habitat	Assess the impact of fish passage barriers throughout the region and restore access to potentially productive habitats	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WSDOT	Habitat	Fully implement the Environmental Mitigation Program consistent with the lower Columbia salmon recovery plan	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Yakama Nation	Habitat	Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing incentives (financial or otherwise) and increasing program marketing and outreach							X					X					X	X	X
Yakama Nation	Habitat	Increase the level of implementation of							X					X					X	X	X

Entity	Type/Threat	Action	Columbia Mainstem	Estuary Tributaries	Grays/Chinook	Elochoman-Skamakowa	Mill-Germany-Abnthy	Lower Cowlitz	Upper Cowlitz	Toutle	Coweeman	Kalama	Lower NF Lewis	Upper NF Lewis	EF Lewis	Salmon	Washougal	Bonneville Tributaries	Wind	L White Salmon	Upper Gorge
		habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding																			

9 Planning Chronology

Lower Columbia Recovery Planning Process

March 1998 The Lower Columbia Fish Recovery Board (LCFRB) is established by the Washington State Legislature to coordinate the development of a regional recovery plan for listed salmon and steelhead in the lower Columbia.

1998-2000 Organizing phase – Developing work plans, securing funding and hiring staff.

June 2000 LCFRB begins watershed planning assessment phase for 2 multi-WRIA planning units

June 2001 LCFRB appoints representatives to the Lower Columbia Recovery Plan Steering Committee to coordinate the Washington side of the recovery plan.

September 2001 Governor Locke appointed representatives from the LCFRB to the Oregon-Washington Executive Committee to oversee the development of the bi-state Willamette/Lower Columbia domain recovery plan.

October 2001 Northwest Power and Conservation Council initiates Subbasin Summary planning.

January 2002 ESA recovery planning, NPCC subbasin planning and watershed planning merge to share information, gather data and develop common goals

Date	Event	Location
1/3/02	L Columbia/Willamette Salmon Recovery Executive Committee-Resources Work Group	Portland
1/4/02	L Columbia Recovery Plan Steering Committee	Vancouver
1/7/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
1/10/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
1/14/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
2/7/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
2/11/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
2/14/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
3/11/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
3/14/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
3/19/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
4/8/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
4/11/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso

Date	Event	Location
4/17/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
5/7/02	NOAA Fisheries LC/W Technical Recovery Team	Portland
5/9/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
5/10/02	L Columbia Recovery Plan Fish Workgroup	Kelso
5/10/02	L Columbia Recovery Plan Habitat Workgroup	Kelso
5/13/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
5/28/02	L Columbia/Willamette Salmon Recovery Executive Committee/Technical Recovery Team	Portland
5/30/02	All Commissioners Meeting	Kelso
6/5/02	Recovery Plan Fish Workgroup	Kelso
6/5/02	Recovery Plan Habitat Workgroup	Kelso
6/10/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
6/13/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
6/13/02	Recovery Plan Program Workgroup	Kelso
6/27/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
7/8/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
7/11/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
7/12/02	Joint Senate Committee	Olympia
7/22/02	L Columbia/Willamette Salmon Recovery Executive Committee-Outreach	Portland
7/23/02	Recovery Plan Program Workgroup	Kelso
7/25/02	Sponsors Workshops - Kelso	Kelso
8/1/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
8/7/02	NOAA Fisheries Technical Recovery Team	Portland
8/8/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
8/12/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
8/27/02	L Columbia Recovery Plan Program Workgroup	Kelso
9/9/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
9/11/02	L Columbia Recovery Plan Steering Committee	Kelso
9/12/02	Grays-Elochoman-Cowlitz Planning Unit	Vancouver
9/16/02	Estuary Planning Group	Portland
9/17/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
9/20/02	NOAA Fisheries - Lewis River Case Study Workshop	Kelso
10/7/02	L Columbia Recovery Plan Program Workgroup	Kelso
10/10/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
10/14/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
10/23/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
11/1/02	L Columbia/Willamette Salmon Recovery Executive Committee - Facilitator Committee	Portland

Date	Event	Location
11/6/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
11/8/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
11/11/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
11/12/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
11/14/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
11/15/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
11/18/02	L Columbia Recovery Plan Habitat Workgroup	Kelso
11/18/02	L Columbia Recovery Plan Program Workgroup	Kelso
11/19/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
11/20/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
11/26/02	L Columbia Recovery Plan Technical Framework Group	Vancouver
12/4/02	Broad Sense Recovery Goals Committee	Longview
12/9/02	Salmon-Washougal-Lewis Planning Unit	Vancouver
12/11/02	L Columbia Recovery Plan Fish Workgroup	Kelso
12/11/02	L Columbia Recovery Plan Habitat Workgroup	Kelso
12/12/02	Grays-Elochoman-Cowlitz Planning Unit	Kelso
12/17/02	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
1/6/03	Broad Sense Recovery Goals Committee	Longview
1/9/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
1/13/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
2/3/03	L Columbia/Willamette Salmon Recovery Executive Committee - Outreach	Portland
2/4/03	Broad Sense Recovery Goals Committee	Longview
2/10/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
2/12/03	Broad Sense Recovery Goals Committee	Longview
2/13/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
2/20/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
2/20/03	L Columbia Recovery Plan Steering Committee	Kelso
2/27/03	Broad Sense Recovery Goals Committee	Longview
2/27/03	Estuary Planning Group	Portland
3/4/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
3/10/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
3/13/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
3/18/03	Broad Sense Recovery Goals Committee	Longview
3/25/03	Broad Sense Recovery Goals Committee	Longview
4/10/03	Grays-Elochoman-Cowlitz Planning Unit	Longview
4/14/03	Salmon-Washougal-Lewis Planning Unit	Kelso
4/15/03	L Columbia/Willamette Salmon Recovery Executive Committee/Technical Recovery Team	Portland

Date	Event	Location
4/22/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
4/22/03	Estuary Planning Group	Portland
5/5/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
5/6/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
5/8/03	Broad Sense Recovery Goals Committee	Portland
5/8/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
5/9/03	ESA Assurances Group Meeting	Olympia
5/12/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
5/13/03	ESA Assurances Group Meeting	Olympia
5/19/03	Broad Sense Recovery Goals Committee	Longview
5/28/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
6/9/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
6/10/03	Broad Sense Recovery Goals Committee	Longview
6/12/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
6/16/03	NOAA Fisheries Technical Recovery Team	Portland
6/19/03	L Columbia Recovery Plan Steering Committee	Kelso
6/25/03	Lower Columbia Recovery Plan Program Workgroup	Kelso
7/1/03	Wahkiakum County Commissioners	Cathlamet
7/2/03	L Columbia Recovery Plan Steering Committee	Kelso
7/7/03	Lewis County Commissioners	Chehalis
7/7/03	Skamania County Commissioners	Stevenson
7/8/03	Cowlitz County Commissioners	Kelso
7/9/03	Clark County Commissioners	Vancouver
7/10/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
7/14/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
7/15/03	Recovery Scenario Adhoc Committee	Longview
7/17/03	Recovery Scenario Adhoc Committee	Longview
7/17/03	NOAA Fisheries Technical Recovery Team	Portland
7/22/03	Broad Sense Recovery Goals Committee	Longview
7/23/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
7/24/03	Estuary Planning Group	Portland
8/5/03	Public Workshop	Toledo
8/6/03	Public Workshop	Longview
8/7/03	Public Workshop	Cathlamet
8/11/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
8/14/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
8/18/03	Public Workshop	Stevenson
8/19/03	Public Workshop	Ridgefield

Date	Event	Location
8/20/03	Clark County ESA Task Force	Vancouver
8/20/03	Public Workshop	Vancouver
8/21/03	Cowlitz County Commissioners	Kelso
8/25/03	Recovery Scenario Adhoc Committee	Vancouver
8/28/03	L Columbia Recovery Plan Steering Committee	Kelso
9/2/03	Recovery Scenario Adhoc Committee	Vancouver
9/8/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
9/8/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
9/11/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
9/15/03	Recovery Scenario Adhoc Committee	Vancouver
9/18/03	L Columbia Recovery Plan Steering Committee	Kelso
9/22/03	Estuary Planning Group	Portland
10/2/03	L Columbia Recovery Plan Steering Committee	Kelso
10/8/03	Recovery Scenario Adhoc Committee	Vancouver
10/9/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
10/13/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
10/14/03	L Columbia Recovery Plan Steering Committee	Kelso
11/4/03	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
11/5/03	Estuary Planning Group	Portland
11/10/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
11/12/03	Estuary Mainstem Expert Science Panel	Vancouver
11/13/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
11/13/03	NOAA Fisheries Technical Recovery Team	Portland
11/17/03	Scenario Evaluation Team (SET) Coast	Cathlamet
11/18/03	Scenario Evaluation Team (SET) Gorge	Carson
11/20/03	Scenario Evaluation Team (SET) Cascade	Longview
12/4/03	L Columbia Recovery Plan Steering Committee	Kelso
12/8/03	Salmon-Washougal-Lewis Planning Unit	Vancouver
12/11/03	Grays-Elochoman-Cowlitz Planning Unit	Kelso
12/17/03	NOAA Fisheries Technical Recovery Team	Portland
12/18/03	Estuary Planning Group	Portland
12/18/03	L Columbia Recovery Plan Steering Committee	Kelso
1/6/04	Cowlitz Tribe	Toledo
1/8/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
1/12/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
1/13/04	Estuary Planning Group	Portland
1/15/04	L Columbia Recovery Plan Steering Committee	Kelso
1/20/04	Estuary Planning Group	Portland

Date	Event	Location
1/21/04	Estuary Oversight Meeting	Portland
1/22/04	WA House of Representatives Capital Committee	Olympia
2/5/04	L Columbia Recovery Plan Steering Committee	Kelso
2/9/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
2/12/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
2/13/04	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
2/18/04	4-H Integration Work Group	Vancouver
2/24/04	NOAA Fisheries Technical Recovery Team	Portland
2/26/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
2/27/04	4-H Integration Work Group	Vancouver
3/1/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
3/2/04	Wahkiakum County Commissioners	Cathlamet
3/3/04	Clark County Commissioners	Vancouver
3/4/04	4-H Integration Work Group	Vancouver
3/4/04	L Columbia Recovery Plan Steering Committee	Vancouver
3/8/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
3/8/04	Project Sponsors Workshop	Stevenson
3/9/04	Skamania County Commissioners	Stevenson
3/9/04	Project Sponsors Workshop	Kelso
3/10/04	Project Sponsors Workshop	Vancouver
3/11/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
3/12/04	4-H Integration Work Group	Vancouver
3/15/04	Lewis County Commissioners	Chehalis
3/16/04	Cowlitz County Commissioners	Kelso
3/16/04	Estuary Oversight Meeting	Portland
3/18/04	L Columbia Recovery Plan Steering Committee	Kelso
3/26/04	Estuary Oversight Meeting	Portland
3/31/04	4-H Integration Work Group	Vancouver
4/1/04	L Columbia Recovery Plan Steering Committee	Kelso
4/8/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
4/12/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
4/19/04	Workshop S Cascade Vancouver	Vancouver
4/20/04	Workshop N Cascade Longview	Longview
4/21/04	Estuary Planning Group	Portland
4/22/04	Workshop Coast Cathlamet	Cathlamet
4/23/04	Workshop Gorge Carson	Carson
5/6/04	L Columbia Recovery Plan Steering Committee	Kelso
5/10/04	Salmon-Washougal-Lewis Planning Unit	Vancouver

Date	Event	Location
5/11/04	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
5/13/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
5/20/04	Lower Columbia Fish Recovery Board Recovery Plan Retreat	Kelso
6/10/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
6/14/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
6/22/04	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
6/30/04	Cowlitz County Commissioners	Kelso
7/2/04	Recovery Scenarios	Longview
7/8/04	NW Power and Conservation Council Independent Science Review Panel	Portland
7/12/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
7/15/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
7/22/04	Cowlitz-Wahkiakum Council of Governments	Kelso
7/29/04	L Columbia/Willamette Salmon Recovery Executive Committee	Portland
8/9/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
8/12/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
9/9/04	Cowlitz County Commissioners	Kelso
9/9/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
9/13/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
9/13/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
9/21/04	WA House of Representatives Environmental Committee	Olympia
9/29/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
10/7/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
10/11/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
10/18/04	Public Workshop Camas	Camas
10/21/04	Public Workshop Mossyrock	Mossyrock
10/25/04	Public Workshop Stevenson	Stevenson
10/26/04	Public Workshop Kelso	Kelso
10/27/04	Public Workshop Cathlamet	Cathlamet
11/1/04	Public Workshop Vancouver	Vancouver
11/3/04	Workshop Agency and Technical Kelso	Kelso
11/8/04	NW Power and Conservation Council Public Hearing	Vancouver
11/9/04	NOAA Fisheries Delisting Criteria and Hatchery Policies Workshop and Public Hearing	Portland
11/18/04	Lewis County Commissioners	Chehalis
11/18/04	Grays-Elochoman-Cowlitz Planning Unit	Kelso
11/22/04	Salmon-Washougal-Lewis Planning Unit	Vancouver
12/10/04	Lower Columbia Fish Recovery Board Recovery Plan Retreat	Kelso

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This section includes a comprehensive list of references including those cited in Volume I of the *Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan* and Technical Appendix A.

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