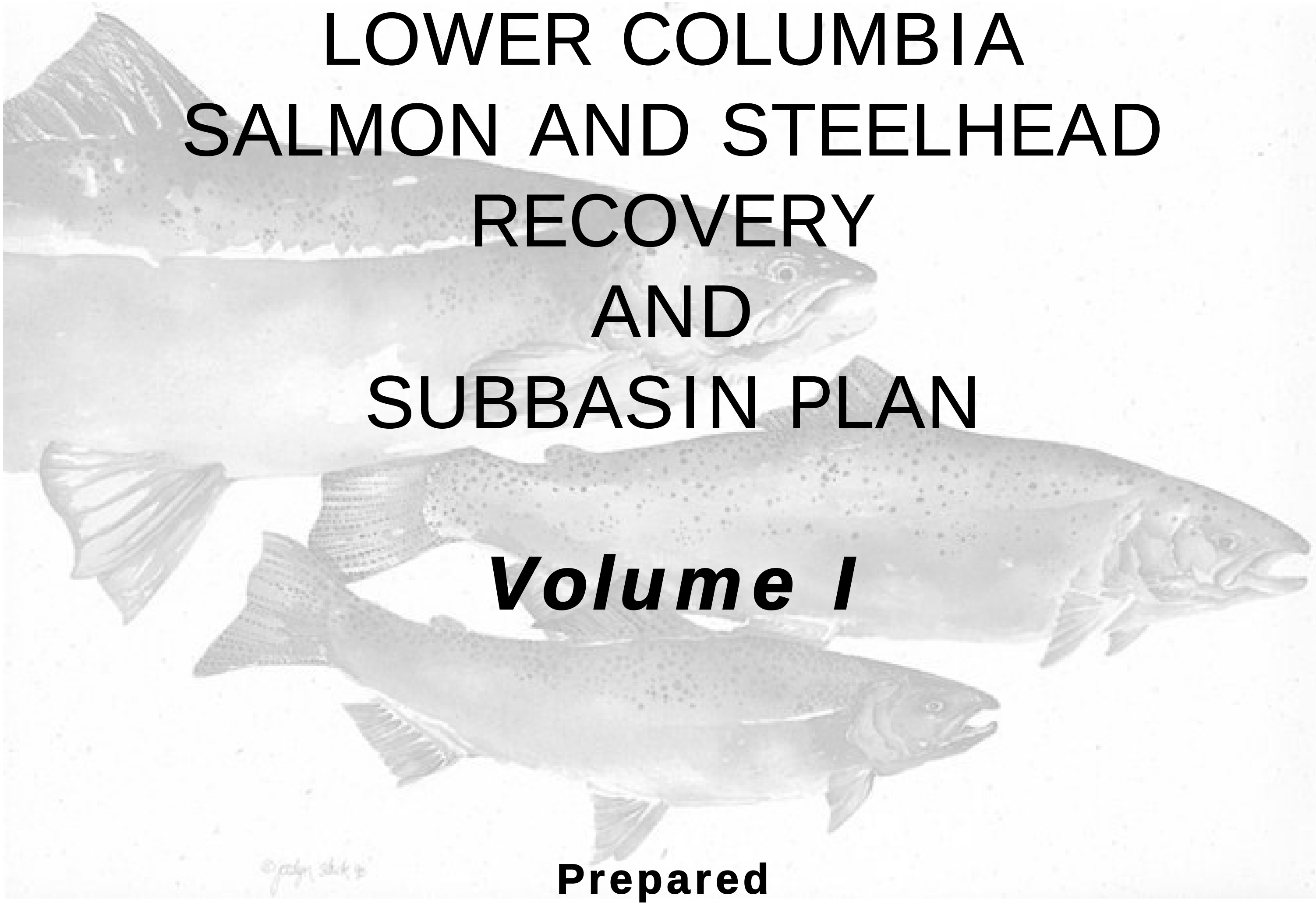

LOWER COLUMBIA SALMON AND STEELHEAD RECOVERY AND SUBBASIN PLAN

Volume I

Prepared For Northwest Power And Conservation Council

MAY 28, 2004
DRAFT

Prepared By:
Lower Columbia Fish Recovery Board

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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John Barnett	Tribal Representative	Cowlitz Indian Tribe	1998-current
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VOLUME I

1 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 a balanced predator/prey relationships.

This Plan serves as a recovery plan for Washington lower Columbia salmon and steelhead populations. It also serves as Northwest Power and Conservation Council Fish and Wildlife Plan for eight full and three partial lower Columbia subbasins.

Salmon and trout of the lower Columbia basin, and its Washington tributaries, have been depleted to the point where wild Chinook salmon, chum salmon, steelhead trout, and bull trout have been listed as Threatened under the federal Endangered Species Act (ESA). Coho salmon are not listed under the ESA, but their numbers are severely depressed, and they are a candidate for ESA listing. Cutthroat trout are also depressed, but are not listed under ESA. 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 tipping the predator balance to the detriment of salmon and steelhead. 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.

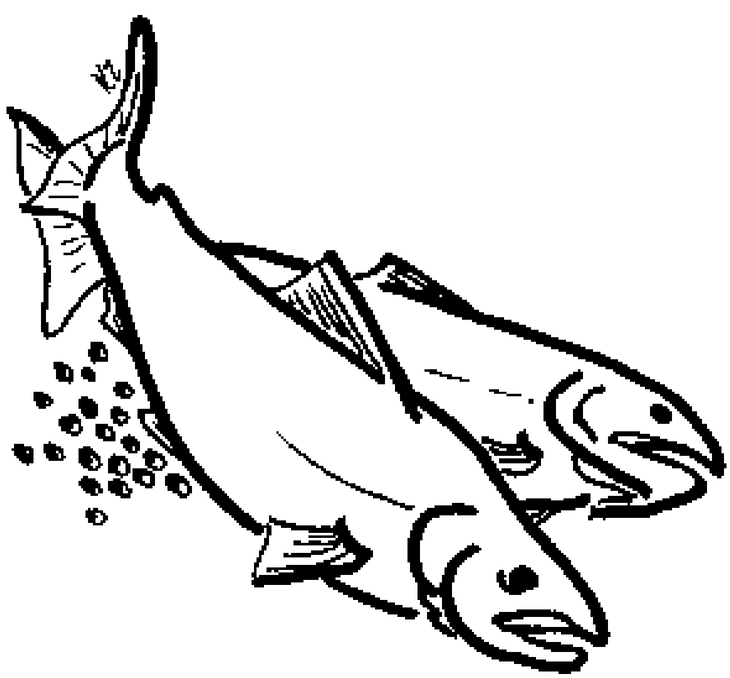
The plan provides:

- A vision for the recovery of salmon and steelhead and for the enhancement of other selected fish and wildlife species.
- An overview of the planning process.
- A brief description of the lower Columbia region and the fish and wildlife species of interest.
- An overview of the threats and factors affecting the health and viability of the species of interest.
- Biological objectives.

- Regional strategies and measures providing a broad framework for achieving the biological objectives. For salmon and steelhead, these strategies and measures address threats and limiting factors across the full life cycle of the fish both within and outside the geographic boundaries of the subbasins. For other fish and wildlife species, the strategies and measures relate only to conditions within the subbasins.
- Plans for monitoring and evaluating progress and for revising or adjusting strategies, measures and actions when necessary in order to achieve biological objectives.
- Detailed subbasin plans. Each subbasin plan provides a vision for the subbasin, a brief description of the subbasin and the species of interest, estimates of the relative impacts of threats and limiting factors on the species, discussion of specific limiting factors and threats and strategies and measures for addressing them. The subbasin plans further provide an analysis of federal, state, and local programs that play a role in implementing the strategies and measures and an implementation plan describing actions to be taken, schedules, priorities, and the responsible agencies and organizations.

The plan is organized into two volumes. Volume I describes the regional elements of the plan. Volume II contains detailed subbasin applications of the regional framework. Vision statements for each of the subbasins that comprise the lower Columbia region in Washington are included in the individual subbasin plans found in Volume II of the plan.

The Plan is accompanied by a Technical Foundation that describes the species of interest in detail, including their current status, life history, the environmental conditions upon which they depend, and threats and limiting factors. It also documents various federal, state, and local programs that play or are expected to play a significant role in achieving the Plan's biological objectives. Finally, the Technical Foundation documents the various analytical methods used to evaluate impact of various threats and limiting factors.



2 Background

2.1 Planning Goal

It is the goal of this planning process to develop 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.

2.2 An Integrated Plan

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

- 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.

2.2.1 ESA Recovery Planning

Because of the declines in abundance, all native salmonid species in the lower Columbia region have been proposed for listing under the ESA. Four species have been listed as "threatened", one is a candidate for listing, and one has been withdrawn from listing consideration:

- The Lower Columbia Chinook salmon Evolutionarily Significant Unit (ESU) was listed as a threatened species 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 officially listed as threatened on March 25, 1999.
- On March 19, 1998, NMFS issued a formal notice listing 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.

- Lower Columbia coho remain a candidate species for a potential ESA listing, with a listing decision pending.
- On June 10, 1998, the Untied 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 Departement 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.
- On May 28, 2004, National Oceanic and Atmopheric Administration (NOAA) Fisheries is expected to issue a draft hatchery policy for listing determinations.

As the listing agency for anadromous salmonids under the ESA, NOAA Fisheries is responsible for developing plans to recover Chinook and chum salmon and steelhead. The USFWS is responsible for developing a bull trout recovery plan. An ESA recovery plan must include:

- Site-specific actions necessary for recovery,
- Measurable criteria (goals) which, when met, would result in removing the species from ESA protection (delisting), and
- Estimates of the time and cost to carry out recovery actions.

NOAA Fisheries desires to develop recovery plans through collaboration involving federal and state agencies, tribes, local governments, and the public. Under the proposed approach, the recovery plans being developed in Washington and Oregon for the lower Columbia ESUs will be combined with the recovery plans being developed for the Willamette ESUs to create a single domain plan. A recovery domain is a collection of geographically proximate ESUs. The Willamette/Lower Columbia Domain includes the three lower Columbia ESUs and two Willamette ESUs. NOAA Fisheries has initiated efforts to develop a single recovery plan for the Willamette/Lower Columbia Recovery Domain. The Willamette/Lower Columbia ESA Executive Committee, comprised of policy-level representatives from federal agencies, tribes, Washington and Oregon agencies, and local governments, is coordinating the overall domain planning effort and will ensure that; 1) the separate Oregon and Washington planning efforts are consistent and compatible, and 2) they will result in a domain plan that meets ESA requirements.

The Lower Columbia Fish Recovery Board (LCFRB) is coordinating the Washington recovery planning efforts for the lower Columbia region. The LCFRB recovery/subbasin plan will eventually be incorporated in the Willamette/Lower Columbia Domain Plan. It is expected that NOAA Fisheries will approve the LCFRB plan as the ESA recovery plan for those areas of the three listed lower Columbia ESUs in Washington, even if Oregon has not completed its plan for the Oregon portions of the ESUs.

The USFWS has authority over bull trout listed as threatened under ESA, as well as federal jurisdiction over cutthroat trout. The Bull Trout Recovery Plan, which covers an extensive geographical area of the western states, is broken down into four Distinct Population Segments, each of which is further broken into recovery units for which mini-recovery plans have been developed. The recovery planning process, coordinated by the LCFRB, will build on the provisions of the USFWS Lower Columbia Recovery Unit plan to ensure that bull trout recovery efforts are woven 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 placed bull trout recovering planning on hold pending the outcome of a 5-year status review of the species, this plan addresses bull trout recovery. The USFWS is a participant in the planning process and providing advice on bull trout matters.

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.

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

2.2.3 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.

2.2.4 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. Development of the strategy has been merged with the recovery planning effort and strategy has evolved into a integral element of the Plan.

2.3 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 2). 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.

Approximately 464,000 people live in the planning area, which includes all of Clark, Cowlitz, Skamania, and Wahkiakum Counties and portions of Lewis, Pacific and Pierce Counties. Thirteen cities are located in the planning area, as well as numerous unincorporated communities.

Several tribes have lands of interest in the planning area. Lands of interest to the Yakama Nation include areas in Cowlitz, Lewis, Clark, and Skamania Counties. The Cowlitz and Chinook tribes also have lands of interest within the lower Columbia region. Within these areas, reserved fishing and hunting rights are exercised, natural resources are co-managed, and tribal trust lands are inhabited.

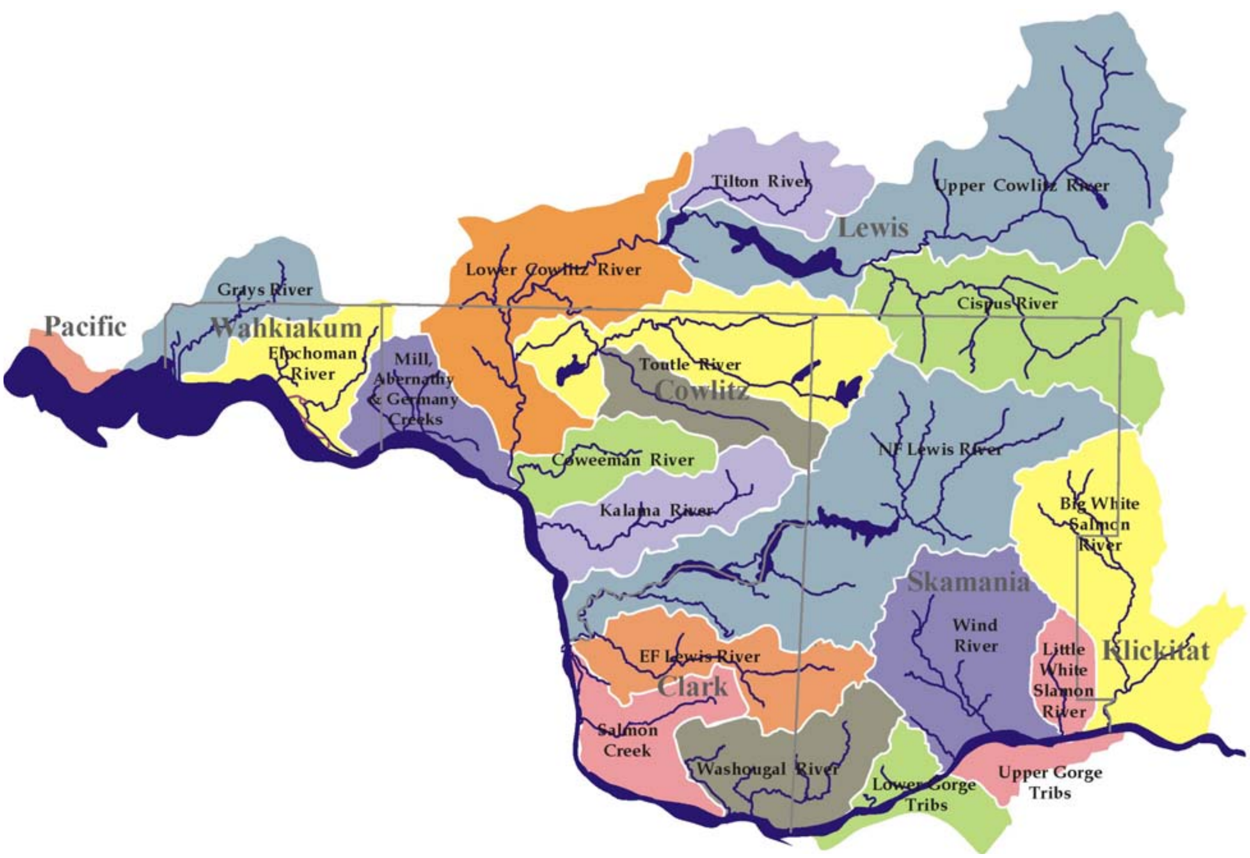


Figure 2-1 Lower Columbia River watersheds (Northwest Power and Conservation Council subbasins.)

2.4 Planning Horizon

The Plan uses a planning period or horizon of 25 years. The goal is to achieve recovery of the listed salmon species and the biological objectives for other fish and wildlife species of interest within this time period. It is recognized, however, full restoration of habitat conditions and watershed process for all species of interest will likely take 75 years or more.

2.5 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 the Plan's Technical Foundation, which focused on 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, sets forth recovery targets and biological goals, and explains the analytical methods used.

The second phase involved the development of the Plan itself. It focuses on the last two of the five questions. In addition to summarizing key information from the Technical Foundation, the plan provides biological objectives; regional and subbasin strategies, measures and actions; implementation plans; and monitoring and adaptive management measures.

In the end, the Plan will provide common goals and a coordinated course of action that is scientifically sound, acceptable to the public, and economically sustainable. Protection, restoration, and enhancement actions will be prioritized to provide maximum benefit and ensure the efficient use of resources. The plan will focus on outcomes and allow implementing agencies and local governments the flexibility to craft innovative, yet scientifically sound, approaches that best fit local conditions and values.

2.6 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 in the process through involvement on the LCFRB, the Recovery Planning Steering Committee (RPSC), planning 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 in the development of estuary and mainstem assessment.

2.7 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. Three 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 possible 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 45-day public comment period will be held on the draft plan. Public workshops will also be conducted.

3 Fish and Wildlife Species

The fish and wildlife species included within the scope of the Plan were selected based on two sets of criteria. As an ESA recovery plan, all ESA listed and candidate salmonid species are included. Other fish and wildlife species were selected for inclusion based on the guidance provided in NPCC *Technical Guide of Subbasin Planners (NPCC 2001). Technical Guide* criteria for selecting species include designation as federal endangered or threatened species; ecological significance; cultural significance; and local significance. Selected species for NPCC subbasin planning purposes are used to characterize the status, functions, and management actions in the subbasin particularly as affected by construction and operation of the federal Columbia River hydropower system.

A species list was developed by the LCFRB and the WDFW based on a review of potential candidates of interest in the eight lower Columbia subbasins in Washington and the three subbasins lying in both Washington and Oregon. 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. All species are addressed with biological objectives and strategies developed for them. Objectives and strategies take different forms due to inherent differences in species significance, ecological interactions, information available, and management structures in place.

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 3-1).

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.

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.

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

Table 3-1. Species included in this plan, listing status, and planning context. Ecological significance refers to species that are important components of the aquatic 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	Listed1	Ecological2	Cultural	Economic2	Recreation
Focal Species					
Fall Chinook	FT	X	X	X	X
Chum	FT	X	X	X	X3
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	X4			
Other Sensitive Species					
Bald Eagle	FT	X	X		
Sandhill Crane	WE			X5	
Dusky Canada Goose				X5	X
Col. Whitetail Deer	FE	X4	X		
Seals & Sea Lions	FT11	X			
Western Pond Turtle	WE				
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		X8	X
American Shad		X7		X	X
Caspian Tern		X6		X	
Osprey		X			
Yellow Warbler		X10			
Red-eyed Vireo		X10			
River Otter		X9			
Species of Recreational Significance					
Walleye7		X		X	X
Smallmouth Bass7		X		X	X
Channel Catfish7		X		X	X

1 Listing status: FT = Federal threatened, FE = Federal endangered, FC = Federal candidate, WE = Washington endangered, WT = Washington threatened.
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 endangered, harbor seals and California sea lions are not listed.

Detailed descriptions of the biology and life history of each species are found in Volume 1 of the Technical Foundation for salmonids and Volume III for other fish and wildlife species; except for river otter, bald eagle, and osprey, which have not yet been incorporated into the

Technical Foundation. The following subsections are intended to briefly describe the life history of each focal species as it relates to potential use of lower Columbia River mainstem and estuary habitats.

3.1 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.

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 3-2. 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	139,000	6,500
Bright fall Chinook	19,000	9,000
Chum	870,000	6,000
Winter steelhead	99,000	3,500
Summer steelhead	28,000	1,500
Coho	434,000	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.

3.1.1 Chinook Salmon

Lower Columbia River Chinook (*Oncorhynchus tshawytscha*) are classified as fall or spring run based on when adults return to fresh water. 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.

Fall Chinook populations occur in most Washington tributaries of the lower Columbia River (Figure 3-1). 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.

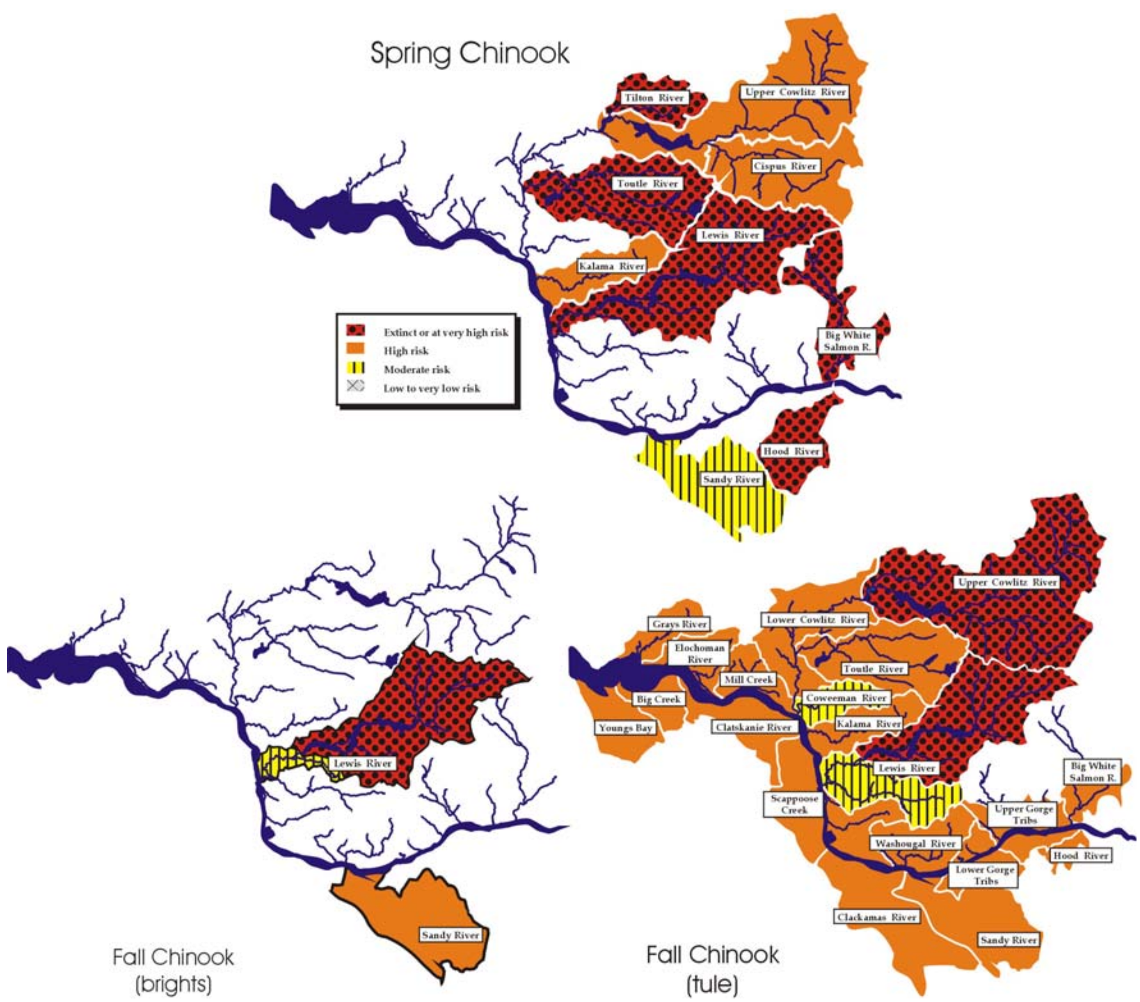


Figure 3-1. Historical demographically independent Lower Columbia Chinook salmon populations in the lower Columbia River ESU and their present status.

3.1.2 Chum Salmon

Chum salmon (*Oncorhynchus keta*) return to the Columbia River in late fall, primarily from mid-October through November. 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.

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 3-2). Chum salmon are presently at significant demographic risk and have likely lost much of their original genetic diversity.

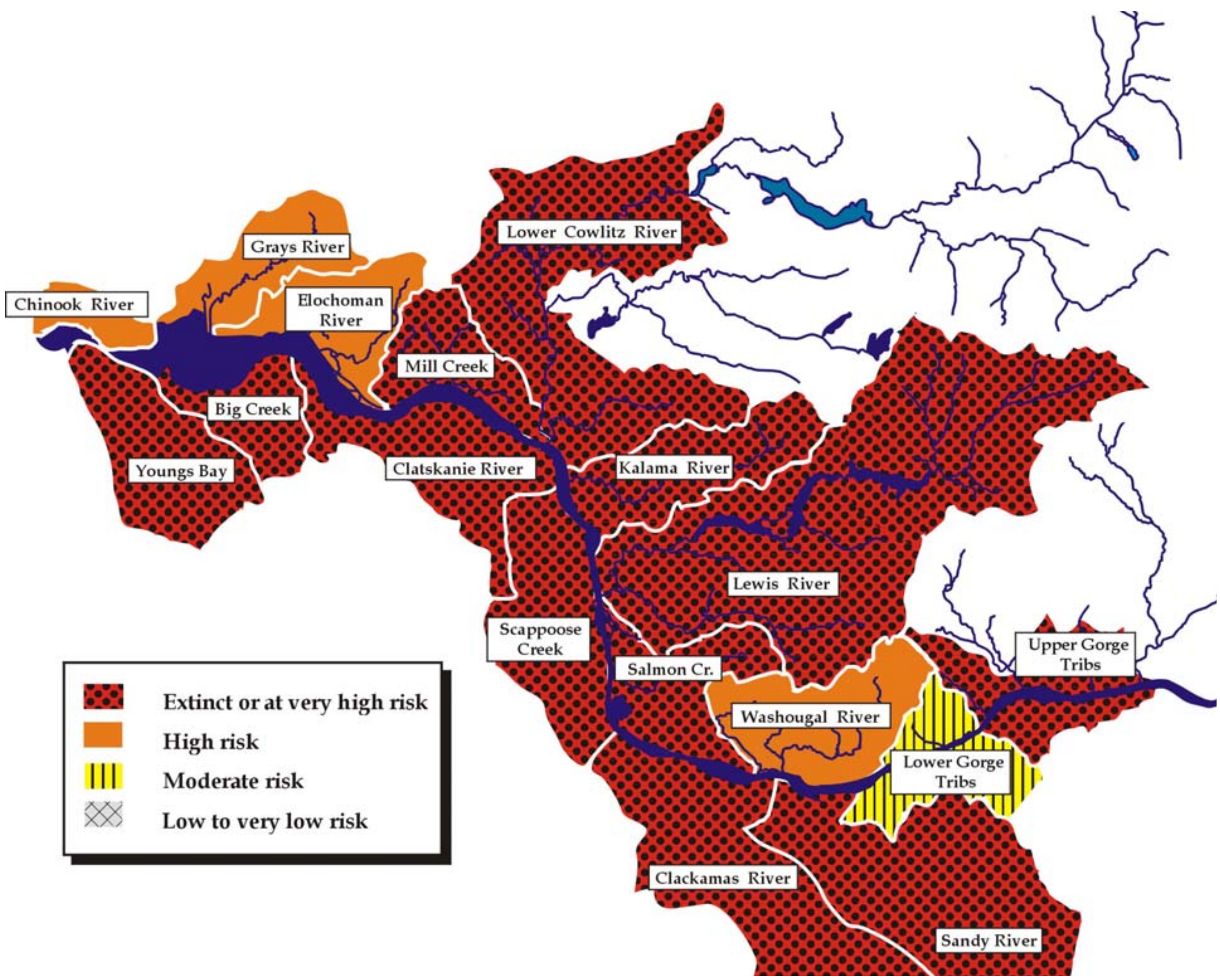


Figure 3-2. Historical demographically independent chum salmon populations in the lower Columbia River ESU.

3.1.3 Coho Salmon

Lower Columbia adult coho salmon (*Oncorhynchus kisutch*) enter watersheds 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: 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.

Historically, coho were present in all lower Columbia River tributaries (Figure 3-3). Currently, very few wild coho salmon spawn in lower Columbia River subbasins. A number of local populations of coho salmon in the area have become extinct, and the abundance of many others is depressed. Until recently, Columbia River coho salmon were managed as a hatchery stock. Present natural coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. Widespread hatchery production with many out-of-basin (but mostly within-ESU) stock transfers has homogenized many lower Columbia River coho 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.

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 remain a candidate species for a potential ESA listing, with a listing decision pending.

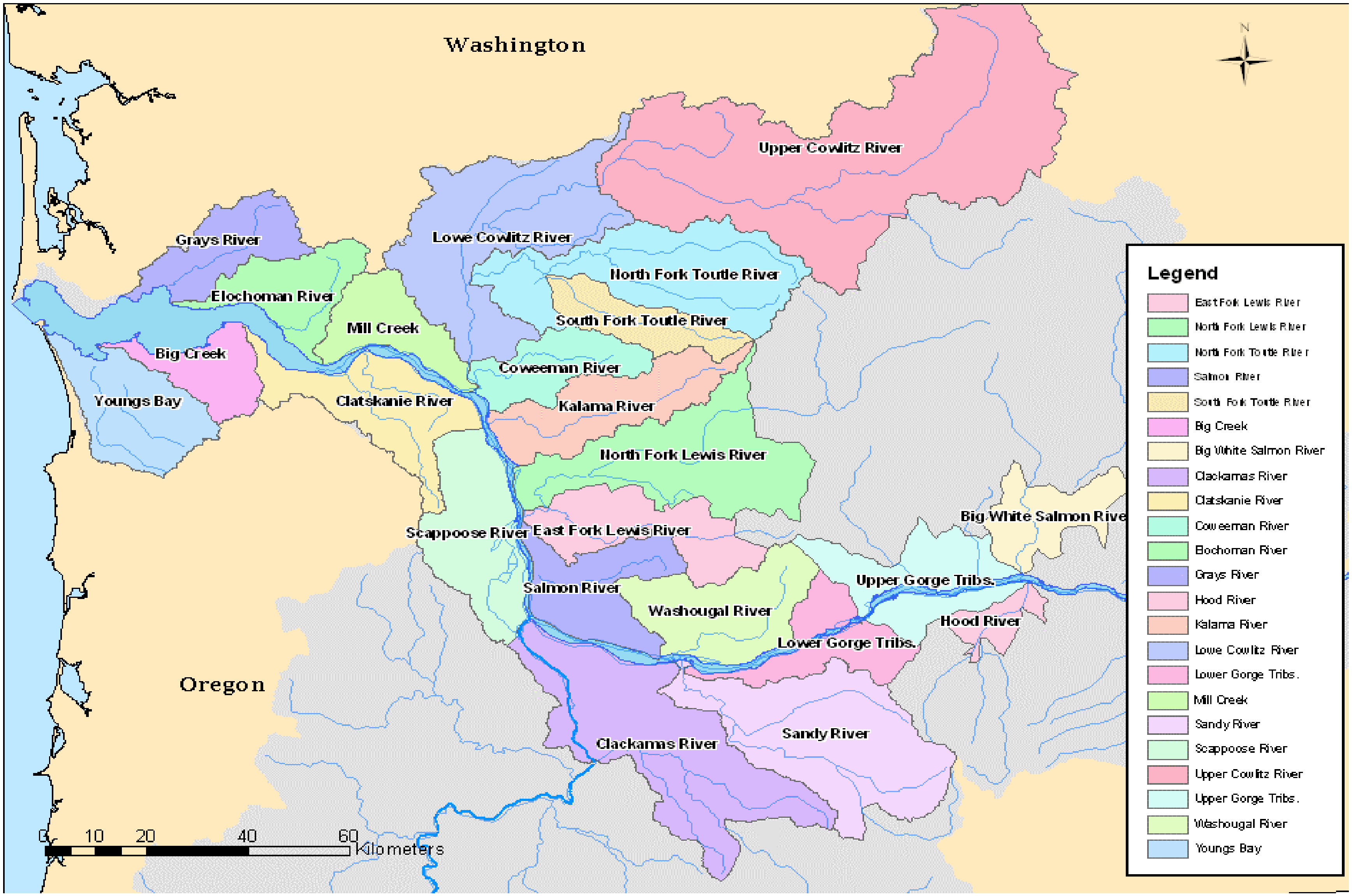


Figure 3-3. Distribution of historical coho salmon populations among Washington lower Columbia River subbasins.

3.1.4 Steelhead

Steelhead (*Oncorhynchus mykiss*) are rainbow trout that migrate to and from the ocean. Lower Columbia River steelhead include summer and winter runs. 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 3-4) 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.

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. 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.

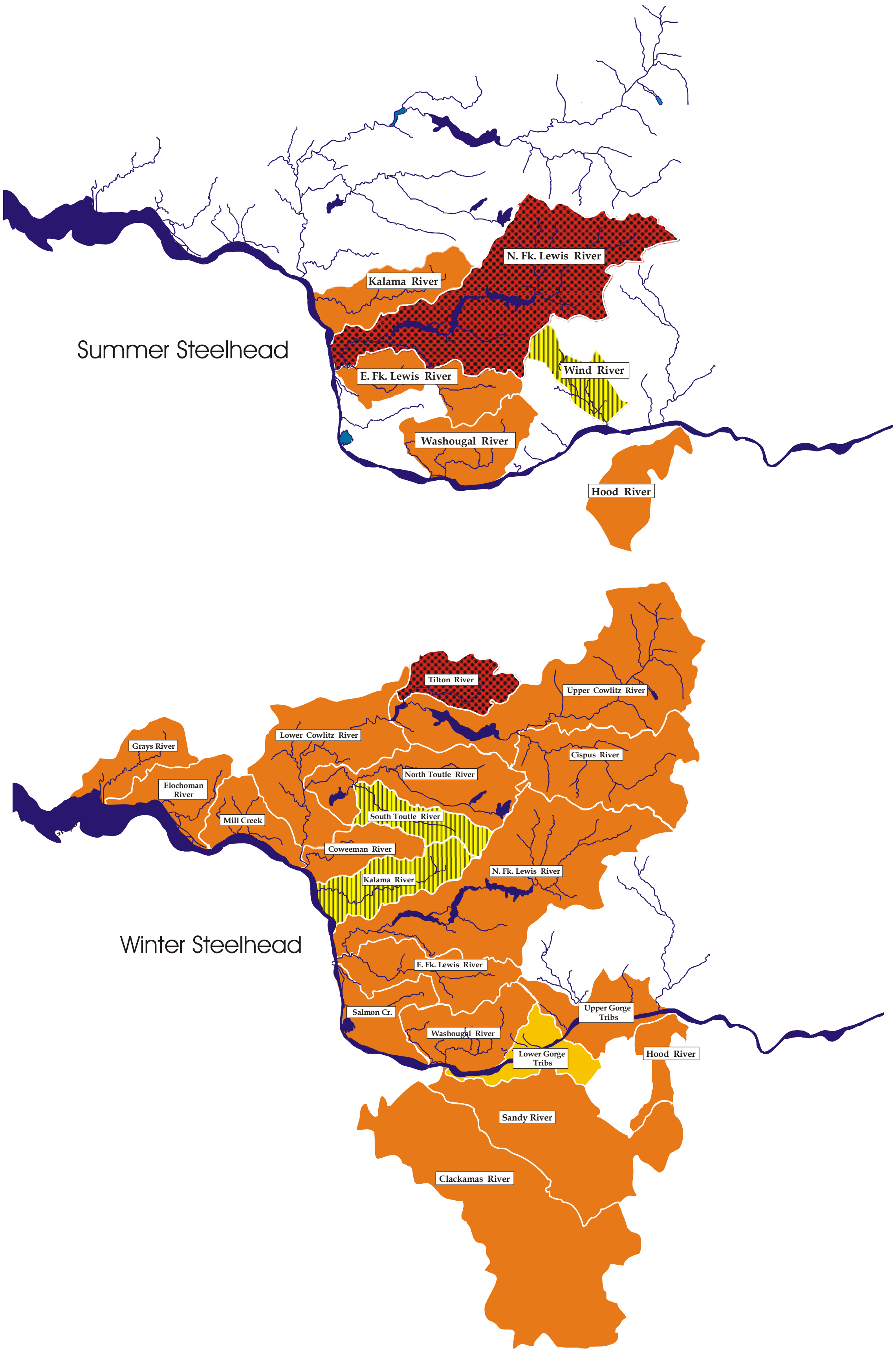


Figure 3-4. Historical demographically independent summer (upper) and winter steelhead (lower) populations in the lower Columbia River ESU.

3.1.5 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. 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.

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.

Bull trout are listed as threatened throughout their range. Because of widespread distribution, isolated populations, and variations in life history, bull trout populations are grouped by Distinct Population Segments (DPS) rather than ESU. Bull trout are also grouped by recovery units, which serve as subsets of a DPS. 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.

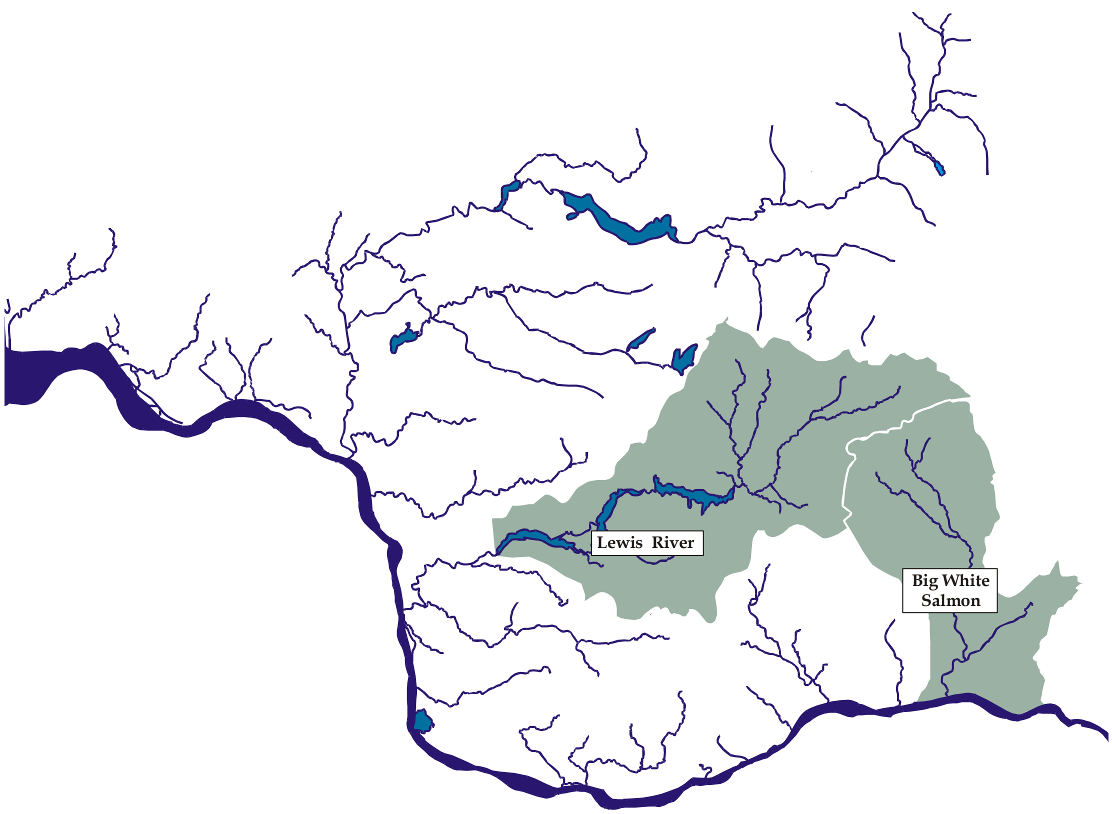


Figure 3-5. Distribution of historical bull trout populations among lower Columbia River subbasins.

3.2 Other Sensitive Species

3.2.1 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 its 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).

3.2.2 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, which continued until passage of the federal Migratory Bird Treaty Act in 1918. Cranes were again found summering in 1972 in Klickitat County, but it was not until 1979 that nesting was confirmed. Up to 1,000 sandhills have wintered on lower Columbia bottomlands in recent years.

3.2.3 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 subbspecies, protect the dusky subspecies, improve habitat on public lands, outline critical habitats for acquisition, and quantify the dollar value of agricultural crop losses.

3.2.4 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), have 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.

3.2.5 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.

3.2.6 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.

3.3 Species of Ecological Significance

3.3.1 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.

3.3.2 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).

3.3.3 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.

3.3.4 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.

3.3.5 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.

3.3.6 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.

3.3.7 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.

3.3.8 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.

3.3.9 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.

3.3.10 Yellow Warbler

Yellow warbler (*Dendroica petechia*) are an excellent indicator of riparian zone structure an 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.

3.3.11 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.

3.3.12 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.

3.4 Species of Recreational Significance

3.4.1 Walleye

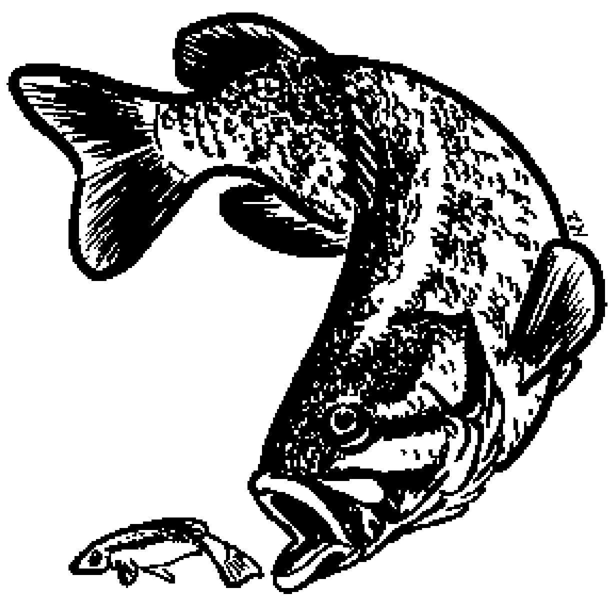
Walleye (*Stizostedium vitreum*) were introduced from the Mississippi River basin into the Grand Coulee area and over the last 40 years have gradually expanded downriver until significant populations are now found throughout the lower Columbia. Distribution in the lower Columbia is patchy. Walleye are 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.

3.4.2 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).

3.4.3 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.



4 Limiting Factors and Threats

The combination of habitat degradation, dam building and operation, fishing, hatchery operations, and ecological changes have conspired, along with natural environmental fluctuations, to reduce and limit lower Columbia River salmonid populations. Other fish and wildlife species have been variously affected – many have decreased but others have increased. Understanding these threats and limiting factors and how they function is essential to the development of the strategies and measures required for recovery as described in Chapter 7 that follows. Thorough overviews of the threats and limiting factors have been provided in Volume I, Chapter 3 of the Technical Foundation. Extensive details of the threats and limiting factors in each subbasin are presented in Volume II of the Technical Foundation.

This chapter summarizes the biologically-based limiting factors and ongoing threats for focal salmon, steelhead, and trout species from two points of view. First, limiting factors are listed according to the biological needs. Then, the topic is addressed from the perspective of threats to those biological needs. By identifying the threats to recovery, specific needs and requirements can be articulated in preparation for determining recovery strategies and measures necessary to alleviate the causes of salmon declines. The limiting factors and threats are described under the broad categories of stream habitats, mainstem and estuary habitat, hydropower, harvest, and hatchery operations. Limiting factors and threats are also summarized for other fish and wildlife species.

4.1 Habitat –Streams

4.1.1 Background

Properly functioning stream habitats are critical for recovering and sustaining healthy populations of salmon 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.

Estimates of current stream habitat capacity to produce salmon and steelhead generally range from 6 to 84% of "properly functioning" benchmark conditions (Table 4-1). 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. Habitat potential is determined by both habitat quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable or optimum habitat for salmon as defined by NOAA Fisheries. PFCs generally represent a reasonable upper bound on the potential for habitat improvement although, in some cases, the large-scale changes required would be difficult to implement (e.g., levee removal). As a general rule, populations may typically be considered viable where properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may also fall short of viability despite properly functioning habitat conditions if distribution has been substantially reduced or out-of-subbasin mortality factors are severe.

Similar estimates of habitat declines do not exist for bull trout. Bull trout prefer cold water and are often most abundant within headwaters areas within 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 4-1. Estimates of fish production from current habitat relative to production if habitat was properly functioning. Current condition of stream habitats for salmon is expressed as a percentage of estimated numbers based on properly functioning conditions as estimated from habitat information using the Ecosystem Diagnosis and Treatment model. Properly functioning conditions are as defined by NOAA Fisheries.

	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.

4.1.2 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. This discussion is concerned with limiting factors at the stream channel scale. These conditions are what the fish experience directly or nearly directly.

Habitat Connectivity

Fish passage barriers that limit access to habitat are a significant factor affecting the life cycle and productivity of many lower Columbia salmonid populations. Barriers that block access to stream habitats primarily include culverts and dams as well as occasional other barriers, such as irrigation diversion structures, fish weirs, beaver dams, road crossings, tide gates, and channel alterations. In some instances, localized impairments such as high temperatures or excessive sediment aggradations cause barriers to fish migration. In many areas, off-channel and estuarine habitats are inaccessible to fish because of levees, roadways, bridges, tide-gates, or by loss of river-floodplain connections. The Sediment Retention Structure on the North Fork Toutle River is a total barrier to salmonids. The hydropower systems on the mainstem Lewis and Cowlitz rivers are responsible for the greatest amount of blocked habitat, although impassable culverts make up approximately 86% of all barriers. (A separate section on the hydropower system is presented below.) 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.

Stream Flow

Current and past land uses, hydro-regulations, water withdrawals, floodplain alterations, and channel manipulations have altered the timing, magnitude, and duration of stream flows in some lower Columbia basins. Altered stream flow patterns have affected aquatic biota in many ways, including increased bed scour from elevated peak flows, reduced summer rearing habitat volume, habitat dewatering (stranding), temperature increases, and impacts to riparian vegetation. Salmon 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).

Water Quality

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. The most widespread water quality impairment in the region is stream temperature, which is particularly sensitive to alterations to stream channels and riparian vegetation. Water quality characteristics that can limit salmonids include:

- Altered stream temperature regimes,
- Reduced dissolved oxygen concentrations,
- Excessive turbidity,
- Chemical contaminants (from point and non-point sources),
- Bacteria, and
- Nutrient over-enrichment.

Substrate and Sediment

Proper substrate and sediment conditions are necessary for spawning, egg incubation, and early rearing of salmonids. Excessive sediment delivered to channels can suffocate salmonid eggs, inhibit emergence of fry from gravels, decrease invertebrate production and feeding success, increase physiological stress, and through adsorption, may facilitate the transport and persistence of chemical contaminants. The effect of fine sediment inputs to stream channels are of particular concern in the lower Columbia region because of land-use practices that have disrupted watershed-scale sediment generation and transport processes. 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.

Habitat Diversity

Salmonids require an array of complex habitat types to carry out freshwater life stages. Fish use pools, riffles, pocket-water, off-channel backwaters, and other habitat types depending on species, life-stage, activity-level, and stream conditions. Structural cover components in the stream channel, including woody debris, boulders, and overhanging banks, contribute to habitat complexity. Habitat diversity can be reduced by:

- Lack of stable instream woody debris,
- Altered habitat unit composition,
- Lack of instream cover components,
- Lack of habitat complexity, and
- Loss of habitat refugia.

Channel Stability

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. Channel stability conditions are impaired in many lower Columbia watersheds because of land-use activities. 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.

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. 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.

Floodplain Function

The interaction of rivers with their floodplains is important for flood flow dampening, nutrient exchange, and maintenance of stream and off-channel habitats. Impairment of floodplain function can alter in-stream, riparian, and off-channel habitats. Floodplain function has been degraded in many lower Columbia River systems, especially along lowland mainstem rivers such as the lower Cowlitz and Lewis. Floodplain alterations that reduce salmon 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.

4.1.3 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 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 past 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 a 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,
- Culvert blockages,
- 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).

4.2 Estuary and Lower Mainstem Habitat

4.2.1 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.

4.2.2 Limiting Factors

The estuary and lower mainstem has important impacts on adult and juvenile salmonid. Adult migration behavior, health, and survival are all affected by conditions at the freshwater:saltwater interface and in lower river mainstem. 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. Connections among these habitats determine whether juvenile salmonids are able to access the full spectrum of habitats they require. Human-induced changes have substantially influenced current habitat conditions in the lower Columbia River mainstem and estuary.

River Flow

Flow effects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower river and estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes. Winter drawdown of reservoirs during winter low flow periods and filling of reservoirs during the spring runoff season has decreased spring freshet magnitude and increased flows over the rest of the year. Reduction of maximum flow levels, dredged material deposition along the shoreline, 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. Moreover, historical springtime overbank flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands; the season when overbank flow is most likely to occur today has shifted from spring to winter. 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,
- Loss of sediment transport,
- Lack of sediment deposition, and
- Reduced large woody debris delivery.

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.

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

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

Connectivity of Habitats

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 salmonid habitat connectivity in the lower mainstem and estuary reduce salmon productivity through:

- 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.

Contaminants

Environmental contaminants have been detected in lower Columbia River water, sediments, and biota at concentrations above available reference levels. 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.

Ecological Interactions

Significant ecological interactions occur in the mainstem and estuary; these interactions are discussed separately in Section 4.6, Ecological Interactions.

4.2.3 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,
- 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,
- 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. 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:

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

4.3 Hydropower

4.3.1 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.

4.3.2 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

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. On the mainstem Columbia, Bonneville Dam affects upstream migration of adults as well as downstream migration of juveniles. Fallback of adult salmon and steelhead after dam passage can be significant, especially during periods of high flow and spill. Recent radiotelemetry data suggests that the upstream passage rate of steelhead and Chinook at Bonneville Dam averages 95-97%. 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. 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. Lower Columbia salmon are limited by hydropower migrational barriers including:

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

4.3.3 Threats

Hydropower operations directly affect fish passage, stream flow patterns, sediment transport dynamics, stream temperature regimes, and stream bank vegetation. 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, negotiate fish ladders with poor success; 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.

4.4 Harvest

4.4.1 Background

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. 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 4-2). 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 4-2. 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-spawning 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.

Week stock management (the practice of limiting fisheries based on annual abundance of particular stocks of concern) of Columbia River fisheries bacame increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction (Table 4-3). In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s.

Table 4-3. 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 4-4). 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 4-4. 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. The 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.

4.4.2 Limiting Factors

The effects of sport, commercial, and tribal ceremonial and subsistence harvests exacerbate lower Columbia salmon and trout natural limiting factors. Fishing generally affects salmon populations through directed and incidental harvest, catch and release mortality, and size, age, and run timing alterations because of uneven fishing on different run components. From a population biology perspective, this causes reduced survival (fewer spawners) as well as chronic alteration of age, size, run timing, fecundity, and genetic characteristics. Most notably, most lower Columbia wild salmon populations are suffering from chronic underescapement. Fewer spawners result in fewer eggs for future generations and diminish marine-derived nutrients delivered via dying adults, now known to be critical to the growth and survival of juvenile salmon in aquatic ecosystems. The degree to which harvest-related limiting factors influence productivity varies by species and location. Generally, 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, and
- Change any of the spawners’ genetic characteristics.

4.4.3 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 actually reduce fishing further, 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 (Table 4-2).

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,
- Pre-spawning mortality, 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:

- High ocean and in-river harvest rates,
- 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,
- Pre-spawning mortality, 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 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,
- Pre-spawning mortality, 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, not one population can be conclusively identified as naturally self-sustaining. 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 catch and retention in sport fisheries,
- Pre-spawning mortality, 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 catch in other sport fisheries,
- Poaching.

4.5 Hatchery

4.5.1 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 4-5). 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 4-5. Summary of current lower Columbia River salmonid release numbers (thousands) in Washington subbasin hatchery programs.

	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.

4.5.2 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. Fish culture programs are also being widely used for restoration of wild populations. However, poorly designed hatchery programs often are detrimental to wild salmon production. Comprehensive analyses of the impacts of hatcheries on wild salmon involve investigating a variety of interactive effects, many poorly understood. However, salmonid hatchery practices clearly compound other natural and human-induced limiting factors such as genetic, ecological, and fishing effects.

Genetic Deterioration

Genetic effects of hatchery practices influence wild fish populations because hatchery fish become genetically different from local wild fish within a few generations. Hatchery fish often exhibit reduced fitness and survival per individual compared to wild fish. Loss of genetic variation within a population generally occurs through either genetic drift or selection. *Genetic drift* is most commonly identified by the loss of rare genes. *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. Domestication selection results from unintentional selection for survival in a hatchery environment. 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. When hatchery fish stray and spawn in the wild, the fitness of natural offspring populations can likewise be reduced. The loss of between-population variation or diversity is a primary genetic risk of introducing non-indigenous fish to wild populations. For example, lower Columbia River wild coho salmon are now genetically indistinguishable from hatchery fish stocked for a number of years in large numbers. Fitness can be further reduced by "outbreeding depression" which occurs from the interbreeding of two genetically diverged populations, such as hatchery fish and wild fish. 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.

Ecological Effects

Because hatcheries allow greater than normal survival, large numbers of individuals that would have died in the natural environment survive to increase competition, predation, and disease proliferation among each other and their wild counterparts. The potential for intra- and inter-specific competition for food or space between hatchery and wild populations depends on the degree of spatial and temporal overlap. Competition and crowding can occur in the return migration corridor, in rearing streams, during downstream emigration, in mainstem reservoirs, in the estuary, and in the ocean. 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 and other predators to the increased numbers of hatchery and natural salmonids. Residualism of hatchery salmon and steelhead is common and increases the effects of competition and predation. The release of large numbers of hatchery fish can alter normal population mechanisms and trigger outbreaks of pathogens in natural fish, both in tributary rearing areas and in mainstem migration corridors. Other factors that limit wild salmon production as a result of hatchery practices include collection of broodstock from the wild, changes to water quality downstream of the hatchery, and blocked access to upstream spawning. Ecological effects from hatchery operations limit wild salmon and steelhead productivity through:

- Intra- and inter-specific competition,
- Inter-specific predation
- Disease spread,
- Water quality changes,

- Limitations to migratory access, and
- Spawners removed from the wild for hatchery broodstock.

Demographic Effects

Demographic effects of hatcheries include both positive and negative effects on survival and reproductive success. Both positive and negative effects must be considered in evaluating the biological risks associated with hatcheries. Increased hatchery survival rates may help bolster depleted populations and provide benefits to wild populations especially where hatchery and wild broodstock are similar. Conversely, hatchery fish may depress wild survival through inbreeding, especially where hatchery fish are less fit. Catastrophic loss is always a risk in hatcheries and can result from disease outbreaks or systems failure. Within-hatchery demographic risks are of particular concern where representative historical populations are primarily contained in the hatchery. Demographic effects include:

- Survival rate,
- Reproductive success, and
- Catastrophic loss.

Facility Effects

Hatchery can sometimes affect wild fish population as a result of facility effects. For instance, hatchery weirs and traps sometimes block passage of wild and hatchery fish into upstream areas to limit disease introduction into the hatchery water source. Ineffective screens at hatchery water intakes might entrain and injure wild juveniles. Hatchery water outfalls can be a source of stream nutrient loading where water is improperly treated. Thus, facility effects include :

- Passage,
- Screening, and
- Water quality.

Fisheries Effects

When hatchery production stimulates harvest effort, naturally produced salmon and steelhead are often captured in the same ocean and river fisheries targeting the hatchery production. Because 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 hatchery population is much less and, therefore, the targeted harvest rate is at times much greater than the commingled wild populations can sustain. Harvest management strategies that were focused on hatchery fish harvest were common practice for several species in the lower Columbia for many years. 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 mass adipose fin-clipped and selective regulations are not in place for fall Chinook fisheries. Hatchery fish produced for harvest can threaten wild populations through:

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

4.5.3 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, and
- Blocked habitat at hatchery facilities.

4.6 Ecological Interactions

4.6.1 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. 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 (see Technical Foundation for additional details).

4.6.2 Limiting Factors

<u>Non-native Species</u>

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.

Food Web

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.

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.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type Chinook salmon to overwhelm the production capacity of estuaries. The lower mainstem and estuarine food base may be “overgrazed” when large numbers of ocean-type juvenile salmonids or large releases of hatchery salmonids enter the area en masse. The intensity and magnitude of competition in estuaries depends in part on the duration of residence of hatchery and natural juvenile salmonids. 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 releases of hatchery salmonids enter the 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. These ecological interactions limit salmon by:

- Reduced juvenile salmonid food base,
- Limitations on freshwater productivity that effects other fish, birds, and mammals,
- Decreased fitness, and
- Reduced survival.

Predation

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the lower Columbia River mainstem and estuary. Predation has always been a substantial source of mortality but is expected to have increased significantly in recent years because the abundance of native predators has increased as a result of anthropogenic habitat change. Piscivorous birds, particularly Caspian tern, congregate in the estuary around man-made islands and consume large numbers of migrating juvenile salmon and steelhead. Native and non-native fishes, particularly northern pikeminnow, prey on juvenile salmonids; predation is highest below mainstem dams. Marine mammals prey on adult salmon. These ecological interactions limit salmon by:

- Juvenile losses to birds and fish, and
- Adult losses to marine mammals.

4.6.3 Threats

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.

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 reduce spawning escapement,
- Decreased fitness from reduced food availability, and
- Reduced survival.

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 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.

4.7 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. Given the diversity of species comprising the category of 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.

Four fish species are relatively abundant throughout the lower Columbia: cutthroat trout, white sturgeon, northern pikeminnow, and American shad. 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. The lower Columbia white sturgeon population is among the largest and most productive in the world. Current sturgeon biomass in the unimpounded lower mainstem appears similar to levels during pristine conditions before significant exploitation in the late 1800s. Factors most responsible for the favorable white sturgeon production are access to marine areas, abundant food resources, large volumes of suitable rearing habitat, and consistently favorable hydrologic conditions during the spawning timeframe, which enhances recruitment. Another fish species currently experiencing high productivity and abundance in the lower Columbia River is the northern pikeminnow. Pikeminnow appear to have benefited from habitat changes within the lower Columbia River. Their abundance in the Columbia basin is highest from the estuary to The Dalles Dam; above The Dalles, abundance decreases significantly. In the lower Columbia, pikeminnow are concentrated around hydroprojects, particularly Bonneville Dam and multiple dams within the Cowlitz and Lewis subbasins. 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.

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. There are two available indicators of Columbia River Pacific lamprey population abundance, however, 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 year (1997-2001) passage counts at Bonneville Dam were low compared to historical passage, but the 2002 passage count approached the historical average. Pacific lamprey Bonneville Dam passage counts are missing from 1970-1996, 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 time period. Nevertheless, 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. As for eulachon, the only available long-term abundance indicator is fishery harvest levels, which, as previously discussed, is a poor estimator of population abundance. Evidence suggests eulachon experienced low run sizes in the 1990s, which appears to be related to low ocean productivity; since 2001 eulachon returns are showing signs of increased abundance. Although limited data are available for eulachon, Columbia River population abundance and viability is believed to be limited by mainstem dam passage difficulties that have restricted access to historical spawning areas and quality and quantity of available spawning habitat in the lower Columbia River ecosystem.

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. 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. 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, primarily because these fish are adapted to lakes and impoundments and their productivity is relatively low in the free-flowing reach below Bonneville Dam. 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. 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 (both historically and currently).

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.

Three avian species native to the region that historically were not present in the lower Columbia River ecosystem are now consistently found in the area because of human-induced habitat change. Caspian terns prefer newly formed, flat, sandy, unvegetated, mid-channel habitat;

this habitat type has become more prevalent in the lower Columbia River as a result of dredge material disposal. 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. The lower Columbia Caspian tern breeding colony is highly susceptible to catastrophic events such as disease, oil spills, or storm events because of its high concentration. 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. 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. Approximately 16,000 dusky Canada goose currently winter in the Willamette Valley and SW Washington.

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. The populations have remained stable because of adult influx from nearby populations. Evidence suggests that bald eagle nesting habitat in Washington may be saturated, based on increasing observations of nesting in developed areas. Osprey appear less selective of breeding sites than bald eagle, as they are often observed nesting on man-made structures such as channel markers or power poles.

Two vastly different species (Columbian white-tailed deer and western pond turtle) have extremely low abundance levels in the lower Columbia River ecosystem. Columbian white-tailed deer are a federal endangered species. Columbian white-tailed deer are concentrated in floodplain and mid-channel islands habitats in the vicinity of Cathlamet, WA, and Westport, OR; they are closely associated with oak/Douglas fir forest within 200 m of a stream/river. Evidence suggests that this habitat type has decreased compared to historical conditions as a result of urban development. The lower Columbia population, which has experienced a long-term decline, was significantly affected by flooding conditions in 1996. The western pond turtle is a Washington state endangered species; they are limited to localized areas within Skamania and Klickitat counties. Reasons for decline include wetland and riparian habitat loss, as well as predation on juveniles by native and introduced species.

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. Both species are abundant elsewhere in the Pacific Northwest and throughout their range. Both species are considered indicators of riparian habitat; 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) while red-eyed vireos are 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.

4.7.1 Other Sensitive Species

Bald Eagle

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). 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 4-6).

Table 4-6. 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

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 4-7). Predation is the primary cause of chick mortality, but intraspecific aggression, drowning, starvation, parasites, and accidents such as fence entanglements and road-kills contribute to losses. Cranes are also affected by grazing and haying practices, water availability and management, and habitat loss. 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 affected by disturbance by hunters and other recreational users.

Table 4-7. 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

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 4-7).

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. Currently, habitat conversion and losses coupled with the low productivity of the population are the most important limitations to the population. Because of their presence in the mainstem and estuary, Columbian white-tailed deer 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 Columbian white-tailed deer. Columbian white-tailed deer limiting factors are addressed more fully in the USFWS recovery plan.

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 such, seals and sea lions are addressed in the Ecological Interactions sections found throughout this Management Plan.

Western Pond Turtle

Little is known about the western pond turtle, but their presence in Skamania and Klickitat counties suggests that they are affected by subbasin habitat limiting factors identified for those areas. Western pond turtles appear to be limited by loss of riparian and wetland habitats, as well as predation by introduced species. Wetland draining, filling, and development eliminated considerable habitat during the past century. The variability of Pacific Northwest weather probably results in high variation of hatching success. 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.

4.7.2 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.

White Sturgeon

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. White sturgeon eggs and juveniles may be susceptible to direct mortality during Columbia River dredging operations (Table 4-8). 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 4-8). 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

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 4-8).

Table 4-8. 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 4-9).

Table 4-9. 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

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 4-10). Although adult lamprey can negotiate waterfalls, they apparently have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile passage systems engineered for salmonids.

Table 4-10. 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), opportunistic predaceous minnow has flourished with habitat changes in the mainstem Columbia River and its tributaries. The larger individuals in the population are considered a predation threat to migrating juvenile salmonids. As such, pikeminnow are addressed in the Ecological Interactions sections found throughout this Management Plan.

American Shad

American shad have flourished in the altered lower Columbia River ecosystem. 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 found throughout 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. Caspian terns nest on bare open ground of islands or beaches. Dredging the navigational channel created several islands in 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 such as disease, oil spills, or storm events.

Osprey

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 4-11).

Table 4-11. 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

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 warbler are likely affected by the same limiting factors included in the mainstem and estuary habitat section addressing salmonids; particularly, yellow warblers are negatively affected by floodplain development and loss of riparian and wetland habitat.

Red-Eyed Vireo

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 vireo are likely affected by the same limiting factors included in the mainstem and estuary habitat section addressing salmonids; particularly, red-eyed vireos are negatively affected by floodplain development and loss of riparian and wetland habitat.

River Otter

River otter are an understudied species 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 otter 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.

4.7.3 Species of Recreational Significance

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. 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 such, they are addressed in the Ecological Interactions sections found throughout 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 such, they are addressed in the Ecological Interactions sections found throughout 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.

5 Scientific Foundation for Recovery

This chapter sets forth 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 Foundation. Now, the next significant step leading toward a recovery plan is to lay out the biological basis for establishing the subsequent recovery objectives, regional strategies and measures, subbasin restoration actions, and an implementation plan. Therefore, this chapter addresses the principles for biological recovery, the salmonid life cycle as an integrating model for recovery, some possible avenues for recovery, and the issue of managing uncertainty.

5.1 Viability and Use Recovery Goals

Recovery planning analyses must address both scientific population viability goals related to the ESA, and societal, cultural, and economic goals related to harvest, and land and resource uses affecting habitat and watershed processes. Population viability goals generally represent minimum standards for fish restoration. These standards signify a level where unique groups of populations are no longer in danger of extinction or threatened with extinction. Beyond viability, goals generally correspond to higher levels of recovery for some fish populations that maintain population viability while also providing additional for additional fish, land or resource uses. The basis for identifying higher recovery goals is much less defined than the basis for population viability goals. Many recovery planning efforts that focus solely on minimum persistence standards do not address use goals other than to limit incidental fishing impacts to achieve desired population levels. Systematic analyses can help clarify the relationships between viability and broader recovery goals, and define bounds for realistic restoration levels.

Recovery efforts can and should aspire to restore salmon to various degrees across a continuum of status levels (Figure 5-1). *Extinction* is the obvious low bound on population status. Extinction typically refers to the irreversible disappearance of a species or, in the case of Pacific salmon, an ESU. Local extinctions of subpopulations are sometimes referred to as *extirpation.* A species or ESU that is not at risk of extinction is typically referred to as *viable*. Viability is also equivalent to having a high likelihood of long-term persistence. The federal ESA qualifies non-viability at two levels: *endangered* with extinction and *threatened* with becoming endangered with extinction. *Capacity* is at the opposite end of the status spectrum from extinction. Capacity is the maximum number of individuals that available habitat and resources can support.

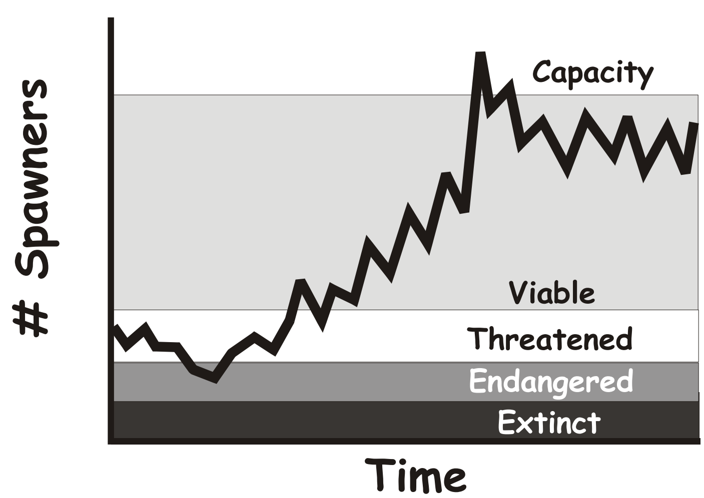


Figure 5-1. Continuum of abundance levels corresponding to various fish recovery standards.

Fish *recovery* refers to the restoration of fish status to some level at or above viability. Specific recovery goals are defined anywhere within the range between minimum viability and the hypothetical capacity of a fully restored habitat (see Chapter 5). From an ESA standpoint, recovery refers to the abundance required for an ESU to not be threatened or endangered with extinction (i.e. the minimum level consistent with viability). However, healthy, harvestable populations require recovery to levels greater than the minimum viability standard. Furthermore, restoration of specific ecosystem functions might require recovery to even higher levels near system capacity.

Recovery targets and criteria for listed salmon and steelhead have been developed in consultation with the NOAA Fisheries Technical Recovery Team (TRT) and the Willamette/Lower Columbia ESA Executive Committee, as described in later sections. Recovery goals and analyses in the LCFRB planning process must address Viable Salmonid Population (VSP) guidelines and corresponding Willamette/Lower Columbia TRT criteria for consistency with federal ESA requirements. The LCFRB process for identifying goals is described in the Biological Objectives chapter below and the detailed methods are described in Chapter 5 of the Technical Foundation.

5.2 Biological Needs

Population viability guidelines for fish abundance, productivity, diversity, and spatial structure and habitat have been identified by NOAA Fisheries based on VSP concepts (McElhany et al. 2000). The VSP concept provides a general framework for analysis of population viability by describing criteria for adult population productivity, growth rate, and abundance, abundant juvenile migrant production, within-population diversity and spatial structure, and healthy freshwater, estuarine, and marine habitats. Fundamental relationships should be addressed 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. These are described more fully in Chapter 6.

5.2.1 Minimum viable populations

Small salmon population sizes are subject to a variety of limiting factors 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. Underlying population processes, as expressed in the VSP, including abundance, productivity, diversity, spatial distribution, and available habitat are intimately related and are the ultimate determinants of whether populations are viable or doomed.

Abundance refers to the population sizes needed for recovery to levels that will ensure long-term persistence and viability and are established based on the buffer needed to avoid the risks of extinction in the face of normal environmental variation. Viable population size guidelines (developed by NOAA Fisheries) 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. 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.

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. Extinction risks depend on the combination of abundance and productivity. For instance, risks might be much less for a highly productive population even at low spawning escapements than for a larger population where productivity is low. Productivity guidelines are reached when: 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.

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. Diversity guidelines 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.

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 increased population viability. Thus, spatial structure guidelines 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.

Habitat quantity and quality, together with the biological attributes, are important determinants of population viability. 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.

5.2.2 Variation among populations within species

While many salmon populations are in danger of extinction, others, such as those in parts of Canada and Alaska, are healthy and can readily sustain fisheries. However, healthy populations are the exception rather than the rule in the Columbia River basin where some populations have already disappeared and others are at or near the brink of extinction. Each salmon species is comprised of many related but different populations, each of which is specifically adapted, naturally selected over hundreds of generations, to the unique local conditions of their natal watersheds and the other habitats they experience during their migratory life. 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. Once lost, the unique features of each population may be gone forever. Therefore, preservation of unique groups of salmon populations is a central tenet in the development of recovery standards.

5.2.3 The difference between wild and hatchery fish

By both design and happenstance, fish produced in hatcheries sometimes intermingle with wild fish in spawning areas and contribute to natural production. Hatchery contributions to wild populations vary widely among species and populations depending on hatchery proximity and practices. Effects of natural spawning by hatchery fish have been controversial and include; 1) reduced fitness and viability of wild populations due to the introduction of domesticated or non-local hatchery fish that are ill-suited to local conditions and 2) the difficulty of accurately measuring numbers and productivity of wild populations where hatchery influence is significant. These concerns can be at odds with the fishery mitigation and conservation values of hatcheries, including preserving genetic stocks where habitat is gone, reintroducing fish in areas where habitat has been restored, and bolstering survival. Where defined in terms of population viability, recovery will depend on sustainable long-term production of wild fish in natural habitats. Populations maintained through a continuing influx of hatchery fish may not be sustainable if they might become extinct whenever the subsidy is removed.

5.2.4 Ocean and climatic variability

Recovery planning can only address factors within human control, but actions to address these factors must be considered in light of the significant effects that ocean variation has on salmon survival. Large fluctuations in salmon numbers during the last several decades have highlighted the importance of ocean conditions in regulating salmon survival and abundance. Healthy populations are able to ride out the declines without lingering effects. Ocean conditions have always varied and always will. 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 decline is the one from which the population cannot recover.

5.3 Biological and social values

Considerations of both biological and social values are implicit in the definition of recovery standards. Definition of appropriate recovery standards will require difficult decisions by policy makers to balance a complex of competing biological and social values. Biological constraints provide the limitations for policy decisions but social values will ultimately drive where within these constraints we aim. Social rather than biological values will increasingly drive definitions of recovery standards as population numbers increase above the minimum viability threshold necessary to safely conserve the species and meet the legal requirements of the ESA. People will care about which standards are specified because each alternative has large implications to different combinations of social, economic, and cultural costs and benefits. Of course, not everyone will agree that different standards above the viability minimum are driven primarily by social rather than biological values. 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. The real pitfall occurs when the biological and social tradeoffs implicit in various standards are not clearly articulated and/or distinguished.

5.4 Accounting for Limiting Factors

The planning process must describe how harvest, hatchery, hydropower, habitat and ecological factors have influenced key fish species in the past, their current impacts, and the anticipated trajectory of these influences. The recovery planning process must weigh all the human-induced effects on mortality at the various life stages, identify how mortality can be reduced overall, and determine how the distribution of mortality may be changed among life stages to meet delisting and other social goals.

Recovery planning analyses must equitably address all human-induced mortality factors that limit fish status and have contributed to fish declines. These factors are sometimes referred to as the four Hs (hatcheries, harvest, hydropower, and habitat), but also include ecological changes like predation and competition from introduced species. Reference to the convenient 4-H label characterization highlights the need to treat all factors limiting recovery in a similar and comprehensive fashion. The comprehensive treatment of factors limiting fish recovery also warrants careful consideration of other influences that are beyond our control, such as environmental conditions including 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 highly variable survival rates. For instance, it would be inappropriate to assume that fish were headed for extinction based solely on abundance and productivity trends during a periodic down-cycle in ocean conditions. Similarly, a conclusion that recovery had been achieved following bumper returns in good ocean years would be equally fallacious. Recovery planning analyses must consider variable ocean conditions as an uncontrollable backdrop to the effects of human activities on salmon. Periodic 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.

Therefore, a comprehensive analysis of all human and environmental factors limiting recovery is needed to ensure the effectiveness of related salmon recovery efforts. For instance, it would do little good to implement aggressive land use limitations to improve tributary stream habitats if benefits are offset by an excessive harvest response. Conversely, reductions in fisheries to improve spawning escapement will not restore fish populations if productivity is continually eroded by declines in freshwater survival. The comprehensive analysis of all factors limiting recovery helps ensure equitability in balancing the costs of salmon recovery among different stakeholders. Without a systematic analytical approach for assessing impacts, discussions of site and action-specific recovery actions are easily confounded by counterproductive finger-pointing. This type of comprehensive analysis was begun in the Technical Foundation and is further described in Chapter 5 of this Management Plan.

5.5 The Salmon Life Cycle – An Integrating Concept

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 5-2). 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. The life cycle approach also provides the means of distinguishing wild and hatchery fish and explicitly evaluating the effects of their interactions. It also incorporates the abundance and productivity elements of the NOAA Fisheries VSP approach.

The life cycle concept is integral to recovery planning because it is the basis for the models used to estimate recovery planning ranges as described in Volume I, Chapter 5, and again in the Biological Objectives chapter that follows. Furthermore, recovery planning at the subbasin/population level must identify the life-stage(s) that limit each population so that specific recovery actions can be determined.

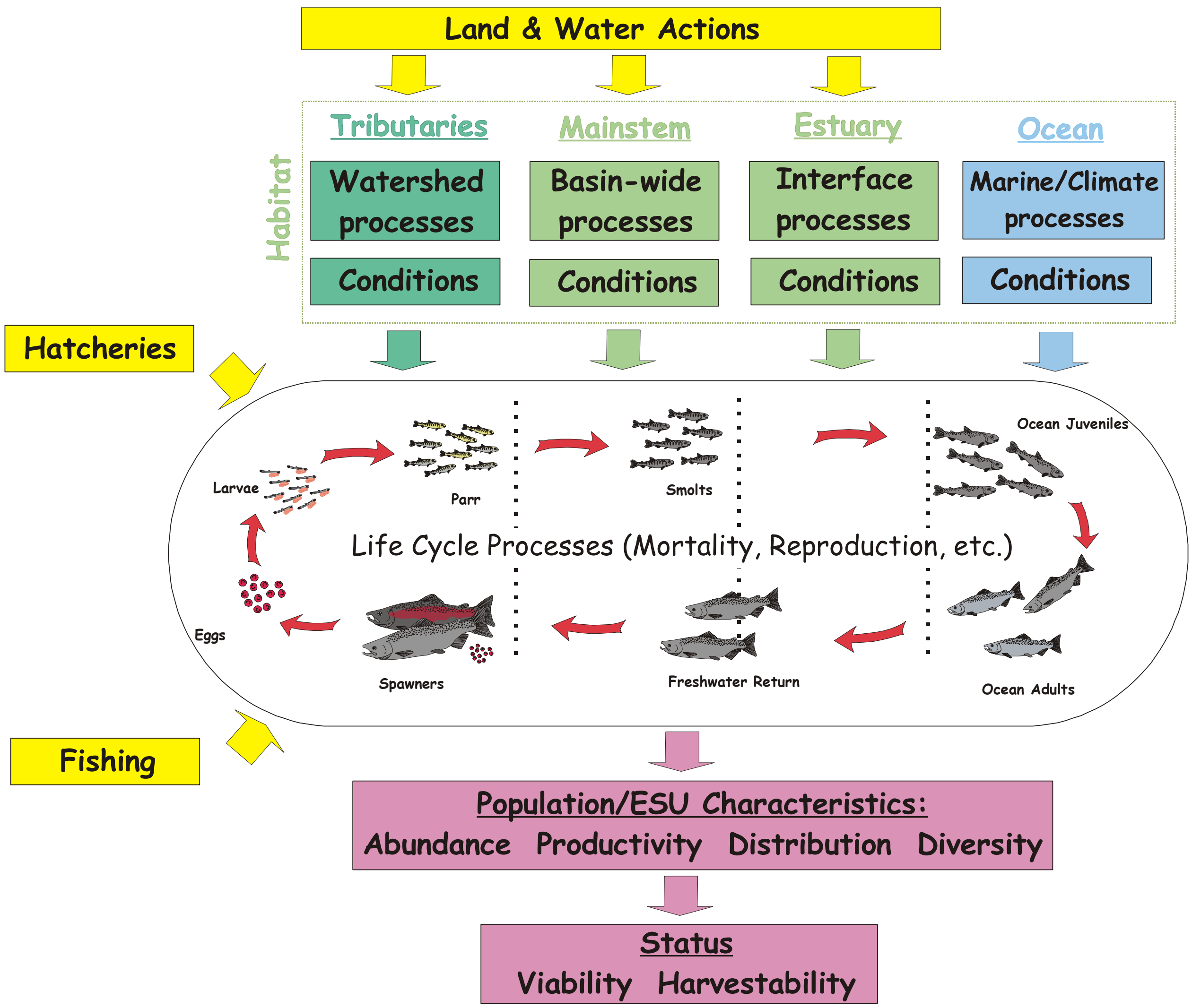


Figure 5-2 The basic salmonid life cycle, indicating how habitat, including dams, fishing, and hatcheries impinge on survival at various stages, and how this integrated process affects the viability and surplus production of the populations.

5.6 Identifying Recovery Measures

Opportunities for recovery must weigh the likelihood of population expansion against the factors that limit the population. In Chapter 5, Volume I of the Technical Foundation, the likelihood of each population's persistence under current conditions was assessed and their potential for rebuilding was ranked. Then the impact factors for each human-induced limitation, tributary habitat, hydro habitat, estuary habitat, hatcheries, fishing, and predation, were quantified for each species in each subbasin. The combination of the rebuilding potential and the impact factors will help to identify the avenues for recovery of each population. In the Biological Objectives Chapter (below), populations are categorized according to their likely ability to contribute to ESU recovery. Then region-wide strategies and measures are identified that, applied case-by-case in subbasins, are expected to lead to successful recovery. In the subbasin chapters that follow, specific remedial measures for habitat, hatchery, and/or fishery management prescriptions can be developed.

5.7 Measuring and Managing Uncertainty

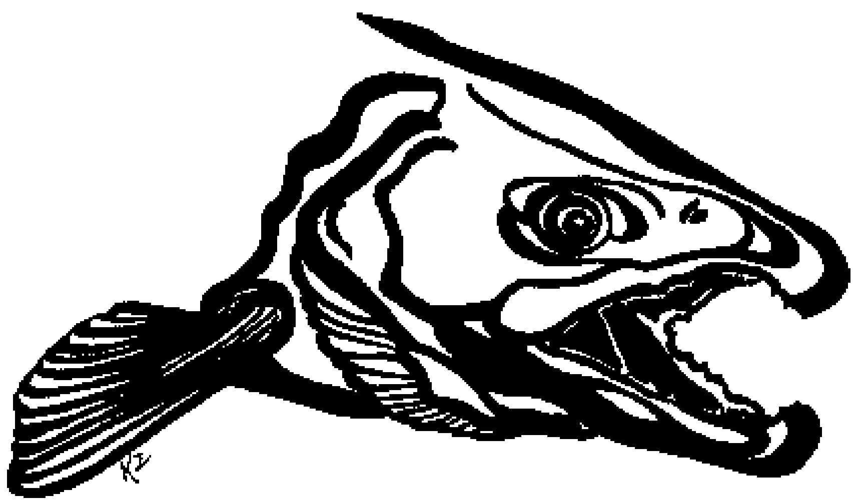
Incomplete human understanding of biological systems, and the effects of human activities and management practices on those systems, necessarily results in uncertainty about the outcomes of the Management Plan. Uncertainty about the outcome of recovery prescriptions will be generally accommodated in several ways. First, the use of planning ranges is a clear representation of the inability to quantify exactly how many fish are expected to be produced by a given subbasin, mainstem, estuary, and ocean habitat combination. Planning ranges will allow achievement of the recovery target without precision. Second, because populations are combined into ESUs for ultimate determinations of recovery (i.e., delisting), the relatively independent capacity for rebuilding in each population allows for some very successful rebuilding in one population to compensate for less rebuilding in another population within the same ESU (see description of Biological Objectives below). Third, uncertainty will also be accommodated through monitoring and research that provides an information feedback loop for modifying prescribed actions to increase the likelihood of recovery. 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.

Expectations for successful recovery management prescriptions 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. Additionally, all models and analytical approaches 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. The monitoring and analyses will provide feedback for management adjustments, as well 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.

Recovery planning and implementation is an imperfect process, however, because inherent uncertainties complicate the process of deriving, deducing, inferring, or interpolating estimates needed to continually characterize and evaluate fish status and limiting factors. To a large degree, detailed descriptions of data quality and uncertainty will be a product of analyses. Significant analysis may be required to quantify the degree of uncertainty and its significance to other inferences. Analyses thus ultimately provide a context for interpretation of data quality and uncertainty.

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. In this recovery planning process, uncertainties will be addressed by the following.

- Explicitly identifying uncertainties and transparently communicating methods, strengths, and limitations of each analysis.
- Incorporating known uncertainties into the risk-based population viability modeling framework for integrated fish life cycle analyses. For instance, expressing ocean survival as a random variable that affects extinction risk incorporates uncertainty in ocean conditions. 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.



6 Biological Objectives

6.1 Recovery Criteria

Biological objectives describe changes needed to achieve the visions set forth in this plan for fish and wildlife species of interest. Where our data and knowledge of a species permit, the objectives provide measurable benchmarks for scaling actions and monitoring progress in protection and recovery. Where our data and understanding are lacking or insufficient, objectives 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 is less than complete. For this reason, it should be expected that objectives will, over time, be refined and sharpened as our knowledge and understanding increase.

This chapter characterizes biological objectives for salmon and steelhead based on: 1) recovery criteria identified by the NOAA Fisheries TRT scientists, 2) a recovery scenario that establishes priorities among populations and subbasins, 3) planning ranges that identify sideboards for population levels consistent with recovery, and 4) incremental improvements needed to meet population objectives prescribed by the scenario. For other fish and wildlife species, objectives 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.

A TRT was convened in 2000 by NOAA fisheries to provide scientific advice for the Willamette/Lower Columbia Recovery Domain. The TRT has identified a series of criteria consistent with restoration of viable ESU of salmon and steelhead listed under the U.S. Endangered Species Act (McElhany et. al. 2003). Under the ESA, NOAA Fisheries must identify measurable and objective delisting criteria as part of recovery planning. The delisting criteria must describe the conditions under which a listed species or ESU is no longer in danger of extinction (endangered) or likely to become so in the foreseeable future (threatened).

The Willamette/Lower Columbia TRT developed recovery criteria based on a hierarchy of ESU, Strata, and Population standards (Figure 6-1). These standards can be distilled to 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, gorge) and life history types (spring run, fall run, etc.).

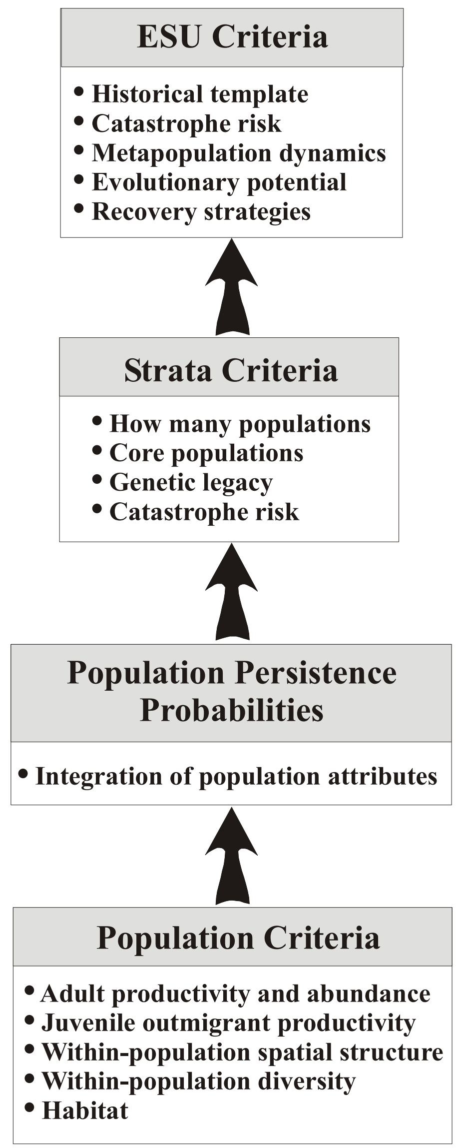


Figure 6-1. Willamette/Lower Columbia viability criteria (from McElhany et al. 2003). The bullets list key considerations involved in each criteria.

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.

ESU criteria developed by the TRT address the overall extinction risk in each species listed under the ESA (Box 1). ESA-listed lower Columbia River ESUs include both Washington and Oregon populations. This recovery plan is focused on Washington lower Columbia River subbasins but also provides a framework for considering Oregon populations in the development of a domain plan.

Strata criteria address representative subunits of each ESU (Box 1). Each ESU consists of two or more strata containing different life history and ecological zone combinations (Figure 6-2). 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.

Population criteria identify features of a viable population (one with high probability of persistence and corresponding low probability of extinction). Populations have been delineated by NOAA Fisheries and the Washington Department of Fish and Wildlife based on a review of current and historical information (Myers et al. 2003). Viability can be related to adult abundance, adult productivity, juvenile abundance, spatial structure, diversity, and habitat conditions (Box 2). These standards were based on the VSP concept developed by NOAA fisheries and incorporate species, population size, population quality, and habitat metrics (McElhany et. al. 2000). These population attributes are highly interrelated. High abundance requires high productivity to rebound quickly from years of poor ocean survival. High productivity depends on good habitat quality and genetic diversity. Spatial structure reflects habitat availability as well as fish numbers.

Box 1. ESU and Strata Level Recovery Guidelines from the Willamette/L. Columbia Technical Recovery Team.

ESU-Level Recovery Strategy Criteria Guidelines

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 Criteria Guidelines

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.

Figure 6-2. 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.

Box 2. Population level viability guidelines 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.

TRT standards also provide an integrated scoring or rating system to project population persistence probabilities from population criteria and to estimate ESU viability based on the status of individual populations in the various strata (McElhany et al. 2003). Each population attribute 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. Attribute scores are averaged to categorize net population persistence level. Additional details on the application of population scoring in this recovery plan can be found in Volume I, Chapter 4 of the Technical Foundation document.

Table 6-1. Population persistence categories used to score fish status relative to recovery criteria guidelines (McElhany et al. 2003).

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-year persistence probabilities.*

TRT viability criteria provide guidelines for recovery planning and a biological framework for how integrated status assessments should be made. Criteria do not anticipate every combination of cases that might be encountered and allow for some flexibility in application consistent with the overarching intent.

6.2 Salmon and Steelhead Recovery Scenario

The recovery scenario is a combination of populations and population attributes that meet recovery standards for all listed species in the region. Salmon recovery standards require preservation and restoration of a representative subset of the populations in each lower Columbia ESU. Not every population of every species needs to be restored to high levels to achieve recovery and delisting pursuant to the U.S. Endangered Species Act (McElhany et al. 2003). Thus, different scenarios may fulfill the biological requirements for recovery.

Different scenarios 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, costs, and tradeoffs. This section describes a preferred scenario that was developed through a collaborative process with a representative group of stakeholders and also describes the approach to scenario development, alternatives considered, and the rationale for selecting the preferred alternative.

The number of populations and corresponding population levels needed to achieve recovery are based on guidelines identified by the Willamette/Lower Columbia TRT. The current status and objectives for populations outlined in the scenario are based on the TRT viability criteria. The criteria take into consideration abundance, productivity (population rate of growth), genetic and life history diversity, spatial distribution, and habitat conditions. The current status of populations was scored by the TRT and the LCFRB. The current status ranking represents an average of the TRT and LCFRB scores.

Consistent with TRT recovery criteria, recovery scenarios designate populations at different levels of restoration. Populations were sorted into three categories. ***Primary populations*** are those that would be restored to high or better probabilities of persistence. ***Contributing populations*** are those where low to medium improvements will be needed to achieve stratum-wide average of moderate persistence probability. ***Stabilizing populations*** are those maintained at current levels. Primary, contributing, and stabilizing populations were identified for all Washington lower Columbia River recovery strata.

Population priorities and improvements identified in the scenario were developed based on biological significance and recovery implementation considerations. These include current viability status, potential for improvement, historical significance, proximity to other selected populations with reference to catastrophic risks, location relative to strata with reduced expectations, expected progress as a result of existing programs, absence of apparent impediments toward recovery, and other management considerations (e.g. fish trapping ability). Thus, primary populations typically include those of high significance and medium viability that can be expected or will be necessary to reach a high level of viability. In instances where factors suggest that a better than high viability level can be achieved, populations have been designated as High^{+}. High^{+} is not equivalent to a Very High rating, but indicates that the population is targeted to reach a viability level at the upper end of the High range. Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery. Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high. Rationales for selection are detailed later in this chapter. Additional details on scenario development methods can be found in the “Alternatives Considered” section (5.3.3).

The scenario does not include current status ranking for Oregon populations. In the scenario, assumptions were made regarding the necessary viability status of Oregon populations that when considered with Washington biological objectives would meet overall strata recovery. These assumptions were developed in consultation with the Oregon Department of Fish and Wildlife. Final biological objectives for Oregon populations will be developed separately, however plans of both states will ultimately be incorporated into a domain-wide recovery plan.

6.2.1 Preferred Alternative

The recovery scenario describes population-scale biological objectives for all species for all three strata in the lower Columbia ESUs (Table 6-2). Recovery criteria identified by the TRT do not require that every population be recovered to high levels of viability. Criteria thus allow efforts to be concentrated in subbasins where benefits can be most effectively achieved. These include subbasins where multiple species benefit from actions. Also included are subbasins where development has not degraded habitat to very poor conditions that might be very costly to reverse.

The scenario restores Washington salmonid populations to at least a medium average viability for each species and each of three recovery strata (Table 6-3, Table 6-4, and Table 6-5). 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 opportunities in the Gorge are limited by the small numbers of populations and uncertainty is high primarily because of constraints imposed by Bonneville Dam. Representative core and legacy populations were included in the scenario via biological significance considerations. Populations not targeted for substantial improvements were designated as stabilizing to recognize the need for significant protection and restoration that ensures no additional declines in status before other recovery goals are met. More than the minimum number of populations and improvement increments consistent with viability have been incorporated into the scenario to provide safety factors should not all attempts prove successful. These additions also compensate for uncertainties in Gorge strata recovery for some species to ensure ESU viability.

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 stratum; the Cowlitz, Kalama, Lewis, and Washougal in the Cascade stratum; and the lower Gorge in the Gorge stratum. Substantial improvements are not required in some severely degraded subbasins although criteria require additional protection and restoration efforts to prevent further declines until recovery of other populations is achieved. Examples include Salmon Creek and the Tilton River.

Recovery will require significant actions in most subbasins because of the distribution of different species and life stages and the risk reduction demands of viability criteria (Figure 6-3). However, different species may be the focus of efforts in any one subbasin. Thus, recovery efforts might concentrate in specific portions of a subbasin and concentrate on specific threats. For instance, spring Chinook reintroduction and recovery into high-quality habitats of the upper Cowlitz and Cispus will be key to meeting objectives for spring Chinook of which only a few populations occurred in the ESU. Multi-species benefits might still accrue from efforts required for specific species.

Table 6-2. Summary of primary (P), contributing (C), and stabilizing (S) designations for each subbasin and population identified in the preferred scenario. X refers to subset of larger population. Primary populations are generally proposed for improvement to high or better levels of viability, contributing populations to moderate levels, and stabilizing populations maintained no lower than current levels. Primary populations identified for greater than high viability objectives are denoted with an '*'. Dashes indicate species is not present.

PREFERRED RECOVERY SCENARIO								
		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*	P[1]	--	P
	Mill/Abernathy/Germany	C	--	--	P	C[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	--	S	--	S
	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	S
	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

[1] *Not listed under U.S. Endangered Species Act.*

Figure 6-3. Numbers of primary, contributing, and stabilizing populations in each subbasin for lower Columbia River salmon recovery strata.

Table 6-3. Current population viability and targets in the Coast Strata corresponding to a preferred salmon and steelhead recovery scenario. Population designations are Primary (black box), Contributing (grey box), and Stabilizing (unshaded).

Watershed	Tule Fall Chinook		Chum		Winter Steelhead		Coho	
	Now	Goal	Now	Goal	Now	Goal	Now	Goal
Grays/Chinook	L^+	H	L^+	H^+	L^+	H	L	H
Elochoman/Skamokawa	L^+	H^+	L	H^+	L^+	M	L	H
Mill/Abernathy/Germany	L	M	VL	H	L^+	H	L	M
Youngs Bay (OR)	*na*	*L*	*na*	*H*	*na*	--	*na*	*L*
Big Creek (OR)	*na*	*L^+*	*na*	*L*	*na*	--	*na*	*H*
Clatskanie (OR)	*na*	*H*	*na*	*M*	*na*	--	*na*	*L*
Scappoose (OR)	*na*	*L*	*na*	*L*	*na*	--	*na*	*H*
No. populations	**7**	**7**	**7**	**7**	**7**	**3**	**7**	**7**
Average	**L**	**M**	**L**	**M^+**	**L**	**M^+**	**na**	**M**
No. rated high (H) or greater	**0**	**3**	**0**	**4**	**0**	**2**	**na**	**4**

1. *Status designations are those used in the TRT viability criteria and represent composite of abundance, productivity, diversity, spatial distribution, and habitat factors:*
   VH – Very High Probability of Persistence (99% or greater) over 100 years.
   H – High Probability of Persistence (95% to 99%) over 100 years.
   M – Medium Probability of Persistence (75% to 95%) over 100 years.
   L – Low Probability of Persistence (40% to 75%) over 100 years.
   VL – Very Low Probability of Persistence (0% to 40%) over 100 years.
2. *In the absence of coho status scores, WA coho populations were scored at low or very low probability of persistence.*
3. *OR primary populations were assumed based on levels needed to achieve strata requirements. No assumptions were made regarding the feasibility of achieving high viability. If there were no OR primary populations for a species, the OR populations were assumed to target a medium level of persistence.*
4. *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.*

Table 6-4. Current population viability and targets in the Cascade Strata corresponding to a preferred salmon and steelhead recovery scenario. Population designations are Primary (black box), Contributing (grey box), and Stabilizing (unshaded).

Watershed	Fall Chinook tule		Fall Chinook bright		Spring Chinook		Chum		Winter steelhead		Summer steelhead		Coho	
	Now	Goal	Now	Goal	Now	Goal	Now	Goal	Now	Goal	Now	Goal	Now	Goal
L. Cowlitz	L+	M	--	--	--	--	VL	M	L	M	--	--	L	H
U. Cowlitz	VL	VL	--	--	L	H+	--	--	L	M	--	--	VL	M
Cispus	--	--	--	--	L	H+	--	--	L	M	--	--	VL	M
Tilton	--	--	--	--	VL	VL	--	--	VL	L	--	--	VL	L
Toutle (SF)	xx	xx	--	--	VL	M	--	--	M	H+	--	--	L	H
Toutle NF	L	L	--	--	xx	xx	--	--	L	H	--	--	L	H
Coweeman	M	H+	--	--	--	--	xx	xx	L+	H	--	--	L	H
Kalama	L+	H			VL	H	VL	L	M+	H+	L+	H	L	M
NF Lewis	--	--	M+	H+	VL	H	xx	xx	L	M	VL	VL	VL	M
EF Lewis	M	H+	--	--	--	--	VL	H	L+	H	L+	H	L	H
Salmon	VL	VL	--	--	--	--	VL	VL	L	L	--	--	VL	VL
Washougal	L+	H	--	--	--	--	L	H+	L+	M	L+	H+	L	M
Sandy (OR)	*na*	*L+*	*na*	*H*	*na*	*H*	*na*	*H*	*na*	*H*	--	--	*na*	*H+*
Clackamas (OR)	*na*	*M*	--	--	--	--	*na*	*M*	*na*	*H*	--	--	*na*	*H+*
No. pop.	**10**	**10**	**2**	**2**	**7**	**7**	**7**	**7**	**14**	**14**	**4**	**4**	**14**	**14**
Average	**L**	**M+**	**M**	H+	**VL**	**M+**	**VL**	M	**L**	**M+**	**L**	**M+**	**na**	**M+**
No. ≥ H	**0**	**4**	**0**	**2**	**0**	**5**	**0**	**3**	**0**	**7**	**0**	**3**	**na**	**7**

1. *Status designations are those used in the TRT viability criteria and represent composite of abundance, productivity, diversity, spatial distribution, and habitat factors:*
   VH – Very High Probability of Persistence (99% or greater) over 100 years.
   H – High Probability of Persistence (95% to 99%) over 100 years.
   M – Medium Probability of Persistence (75% to 95%) over 100 years.
   L – Low Probability of Persistence (40% to 75%) over 100 years.
   VL – Very Low Probability of Persistence (0% to 40%) over 100 years.
2. *xx indicates where TRT populations include several watersheds.*
3. *In the absence of coho status scores, WA coho populations were scored as low or very low probability of persistence.*
4. *OR primary populations were assumed based on levels needed to achieve strata requirements. No assumptions were made regarding the feasibility of achieving high viability. If there were no OR primary populations for a species, the OR populations were assumed to target a moderate level of persistence.*

Table 6-5. Current population viability and targets in the Gorge Strata corresponding to a preferred salmon and steelhead recovery scenario. Population designations are Primary (black box), Contributing (grey box), and Stabilizing (unshaded).

Watershed	Tule fall Chinook		Spring Chinook		Chum		Winter steelhead		Summer steelhead		Coho	
	Now	Goal	Now	Goal	Now	Goal	Now	Goal	Now	Goal	Now	Goal
L. Gorge	L	M	--	--	M^+	H^+	L^+	H	--	--	L	H
U. Gorge	L	L	--	--	VL	M	L^+	M	M^+	H^+	L	H
White Salmon	L	M	VL	L	--	--	--	--	--	--	VL	L
Hood (OR)	*na*	*L^+*	*na*	*H*	--	--	*na*	*H*	*na*	*H*	*na*	*M*
No. populations	**4**	**4**	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**na**	**4**
Average	**L**	**M−**	**VL**	**M^+**	**L**	**M^+**	**L**	**M^+**	**L**	**H**	**na**	**M**
No. rated high or greater	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**0**	**2**	**na**	**2**

1. *Status designations are those used in the TRT viability criteria and represent composite of abundance, productivity, diversity, spatial distribution, and habitat factors:*
   - *VH – Very High Probability of Persistence (99% or greater) over 100 years.*
   - *H – High Probability of Persistence (95% to 99%) over 100 years.*
   - *M – Medium Probability of Persistence (75% to 95%) over 100 years.*
   - *L – Low Probability of Persistence (40% to 75%) over 100 years.*
   - *VL – Very Low Probability of Persistence (0% to 40%) over 100 years.*
2. *In the absence of coho status scores, WA coho populations were scored at low or very low probability of persistence.*
3. *OR primary populations were assumed based on levels needed to achieve strata requirements. No assumptions were made regarding the feasibility of achieving high viability. If there were no OR primary populations for a species, the OR populations were assumed to target a moderate level of persistence.*

6.2.2 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

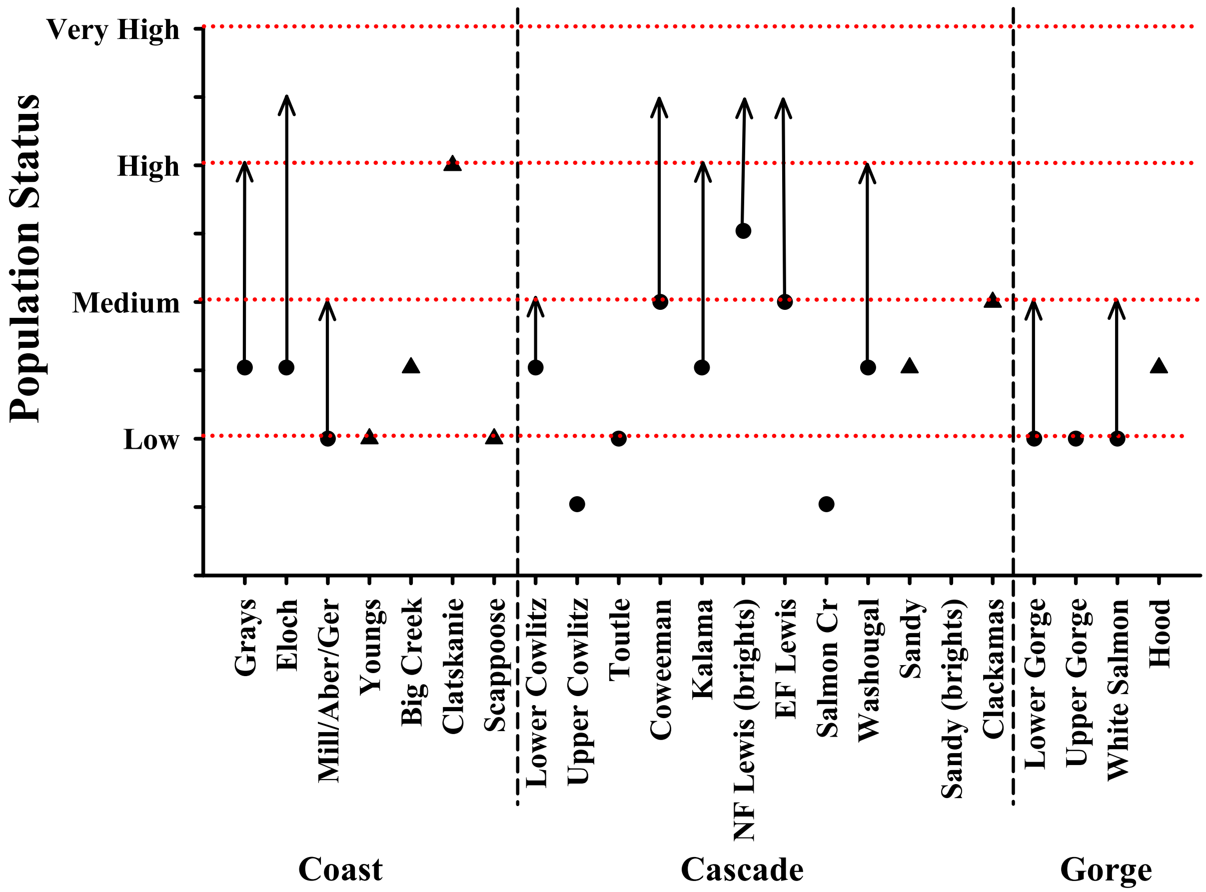


Figure 6-4. Improvements in population viability for fall Chinook corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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.

Grays (Primary, High) – 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.

Elochoman (Primary, High$^+$) – Elochoman fall Chinook population were targeted for High+ status to address ESU and coast strata risks in meeting tule fall Chinook recovery criteria. 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. Additionally, the current habitat condition is better than many other watersheds for fall Chinook.

Mill/Abernathy/Germany (Contributing, Medium) – Mill/Abernathy/Germany tule fall Chinook population targeted for medium status in response to current adult spawning return information. 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.

Lower Cowlitz-Below Mayfield Dam (Contributing, Medium) – 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.

Upper Cowlitz-Above Mayfield Dam (Stabilizing, Very Low) – Upper Cowlitz fall Chinook population (upstream of Merwin Dam) 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.

Toutle (Stabilizing, Low) – 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.

Coweeman (Primary, High$^+$) – 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.

Kalama (Primary, High) – 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.

<u>*NF Lewis (Primary, High+)*</u> – 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.

<u>*EF Lewis (Primary, High+)*</u> – 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.

<u>*Washougal (Primary, High)*</u> – 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.

<u>*Lower Gorge-Below Bonneville Dam (Contributing, Medium)*</u> – 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.

<u>*Upper Gorge-Above Bonneville Dam (Stabilizing, Low)*</u> – 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.

<u>*White Salmon (Contributing, Medium)*</u> – 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 Chinook 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

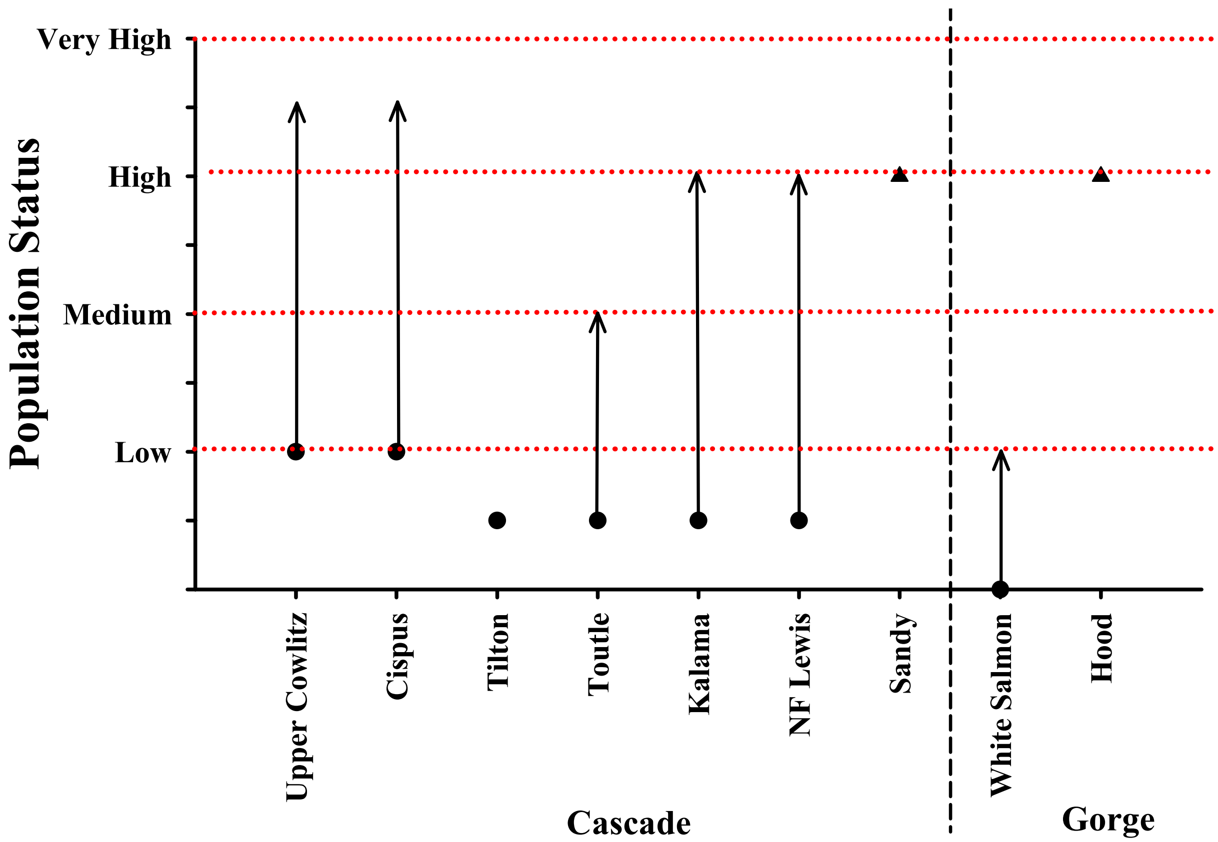


Figure 6-5. Improvements in population viability for spring Chinook corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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.

<u>Toutle (Contributing, Medium)</u> – 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.

<u>Kalama (Primary, High)</u> – 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.

<u>White Salmon (Contributing, Low)</u> – This population was historically significant but is currently extinct. Reintroduction would include use of an outside stock (most likely Klickitat, which is outside the lower Columbia ESU) and would require passage upstream of Condit Dam. 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.

<u>Chum</u>

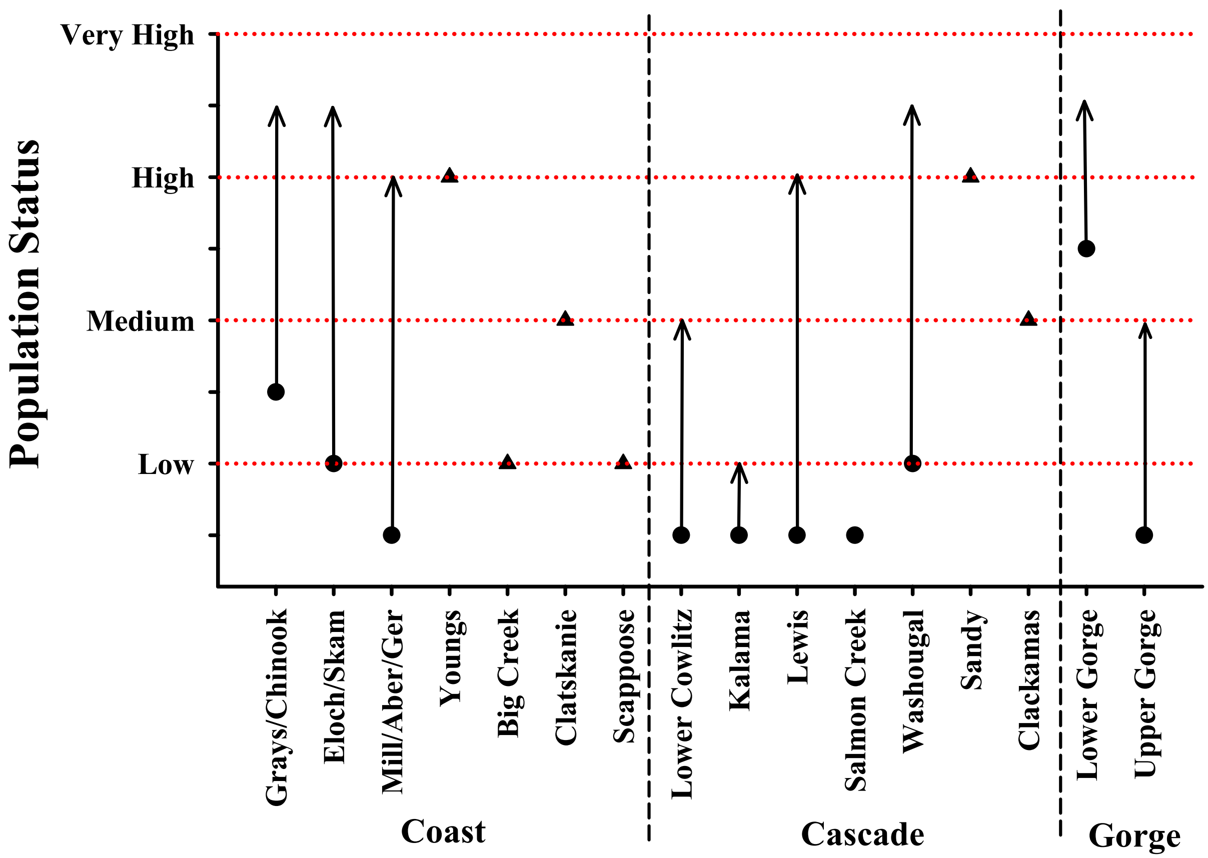


Figure 6-6. Improvements in population viability for chum corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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 (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

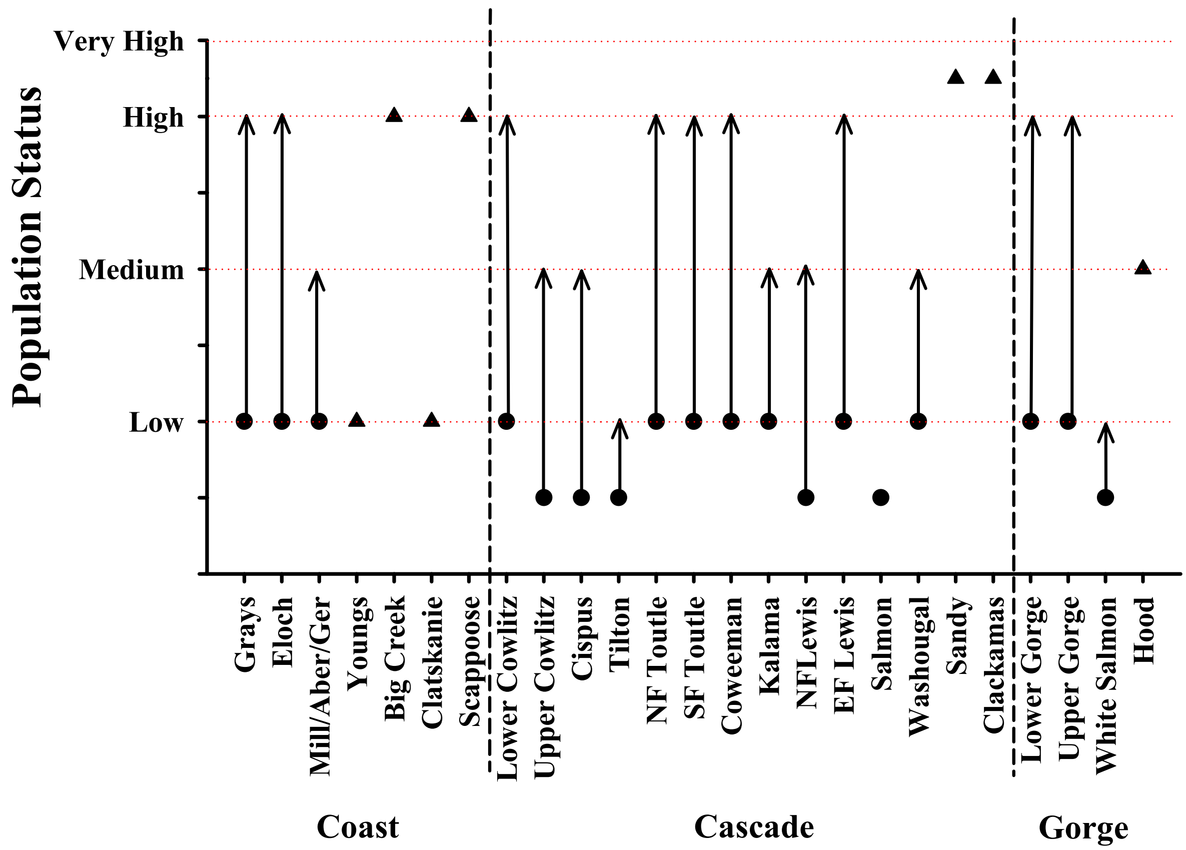


Figure 6-7. Improvements in population viability for coho corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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.

<u>Grays (Primary, High)</u> – 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.

<u>Elochoman (Primary, High)</u> – 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.

<u>Mill/Abernathy/Germany (Contributing, Medium)</u> – There is coho production in all three streams. There are no hatchery programs in these tributaries. The historical stock was principally late returning coho.

<u>Lower Cowlitz-Below Mayfield Dam (Primary, High)</u> – 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.

<u>*Upper Cowlitz/Cispus (Contributing, Medium)*</u> – 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.

<u>*Tilton (Contributing, Low)*</u> – Improvements to the Tilton coho population are linked to successful reintroduction and passage upstream of Mayfield Dam.

<u>*SF Toutle (Primary, High)*</u> – 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.

<u>*NF Toutle (Primary, High)*</u> – 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.

<u>*Coweeman (Primary, High)*</u> – 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.

<u>*Kalama (Contributing, Medium)*</u> – 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.

<u>*NF Lewis (Contributing, Medium)*</u> – Success is associated with reintroduction to habitats upstream of the dams in the Lewis River, which will be dependent on successful passage measures.

<u>*EF Lewis (Primary, High)*</u> – 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.

<u>*Washougal (Contributing, Medium)*</u> – 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.

<u>*Lower Gorge-Below Bonneville Dam (Primary, High)*</u> – 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 tributarties.

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

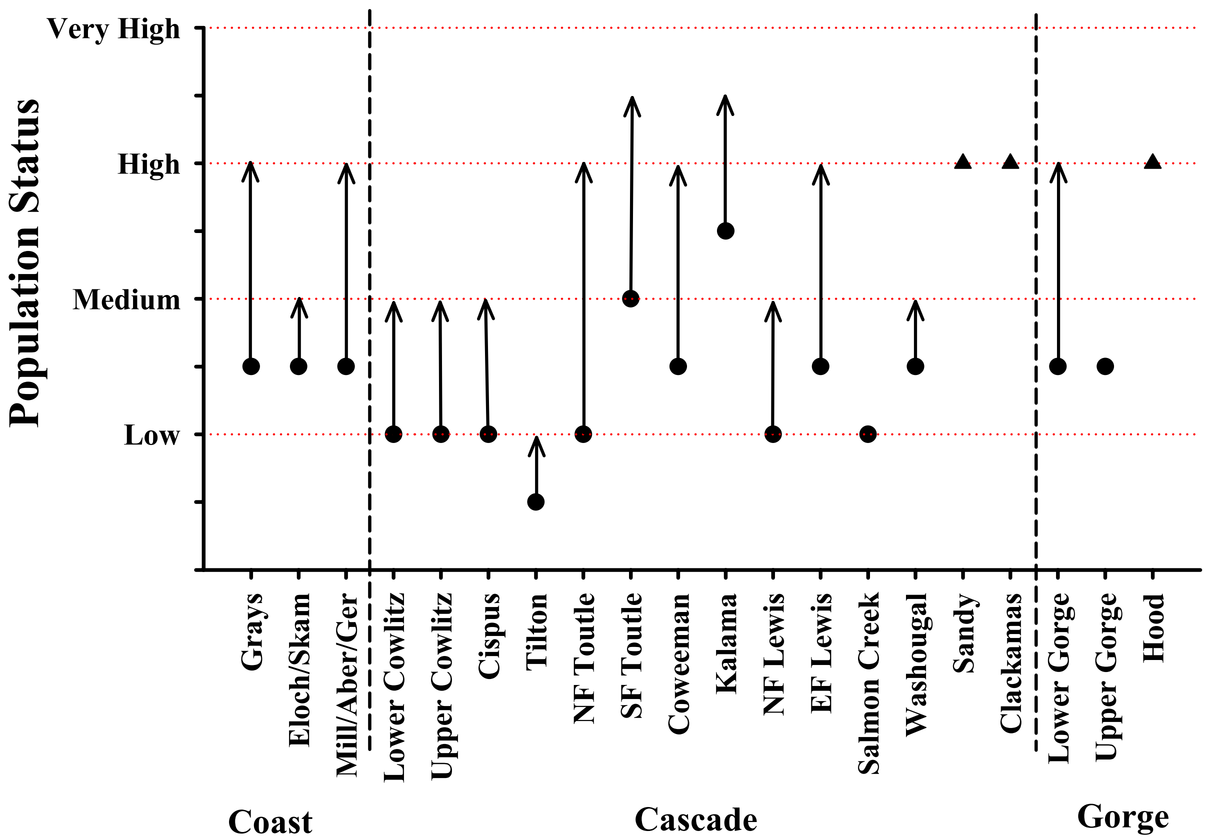


Figure 6-8. Improvements in population viability for winter steelhead corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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.

<u>*Elochoman/Skamokawa (Contributing, Medium)*</u> – There is winter steelhead production in both Elochoman River and Skamokawa Creek. Local and non-local stock hatchery programs occur in the Elochoman.

<u>*Mill/Abernathy/Germany (Primary, High)*</u> – There is winter steelhead production in all three streams with fair historical significance. There are no hatchery programs in these tributary streams.

<u>*Lower Cowlitz-Below Bonneville Dam (Contributing, Medium)*</u> – 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.

<u>*Upper Cowlitz/Cispus (Contributing, Medium)*</u> – 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.

<u>*Tilton (Contributing, Low)*</u> – 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.

<u>*SF Toutle (Primary, High$^+$)*</u> – 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 steelhead hatchery program in the watershed. This population is targeted for High$^+$ to address ESU recovery risks.

<u>*NF Toutle (Primary, High)*</u> – 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.

<u>*Coweeman (Primary, High)*</u> – Current status is average for the lower Columbia. There is a small steelhead hatchery program in the basin.

<u>*Kalama (Primary, High$^+$)*</u> – 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.

<u>*NF Lewis (Contributing, Medium)*</u> – 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.

<u>*EF Lewis (Primary, High)*</u> – 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.

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. No wild winter steelhead occur in these systems and populations are subject to Bonneville Dam passage concerns.

Summer Steelhead

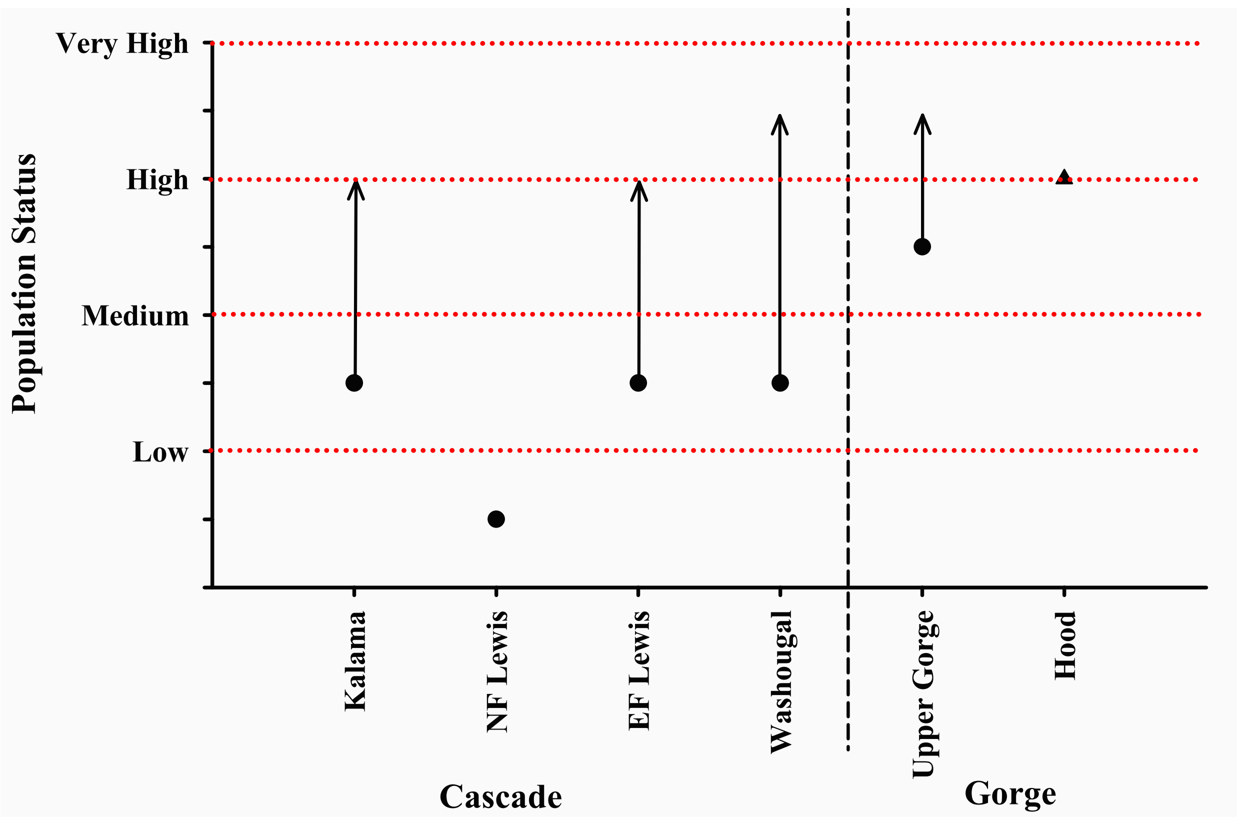


Figure 6-9. Improvements in population viability for summer steelhead corresponding to biological objectives identified in recovery scenario for Washington. Oregon populations displayed with (▲) correspond to hypothetical biological objective to achieve ESU recovery across both states.

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.

6.2.3 Alternatives Considered

The preferred scenario was developed through a collaborative process with representative stakeholders based on:

- ✓ Recovery criteria defined by the NOAA Fisheries Willamette/Lower Columbia TRT;
- ✓ Biological significance of each population; and
- ✓ Constraints and opportunities for recovery.

As noted in Section 5.1, TRT recovery criteria define ESU viability based on: 1) a high probability of persistence of each species, life history type, and ecological zone stratum, 2) at least two population per strata at high viability with a strata average of moderate, 3) representative core and legacy populations as well as catastrophic risks considered, 4) non-deterioration of any population until ESU recovery is assured, and 5) higher levels of recovery in more populations because not all attempts will be successful. Biological significance refers to current status, potential productivity, and genetic heritage. Biologically-ideal candidates for recovery would be currently productive, have potential for significant improvements in productivity, and would be representative of the historical population. Thus, a population close to viability that is a genetic legacy and has a high potential for increased productivity would have high biological significance. Conversely, a population far from viable that is not a genetic legacy and has a low productivity increase potential would have low biological significance. An index of biological significance was developed to help group populations based on these features. These categories informed further considerations of population priorities in the recovery scenario. Biological significance methods and results are detailed in Volume I Chapter 5 of the Technical Foundation.

The ease of recovery was identified based on a qualitative comparison of constraints, costs, and opportunities associated among populations. This involved a collaborative process in a series of Scenario Evaluation Team (SET) workshops held in November 2003. Scenario workshops were held in each stratum to assist in scoping recovery scenarios. The Scenario Evaluation Teams (SETs) included fish and habitat experts, policy staff from state and federal agencies, local elected officials, community leaders, timber company representatives, and citizens. Using the biological significance or potential ratings and excerpts from the technical foundation relating to fish population status and factors limiting recovery, the SETs discussed the potential opportunities and constraints for recovering each population in a stratum. The discussions focused on possible technical, legal, social, cultural, and economic considerations associated with recovery. Based on this discussion, the SETs rated the relative ease of recovering each population. It should be noted that ratings of the relative ease of recovery should not be interpreted as indicating whether a recovery of a population is feasible. Rather the ratings only indicate what the SET believed to be the ease of recovering one population relative to others of the same species.

A "Minimum Action Recovery Scenario" (MARS) was developed based on the TRT recovery criteria (with the exception of risk reduction measures), biological significance, and feasibility information (Table 6-6). As the title suggests, this scenario identified one example of the minimum improvement in population viability needed to satisfy TRT criteria of two populations at high viability and a strata average of moderate. Preference was given to populations that are healthiest or most viable and offer the greatest potential for increased productivity and abundance. Preference was given to the populations identified by the SETs as having the relative greatest ease of recovery. (Ease includes social/economic, legal, technical and cost considerations.) Preference was also given to watersheds where recovery efforts provide multi-species benefits wherever possible. Inherent in this definition is the presumption that the MARS would also minimize the scope, effort, and cost of recovery, but not the risk of failure. The MARS scenario assumed that all recovery targets for viability are feasible and could be achieved.

MARS served as the starting point for efforts to develop a final recovery scenario. MARS did not include adjustments for the potential risk of failing to meet viability targets for one or more of the selected populations. Nor, did MARS take into consideration major technical impediments to recovery such as the potential difficulty of establishing a viable chum population above Bonneville Dam. Further, the scenario would not necessarily achieve the recovery planning goal of "healthy, harvestable" population levels. "Healthy, harvestable" levels would not only achieve viability, but also provide for the additional productivity and abundance necessary to support harvest increases and other indirect utilization of fish resources, such as hydroelectric generation and urban and economic development.

A Working Scenario was developed as a refinement of MARS that included additional populations or improvement increments to meet TRT risk reduction criteria, balance risks where prospects for recovery of some strata was highly uncertain, and provide harvest opportunities. The Working Scenario builds upon MARS by adjusting population recovery goals to better reflect biological feasibility and to reduce the overall risk of failing to achieve recovery goals. For example, improving chum populations in the Gorge Strata to a high viability level may not be realistically feasible because of inundation of tributary habitat above Bonneville Dam and the difficulty chum have in passing significant barriers, such as dams. This is not to say that recovery will not be attempted but rather that success will be uncertain given the continued existence of Bonneville Dam. In such cases, the Working Scenario compensates for these deviations by proposing higher recovery levels for other populations. These compensation measures are intended to achieve an equivalent or better probability of ESU viability compared to those specified by the TRT criteria.

Table 6-6. Alternative to preferred scenario. Summary of primary (P), contributing (C), and stabilizing (S) populations for each subbasin and population as identified in the Minimum Action Recovery Scenario (MARS) upon which the working scenario is based. X refers to subset of larger population. Primary populations are generally proposed for improvement to high or very high levels of viability, contributing populations to medium levels, and stabilizing populations maintained no lower than current levels. Populations where large impediments make recovery prospects highly uncertain are denoted by '!'. Dashes indicate species is not present. Oregon populations are denoted with 'O'.

MINIMUM ACTION RECOVERY SCENARIO (NOT SELECTED - DOES NOT ADDRESS RISK OR FEASIBILITY)

		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	P[1]	--	P
	Mill/Abernathy/Germany	C	--	--	C	C[1]	--	C
	Youngs Bay	O	--	--	O	O[1]	--	O
	Big Creek	O	--	--	O	O[1]	--	O
	Clatskanie	O	--	--	O	O[1]	--	O
	Scappoose	O	--	--	O	O[1]	--	O
CASCADE	Lower Cowlitz	C	--	--	C	C	--	P
	Upper Cowlitz	S	--	P!	--	C	--	C
	Cispus	--	--	P!	--	C	--	C
	Tilton	--	--	S	--	S	--	S
	SF Toutle	X	--	S	X	P	--	C
	NF Toutle	S	--	--	X	C	--	P
	Coweeman	P	--	--	X	C	--	C
	Kalama	C	--	P	C	P	P	S
	Lewis (NF)	X	P	P!	X	C	S	C
	EF Lewis	P	--	--	P	P	P	P
	Salmon	X	--	--	S	S	--	S
	Washougal	C	--	--	P	C	P	C
	Sandy	O	O	O	O	--	--	O
	Clackamas	O	--	--	O	--	--	O
GORGE	Lower Gorge	P!	--	--	P	P	--	P
	Upper Gorge	S	--	--	P!	S	P	P
	White Salmon	P!	--	P!	--	--	--	C
	Hood	O	--	O	--	--	O	--

[1] *Not listed under U.S. Endangered Species Act.*

The Working Scenario represents the second of a three step process to develop a recovery scenario defining the recovery goals for lower Columbia salmon and steelhead recovery. The third and final step involved further review and adjustments to define a "preferred" scenario that would be technically sound and balanced.

6.3 Salmon and Steelhead Population Objectives

6.3.1 Planning Ranges

Recovery planning ranges provide approximate benchmarks for describing the biological objectives for each population consistent with a scenario that meets ESU recovery criteria. Planning ranges are fish numbers for each population at: 1) minimum averages needed to ensure population viability (avoid extinction) and 2) realistic maximums that might be achieved by widespread restoration of favorable habitat conditions for salmon. Comparisons of current numbers and planning ranges provide an index of the difference between current, viable, and potential population levels (Figure 6-10). Planning ranges are intended to be used in close conjunction with TRT population attributes (abundance, productivity, spatial structure, diversity, habitat).

The low bound of the planning range is equivalent to a high level of viability as described by the TRT (≥95% probability of persistence over 100 years). This bound represents potential delisting goals for ESA populations. Viable population levels were based on Population Change Criteria derived by NOAA Fisheries using annual trends and variance in spawner numbers or indices. Detailed methods for deriving target planning ranges may be found in the Technical Foundation Volume I, Chapter 5.

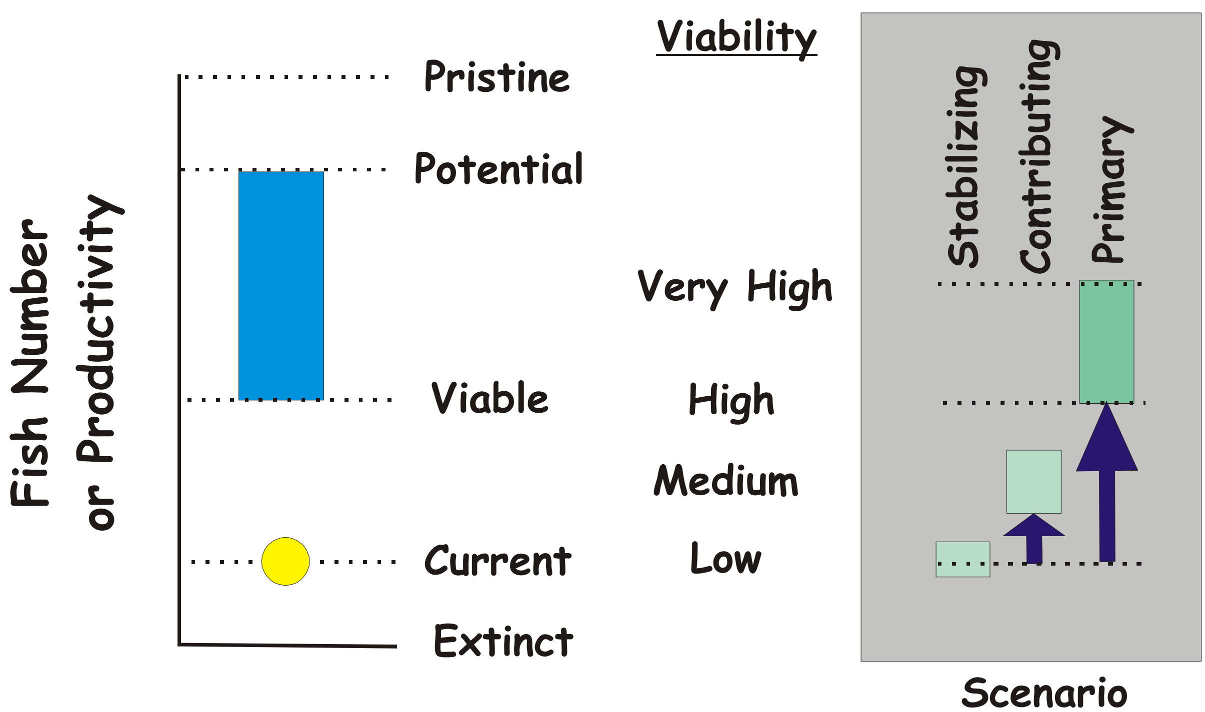


Figure 6-10. Depiction of generic recovery planning ranges relative to viability levels identified by the Willamette/Lower Columbia Technical Recovery Team.

The upper end of the planning range represents the theoretical capacity if currently-accessible habitat was restored to good, albeit not pristine, conditions represented by the "properly functioning conditions". Properly functioning conditions have been identified by NOAA Fisheries as benchmarks for habitat protection and restoration efforts. The upper bound of the planning range represents a hypothetical limit to potential population levels rather than a goal. Very high levels of viability are assumed to occur at population levels less than the potential reflected by the high bound on the planning range.

Planning ranges were described both in terms of spawner numbers and population productivity. Greater fish numbers generally correspond to greater population productivity and increased population viability. Each alternative for describing status lends itself to different applications and analyses. Fish numbers can be measured directly and provide an intuitively easy-to-understand description of how well a population is doing. Productivity (replacement rate) provides a more direct description of the dynamics that determine status and viability. Viability level reflects persistence probabilities and extinction risks that are a particular concern for conservation and preservation of sensitive populations, including those listed under the ESA.

Planning ranges are species and population specific. Numbers vary among individual populations as a result of subbasin differences in habitat quantity, habitat quality, fish distribution, population productivity, etc. Threatened or endangered ESUs typically include some populations where current numbers fall within the target planning range but a majority of populations fall below the planning range. Recovery will require increasing numbers and productivity relative to the planning target range for a significant number of historical populations for each species and ESU as prescribed by TRT criteria and reflected in the recovery scenario.

6.3.2 Improvement Increments

Productivity improvement increments identify specific biological objectives for each population based on planning ranges and the preferred recovery scenario. Increments are the proportional improvements in population productivity needed to recover populations from current status to medium, high, and very high levels of population viability consistent with the recovery scenario. Productivity is defined as the inherent population replacement rate and is typically expressed as a median rate of population increase (PCC) or a recruit per spawner rate (EDT). Thus, for primary populations identified in the recovery scenario to move from a current viability of low to a high level of viability, productivity might need to increase by X%. A contributing population that needs to move from low to medium might only require an increase of one-half X%.

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.

Incremental improvements were related to human and other potentially manageable impacts to identify potential avenues for recovery and targets for improvement in each factor consistent with recovery objectives. 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 (see Technical Foundation Volume I, Chapter 5). Impact values were developed for a base period corresponding to species listing dates. For planning purposes, targets for each factor category were proportional to the scale of that particular impact. Thus, a 50% improvement increment would require an 80% productivity impact to be reduced by half to 40%. A 10% productivity impact reduced by half would be 5%.

Box 3. Summary of methods for deriving productivity improvement increments.

- ✓ Improvement increments were inferred using existing analytical frameworks including PCC assessments conducted by NOAA Fisheries and EDT assessments conducted by WDFW.
- ✓ Required improvements in productivity to reach High viability were based on NOAA Fisheries' analyses of Population Change Criteria and current population trends.
- ✓ Productivity improvements for contributing populations were based on half the distance between current productivity and productivity at viability.
- ✓ 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.
- ✓ Species average increments were used for populations where component data were lacking.
- ✓ Recovery plan implementation measures include examination of the validity of these approximations following development and adaptation of new tools for integrated life cycle analysis that meshes an age-structured population model with stage-specific density-dependence like EDT with a stochastic empirical approach like PCC to directly estimate persistence probabilities under different combinations of mortality factors.

Because impacts act at various stages of the salmonid life cycle, their effects 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%. (Remainder is 40% of 40% which equals 16%). 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 30% improvement increment would require only a 9% reduction 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.

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 400% 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 30-60% for chum and 10-30% 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.

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.

These analyses address the subset of all threats to viability that could be quantified with productivity impacts as reflected in the Technical Foundation Volume I, Chapter 5. Recovery strategies and measures detailed elsewhere in this plan address both quantifiable and unquantifiable threats.

Table 6-7. Population abundance and productivity planning ranges for lower Columbia River Chinook populations.

	Viability		Avg.	Planning range		Prod.	Baseline impacts							Impacts at goal					
Population	**Current**	**Goal**	**no.**	**High**	**PFC+**	**Incr.**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**	**Δ**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**
Coast Fall																			
Grays/Chinook	**Low+**	**High**	73	1,400	1,400	30%	0.37	0.35	0.00	0.22	0.65	0.19	9%	0.34	0.32	0.00	0.20	0.59	0.18
Eloch/Skam	**Low+**	**High+**	140	1,400	4,500	430%	0.30	0.35	0.00	0.23	0.65	0.40	56%	0.13	0.16	0.00	0.10	0.29	0.17
Mill/Aber/Germ	**Low**	**Med**	250	2,000	3,200	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)	--	**Low**	--	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Big Creek (OR)	--	**Low+**	--	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clatskanie (OR)	--	**High**	--	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scappoose (OR)	--	**Low**	--	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Fall																			
Lower Cowlitz	**Low+**	**Med**	602	3,900	33,200	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	**V Low**	**V Low**	0	1,400	10,800	0%	0.71	0.38	1.00	0.23	0.65	0.20	--	--	--	--	--	--	--
Toutle	**Low**	**Low**	1,000	1,400	14,100	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	**Med**	**High+**	425	3,000	4,100	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	**Low+**	**High**	1,192	1,300	3,200	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	**Med**	**High+**	235	1,900	3,900	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	**Low+**	**High**	1,225	5,800	5,800	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)	--	**Med**	56	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sandy (OR)	--	**Low+**	208	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gorge Fall																			
L. Gorge (Hamilton)	**Low**	**Med**	--	1,400	2,800	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)	**Low**	**Low**	138	1,400	2,400	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	**Low**	**Med**	174	1,600	3,200			0.30	0.60	0.27	0.65	0.11	--	--	--	--	--	--	--
Hood (OR)	--	**Low+**	--	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade L Fall																			
Lewis NF	**Med+**	**High+**	6,493	6,500	16,600	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)	--		445	5,100	10,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Spring																			
Upper Cowlitz	**Low**	**High+**	365	2,800	8,100	--	0.82	0.20	0.90	0.31	0.53	0.27	--	--	--	--	--	--	--
Cispus	**Low**	**High+**	150	1,400	2,300	--	0.88	0.20	1.00	0.31	0.53	0.27	--	--	--	--	--	--	--
Tilton	**V Low**	**V Low**	150	1,400	2,800	--	--	0.20	1.00	0.31	0.53	0.27	--	--	--	--	--	--	--
Toutle	**V Low**	**Med**	150	1,400	3,400	--	1.00	0.20	0.00	0.31	0.53	0.45	--	--	--	--	--	--	--
Kalama	**V Low**	**High**	105	1,400	900	--	0.92	0.20	0.00	0.31	0.53	0.45	--	--	--	--	--	--	--
Lewis NF	**V Low**	**High**	300	2,200	3,900	--	0.81	0.20	0.90	0.31	0.53	0.45	--	--	--	--	--	--	--
Sandy (OR)	--	**High**	2,649	2,600	5,200	--	0.63	0.20	0.92	0.34	0.53	0.70	--	--	--	--	--	--	--
Gorge Spring																			
White Salmon	**V Low**	**Low**	0	1,400	2,800	--	--	0.20	0.92	0.34	0.53	0.70	--	--	--	--	--	--	--
Hood (OR)	--	**High**	0	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 6-8. Population abundance and productivity planning ranges for lower Columbia River chum populations.

	Viability		Avg.	Planning range		Prod.	Baseline impacts							Impacts at goal					
Population	**Current**	**Goal**	**no.**	**High**	**PFC+**	**Incr.**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**	**Δ**	**Trib**	**Est**	**Dams**	**Pred**	**Harv**	**Hat**
Coast																			
Grays/Chinook	**Low+**	**High+**	960	4,300	7,800	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	**Low**	**High+**	<150	1,100	8,200	140%	0.86	0.28	0.00	0.23	0.05	0.03	18%	0.70	0.23	0.00	0.19	0.04	0.03
Mill/Ab/Germ	**V Low**	**High**	<150	1,100	3,000	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)	**--**	**High**	<150	1,100	2,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Big Creek (OR)	**--**	**Low**	<150	1,100	2,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clatskanie (OR)	**--**	**Med**	<150	1,100	2,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scappoose (OR)	**--**	**Low**	<150	1,100	2,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade																			
Cowlitz	**V Low**	**Med**	<150	1,100	135,700	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	**V Low**	**Low**	<150	1,100	12,200	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	**V Low**	**High**	<150	1,100	71,000	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	**V Low**	**V Low**	<150	1,100	4,200	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	**Low**	**High+**	<150	1,100	9,400	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)	**--**	**Med**	<150	1,100	2,200	--	--	--	--	--	--	--							
Sandy (OR)	**--**	**High**	<150	1,100	2,200	--	--	--	--	--	--	--							
Gorge																			
Lower Gorge	**Med+**	**High+**	542	2,600	3,100	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	**V Low**	**Med**	<100	1,100	5,900	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 6-9. Population abundance and productivity planning ranges for lower Columbia River steelhead populations.

	Viability		Avg.	Planning range		Prod.	Baseline impacts							Impacts at goal					
Population	Current	Goal	no.	High	PFC+	Incr.	Trib	Est	Dams	Pred	Harv	Hat	Δ	Trib	Est	Dams	Pred	Harv	Hat
Coast Winter																			
Grays/Chinook	**Low+**	**High**	150	600	2,300	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	**Low+**	**Med**	150	600	1,000	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	**Low+**	**High**	150	600	1,500	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	**Low**	**Med**	--	600	1,500	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	**Low+**	**High**	228	800	1,200	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	**Med**	**High+**	453	1,400	1,900	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	**Low**	**High**	176	700	3,500	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	**Low**	**Med**	0	600	1,600	--	0.498	0.137	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Cispus	**Low**	**Med**	0	600	1,200	--	0.520	0.136	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Tilton	**V Low**	**Low**	0	600	1,300	--	0.854	0.137	1.000	0.235	0.100	0.300	--	--	--	--	--	--	--
Kalama	**Med+**	**High+**	541	600	700	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	**Low**	**Med**	--	600	3,400	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	**Low+**	**High**	77	600	1,300	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	**Low**	**Low**	--	600	1,200	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	**Low+**	**Med**	421	600	1,000	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)	**--**	**High**	277	1,000	2,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sandy (OR)	**--**	**High**	589	1,800	3,600	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gorge Winter																			
L. Gorge (HHD)	**Low+**	**High**	--	200	300	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)*	**Low+**	**Low+**	--	100	100	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)	**--**	**High**	436	1,400	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cascade Summer																			
Kalama	**Low+**	**High**	291	700	1,000	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	**V Low**	**V Low**	--	600	1,200	--	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	**Low+**	**High**	463	200	400	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	**Low+**	**High+**	136	500	900	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 Summer																			
Wind	**Med+**	**High+**	391	1,200	1,900	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)	**--**	**High**	154	600	1,200	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes (for Table 6-7*,* Table 6-8*, and* Table 6-9*)*

1. *Current viability is based on Technical Recovery Team viability rating approach.*
2. *Viability goal is based on working scenario.*
3. *Recent average numbers are observed 4-year averages or assumed natural spawning escapements. Data typically is through year 2000.*
4. *Abundance planning range refers to average equilibrium escapement numbers at high viability as defined by NOAA's Population Change Criteria and potential as defined by WDFW's Ecosystem Diagnosis and Treatment(EDT) assessments under properly functioning habitat and historical estuary conditions.*
5. *Current and planning range productivity values are expressed in terms of intrinsic rate of population increase. Estimates are available only where data exists to EDT and population trend assessments.*
6. *Productivity increment indicates needed improvements to reach population viability goal.*
7. *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.*
8. *Δ refers to improvement required in each impact 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.)*
9. *Impacts at goal are values consistent with productivity and viability goals where reductions in each factor are evenly distributed in proportion to baseline impacts.*
10. *Uncertainties in the various parameters upon which this analysis is based sometimes produce inconsistent results for specific populations.*
11. *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).*
12. *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.*
13. *Improvement increments do not consider effects of measures implemented since listing.*
14. *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.)*
15. *Productivity improvements are approximations based on existing data and assessments. These approximations are considered working hypotheses that provide a benchmark for scaling recovery strategies and a reference point for future monitoring, evaluation, and adaptation.*

6.4 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.

6.5 Other Fish and Wildlife Species

6.5.1 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 as well as 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, management, and potentially negative economic (crop depredation) significance. They are a Washington state listed species, based partially on concern for the wintering population within the subbasins. 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.

Seals and Sea Lions

Objective: ***Maintain current seasonal population abundance while limiting perceived 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 perceived to be a significant predator of adult salmonids.

Western Pond Turtle

Objective: ***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 >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 captive bred stock. 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.

6.5.2 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.

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 are an indicator 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.

6.5.3 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.

7 Regional Strategies and Measures

7.1 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. Descriptions of subbasin-specific applications of these strategies and measures are found in the subbasin chapter. 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 development and review 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. 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.

7.2 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.

7.2.1 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.

R.H2. Substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required to achieve recovery.

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.

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.

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.

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.

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.

7.2.2 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.

7.3 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.

7.3.1 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.

7.3.2 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. Give priority to restoring access to currently inaccessible high quality habitat for primary and contributing fish populations.

Explanation: Providing access to isolated habitat can provide immediate and lasting benefits to fish populations. Restoring access may include removal of culverts, providing fish passage at dams, and reconnecting isolated side channels and wetlands.

S.S4. 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.S5. 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.S6. Implement habitat protection and improvement actions in all areas 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.S7. 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.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. 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. The amount and quality of habitat that can be opened for various populations varies considerably across the region.

S.S10. Use existing procedures and programs wherever possible to take maximum advantage of opportunities for efficient implementation of habitat improvement 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.S11. 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.

7.3.3 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

- 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)

<u>Explanation:</u> 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

- 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

- 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

Explanation: 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

<u>Explanation:</u> 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

- 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

- 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

- 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

- 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

- 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

- 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

- 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

- 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

- 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

<u>Explanation:</u> 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.

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

- 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

<u>Explanation:</u> 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

- Limit intensive recreational use where there is harassment potential
- Actively rehabilitate areas damaged by intensive recreational use

<u>Explanation:</u> 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.

7.4 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.

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.

7.4.1 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.

<u>Explanation</u>: 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.

<u>Explanation</u>: 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.

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.

<u>Explanation</u>: 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.

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 macrodetritus-based food web. The current estuary food web is microdetritus 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.

7.4.2 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.

7.4.3 Measures

E.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

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. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain addresses the following juvenile rearing limiting factors: shallow water, low velocity, and peripheral habitats.

E.M3. Protect and restore riparian condition and function.

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.M4. Limit the effects of toxic contaminants on salmonid and wildlife fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: There is little understanding of the short- and long-term effects of contamination on salmonids, resident fish, or wildlife species.

E.M5. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem.

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.M6. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

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.M7. Mitigate channel dredge activities in the Columbia River estuary and lower mainstem that reduce salmon population resilience and inhibits recovery.

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.M8. Restore or mitigate for impaired sediment delivery processes and conditions affecting the Columbia River estuary and lower mainstem.

Explanation: Sediment dynamics are a critical component of estuary and lower mainstem (and nearshore) 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.

7.5 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.

7.5.1 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.

<u>Explanation</u>: 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. North Fork Lewis dams have similarly blocked 95% of winter steelhead, 50% of summer steelhead, and 90% of spring Chinook habitat in that system.

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.

<u>Explanation</u>: 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.

<u>Explanation</u>: 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.

7.5.2 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.

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 include passage at Bonneville Dam, local effects of operations on tailrace habitats, and widespread ecosystem effects of changes in flow, temperature, and sediment transport patterns.

7.5.3 Measures

D.M1. Evaluate and adaptively implement anadromous fish reintroduction upstream Cowlitz, Lewis, and White Salmon dams and facilities as part of dam relicensing processes or requirements.

Explanation: Experimental 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. Substantial uncertainty exists in the feasibility and costs of restoring effective 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.

Explanation: Effective passage facilities are crucial for upper Gorge salmon populations as well as every other upstream anadromous fish population.

D.M3. Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon incubation and migration periods.

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 hydrosystems to provide appropriate flows for salmon spawning and rearing habitat in the areas downstream of the hydrosystem.

Explanation: The quantity and quality of spawning and rearing habitat for salmon, in particular fall chinook 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.

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.

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.M.6. Maintaining a flow regime, including minimum flow requirements, that enhance the spawning and rearing habitats for natural salmonid populations downstream of the North Lewis and Lower Cowlitz hydrosystem.

Explanation: The water flow discharged at Mayfield Dam in the Cowlitz and Merwin Dam in the Lewis is critical to the quantity and quality of habitat available for spawning adult salmon in the fall and rearing juvenile salmon in the spring and summer. Adequate flow during the spawning and rearing periods is particularly impartial to wild fall Chinook in the Lower Cowlitz and lower North Fork Lewis.

7.6 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. The strategy includes a discussion of the impacts of harvest on naturally-spawning fish populations and the 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.

7.6.1 Working Hypotheses

F.H1. Salmon recovery is predicated on restoration of healthy, harvestable naturally-spawning populations.

<u>Explanation:</u> 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.

<u>Explanation:</u> 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.

<u>Explanation:</u> 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.

7.6.2 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.

7.6.3 Measures

General

F.M1. ESA Fishery Management Plans for lower Columbia ESUs will be revised or adjusted 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. Lower Columbia populations set in the Lower Columbia Recovery Plan will be considered in annual fishery management processes.

Explanation: Lower Columbia populations 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.

F.M3. 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.

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.

Fall Chinook

F.M5 Review of NOAA Fisheries' recovery exploitation rate of fall Chinook tules and update risk assessment to include more tule populations.

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. Other populations should be added to the RER as they become more productive and appropriate biological data becomes available. 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.

F.M6. Consider a sliding scale harvest plan based on annual abundance indicators for tule fall Chinook.

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.

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			
	Cowee.	Very low (<0.15%)	Low (0.15-0.25%)	Medium (0.25-0.40%)	High (>0.4%)
Parent spawner status1	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.M7. Periodic review of harvest relative to habitat productivity and capacity to assure harvest objectives are synchronized with habitat changes.

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.

F.M8. Commitment from agencies and tribes in PFMC, NOF, and Compact to specifically manage annually for lower Columbia naturally-spawning tules and to establish a collaborative U.S. policy position for the international table in PSC.

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.

F.M9. Improve tools to monitor and evaluate fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits.

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

F.M10. Manage ocean, Columbia River, and tributary fisheries to meet the spawning escapement goal for lower Columbia bright fall Chinook.

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.

F.M11. Develop a more detailed process for in-season monitoring of stock specific harvest in the Columbia River.

Explanation: Evaluate process and resources used by management agencies to monitor in-season harvest of listed species. Assure monitoring and tag analysis is adequate for accurate and timely estimates of stock specific impacts to enable in-season regulatory adjustments as necessary. Assure that investments into in-season monitoring programs are long term to match recovery timelines.

F.M12. Develop a basin wide fish marking plan that is adequate for monitoring fall Chinook tule interception rates in specific fisheries and for monitoring escapement of naturally-spawning fish.

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.

F.M13. Develop a mass marking plan for hatchery tule Chinook for tributary harvest management and for naturally-spawning escapement monitoring.

Explanation: 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.

F.M14. Address technical issues regarding mass marking and advocate for budget to mark and monitor recoveries of Chinook in fisheries and escapement.

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.

Chum

F.M15. Columbia River Compact agencies will evaluate effectiveness of the current time and area management strategy for the commercial fishery.

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.

F.M16. Develop more specific chum management details for pre-season and in-season management of the late fall commercial fishery.

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.

F.M17. Monitor chum handle rate in tributary winter steelhead and late coho sport fisheries.

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.

Steelhead

F.M18. Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries.

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.

F.M19. Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead.

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.

FM20. Establish specific naturally-spawning steelhead encounter triggers for in-season Columbia River fishery adjustments needed to support lower Columbia recovery goals and strategies.

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.

F.M21. Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead.

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).

F.M22. Monitor naturally-spawning steelhead handle rate in tributary salmon and steelhead fisheries.

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.

Coho

F.M23. Sliding scale harvest based on annual abundance indicators for naturally-spawning Columbia River coho.

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.

F.M24. Maintain selective sport fisheries in Ocean, Columbia River, and tributaries and monitor naturally-spawning stock impacts.

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.

F.M25. Columbia River commercial fisheries managed by time, area, and gear to target on hatchery fish and minimize impacts to naturally-spawning fish.

Explanation: Commercial fisheries should utilize Select Area off-channel sites to harvest net pen reared hatchery coho. Continue to regulate mainstem commercial fisheries targeting Chinook 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.

F.M26. Technical review of adequacy of harvest management strategy developed for protection of naturally-spawning Clackamas late coho to also protect naturally-spawning Washington late coho.

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.

Spring Chinook

F.M27. Columbia River selective fisheries are monitored and estimates are provided of impacts to naturally produced lower Columbia spring Chinook are made.

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.

F.M28. Monitor and evaluate handling mortality impacts to released naturally-spawning spring Chinook in Columbia River fisheries.

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.

F.M29. 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.

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.

F.M30. 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.

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.

7.7 Hatchery

This hatchery strategy describes near-term and long-term strategies and measures to ensure that hatcheries support recovery of naturally-spawning fish.

7.7.1 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.

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.

7.7.2 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.

7.7.3 Measures

General

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 WDFWs 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. 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.

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 Planning Council's Artificial Production Review and Evaluation (APRE), the Benefit-Risk procedure developed by WDFW, 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. Mark hatchery-produced fish to assure they 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. Adaptively manage hatchery programs to respond to future knowledge 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 Planning (HGMP) process.

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.

H.M11. Procure new funding and 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.

Fall Chinook

H.M12. Hatchery releases in watersheds without hatchery programs only occur if necessary for recovery of the natural population.

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.M13. 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.

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.

H.M14. Use of local watershed broodstock only in hatchery programs.

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.M15. Juvenile release strategies to minimize naturally-spawning fish interactions.

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.M16. Hatchery operation strategies to protect Lewis naturally-spawning fall Chinook.

<u>Explanation:</u> 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.M17. Mark hatchery 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.

<u>Explanation:</u> 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.

<u>Spring Chinook</u>

H.M18. Facilities utilized for reintroduction efforts.

<u>Explanation:</u> 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.M19. Reintroduction of spring Chinook in upper Cowlitz and Lewis beginning with hatchery supplementation.

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.M20. Develop plans for future hatchery programs relationship with reestablished natural-origin spring Chinook populations, including integrated and segregated options.

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.M21. Hatchery brood stock watershed transfer policies.

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.M22. Juvenile release strategies to minimize impacts to naturally-spawning populations.

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.M23. Mark hatchery production for identification and harvest.

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.M24. Supplementation programs developed.

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.

H.M25. Chum enhancement at Grays and Chinook hatcheries.

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.M26. Use of Hatcheries for chum enhancement and risk management.

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.M27. DNA data utilized to select appropriate brood stock.

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.M28. Hatchery brood stock watershed transfer policies.

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.M29. Reintroduction of winter steelhead in upper Cowlitz and Lewis rivers.

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.M30. Late winter steelhead brood stock development at Elochoman, Cowlitz, Kalama, and Lewis hatcheries.

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.M31. Hatchery brood stock watershed transfer policies.

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.M32. Juvenile release strategy to minimize impacts to naturally-spawning fish.

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.M33. Complementary conservation/harvest programs with local steelhead stocks.

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.M34. Mark harvest production.

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.M35. Maximize harvest and removal of non-local summer and early winter steelhead.

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.M36. Develop hatchery supplementation programs for coho.

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.M37. Reintroduction of coho in upper Cowlitz and upper Lewis rivers.

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.M38. Develop local brood stocks for coho.

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.M39. Develop coho transfer policies as local brood stock is developed.

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.M40. Juvenile release strategies to minimize interaction with naturally-spawning fish.

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.M41. Mark hatchery harvest production.

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.M42. Establish naturally-spawning production sanctuary areas to be used for indicator stock programs.

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.

7.8 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.

7.8.1 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.

7.8.2 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.

7.8.3 Measures

Non native Species

I.M1. Implement regulatory, control, and education measures to prevent additional species invasions.

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.

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.

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.

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. Consider the potential for both positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures.

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.

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.

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.

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.

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. Establish regulatory flexibility 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.

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.

7.9 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.

7.9.1 Working Hypotheses

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. Contaminants play a substantial role in reproductive success. 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 attracted sandhill cranes and dusky Canada goose to overwinter in the area because of the high forage value of many agricultural crops. 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.

7.9.2 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.

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.

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.

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.

7.10 Education, Outreach, and Enforcement

In addition to strategies and measures that address specific limiting factors and threats to species of interest, this plan also includes strategies and measures for education, outreach, and enforcement. Education refers to the development or promotion of general knowledge or training. Outreach refers to directed educational and involvement efforts intended to focus on specific problems or actions. Enforcement refers to local, state, tribal or federal actions to obtain compliance with laws, rules, regulations, or agreements and/or obtain penalties or criminal sanctions for violations. This section describes an overarching regional vision for education, outreach, and enforcement. Specific measures have also been reflected in preceding sections on specific factor/threat categories as appropriate.

7.10.1 Working hypotheses

EO.H1. Recovery cannot be achieved without voluntary actions across a broad segment of society encompassing all limiting/factors and threats.

Explanation: Marshalling of the collective public will for fish and wildlife conservation and restoration will be key to effective implementation of the strategies and measures identified in this plan. The scale and costs of necessary improvements is too broad for strictly a mandatory or regulatory solution. Voluntary actions include both direct actions and support for costs of recovery.

EO.H2. Effective education and outreach activities can return multi-fold benefits in the form of increased and more effective public involvement and implementation of voluntary actions that contribute to recovery.

Explanation: Education and outreach will improve the understanding of the problems related to fish recovery, stimulate interest in the problems, and help focus this interest on effective solutions. No amount of prescriptive planning detail can substitute for a well informed and dedicated public.

EO.H3. Incentives for public involvement in fish and wildlife protection and restoration often prove much more effective than mandatory or regulatory requirements.

Explanation: Incentives in the form of benefits or considerations, financial or otherwise, may be particularly effective for inducing specific actions.

EO.H4. Recovery will also require regulatory solutions including new requirements and agreements as well as increased enforcement of existing requirements and agreements.

Explanation: Laws, rules, regulations, and agreements are an important complement to voluntary actions for fish and wildlife protection and restoration. These requirements and agreements are most effective when they are consistently applied and enforced.

7.10.2 Strategies

EO.S1. ***Employ a combination of education, outreach, and regulatory means for facilitating implementation of this plan.***

EO.S2. ***Employ partnerships and collaborative processes to the maximum extent possible in the implementation of this plan.***

EO.S3. ***Incorporate incentives for habitat protection and restoration in preference to mandatory or regulatory measures.***

EO.S4. ***Use existing Federal, State, Tribal, and local authorities.***

EO.S5. ***Focus on effective enforcement of existing laws, rules, regulations, or agreements but consider new requirements and agreements where necessary and appropriate .***

7.10.3 Measures

Education

EO.M1. ***Continue to publicize recovery planning activities, recovery implementation activities, and progress through dedicated public involvement processes and the information media.***

EO.M2. ***Facilitate education through training of teachers and assistance with curricula for primary, secondary, and post secondary school programs.***

EO.M3. ***Facilitate education through cooperation with existing fish and habitat volunteer programs.***

EO.M4. ***Facilitate education through cooperation with Federal, State, Tribal, and local authorities in the development and implementation of appropriate programs.***

EO.M5. ***Facilitate education through training and/or providing information to fishing guides and charter boat skippers.***

EO.M6. ***Use hatcheries and hatchery personnel as an outlet to educate the public in watershed stewardship and natural rsource protection.***

Outreach

EO.M7. ***Facilitate public outreach for the purposes of specific habitat protection and restoration activities through existing authorities and programs.***

EO.M8. ***Utilize and further develop existing public and private utility environmental programs.***

EO.M9. ***Utilize and further develop private timber company environmental programs.***

EO.M10. ***Encourage development of new environmental programs in private industry.***

EO.M11. ***Consider public outreach program investment as a mitigation requirement for development projects.***

Enforcement

EO.M12. ***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.***

EO.M13. 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.

EO.M14. Maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective inventory and enforcement of water diversion and pump screen requirements.

EO.M15. Establish cooperative enforcement partnerships among agencies, public, land owners, and industry.

EO.M16. Establish priorities to emphasize protection in key areas and facilities where recovery efforts are focused.

8 MONITORING, RESEARCH, AND EVALUATION

8.1 Overview

As noted repeatedly in this plan, our knowledge and understanding of the biology, complex life histories, and ecosystem relationships varies considerable 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 asks for 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 and set of actions to take, 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.

Measures were 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 questions or quantities 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 the planning process proceeds. Refinements will be predicated on the availability of resources for conducting an integrated monitoring, research, and evaluation program.

8.2 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.***

8.3 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 solutions with direct application to the implementation of effective recovery measures with an emphasis on adaptive, experimental evaluations of measure effects 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.***

8.4 Monitoring Measures

8.4.1 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 statistical efforts. Routine monitoring obtains repeated measurements of a selected series of units over a period of time to quantify and distinguish changes from background noise (ISAB 2003). Statistical monitoring provides inferences to larger areas and time periods than the sample based on probabilistic selection of study sites and repeated visits over time (ISAB 2003). Status monitoring is focused on salmonid population parameters appropriate for viability assessments as defined by NOAA's Willamette/Lower Columbia River Technical Recovery Team (abundance, productivity, spatial structure, diversity).

Statistical Monitoring

1. ***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.

2. ***Monitor diversity of representative populations of chinook, chum, coho, steelhead, and bull trout in each recovery strata.***

   Objective: Identify within and among population differences in life history and genetic diversity as an indicator of population viability and a means of delineating management units.
   Indicator: Run timing or size/sex/age composition from routine monitoring, individual allozyme or DNA samples.
   Sampling: Replicate random samples in one or more years, repeated at periodic intervals.
   Analysis: With-in and among sample differences, changes over time.

Routine Monitoring

3. ***Monitor trends and variation in annual abundance and distribution of representative wild populations of Chinook, chum, coho, steelhead, and bull trout in each recovery strata.***

   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.

4. ***Monitor trends and variation in annual juvenile production of representative wild 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: Screw traps at representative index sites.
Analysis: Annualized population growth rate, juveniles per spawner.

5. ***Monitor trends and variation in productivity of representative wild 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 information.
Sampling: Size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data.
Analysis: Run reconstruction.

Table 8-1. Current biological status monitoring activities by subbasin and species.

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
COAST[1]	Grays/Chinook	AA	--	--	AA/JM	AM	--	PA
	Elochoman/Skamokawa	AA	--	--	PA		--	PA
	Mill/Abernathy/Germany	AA	--	--	PA	JM	--	PA
	Youngs Bay	AA	--	--			--	AM
	Big Creek	AA	--	--			--	AM
	Clatskanie	AA	--	--			--	AM
	Scappoose	AA	--	--			--	AM
CASCADE	Lower Cowlitz	AA	--	AA	PA		--	PA
	Upper Cowlitz		--	AA/JA		AA/JA	--	AA/JA
	Cispus		--	AA/JA		AA/JA	--	AA/JA
	Tilton		--				--	AA/JA
	SF Toutle	AA	--	AA		AA	--	PA
	NF Toutle	AA	--	--		AA	--	PA
	Coweeman	AA	--	--	PA	AA	--	PA
	Kalama	AA	--	AA	PA	AA/JA/BR	AA/JA/BR	PA
	Lewis NF		AA/JA/JT	AA	PA		AA/JA	PA
	Lewis EF	AA	--	--	PA	AA	AA	PA
	Salmon		--	--	PA			PA
	Washougal	AA	--	--	PA	AA	AA	PA
	Sandy	AA	AA	AA		AA/JM	--	AM/JM
	Clackamas	PA	--	AA/JM		AA/JM	--	AM/JM
GORGE	Lower Gorge	AA	--	--	AA/JM			PA
	Upper Gorge	AA	AA	AA	PA		AA/JM	PA
	White Salmon	AA	AA	--	--	--		--
	Hood	AM	--	AA/JA	--	AA/JA	AA/JA	--

AA = Annual adult abundance, AM = Annual adult index monitoring, PA = Periodic adult abundance indices.
JA = Annual juvenile abundance, JM = Juvenile monitoring, JT = Juvenile coded-wire tagging.
BR = Biological research

6. ***Monitor trends in abundance and distribution of other fish and wildlife species of interest.***

Objective: Changes in status.
Indicator: Relative abundance of adults or juveniles.
Sampling: As appropriate by species.
Analysis: Trends.

8.4.2 Habitat Status Monitoring

Habitat status monitoring identifies the cumulative effect of human activities trends and recovery measures on critical limiting factors. Habitat monitoring may occur at watershed and local spatial scales.

Statistical Monitoring

7. ***Conduct comprehensive survey of watershed conditions and processes across the Washington lower Columbia Region.***

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, road density, landslides, wetlands.
Sampling: Primarily remote sensing and available GIS information. Repeat at 10-20 year intervals.
Analysis: Spatial and categorical summaries.

8. ***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.

9. ***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.

10. Conduct comprehensive survey of water quality and quantity across the Washington lower Columbia Region.

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.

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.

Table 8-2. Example benchmarks for evaluation of stream habitat suitability for salmonids approximately based on Properly Functioning Conditions identified by NOAA.

Limiting factor	*Example Benchmark*
Habitat connectivity	• Upstream and downstream fish passage at all flows
Stream flow	• Flow regime comparable to undisturbed basin of similar size, geology, and geography • Zero or minimum increase in drainage network due to roads • Roads < 2mi/sq mi, no valley bottom roads
Water quality	• Stream temp 50-57 F or within natural ranges • Low turbidity
Substrate and sediment	• <12% fines • dominant substrate = gravel • embeddedness < 20% • Roads <2 mi/sq mi, no valley bottom roads • No concentration of disturbance in unstable or potentially unstable areas
Habitat diversity	• LWD (>24" diam, >50 ft. length) > 80 pieces/mile • Pool quality = pools >1 meter deep with good cover • Backwaters available with cover
Channel stability	• Width-to-depth ratio <10 • Stream banks >90% stable (<10% actively eroding)
Riparian function	• Riparian areas >80% intact • Percent similarity to potential natural vegetation >50%
Floodplain function	• Off-channel areas hydrologically linked to main channel and overbank flows frequently occur

Routine Monitoring

11. Monitor trends in watershed conditions and processes through periodic sampling of representative and indicator sites.

Objective: Detect changes in watershed conditions and processes that affect stream habitat forming processes.

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.

Analysis: Within and among site differences, changes over time.

*12. **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 temporal 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 in conditions.

Analysis: Within and among site differences, changes over time.

*13. **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.

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.

8.4.3 Action Effectiveness Monitoring

Action effectiveness monitoring determines if specific habitat, hydropower, hatchery, harvest, and ecological interaction measures produce the specific intended effect. 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 are 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. Action effectiveness monitoring can be used to evaluate the effects of individual projects and/or suites of actions.

Stream Habitat

14. 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.

15. 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.

16. 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.

Objective: Identify and quantify relationships.
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.

Mainstem/Estuary

17. 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.

Hydropower

18. 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.

19. ***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.

<u>Harvest</u>

20. ***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.
Analysis: In-season and post-season estimates from run reconstructions, impact rates relative to benchmarks, observed vs. expected impact rates.

21. ***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 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.

<u>Hatchery</u>

22. ***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.

23. ***Monitor numbers and performance of hatchery fish returning to hatcheries.***

Objective: Evaluate hatchery performance 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.

24. ***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.

Ecological Interactions

25. 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.

26. 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.

27. 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.

28. 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.

29. 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.

8.4.4 Implementation/Compliance Monitoring

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

30. ***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).

8.5 Critical Uncertainty Research

Critical uncertainty research targets specific questions or quantities 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.

8.5.1 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.***

8.5.2 Stream Habitat

2. ***Validate EDT estimates of fish productivity and capacity based on empirical habitat and fish productivity data.***
3. ***Determine relative short term and long term tradeoffs in the benefits of site-specific and process based actions.***

8.5.3 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:

4. ***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.***
5. ***Implement selected restoration projects as experiments, so that we can learn as we go.***
6. ***Implement pre- and post-restoration project monitoring programs, to increase the learning.***
7. ***"Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.***
8. ***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.***
9. ***Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.***

10. ***Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.***
11. ***Identify and implement off-site mitigation projects in CRE tributaries.***
12. ***Establish a data and information sharing network so that all researchers have ready and up-to-date access.***
13. ***Increased genetic research to identify genotypic variations in habitat use.***
14. ***Understanding salmonid estuarine ecology, including food web dynamics.***
15. ***Understanding sediment transport and deposition processes in the estuary.***
16. ***Understanding juvenile and adult migration patterns.***
17. ***Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.***
18. ***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.***
19. ***Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.***
20. ***Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.***
21. ***Improve our understanding of the role between micro- and macro-detrital inputs, transport, and end-points.***
22. ***Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.***
23. ***Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.***
24. ***Increase our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.***

8.5.4 Hydropower

25. ***Determine feasibility of re-establishing self-sustaining anadromous populations upstream of hydropower facilities in the Lewis and Cowlitz systems.***
26. ***Determine effects of flow on habitat in the estuary & lower mainstem.***
27. ***Identify delayed effects of passage on fish condition and survival.***

8.5.5 Harvest

28. ***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.***
29. ***Evaluate appropriateness of stocks used in weak stock management.***

8.5.6 Hatchery

30. ***Determine relative performance of hatchery and wild fish in wild in relation to broodstock divergence and hatchery practices.***

31. ***Experimentally determine net effects of positive and negative hatchery effects on wild populations.***

32. ***Experimentally evaluate the efficacy of hatchery program integration, segregation, and supplementation.***

33. ***Determine hatchery effects on disease and predation on wild fish.***

8.5.7 Ecological Interactions

34. ***Experimentally evaluate nutrient enrichment benefits and risks using fish from hatcheries or suitable analogs (same as measure I.M6).***

35. ***Determine the interactions and effects of shad on salmonids.***

36. ***Determine the significance of marine mammal predation on adult and juvenile salmonids and alternatives for management in the Columbia River mainstem and estuary.***

8.5.8 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:

37. ***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.***

38. ***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.***

39. ***Productive capacity of each potential local bull trout population.***

40. ***Presence of bull trout and potential importance for recovery of Cowlitz and Kalama rivers.***

41. ***More thorough understanding of the current and future role that the mainstem Columbia should play in the recovery of bull trout.***

42. ***Effectiveness and feasibility of using artificial propagation in bull trout recovery.***

43. ***Describe the genetic makeup of bull trout in the mainstem Columbia and Klickitat rivers.***

8.5.9 Other Species of Interest

44. ***Identify status, limiting factors, and management alternatives for lamprey.***

45. ***Determine relative significance of mainstem and tributary spawning, environmental and habitat conditions related to population dynamics of smelt.***

46. ***Determine impacts of shad on salmonids and other ecosystem effects.***

8.6 Evaluation Measures

1. ***Periodically evaluate biological status relative to population and ESU objectives to determine whether necessary improvements are being achieved.***

   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 10-year intervals (see Evaluation Measure No. 12). Evaluations will also consider and correct for confounding effects of regional climate patterns.

2. ***Refine biological objectives consistent with recovery as new information becomes available on status and viable population or ESU characteristics.***

   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. Revised objectives will be considered at 10-year intervals concurrent with the global review of plan progress identified in Evaluation Measure No. 12 below.

3. ***Periodically evaluate habitat status relative to baseline conditions and benchmarks to determine whether appropriate progress is being made toward desired future conditions.***

   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 10-year intervals (see Evaluation Measure No.12). Evaluations will also consider and correct for confounding effects of regional climate patterns.

4. ***Evaluate whether recovery strategies, measures, and actions are being implemented as planned.***

   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.

5. ***Refine and reprioritize plan implementation at the programmatic level based on evaluations of implementation and compliance.***

   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 5-year intervals (see Evaluation Measure No. 11).

6. ***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).***

   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 tooccur at different scales and periods. Evaluations will be ongoing and also incorporated into regular plan-wide reviews.

7. ***Refine and reprioritize existing recovery strategies, measures, and actions for each limiting factor/threat category based on results of action-effectiveness evaluations.***

   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 at 10-year intervals (see Evaluation Measure No. 12).

8. ***Use results of critical uncertainty research to identify new or refine and reprioritize existing recovery strategies, measures, and actions.***

   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 10-year intervals (see Evaluation Measure No. 12)

9. ***Periodically evaluate strengths and weaknesses of the available monitoring and research to determine adequacy for assessing progress and identifying appropriate course corrections.***

   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.

10. ***Identify appropriate alternative approaches and revise priorities for monitoring and research based on results of evaluations.***

    Explanation: Adjustments in the implementation of related measures can be made as new information is available. Large-scale revisions will be considered at 10-year intervals (see Evaluation Measure No. 12).

11. ***Prepare written plan implementation progress reports to participating agencies, stakeholders, and the public at 5-year intervals.***

    Explanation: Programmatic reviews are more effectively evaluated at shorter intervals than are biological and habitat responses. More frequent reviews will provide an opportunity for course corrections.

12. ***Review and revise this plan in a collaborative agency, stakeholder, and public process at 10-year intervals based on a global review of all facets of progress toward recovery, particularly including biological and habitat status evaluations .***

    Explanation: Biological and habitat status evaluations will require at least 10 years for effective identification of trends. Shorter time series of data do not provide sufficient power to distinguish long term trends from annual noise. A 10-year interval also affords an opportunity for a more comprehensive review of progress in implementation, compliance, action effectiveness, and critical uncertainty research.

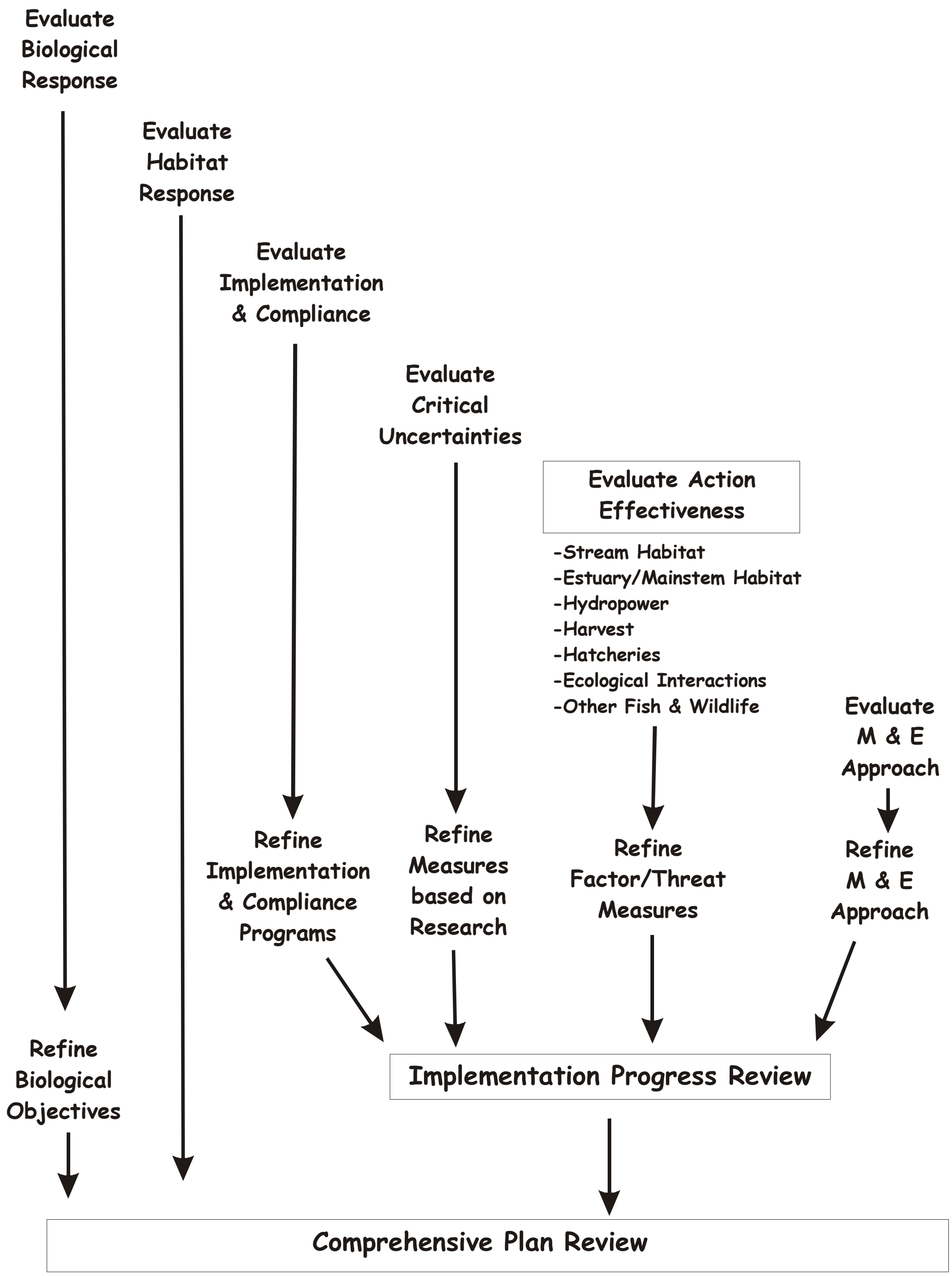


Figure 8-1. Logic path for evaluating and revising recovery planning objectives, strategies, and measures based on monitoring and research.

8.7 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. ***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.

2. ***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.

3. ***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.

9 ECONOMIC CONSIDERATIONS

9.1 OVERVIEW

This chapter on economic considerations includes an economic and demographic profile of the subbasin plan's region, a description of economics analysis methods by which recovery measures may be evaluated, and several economic assessments of example recovery measures. This material is addressed in more detail in the Technical Foundation Volume V. These descriptions do not represent a comprehensive assessment of proposed recovery measures but rather a description of the framework for incorporating economic considerations into the recovery planning process.

9.2 ECONOMIC AND DEMOGRAPHIC PROFILE

The region encompasses five counties in southwest Washington: Wahkiakum, Lewis, Cowlitz, Clark, and Skamania. The region has a mix of urban and rural land uses, with Clark County the most urban (549.7 persons per mile^2) and Skamania the least (6.0 persons per mile^2) (Table 9-1).

Natural resource based industries are declining in importance to the region's economy. Timber related employment (logging services, sawmills, and pulp and paper manufacturing) has been declining. Agriculture production in the region is along the north to south corridor of central Lewis County, Cowlitz County, and Clark County and includes mostly hay and raspberries for crops and cattle, dairies, and broilers for livestock. Agriculture income has not changed much in recent years. Commercial fishing employment is mostly related to ocean fish resources with landings in Ilwaco, Washington. There is also a lower Columbia River salmon gillnet fishery. There are no large seafood processors in the region, and industry trends have been for declining labor requirements. Economic sector growth has been in high-technology, tourism and health services, and government.

The unemployment rate in the region has trended consistent with Washington's rate. Clark County is consistently lower than the region's rate and the other four counties consistently higher than the statewide rate. Overall population has grown (53% between 1980 and 2000) in response to economic opportunities and the area's attractiveness to retirees. Clark County's population growth (80% between 1980 and 2000) is tied to the Portland-Vancouver Metropolitan Area's trends, given the short commuter distance to businesses on the Oregon side of the Columbia River and a more favorable tax exposure for residents located in Washington. The four other counties' population growth (19% between 1980 and 2000) has been much less as job opportunities at timber related businesses (logging services, sawmill, and paper and pulp product manufacturing) have been declining. There are no Indian reservations located in the region, and there is a lower regional (1.0% in 2000) than statewide (1.6% in 2000) Indian race composition. The race white (81.8% statewide and 90.0% in the region in 2000) is the overwhelming ethnicity. The older age cohort (65 and over) has been growing faster in the region when Clark County is omitted (2.2% between 1980 and 2000) than in Washington (0.8%) and the nation (1.1%). Clark County's change in the older age cohort (0.5% between 1980 and 2000) has been less than the State and nation, which is reflective of a younger age group migration to take advantage of the metropolitan area employment opportunities.

Table 9-1. Economic and Demographic Characteristics of Planning Region.

	Planning Region Counties												State of	
	Wahkiakum		Lewis		Cowlitz		Clark		Skamania		Total		Washington	U.S.
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	Amount
Population (Year 2000)														
Number	3,824	1%	68,600	13%	92,948	18%	345,238	66%	9,872	2%	520,482	100%	5,894,121	281,421,906
Incorporated	14.8%		40.5%		58.3%		51.8%		18.2%		50.6%		59.6%	--
Unincorporated	85.2%		59.5%		41.7%		48.2%		81.8%		49.4%		40.4%	--
Age														
Under 18	23.4%		26.5%		26.8%		28.7%		26.6%		28.0%		25.7%	25.7%
18 to 64	58.1%		58.0%		59.9%		61.8%		62.4%		60.9%		63.1%	61.9%
65 and over	18.5%		15.5%		13.3%		9.5%		11.0%		11.1%		11.2%	12.4%
Ethnicity														
White	93.5%		93.0%		91.8%		88.8%		92.1%		90.0%		81.8%	75.1%
Other	6.5%		7.0%		8.2%		11.2%		7.9%		10.0%		18.2%	24.9%
Education														
High school over age 25	84.2%		80.5%		83.2%		87.8%		85.9%		86.0%		87.1%	80.4%
Median household income in 1999 ($	39,444		35,511		39,797		48,376		39,317		--		45,776	41,994
Economic (Year 2000)														
Wage and salary employment	915	0%	26,502	14%	41,364	21%	123,411	64%	2,134	1%	194,326	100%	2,940,967	139,002,000
Proprietary employment	734	1%	7,848	15%	7,190	14%	35,522	68%	770	1%	52,064	100%	612,059	27,756,800
Employment by industry	1,649	1%	34,350	14%	48,554	20%	158,933	65%	2,904	1%	246,390	100%	3,553,026	166,758,800
Farm and agricultural services	411	5%	2,960	34%	1,664	19%	3,615	41%	158	2%	8,808	100%	143,388	5,234,100
Farm	175	4%	1,755	39%	702	15%	1,818	40%	96	2%	4,546	100%	80,004	3,113,000
Agricultural services	236	6%	1,205	28%	962	23%	1,797	42%	62	1%	4,262	100%	63,384	2,121,100
Mining	0	0%	664	51%	164	13%	467	36%	0	0%	1,295	100%	5,411	784,200
Manufacturing (incl. forest product	303	1%	4,535	13%	10,295	29%	20,571	57%	366	1%	36,070	100%	371,171	19,114,800
Services	587	0%	19,267	13%	27,350	18%	100,458	67%	1,324	1%	148,986	100%	2,270,912	109,235,400
Construction	0	0%	1,677	9%	3,260	18%	13,409	73%	128	1%	18,474	100%	214,331	9,446,300
Government	262	1%	5,247	16%	5,821	18%	20,413	63%	871	3%	32,614	100%	547,813	22,944,000
Gross farm sales ($000's) (Year 1997	2,715	2%	82,778	57%	15,919	11%	43,083	30%	1,532	1%	146,027	100%	4,767,727	--
Crops	3%		28%		46%		40%		87%		34%		68%	--
Livestock	97%		72%		54%		60%		13%		66%		32%	--
Personal income ($000's)	86,440	1%	1,512,443	10%	2,309,418	16%	10,335,767	71%	224,570	2%	14,468,638	100%	191,644,569	8,677,490,000
Net earnings	42,623	0%	832,904	9%	1,425,077	15%	6,986,115	74%	143,468	2%	9,430,187	100%	130,901,069	5,869,194,000
Transfer payments	20,009	1%	374,768	17%	479,724	21%	1,328,400	59%	36,471	2%	2,239,372	100%	24,240,285	1,171,083,000
Dividends, interest, and rent	23,808	1%	304,771	11%	404,617	14%	2,021,252	72%	44,631	2%	2,799,079	100%	36,503,215	1,637,213,000
Poverty rate (Year 1999)	8.1%		14.0%		14.0%		9.1%		13.1%		10.7%		10.6%	12.4%
Geographic (Year 2000)														
Area (square miles)	264	4%	2,408	40%	1,139	19%	628	10%	1,656	27%	6,095	100%	66,544	3,537,438
Density (persons per square mile)	14.5		28.5		81.6		549.7		6.0		85.4		88.6	79.6
Commute patterns														
Average travel time to work	28.1		25.7		21.3		24.7		29.7		24.4		25.5	25.5

Sources: U.S. Census Bureau, U.S. Bureau of Economic Analysis, and USDA National Agricultural Statistics Service.

9.2.1 PROFILES BY COUNTY

Wahkiakum and Cowlitz Counties

Population changes are viewed as important economic indicators because people tend to follow jobs. The recessions of the early 1980's and job losses in the timber industry caused the population to stagnate in Cowlitz County and decline 14% in Wahkiakum County between 1980 and 1991. Population growth for both counties has been positive since then. Economic recovery has resulted from: expansion of non-timber manufacturing, the opening of a new paper mill (Norpac), the opening of the Three Rivers Mall, capital projects at the Port of Longview, and the rebuilding of Weyerhaeuser's pulp mill. From 1970-2001, the population in Cowlitz County grew 37% (from 68,616 to 93,900) and Wahkiakum County increased 6% (3,592 to 3,800); meanwhile the State's population grew over 75%. Wahkiakum County, with its extremely small employment base, has been more susceptible to wide fluctuations. Over time, Wahkiakum and Cowlitz counties have transitioned from goods- to services-producing industries.

Lewis County

After several years of economic distress in the first half of the 80's, primarily associated with cutbacks in the timber industry, Lewis County has shown fairly consistent positive growth. Positive factors for the Lewis County economy include the large factory outlet mall in Centralia, TransAlta Canada’s boosted production at the Centralia coal mine and investment in the coal-fired steam plant, TransAlta Canada’s plans to build a new 248 megawatt (MW) gas-fired, combined cycle power plant at Centralia Power Plant site, and Chehalis Power Ltd. agreement to build a 520-megawatt plant in Chehalis.

Lewis County has some comparative transportation advantages, including Interstate 5, Highway 12, and access to deep-water ports of Seattle-Tacoma, Portland-Vancouver, and Olympia. Port areas in Centralia and Chehalis have also recently been certified as Foreign Trade Zone (FTZ) sites which should give a boost to trade and manufacturing in the area. Economic diversity is a concern in Lewis County. Some of the major industries are dominated by one market segment; for example, about 60% of manufacturing employment is in lumber and wood products. A disproportionately large part of the counties growth has been from migration (as opposed to growth from births). An estimated 15% of workers residing in Lewis County commute to workplaces outside the County. The average wage is less than the statewide average; unemployment rate is considerably higher than the State's.

Clark County

Clark County was the fastest growing county in Washington for most of the 1990s, because of new investment, especially in high-technology manufacturing, and immigration as a result of available land, lower property taxes, lower housing costs, and good schools. The County is part of the greater Portland metropolitan area, and took part in the region's strong economic growth. One-third of the County's labor force commutes across the Columbia River to Portland. The City of Vancouver tripled because of the annexation of a number of unincorporated areas. Rapid population growth was accompanied by the expansion of consumer-related industries such as retail trade, banking, insurance, real estate, health care, and social services. However, many corporate-related services, such as law offices, management consulting, engineering, and architects, remained concentrated in the core Portland area.

In recent years, economic growth in the Portland metro area slowed because of the Asian economic crisis, slower growth in high technology, and recovery of California industries, reducing immigration. What lies ahead for the County is partly dependent upon its link to the Portland metro area, which is quickly approaching capacity. Clark County has a higher proportion of its property developed for residential uses. Further, the State sales tax and the lack of the sales tax in Oregon mean that the County only has two-thirds of the State per capita taxable sales, as many residents shop just over the border to avoid the tax. These factored together mean that the County has a relatively lower tax base to draw from for infrastructure and basic services, such as roads, schools, and parks.

Skamania County

For decades, Skamania County's economy rested on timber—directly, through logging and milling; and indirectly, through U.S. Forest Service employment. Geography (i.e. 80% of the county is part of the Gifford Pinchot National Forest; 15% of the county in the Columbia Gorge National Scenic Area) and politics have greatly influenced the Skamania County economy. Over half of the Skamania labor force commutes to work outside the County because of fewer job opportunities.

Major events and factors in Skamania County’s economy include: construction of a second powerhouse at the Bonneville Dam from 1978-82, creation of the Columbia Gorge National Scenic Area in 1986, closing of the largest mill remaining in the County, Stevenson Co-Ply, in early 1992, construction of the Skamania Lodge, a conference center and destination resort, in 1993, and the drop in federal employment from a peak of 420 to only 240 workers in 1996. Skamania Lodge, and all its associated service industries, is now the largest private sector employer in the County.

9.2.2 OUTLOOK FOR REGION ECONOMIES

Communities in the Pacific Northwest are undergoing significant social and economic transition as traditional industries decline, new industries emerge, and populations age and expand with the flow of migrants from inland areas. Rapid downturns in the wood products industries and decreases in available fishery stocks' have reduced the importance of these industries. Industries benefiting from tourism and retirement have been expanding, leading to diversification in communities having visitor attractions. Many communities have chosen to take advantage of these trends by focusing on developing their tourism and other service industries as traditional natural resource based industries decline.

National and International Trends in Natural Resources Use

The world experienced some substantial economic growth during the last 20 years because of a relatively peaceful period and integration of technologies, resulting in integration of the economies of developed and developing countries. The result is better markets for some products and increased competition for others, especially natural resource commodities. Increased supply and aquaculture substitutes for natural resource commodities have created downward price pressure on products that are the mainstay of developing countries.

As the world economy slowed recently, additional demand pressures are affecting these commodities, negatively affecting international trade and commodity markets. Some of these trends may be reversing because of the demand for wood products related to the Iraq war, strong growth of the Chinese economy, and devaluation of the U.S. dollar in relation to the Euro and the yen. The long term effect will depend on the trend in these conditions. Both the long term increase in supply because of increases in technology and productivity, and the slow increase in effective demand points to no expectation of long term real price increases for natural resource commodities.

Timber - Timber supply and demand are determined by interactions of global, national, regional, and local consumers, producers, and land owners. International trade in forest products increased during the periods of global trade expansion. The increase was attributable to the developed countries. The most important change in timber production is in the composition of product consumption. There will be less reliance on solid wood products manufactured from logs and greater reliance on engineered and reconstituted products for structural applications. Greater use of recycled fiber will also decrease the demand for timber. An exception may be specialty products produced in the Pacific Northwest from cedar or alder: cedar for decorative products and alder for cabinetry. However, many of the larger timber land owning companies in the Northwest are selling their lands based on expectations of low returns to their investments.

Agriculture - Fertilizer factories, coupled with other technologies and marketing strategies, helped some regions experience strong increases in agriculture output, although on the whole, annual agricultural production growth has slowed in recent years. The developed countries are faced with large subsidies for agricultural producers, while the developing countries face low subsidized world agricultural prices as they are searching to join world markets. The prospect for agriculture is at best constant, inflation adjusted prices.

Commercial Fisheries - Historically, world marine and inland capture fisheries production increased by as much as 6% per year; production growth has been stagnant since the 1990's. This leveling off of the total catch follows the general trend of most of the world's fishing areas, with the majority of stocks being fully exploited. It is very unlikely that substantial increases in total catch will be realized. In contrast, growth in aquaculture production has shown the opposite tendency. There are dozens of promising species being farmed or under development: tilapia, catfish, cod, halibut, red drum, cobia, black cod, and various species of bass, bream, and snapper. Even though there is a concern about the long term sustainability of capture fisheries and water demands of aquaculture, the short to medium term expectations are that increased production will sustain downward pressures on seafood production.

Tourism - Demand for natural resource based recreation is based on available time and disposable income. Population growth and population affluence are the most significant factors to increase in recreation activity. The trend in developed countries is slower population growth and a shift toward older and wealthier populations. Age structure influences recreation activity in that older people tend to travel farther for recreation, stay in developed campgrounds, and stay longer than young people. As more people travel to the Pacific Northwest for vacations, recreation will become an increasingly important export of economies.

Effects of Natural Resource Use Trends on Southwest Washington Communities

In the short to medium term the technological advances have increased world production and reduced real prices for most natural resource commodities. In the longer term, this increased production may have negative environmental effects, such as increased fertilizer run-off, decreased timber diversity, or chemical and disease contamination of water resources. Southwest

Washington is an attractant because of the relative abundance of natural resources. These are a comparative advantage to draw visitors and will become a greater attractant as other areas become more developed. The challenge will be for the southwest Washington areas to protect this comparative advantage while at the same time keeping pace in economic development.

Lessons Learned From the West's Growth and Dependence on Natural Resources

The economic growth of the West was highly dependent on the availability of cheap or free natural resources. For most of the 19th century, American politicians viewed the federal lands as a vast resource to be settled and exploited. Wilderness enthusiasts sought to put recreation on equal footing with extractive uses, while traditional users all argued for a greater allocation. As extractive uses are curtailed, communities argue for resumption of traditional use for the economic benefits. These industries historically supported European settlement and are still widely believed to support the region's rural areas and small cities. Their decline has provoked deep economic anxiety throughout the region.

Changing industrial structure has not triggered a decline in the region or an overall loss of jobs, income, or residents. Environmental protection, rather than threatening economic well-being, enhances welfare and protects the very source of the economic vitality the West enjoys. Logging reductions on federal lands in the Pacific Northwest are an integral part of, and not an impediment to, the region's economic evolution.

There are several public policy alternatives for economic development of the rural West, including: 1) Recognize that local government cannot manipulate local pay and income by subsidizing job creation; 2) Local economic policy should focus on enhancing the ability of existing residents to earn a decent living rather than trolling for additional employers with tax breaks or other subsidies; 3) Public policy should focus on present and future trends, rather than the past; 4) Local economic policy should treat the community's site specific characteristics as important determinants of citizen well-being and local economic vitality; and 5) States with the highest environmental quality and counties with scenic and natural resource amenities have the best economic performance.

Expected Social Changes

The global population is growing, however, the effective demand for natural resource commodities will not increase with population increase. Also, the shift toward lower growth rates and older population in the developed countries will reduce the demand of commodity goods and increase the demands for free time goods and services. The changing population base will influence every aspect of the southwest Washington communities, including the composition and quality of the work force, social and health care needs, education, and housing.

The labor force will be shaped primarily by three factors: the aging of the baby boomers, the shortage of entry level workers due to the low birth rates, and the influx of women into the work force. For Washington, the new job creation is projected to be strongest in the professional, technical, and service fields. Overall, the projected growth rates for the State's occupational sectors are consistent with those on the industry side, confirming that the State's economy will continue to shift toward service-producing activities.

Expected Economic Changes

Declines in natural resources available for harvests and declines in prices have reduced the total employment of these sectors. Global supply/demand changes have decreased the real prices offered for these commodities. Shifting demographic factors are increasing the demand for service jobs that support the tourist and retiree industries.

The outlook for lumber and fiber products is for continued declining production There is some possibility that growth in specialty species such as cedar and alder may provide niche markets for growth in timber based jobs in southwest Washington communities. The southwest Washington communities produce a diversity of crops and livestock; overall, production has diminished. Some communities have been very successful in marketing premium products that supply the growth of housing and leisure time, which is where future growth potential lies. The viability of Oregon and Washington's commercial fishing industry will be dependent on the ability to make more with less. Any seafood development projects will have to include "niche" marketing that sells the cultural and environmental values provided by the Pacific Ocean waters.

Challenges to Economic Growth in Southwest Washington Communities

Industry Seasonality - The southwest Washington economy is heavily influenced by seasonal industries. During the winter months, major layoffs in these industries raise unemployment through much of the region. In the summer, many southwest Washington employers dependent upon tourism report difficulty in securing an adequate supply of workers during the hectic summer months. Such seasonality results in annual average unemployment rates that are higher than elsewhere. Any policy to increase economic activity should include efforts to smooth out the economic seasonality. Economic development efforts should promote any regional comparative advantage. The comparative advantage of the southwest Washington areas is the natural amenities.

Attracting Retirees - As the population ages, the bountiful southwest Washington natural resources and temperate climate attract tourists as well as resident retirees. Attracting retirees may be a policy that fits into some communities' economic objectives. An often overlooked group is residents who grow older in their long-term home communities. Their characteristics and needs are different from those of in-migrating elderly and require a different set of services and policies. For economic development policy, the benefits of attracting this age cohort with the overall cost in public services, changes to land use demands, etc., should be compared.

Economic Development Policies - The Pacific Northwest rural communities that are faring better than others are those that are close to the metropolitan areas. These areas have advantages for economic growth: high quality of life being in a rural setting, sufficient medical, shopping, and other services, and comparably low land values. They also have transportation infrastructure and proximity that allows a convenient driving distance to higher levels of education, medical services, airports, etc. Economic development public policy in other communities needs to recognize the success in these communities and promote the same advantages. The accessibility of rural residents to communication links may attract business and residents. Visitors will be attracted from metropolitan areas for ecological and cultural based tourism. This will make public goods an important part of the local economic base. High technology industries will be attracted to the available quality of life amenities.

9.3 ECONOMIC ANALYSIS METHODS

An economic analysis of the integrated regional strategy's recovery actions is needed for several reasons:

- If economic returns is paramount in selecting actions to implement, then decision makers need to know if benefits will exceed costs.
- The economic effects resulting from the recovery actions should have some equitable spread across stakeholders.
- Limited funding usually means actions have to be ranked and packaged for the order of implementation so as not to exceed available stipends.
- Economic analysis can provide a common measure to help decision makers determine whether a tradeoff between one use (hydropower for example) might produce different economic effects for another use (recreation activity for example).

The problems for declining salmon and steelhead populations are widespread, strategies for rebuilding the populations will be intrusive on the human activities that are causing the problems. Understanding the economics for the changes has to consider all of the human activity to be altered for fixes. The economic benefits can be significant, but there will be costs too. The general characteristics of these costs:

- Many changes will entail doing things differently (i.e. salmon-friendly technologies) and can phased in over time, but will have few costs.
- Many costs can be attenuated, such as offsetting reductions in timber-sale revenues by changing forest-management practices.
- Many costs can be spread out, such as compensating farmers for reductions in sales when they take streamside land out of production.
- Most workers will adapt fairly easily. If recent trends hold, about 50% of displaced workers would find replacement jobs in two months or less, and 55% of those reemployed would have equal or higher wages than before.
- The alternative may be even more costly. The costs of keeping salmon perched on the edge of extinction can be enormous.

The analytical approach will be different, depending on how the information will be used and the recovery actions' purposes. It will be necessary to measure the net economic value (NEV) at the national level if there is a federal perspective on action benefits and costs. NEV implies there is an efficient outcome that will occur when the sum of the benefits outweigh the sum of the costs. Where economic effects measured by jobs or household income in local economies is important to show that different stakeholders are benefiting from project actions, then a regional economic impact (REI) approach to the economic analysis needs to be completed. When it is of importance to know the cheapest action or set of actions to accomplish biological objectives (like a 1% increase in juvenile salmonid survival during downstream passage), then a cost-effectiveness analysis (CEA) is the economic analysis approach.

The following description uses the example of benefits from increasing adult salmonid returns, because that is the underlying goal of the integrated regional strategy. However, many of the actions have other types of benefits, such as for water quality, flood control, and non-fishing recreation opportunities. These other aspects of environmental quality could sometimes serve equally as well for examples.

9.3.1 NET ECONOMIC VALUE

NEV attempts to measure the benefits received less costs for using a resource. NEV's are important if the goal is to allocate society's resources efficiently. In general, benefits are measured by willingness to pay and costs by opportunity costs. Opportunity costs reflect the foregone benefits from the use of a resource. There can be active use of a resource where consumption as well as non-consumption use takes place and there can be passive use of the resource. The economic values of passive use are from existence values (knowledge of continual existence of the resource), bequest values (preserving the resource for future generations), or option values (users having the option to use the resource in the future). The economic value classification scheme for use and non-use of a resource is shown below.

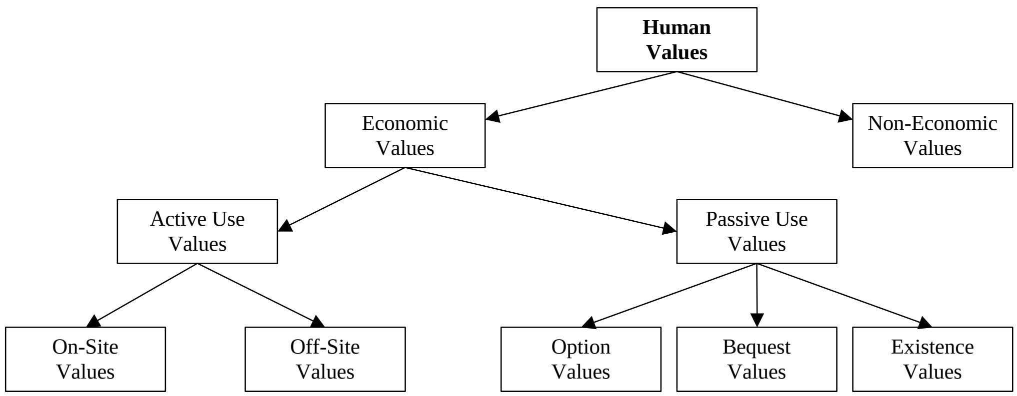


Figure 1. Economic Value Classification Schematic.

Recreational Fishing

The recreational fishing economic values are related to the act of fishing, generally defined as an activity carried out on a per trip or per day basis. The estimated values per day for anadromous fish fishing are listed in Table 9-2. The values are from various other studies brought together to establish comparable levels for what people would be willing to pay for the fishing experience. Each recreational fishing experience may create its own value based on the species, geographic area fished, etc. The value may or may not be similar to another experience. A review of studies in the Pacific Northwest supported the estimate of $52 per day as a general guideline for the NEV from the recreational fishing experience for salmonids.

Commercial Fishing

To compute the NEV from commercial fishing, the costs of harvest (fuel, repairs, labor, etc.) should be subtracted from the gross revenues. Because the fishing season is of short duration, most fishing boats are not limited to salmon fishing. The investment in boat and gear is also used for other fisheries. Also, at low levels of total salmon harvest and with small incremental changes in salmon production, it is often argued that any increased harvest could be taken with almost the same amount of labor, fuel, ice, etc. as before. The current fisheries are greatly overcapitalized, in use of fixed and operating capital as well as labor, implying that almost no additional costs are involved and gross benefits are close to net benefits.

Table 9-2. Anadromous Fish Net Economic Value and Regional Economic Impacts Modeling Factors.

	Commercial Per Fish		Recreational Per Day		Days	Recreational Per Fish	
	REI	NEV	REI	NEV	Per Fish	REI	NEV
Species: Coho							
Ocean							
Alaska	21.29	10.20	60.00	51.43	1.00	60.00	51.43
British Columbia	18.15	8.70	60.00	51.43	1.00	60.00	51.43
Washington ocean	12.49	5.99	60.00	51.43	1.00	60.00	51.43
Washington Puget Sound	16.90	8.67	60.00	51.43	1.00	60.00	51.43
Oregon	17.43	9.17	60.00	51.43	1.00	60.00	51.43
California	20.65	9.35	60.00	51.43	1.00	60.00	51.43
Columbia Basin inland							
Freshwater sport							
Mainstem	--	--	60.00	51.43	1.00	60.00	51.43
Tributary	--	--	60.00	51.43	1.00	60.00	51.43
Gillnet	15.15	8.99	--	--		--	--
Tribal	15.15	8.99	--	--		--	--
Other	--	--	--	--		--	--
Hatchery surplus market	11.94	7.28	--	--		--	--
Hatchery carcass	2.00	1.23	--	--		--	--
Species: Spring/Summer Chinook							
Ocean							
Alaska	69.15	33.83	60.00	51.43	1.00	60.00	51.43
British Columbia	69.99	34.30	60.00	51.43	1.00	60.00	51.43
Washington ocean	48.31	23.68	60.00	51.43	1.00	60.00	51.43
Washington Puget Sound	41.22	21.19	60.00	51.43	1.00	60.00	51.43
Oregon	42.05	21.65	60.00	51.43	1.00	60.00	51.43
California	--	--	60.00	51.43	1.00	60.00	51.43
Columbia Basin inland							
Freshwater sport							
Mainstem	--	--	60.00	51.43	2.00	120.00	102.86
Tributary	--	--	60.00	63.23	2.00	120.00	126.46
Gillnet	98.59	49.95	--	--		--	--
Tribal	98.59	49.95	--	--		--	--
Other	--	--	--	--		--	--
Hatchery surplus market	49.12	26.87	--	--		--	--
Hatchery carcass	2.00	1.23	--	--		--	--
Species: Fall Chinook							
Ocean							
Alaska	69.15	33.83	60.00	51.43	1.00	60.00	51.43
British Columbia	69.99	34.30	60.00	51.43	1.00	60.00	51.43
Washington ocean	48.31	23.68	60.00	51.43	1.00	60.00	51.43
Washington Puget Sound	41.22	21.19	60.00	51.43	1.00	60.00	51.43
Oregon	42.05	21.65	60.00	51.43	1.00	60.00	51.43
California	53.80	22.53	60.00	51.43	1.00	60.00	51.43
Columbia Basin inland							
Freshwater sport							
Mainstem	--	--	60.00	51.43	1.50	90.00	77.15
Tributary	--	--	60.00	63.23	2.00	120.00	126.46
Gillnet	41.22	23.53	--	--		--	--
Tribal	41.22	23.53	--	--		--	--
Other	--	--	--	--		--	--
Hatchery surplus market	29.75	18.25	--	--		--	--
Hatchery carcass	2.00	1.23	--	--		--	--
Species: Summer/Winter Steelhead							
Ocean							
Alaska	--	--	60.00	52.85	1.00	60.00	52.85
British Columbia	22.28	11.44	--	--		--	--
Washington ocean	--	--	--	--		--	--
Washington Puget Sound	--	--	--	--		--	--
Oregon	--	--	60.00	52.85	1.00	60.00	52.85
California	--	--	--	--		--	--
Columbia Basin inland							
Freshwater sport							
Mainstem	--	--	60.00	52.85	2.00	120.00	105.70
Tributary	--	--	60.00	63.23	2.00	120.00	126.46
Gillnet	--	--	--	--		--	--
Tribal	16.89	9.99	--	--		--	--
Other	--	--	--	--		--	--
Hatchery surplus market	14.21	8.73	--	--		--	--
Hatchery carcass	2.00	1.23	--	--		--	--

Notes:
1. Average 1998 dollars per fish. See text for an explanation on how REI and NEV are derived.
2. Hatchery sales include carcass and egg sales.
3. Two days per fish harvested include released wild and retained hatchery fish. For steelhead retained fish only, the CPUE is 0.17 fish per day (or 5.88 days per fish).

The assumption of full employment is implicit in most benefit and cost analysis. But unemployment and excess fishing capacity, both transitory and chronic, are common commercial fishing. Changes in markets or fishing opportunities may make it necessary for people and capital to change occupations and/or locations. Various factors make it difficult for this to happen quickly enough to prevent a period of unemployment and idle capacity.

A portion of the ex-vessel and ex-processor prices are used as measures to facilitate guidelines in any net value of commercial salmon fishing. Specific fisheries with acceptable data can be investigated to determine the net value of the fishery. For this analysis, in order not to complicate the presentation, a 70% margin is used to represent an "average" NEV for most commercial salmon harvested. The 70% margin is applied over a range of annual prices. The remaining 30% represents additional expenses of harvesting and primary processing required to produce a consumer product from Columbia River Basin anadromous fish runs.

Passive Use Values

Economic value is very precisely defined as the relative value of a good or service, or what someone would be willing to pay in exchange for that good or service; this definition describes value to people. Therefore, for a fishery resource to have economic value, people must be willing to give up other valuable resources in order to have the fishery resource. Clearly this makes economic value a function of peoples' preferences and their ability to pay.

There are some people who are willing to pay for a resource, even though they never intend to use it. This type of non-use value is called existence value, because people are willing to pay to ensure that a resource exists, knowing that they will never actually use the resource. Another type of non-use value would be the willingness to pay for future use of the resource or its option price. The option value represents any additional (or less) willingness to pay (above expected consumer surplus) for the option of future use, when future use is uncertain. Passive use values should be considered in decision making (Table 9-3).

9.3.2 REGIONAL ECONOMIC IMPACTS

The NEV must represent the value of the fishery resource itself, and not the value of the related travel and equipment items. These associated costs are instead the source of local or REIs associated with use of the fishery. REIs describe the local or regional effects on jobs and income associated with any specific area chosen as the point of interest. The calculations for REI in this report are in personal income impacts. REI's are important in assessing the distributional impacts of the different allocation possibilities on the financial economies of areas. The information on economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development.

Table 9-3. Passive Use Values Per Unit.

Forest Use Values

For the Pacific Coastal region, 82 separate estimates across 22 recreation activities resulted in an average value of about $39 per recreation activity day in 2003 dollars.

Estimated recreation use values for Oregon's forests to be about $128.11 per trip in 1992 dollars; adjusting for inflation this amounts to $159 per trip in 2003 dollars.

Sportfishing Values

Direct Use Values - Steelhead estimates ranged from $26 per day to $79 per day, while salmon estimates ranged from $24 per day to $79 per day for river fishing for salmon and $37 per day to $100 per day for ocean sportfishing for salmon.

Passive Use Values - Passive use values for a variety of increases in salmon populations ranged from $36 per household to $257 per household (adjusted for inflation to 2003 dollars). The median value per fish was about $2,594 in passive use value per additional fish supplied.

The following are some of the average value estimates for rare and endangered species (all estimates are adjusted for inflation to 2003 dollars):

- Northern spotted owls, $89 per household per year;
- Pacific salmon/steelhead, $80 per household per year;
- Gray whales, $33 per household per year; and
- Bald eagles, $31 per household per year.

Some rare and endangered species values were estimated in the form of a one-time payment:

- Bald eagles, $275 per household;
- Humpback whales, $220 per household;
- Gray wolf, $85 per household; and
- Arctic grayling/cutthroat trout, $19 per household.

Notes: 1. The above estimates are dominated by their passive use value component and includes an active use value component. Estimated values were higher when visitors to sites for the purpose of viewing the species were sampled as compared with a sample of regional or national households that may or may not have ever viewed the species or may have no intention of ever viewing the species.
2. All estimates have been adjusted for inflation to 2003 dollars.

Input/Output Models

Economic input/output (I/O) models are used to estimate the REI from resource changes or to calculate the contributions of an industry to a regional economy. The basic premise of the I/O framework is that each industry sells its output to other industries and final consumers and in turn purchases goods and services from other industries and primary factors of production. Therefore, the economic performance of each industry can be determined by changes in both final demand and the specific inter-industry relationships. The models developed for this project utilize one of the best known secondary I/O models available. The U.S. Forest Service developed IMPLAN, which can be used to construct county or multi-county I/O models for any region in the U.S. The Fishery Economic Assessment Model (FEAM) uses the IMPLAN coefficients to generate the REI from ocean salmon harvests. Estimates of REI from composite stocks harvested from California to Alaska are determined by the information made available on contributions of Columbia River stocks to the ocean fisheries.

Regional Economic Impacts Model Application

On the commercial side, representative budgets from the fish harvesting sector and the fish processing sector, as well as a price and cost structure for processing are used to estimate the impacts of changes. On the recreational side, charter operator budgets and recreational fishermen destination expenditures provide the basic data.

Recreational Fishing REIs - ODFW sponsored a comprehensive survey to compile information about angler characteristics, expenditures, and preferences of recreational anglers. This study has been used as the basis for showing the annual economic impacts of West Coast salmon fisheries. Assumptions from the PFMC model are extended to calculate the impacts from salmon harvested in Alaska and British Columbia. The REI estimates associated with recreationally-fished ocean salmon are shown in Table 9-2. Factors affecting these estimates include the means of fishing, expenditures patterns, and success ratios. The REI per salmon/steelhead harvested recreationally varies considerably whether a fishing trip was guided or used a boat. Estimating procedures usually start with catch numbers. REI's are based on expenditures per angler day. For ocean fishing, one fish per day success rates are used. Within the Columbia Basin, the success rates vary from species to species and by geographic area.

Commercial Fishing Regional Economic Impacts - Representative budgets from the fish harvesting sector and the fish processing sector, as well as price and cost for processing are used to estimate the REI from commercial salmon fishing. The commercial salmon fisheries budget data are from the FEAM. REI by species and geographic region used in this report are listed in Table 9-2. For example, gillnet-caught fall bright Chinook command $1.50 per pound. The yield on this dressed fish, when it is marketed fresh, is 80%. The sales price for the primary product for the fisherman is $2.94 per pound. The community income received from this one pound is $2.86; people in the State outside the local area, that supply goods or services to local area, will receive another $0.50, for a total of $3.36. The total state income generated by one pound of salmon harvested and processed in the Pacific Northwest is $3.36. The average weight of these Chinook is 18.4 pounds. Thus, the total state level impact per landed Chinook is $61.74.

9.3.3 COST-EFFECTIVENESS ANALYSIS

CEA compares the costs and results of alternative actions, or groups of actions, that could be taken to accomplish a specific quantifiable objective. The essential requirements are a measurable objective (or reasonable proxy) and the economic costs of various actions that could be taken to achieve that objective. CEA asks the question: given a particular objective, which is the least cost way of achieving it? Thus, it facilitates choice among options, but cannot answer whether or not any or all of the options are worth doing. CEA is used instead of NEV and REI analysis when there are difficulties in associating monetary values with outcomes (such as the value of wild salmon and steelhead), but where the outcomes can be defined or quantified in non-monetary fashion. CEA can be used to search for and identify scenarios that meet the cost-effectiveness criteria defined by the Northwest Power Planning Act (NPPA).

The critical assumptions for undertaking a CEA for the recovery actions is knowing the project costs and the biological outcomes for an action. There are a number of sources for per unit cost estimates, but there is no substitute for applying engineering standards to determine a project's budget. Table 9-4 shows the recommended middle ranges for a list of habitat improvement projects.

Table 9-4. Potential Habitat Improvement Project Costs.

Habitat Improvement Project	Cost Range
Land Purchase or Acquiring Conservation Easements	$700 per acre for undeveloped forest land to $1.2 million per acre for sites having existing urban land uses
Fencing	$3 to $12 per lineal foot depending on the design and terrain
Riparian Planting	$5 to $135 thousand per acre depending on site access and conditions and the types of materials
Culvert Improvements	$15 thousand each for a forest road to $800 thousand each for a 4-lane highway
Large Woody Debris/Engineered Log Jams	$1 thousand per stream mile when equipment is not needed and up to $80 thousand per structure for large streams where engineered log jams might be used
Streambank Improvements	$30 to $1,000 per lineal foot for excavation and erosion control measures to produce a bank for plantings
Nearshore Restoration	$100 to $1,250 per lineal foot depending on access and replacement/reconstruction needs
Floodplain Restoration	$10 thousand per acre for minor earthwork and hand excavation and up to $300 thousand per acre for major side channel reconnection projects.
Estuary Restoration	$20 thousand per acre and up to $2 million per acre depending on site conditions and extent of earthmoving

9.3.4 LIMITATIONS

NEV, REI, and CEA all have their applicability in evaluation actions. REI results are indicators of the amount of dislocation costs which may occur in the event of reductions in fisheries, but are not indicators of the net loss from such reductions. If sufficient quantitative information and defensible analytical models are available, net gain or loss determined through a benefit-cost analysis is the value suggested for analyzing actions of federally managed fisheries.

REI estimates measured by personal income provide a value that is comparable to similar values often used to describe activities in nonfishing sectors of the economy. If the fishing activity is reduced, personal income is not necessarily reduced by a proportional amount. The effect on personal income in the local economies will depend on alternative activities available and the location of those activities. If there were a reduction in the ocean fisheries, workers in the commercial and recreational fisheries, vessel and processing plant owners, and food fish consumers would be expected to adjust to the reductions by changing activities. The type of the alternative activity determines the net effect of changes in ocean fisheries. The effect on the local economy would differ from the effect on the national economy to the degree the alternative activities were located outside the local community.

The REI estimates provide information on a representative year basis and are an indicator of the possible redirection of money between nonfishing-dependent and fishing-dependent sectors that may occur with changes in the fishery. The amount of redirection represents a dislocation which may have economic and social costs that would not be reflected in a typical NEV analysis. However, it should not be a substitute for a proper assessment using benefit-cost framework.

CEA has a number of inherent limitations. A particular limitation is where there are multiple objectives that cannot be measured in common units, and so cannot be compared on the same basis. In such cases, there is no definitive basis for choosing among scenarios based on cost-effectiveness unless one scenario happens to be the best for all the objectives. One of the most important limitations of CEA is that it does not consider whether the given objective has a value that is greater than its cost. CEA cannot identify the scenario with the most economic benefit because the economic benefit of the objective is not considered.

9.4 APPLICATION TO SELECTED RECOVERY ACTIONS

Recovery actions in this Management Plan do not have the characterization necessary to determine benefits and costs. Five action types were chosen to demonstrate the economic effects, including: restore wetlands, preserve and restore streamside buffers, establish or modify in-stream flows, improve water quality, and reduce outmigration predation. The effects from implementing the actions are to cause changes in the use of natural resources. The economic analysis is to provide information to decision makers about the economic consequences. The economic analysis reviews a variety of consequences, but the emphasis is on what happens to anadromous fish habitat and water quality. REI is the calculation method used in the analysis. NEV methods require more information about a particular recovery action's costs and has to be deferred until actions are better characterized.

Example 1: Restore 3,000 Acres of Tidal Wetlands

Wildlife Impacts

- Species would benefited in proportion to increase in wetland/mudflat area.
- Area would attract significant wildlife for viewing.
- Local data suggests 18 square miles (11,520) attracted about 23 annual wildlife viewing days per acre per year.
- The 3,000 acres of restored wetlands will create about 69,000 wildlife viewing days.
- The cost will be removing the 3,000 acres from fairly low productive agriculture.
- At $49.78 per day, impact of wildlife viewing, the acre impact may be $1,145 per year.
- Total annual impact of wildlife viewing of the restored wetlands may be $3,434,820.
- In terms of full time equivalent jobs, this equals 137 annual jobs (at $25,000 per year).

Fish Impacts

- Increase of salmon smolts could exceed 400,000 individuals.
- Up to 40,000 additional fish would use this reconstructed wetland.
- Smolts are coho, spring Chinook, fall Chinook, or steelhead. The calculations will center on coho, for two reasons:
  - Coho, in their life cycle, are in the stream for one year
  - The status of wild fish is such that they are the "limiting factor" for most management options
- An additional 40,000 fish that would otherwise not migrate to the ocean.
- These fish utilize this area as a "transportation" corridor.
- 40,000 additional fish at 7.5 percent ocean survival; 2,000 additional fish may survive and be available for harvest and spawning areas throughout the Pacific Northwest.
- At a local economic impact of $22.49 to $31.76 per fish (differs by species), the 2,000 fish generate $44,980 to $63,520 of personal income to the Pacific Northwest.
- A smaller amount of income may be generated if any of the 2,000 are harvested in different proportions than historical catch rates of lower Columbia hatchery fish.
- In terms of full time equivalent jobs, this equals 1 to 2.5 additional annual jobs.
- If these restored wetlands are utilized by wild coho smolts, this provides an additional $404,820 of income to the region or 16 additional jobs.

Agriculture Impacts

- Two acres per animal unit month of production may generate $6.11 of income per acre per year from cattle grazing (at two acres per AUM). The amount of income lost by removing 3,000 acres from agriculture may be $18,315 per year.

Table 9-5. Possible Economic Impacts of Restoring 3,000 Acres of Tidal Wetlands.

	Possible Economic Impacts	
Resource Affected	Total Personal Income	Annual Jobs (FTE)
Wildlife (birds) viewing	$3,434,820	137
Fish (coho) enhancement	$44,980 to $404,820	2 to 16
Agriculture (grazing)	<$18,315>	<0.7>
Net gains <losses>	$3,461,485 to $3,821,325	138 to 152

Example 2: Preserve and Restore One Mile of Streamside Buffer Area

Wildlife Impacts

- Buffers retain plant structure for a minimum of 200 to 300 feet beyond stream.
- One mile of buffer (one side of stream) would create 24.2 acres of buffer.
- An acre of improved habitat yields 0.72 annual wildlife days. The result of one mile of improved buffer is $868.89 of income impacts per year from increased wildlife viewing. Based on $49.78 income impacts per wildlife viewing day.
- In terms of annual jobs, 29 miles of buffer creates one job from wildlife viewing.

Fish Impacts

- Buffer widths of 30 m needed to protect salmon egg and juvenile development.
- Given a likely survival to adulthood of 10 to 20% for the smolt, these estimates yield a salmon density less than 10 adults per 100 m^2 (about four per acre).
- Annual yield of coho smolts ranged from 5.5 to 16.9 per 100 m^2 of rearing area.
- Smolts entering the ocean may survive to adults at 2.5 to 7.5% rate.
- The fish utilize this as a "transportation" corridor.
- Coho smolts survive at a 5.5 to 16.9 per 100 m^2 of rearing area and smolts survive up to 7.5%; then up to 0.5 additional adults per acre may survive as a result of the buffer.
- One acre of buffer creates $11.25 ($22.49 per fish) income per acre per year.
- One mile of buffer creates $349 of additional income per mile of buffer per year.
- In terms of annual jobs, 92 miles of created buffer would generate one additional job.
- If these created buffers are utilized by wild coho smolts, this amounts to additional $2,453 of annual income to the Pacific Northwest.

Agriculture or Forestry Impacts

- Cost would be a potential loss of unimproved pasture or timber growth.
- An animal unit month used for grazing cattle generates $6.11 per acre. One mile of buffer not used for grazing has the potential not to generate $148 of income.
- The buffer would affect 15.1 acres of forest. Riparian areas produce low grade wood at about 250 usable board feet per acre per year. Low grade timber creates $99.50 per acre per year. Thus, a mile of buffer results in a loss of $1,502 per year.

Table 9-6. Possible Economic Impacts From Preserving and Restoring Streamside Buffers (Per Mile Restored).

	Possible Economic Impacts	
Resource Affected	Total Personal Income	Annual Jobs (FTE)
Wildlife (birds) viewing	$869	0.03
Fish (coho) enhancement	$273 to $2,454	0.01 to 0.10
Agriculture	<$148>	<0.01>
Forestry	<$1,502>	<0.06>
Net gains <loss>	$1,673 to <$508>	0.06 to <0.03>

Example 3: Restore or Modify In-stream Flows

Fish Impacts

- Flow as low as 30 cfs for spawning and as low as 6 cfs to support fish rearing.
- Coho salmon smolt yield ranged from 5.5 to 16.9 smolts per 100 m^2 of rearing area.
- The flow of the river is essentially zero during the late summer and early fall season, and therefore provides no survival for stream-type salmonids.
- A productive coastal stream provides year round habitat for up to 160 wild spawners.
- Water sources require dam construction to contain water during low-flow periods.
  - Timber management program may increase water availability in late summer.
  - Non-logged watersheds act as a reservoir in the crucial low-water periods.
  - Reservoir storage costs about $3,500 per acre foot. The amortized 50 to 80 year annual cost of such a capital project is $165 to $350 per year.
  - The reservoir economic impact is neutral (after the construction period). The household payment would be offset by a decrease in other household spending.
- For coho, a spawner may produce 2,500 eggs at 3% survival from egg to smolt. At 2.5-7.5% ocean survival, 6 adults may be produced. At a 50% harvest, 3 fish per spawner are harvested. At an economic impact of $22.49 per harvested fish, a spawner generates $67.47. 40 spawners can produce $1,349 of impacts. At a rate of 160 spawners per mile, the economic impact may be $5,398.
- The economic impact of restoring 10 miles of stream may be as high as $53,980.
- If river is used by wild coho smolts, this amounts to additional $485,820 of annual income to the Pacific Northwest.
- There have been periods when the entire flow of river was diverted.
- A 645 acre foot reservoir required to store water for 60 day period. The estimated cost of such a storage is $2,257,000.
- Amortized over 30 years, at 7%, a $181,923 annual payment would be required to repay the capital cost of reservoir construction.
- The local economic impact of such cost is uncertain. It may be neutral and depends on what local spending is curtailed resulting from higher water fees.
- The local household multiplier is 0.77; therefore, up to $140,081 of personal income to the region may be lost resulting from these water payments.

Table 9-7. Possible Economic Impacts From Modifying Minimum Flows to Meet In-Stream Fish Needs.

	Possible Economic Impacts	
Resource Affected	Total Personal Income	Annual Jobs (FTE)
Fish (coho) enhancement	$1,349 to $53,980	0.05 to 2.2
Alternative water storage	$0 to <$140,081>	0 to <5.6>
Net gains <loss>	$53,980 to <$138,732>	2.2 to <5.5>

Example 4: Eliminate Chemicals From Pulp and Paper Manufacturing Discharge

- EPA requires Elemental Chlorine Free (ECF) process for pulp and paper mills with bleached paper grade Kraft processes.
- Technology will cut air pollutant emissions by 60% and eliminate dioxin discharged from pulp, paper, and paperboard mills into rivers and other surface waters.
- EPA estimated the industry needed to invest $1.8 billion in capital expenditures and $277 million per year in operating expenditures to comply with this rule.

Table 9-8. Cost Summary for 96 Pulp and Paper Mills Affected by EPA Rules.

(Cost in Millions)

	Elemental Chlorine Free	
Capital Cost	All mills	Per mill
EPA estimate	$2,100	$21.9
Industry estimate	3,575	37.2
Post Tax Annualized Costs		
EPA estimate	216	2.3
Industry estimate	457	4.8

Notes: 1. Capital cost is an estimate of construction cost.
2. Post tax annualized costs are annualized costs needed to retire the capital costs.

- Two scenarios may happen from the new standards for bioaccumulative chemicals: (1) mills may close, or (2) capital costs will be incurred and water quality will improve. Companies may shut down specific processes to cope with rule requirements rather than making the required upgrades to equipment.
  - Pulp and paper mills annual payroll averaged $50,000 to $55,000. The personal income multiplier for the lower Columbia area is 3.06 for pulp mills and 2.27 for paper mills. The overall effect of a pulp or paper mill closure on the lower Columbia economy may range from $113,500 to $168,300 for every direct job that is lost. The annual effect of a 400 employee mill closure may be a loss of up to $67,200,000 of income. Not all of this impact may be realized in any one period. The total impact on the supporting industries will depend on substitute sales.
  - Increases in costs are borne by all pulp and paper mills
    - + The impact on the paper and pulp industry is across the board, which in effect may increase the amount of income generated.
    - + Annualized costs over time range from $2.3 to $4.8 million, which are passed on to the consumer in terms of sales. At an annual rate, these costs generate $1.04 to $2.64 million of total personal income in the region annually per mill.

  Implement Construction Costs: On a one time basis, the construction of additional treatment facilities at a cost of $21.9 to $37.2 million generates an increase of total personal income of $18 to $30.5 million for the region.

  The effects from the cleaner water are:
  - The result of removing chemicals may benefit communities' water systems.
  - A water quality treatment plant may cost about $119 per acre foot of water. Some of these costs may be avoided if chemicals are not present. However, treatment

plants will be required eventually by EPA regulation. Therefore, calculation of income impacts from increased standards on water treatment are not possible.

- Dioxin and furan compounds are considered carcinogenic and are believed to cause reproductive effects. Environmental persistence and biomagnification are possible with these compounds, so they are likely to affect all levels of the food web, including salmon, bald eagles, otters, and mink. It appears that the most common source of these compounds is the pulp and paper industry. Elimination of these compounds from the waste stream could result in increased reproductive success of sensitive invertebrates species associated with the river systems, and increased sport fishing and resulting tourism from the lifting of fishing advisories in river sections near pulp and paper facilities. It is not clear if commercially important fish or shellfish, such as salmon or crab, should be included in the lower Columbia River advisories, nor is there definitive proof that implementation of EPA Rules would enhance these resources in the near future.
- Not enough is known about possible effects on harvestable quantities of fish or viewable wildlife. Personal income effects related to marine harvests or recreational activity are not estimated.

Table 9-9. Possible Economic Impacts From Elimination of Bioaccumulative Chemicals in Pulp and Paper Manufacturing Water Discharges.

	Possible Economic Impacts	
Resource Affected	Total Personal Income	Annual Jobs (FTE)
Mill closure	<$67,200,000>	<2,208>
Construction impacts (one time event)	$18,000,000 to $30,500,000	720 to 1,220
Clean water effect on fish	(not enough information to calculate)	
Net gains and <losses>	may increase jobs during construction; could result in loss of up to 2,208 local jobs	

Example 5: Provide a Northern Pikeminnow Sport Reward Fishery Program

- The total Columbia/Snake River produces about 200 million smolts. The river system losses are estimated at 115 million. Pikeminnow consume about 16 million smolts. A pikeminnow harvest program (NPMP) reduces this predation by about 3.8 million.
- Commercial and recreational activity throughout the West Coast dependent on Columbia/Snake River system fish production.
  - Net valuation
    - + Net value of commercial catch 70% of ex-vessel value
    - + Net value per angler day $52 to $63
    - + Passive uses not included
  - Regional income impacts
    - + NPMP administrative program - depends on labor
    - + Pikeminnow harvests
      - > Highliners $7 per fish
      - > Recreation anglers $30 per day
    - + Salmonid - from Alaska to California
      - > Commercial harvests 70% of ex-vessel value
      - > Recreational harvests per day $51 to $63
- NPMP economic evaluation results: The NPMP's NEV creates an estimated $2.2 million in wealth because of the pikeminnow fishery and $1.4 to $5.7 million from anadromous fish fishing. A program budget of $3.3 million will generate $2.2 million in REI's and $1.8 million in the regional economies when pikeminnow fishing takes place. Fishing for salmon and steelhead will generate from $2.2 million to $8.3 million in economies from Alaska to California and inland in the Columbia River Basin. In total, the act of fishing for pikeminnow and anadromous fish may create up to $10.1 million in REI. In terms of full time equivalent jobs at $30,000 each, this equals employment of 337 people. Many jobs will be seasonal; the actual number of positions may be much higher than the stated full time equivalent job estimates.

Table 9-10. Northern Pikeminnow Management Program Economic Evaluation.

	Net Economic Value	Regional Economic Impacts
NPMP budget		
Northern pikeminnow fishery	$2.2	$1.8
NPMP administration		$2.2
Subtotal NPMP		$4.0
Anadromous fish fishing	$1.4 to $5.7	$2.2 to $8.3
NPMP at existing program level	$3.6 to $7.9	$6.2 to $12.3

Notes: 1. Table values are in millions.

10. References

This recovery and subbasin plan is based on a detailed summary and analysis of pertinent information that is reported in six volumes of the supporting Technical Foundation. Please refer to the following Technical Foundation volumes for appropriate citations.

WLCFRB (Washington Lower Columbia Fish Recovery Board). 2004a. Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan: Technical Foundation Volume I, Focal Fish Species. Prepared for NOAA Fisheries, U.S. Fish and Wildlife Service, and the Northwest Power and Conservation Council.

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Other documents specifically referenced in this volume include:

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