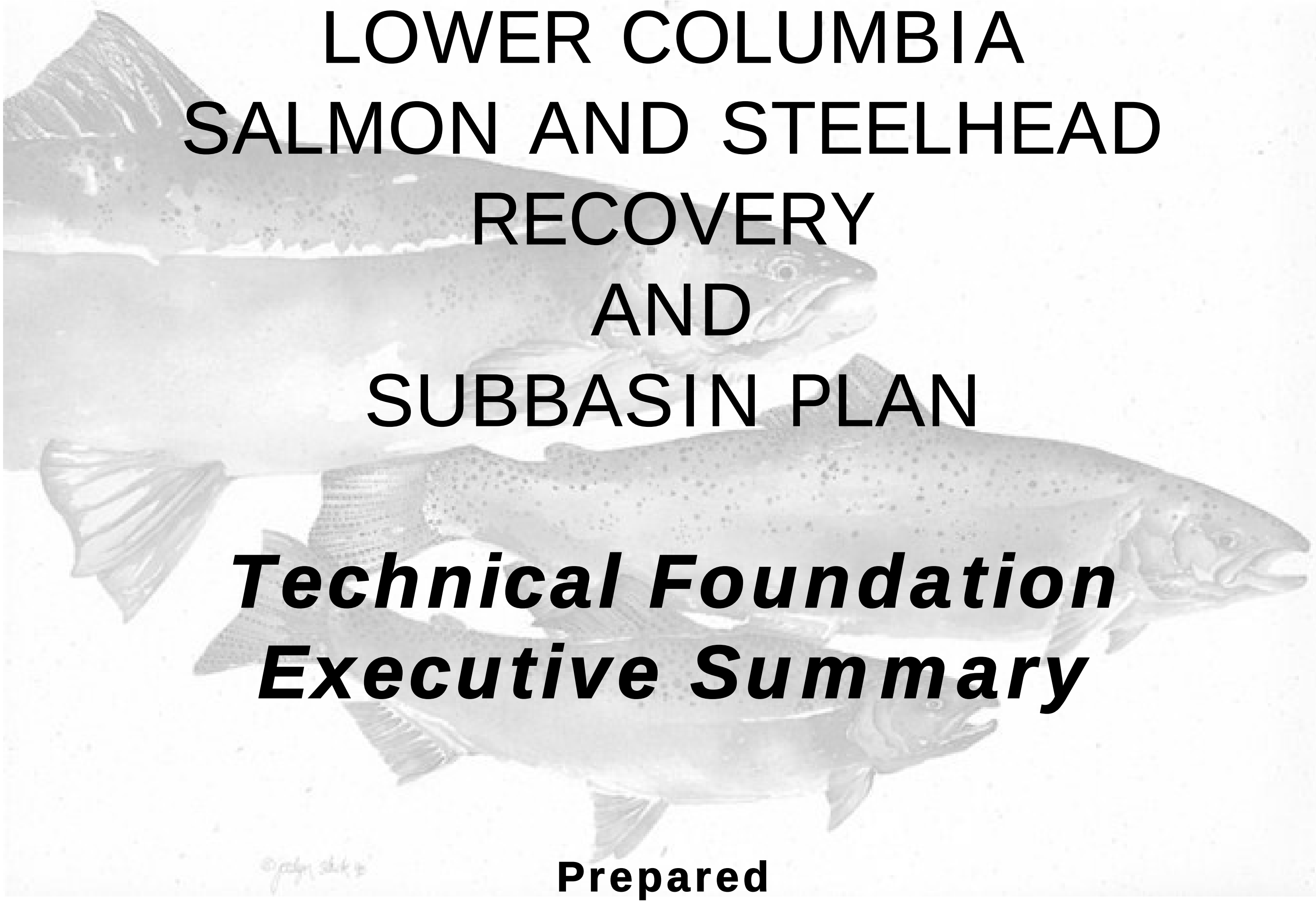

LOWER COLUMBIA SALMON AND STEELHEAD RECOVERY AND SUBBASIN PLAN

Technical Foundation Executive Summary

Prepared For Northwest Power And Conservation Council

MAY 28, 2004
DRAFT

Prepared By:
Lower Columbia Fish Recovery Board

Lower Columbia River Salmon Recovery Plan

Technical Foundation
Executive Summary

Preface

This Executive Summary provides an overview of the Technical Foundation for Recovery and Subbasin Planning prepared under direction of the *Washington Lower Columbia River Fish Recovery Board*. This information provides a basis for an integrated Salmon Recovery and Subbasin Plan prepared by the *Fish Recovery Board*. The Technical Foundation is a 6 volume encyclopedia of information relating to focal and other species addressed by the plan, environmental conditions, ecological relationships, limiting factors, existing programs, and economic considerations. The Technical Foundation summarizes existing information and new assessments completed as part of the planning process.

Technical Foundation volumes include:

Vol. I	Focal Fish Species	*Species overviews, limiting factors, recovery standards, and status assessments for lower Columbia River Chinook salmon, coho salmon, chum salmon, steelhead, bull trout, and cutthroat trout*
Vol. II	Subbasins	*Fish populations and habitat conditions in each of 11 Washington lower Columbia River subbasins*
Vol. III	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning*
Vol. IV	Existing Programs	*Descriptions of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning*
Vol. V	Economic Assessment	*Potential costs and economic considerations for recovery and subbasin planning*
Vol. VI	Appendices	*Methods and detailed discussions of assessments completed as part of this planning process*

This work was funded by the *State of Washington* and the *Northwest Power and Conservation Council*. The Technical Foundation was completed primarily by the *Washington Lower Columbia Fish Recovery Board*, *Washington Department of Fish and Wildlife*, *S.P. Cramer and Associates*, and *The White Company*. This second draft of the Technical Foundation incorporates suggestions and revisions provided by a wide array of agency and public reviewers of an initial draft distributed in 2003. Additional opportunities for review and revision of the current draft will occur as part of ongoing recovery and subbasin planning processes.

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VOLUME I – FOCAL FISH SPECIES

1.0 Introduction

1.1 Overview

This Executive Summary provides an overview of the Lower Columbia Recovery/Subbasin Plan Technical Foundation. The Technical Foundation is the first step in a 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.

To complete a draft recovery/subbasin plan as intended by May 2004, the planning process is separated into two distinct, but related phases: the Technical Foundation and the Management Plan. Together, the two phases are envisioned to address five central questions about listed anadromous fish and other fish and wildlife species in the Lower Columbia Basin:

- 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 Technical Foundation (Phase I) is found in Volumes I through VI. It is a comprehensive collection and analysis of technical information relating to the plan's focal fish and wildlife species and the environmental and human activities and programs that affect their health and viability. The Foundation describes current conditions and sets forth recovery targets, biological goals, and proposed analytical approaches. While considerable data exists, significant gaps and variations remain across the region. To fill these gaps, analyses were designed to capitalize on the strengths and balance the weaknesses of existing fish, habitat, and program data.

The Technical Foundation will be used by federal and state agencies, tribes, local governments, and the people of the region to develop the path to the recovery goals through a collaborative process. The Technical Foundation is intended to inform these decision-makers and the public and to assist them in shaping alternatives, understand potential tradeoffs, develop recovery strategies, identify necessary actions, and set priorities. 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.

1.2 The Recovery Planning Process

The Lower Columbia Fish Recovery Board (LCFRB) is leading a collaborative approach to restoring threatened anadromous fish species and rebuilding other focal fish and wildlife species in the Washington Lower Columbia River region. The collaborative approach builds partnerships with federal, state, tribal, local governments, and the public throughout the region. It integrates several different planning efforts—including (ESA) recovery planning, Northwest Power and Conservation Council (NPCC) subbasin planning, state salmon recovery planning, and state watershed planning—into a single regional planning process. This approach will:

- Ensure consistency in goals, strategies, actions, and priorities;
- Avoid potentially costly duplication of efforts and provide an economy of scale; and
- Establish a partnership of federal, state, tribal and local agencies for effective and efficient restoration of listed salmonids and enhancement of other focal fish and wildlife species.

The planning effort focuses on six salmonid species. Four are listed as threatened under the ESA: chum, Chinook, steelhead, and bull trout. One species, coho, is proposed for listing. Another species, coastal cutthroat, is included as a species of regional interest. These six species comprise 85 individual populations. The plan also addresses selected anadromous and resident fish and wildlife of interest under the NPCC subbasin planning process, including sturgeon, Pacific lamprey, eulachon, northern pikeminnow, American shad, introduced gamefish (walleye, smallmouth bass, and channel catfish), dusky Canada goose, Caspian terns, Columbian white-tailed deer, sandhill crane, western pond turtle, selected neo-tropical birds (red-eyed vireo and yellow warbler), sea lions, and harbor seal.

The planning area encompasses the entire Lower Columbia Salmon Recovery Region excepting the White Salmon Basin, omitted at the request of Klickitat County (Figure 1). 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 basins. These include the Chinook, Grays, Skamokawa, Elochoman, Mill, Abernathy, Germany, Cowlitz, Coweeman, Toutle, Kalama, Lewis, Lake, Salmon Creek, Washougal, Duncan, Hardy, Hamilton, Wind, and Little White Salmon subbasins. Oregon subbasins within the Lower Columbia Salmon Recovery Region are being addressed separately by the State of Oregon. Washington and Oregon work will ultimately be combined to form a domain-wide plan.

1.2.1 Relation Among Planning Efforts

As a local lead entity under state law, the LCFRB is responsible for planning and setting priorities for projects to restore and protect salmon habitat for this region. This board is facilitating implementation of Washington's 1999 statewide strategy to recover salmon in conjunction with the Governor's Salmon Recovery Office. The state strategy calls for collaborating on an incentive-based approach to salmon recovery, increasing enforcement of environmental laws, identifying what actions must be taken immediately to prevent extinction, identifying clear performance measures, and establishing an action plan that can be implemented if restoration performance goals are not met on schedule.

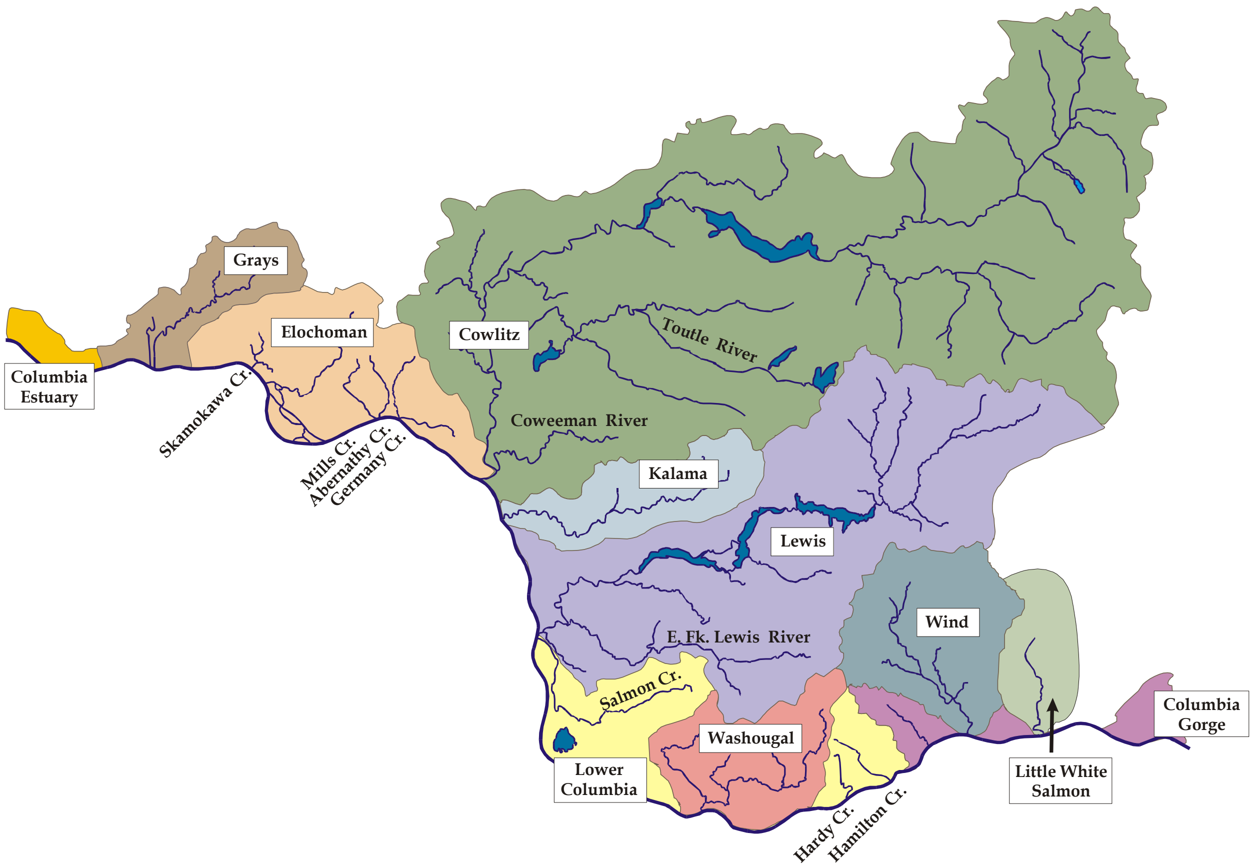


Figure 1. Lower Columbia River watersheds (subbasins as delineated by the Northwest Power and Conservation Council).

Federal ESA recovery planning efforts are administered by NOAA Fisheries in the National Oceanic and Atmospheric Administration for listed Chinook salmon, chum salmon, and steelhead and the U.S. Fish and Wildlife Service (USFWS) for bull trout. NOAA Fisheries desires to develop a recovery plan for listed species in the Willamette and Lower Columbia Region through a collaborative effort involving federal and state agencies, tribes, local governments, and the public. It is intended that NOAA Fisheries approve the LCFRB plan as the ESA recovery plan for those areas of the three listed lower Columbia Evolutionarily Significant Units (ESUs) in Washington. The LCFRB plan also will build on the provisions of the USFWS Lower Columbia Recovery Unit plan to refine bull trout recovery strategies for the lower Columbia and will ensure that bull trout recovery efforts are woven into the broader salmonid recovery strategies and actions for the lower Columbia.

The NPCC is responsible for a program to protect, mitigate, and enhance fish and wildlife adversely impacted by the development and operation of the Columbia River hydropower system. The Council recently initiated a process for the development of individual plans for all subbasins within the Columbia River basin. Completed subbasin plans will be adopted as part of the Council's Columbia River Fish and Wildlife Program and will help direct Bonneville Power Administration (BPA) funding of projects. Along with NOAA Fisheries and USFWS, the NPCC and BPA also intend to use the adopted subbasin plans to help meet the requirements of the 2000 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOpp). The NPCC has contracted with the LCFRB to prepare a recovery/subbasin plan for the

11 lower Columbia subbasins. The LCFRB is also working with the Lower Columbia River Estuary Partnership (LCREP) to prepare plans for the two subbasins that fall in both Oregon and Washington.

The Lower Columbia region is one of seven salmon recovery regions identified by the state in its statewide strategy to recover salmon. Regional recovery organizations have been established for five regions, and the LCFRB serves as the regional organization for the lower Columbia. The Washington Department of Fish and Wildlife (WDFW) has developed a recovery plan template in consultation with NOAA Fisheries and the USFWS and is participating and providing technical support to the regional organizations. The Governor's Salmon Recovery Office is coordinating state agency participation in recovery planning efforts and is helping to address recovery-related policy issues.

Finally, the LCFRB serves as the lead for state-funded watershed planning in much of the region. In this role, the LCFRB works continuously with its watershed planning units to coordinate data collection and analysis and plan development. Habitat and stream flow work is being done to support the recovery plan. The results of this work will be integrated into watershed plans and the recovery plan. In later planning phases, goals and objectives, strategies, and priorities will be coordinated to ensure consistency and compatibility between the watershed management plans and the recovery/subbasin plan.

1.2.2 Overview of the Decision-Making Process

While the final recovery/subbasin plan will be a product of the LCFRB, it must meet the needs of, and be implemented through, the actions of multiple entities. For these reasons, the Lower Columbia Recovery Planning Steering Committee (RPSC) was convened to facilitate and oversee the plan's development. The RPSC's basic functions include providing overall direction and oversight of the recovery planning initiative. Adopting the final plan will require the consensus of the RPSC member organizations, as well as the approval of the LCFRB.

Public comments have been gathered during the planning process. The LCFRB coordinated and conducted public information and outreach efforts in concert with the participating agencies. Comments received during these efforts were used to develop a final draft plan.

The LCFRB will submit the final draft plan to the state, NOAA Fisheries, USFWS, and the NPCC for review and adoption. As part of the recovery planning process coordinated by the LCFRB, recovery goals will be established in consultation with NMFS, USFWS, and WDFW. The NPCC will conduct its own internal and public reviews before adopting the plan into its program.

1.2.3 Participants in the Planning Process

This integrated planning effort is built on effective working relationships and partnerships among the participating governments, agencies, and organizations. These relationships will ensure that the recovery/subbasin plan meets the needs of the different entities and is implemented through their coordinated actions. Representatives from various agencies and organizations, tribes, private property owners, and other stakeholders are participating in the process through involvement on the LCFRB, the RPSC, planning working groups, public outreach, and other coordinated efforts. For more complete details of the planning process, see Volume I, Chapter 1.

2.0 Species Overview

Chapter 2 of Volume I summarizes the life history and population characteristics of Chinook, chum, and coho salmon, as well as steelhead, bull trout, and cutthroat trout, in Washington tributaries, the mainstem, and estuary of the lower Columbia River. That chapter is a review of the life history and requirements of these species from gravel to gravel, and a description of their distribution and genetic diversity within lower Washington tributaries. Here we provide a very brief overview of the species' life history and status.

2.1 Chinook Salmon (*Oncorhynchus tshawytscha*)

Lower Columbia River Chinook are classified as fall or spring Chinook depending on adult migration timing. Fall Chinook dominate in the Washington tributaries of the lower Columbia River, though several tributaries also support spring Chinook. Chinook populations began declining by the early 1900s because of overharvest and poor land use practices. Today, the once abundant natural runs of fall and spring Chinook have been largely replaced by hatchery production. Notable exceptions to this include fall Chinook in the Lewis and Coweeman rivers.

2.1.1 Life History, Abundance, and Distribution

Like other Pacific salmon, the life history of Chinook involves spawning, incubation, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to fresh water. Within this life history cycle, there may be a high degree of variability in response to freshwater environmental conditions and genetic imprinting. The general life history features of lower Columbia Chinook salmon are listed in Table 1.

During the last 10,000 years, flow, water chemistry, and physical features of specific habitats have shaped the characteristics of Chinook salmon populations in the lower Columbia Basin. Fall Chinook were predominant in the Lower Columbia, with runs returning to the larger tributaries on the Washington-side, as well as to some smaller streams (Figure 2). 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 spawn shortly after freshwater entry in September to November. A later-returning component of fall Chinook salmon exists in the Lewis and Sandy rivers. They enter the Columbia River in August to October, but spawning occurs in November to January, with peak spawning in mid-November. Because of the longer interval between freshwater entry and spawning, Lewis fall Chinook salmon are less mature at freshwater entry than tule fall Chinook salmon and are commonly termed lower river "brights".

Table 1. Life history and population characteristics of Chinook salmon originating in Washington portions of the lower Columbia.

Characteristic	Racial Features: Spring	Tule fall	Late fall bright
Number of extant populations	7 (including 4 that are possibly extinct)	13	1
Life history type	Stream	Ocean	Ocean
River entry timing	March – June	August – September	August – October
Spawn timing	August – September	September – November	November – January
Spawning habitat type	Headwater large tributaries	Mainstem large tributaries	Mainstem large tributaries
Emergence timing	December – January	January – April	March – May
Duration in freshwater	Usually 12-14 months	1-4 months, a few up to 12 months	1-4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	Mainstem, tributaries, sloughs, estuary	Mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months
Ocean migration	As far north as Alaska	As far north as Alaska	As far north as Alaska
Age at return	4-5 years	3-5 years	3-5 years
Estimated historical spawners	54,300	91,300	16,100
Recent natural spawners	1,100	5,500	6,500
Recent hatchery adults	12,600 (1990-2000)	37,000 (1991-1995)	NA

Historically in Washington, spring Chinook returned to the Cowlitz, Toutle, Lewis, Kalama, and Big White Salmon rivers (Figure 2). The spring run on the Big White Salmon River was extirpated following construction of Condit Dam. Dams have reduced or eliminated access to spring Chinook spawning areas on the Cowlitz, Lewis, Clackamas, Sandy, and Big White Salmon rivers.

2.1.2 ESU Definition and Status

The Lower Columbia River Chinook Salmon ESU includes all native populations from the mouth of the Columbia River to the Cascade Crest, excluding populations above Willamette Falls (Figure 2). Exclusions from the ESU are stream-type spring Chinook found in the Klickitat River (mid-Columbia ESU) and the introduced Carson spring Chinook. Tule fall Chinook from the Wind and Little White Salmon rivers are included in the ESU, but introduced bright fall Chinook salmon populations in the Wind, White Salmon, and Klickitat rivers are not included.

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

Figure 2. Historical demographically independent lower Columbia Chinook salmon populations in the Lower Columbia River ESU and their present status.

2.2 Coho Salmon (*Oncorhynchus kisutch*)

Coho salmon historically returned to spawn in all accessible lower Columbia River basin tributary reaches. Pristine environments began to be changed in the mid-1800s, often causing declines in salmonid production. Coho runs were further affected by hydro development and harvest pressure in the lower Columbia River. Harvest emphasis moved to coho as Chinook abundance dropped; peak commercial catches of coho in the Columbia River occurred around 1925. Present coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. A number of local populations of coho salmon in the area have become extinct, and the abundance of many others is depressed.

2.2.1 Life History, Abundance, and Distribution

Lower Columbia adult coho salmon 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 mature fish spend 1.5 years feeding in coastal oceans returning to freshwater primarily at age 3 (Table 2). The freshwater life cycle of lower Columbia coho salmon populations follows the timing of seasonal changes in river flow and water temperatures in lower Columbia River tributaries. Late summer and early fall low flows may lead to a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, and increased predation. On the other hand, increased winter floods and decreased water temperatures have also been shown to potentially influence survival.

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 and 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). Currently, very few wild coho salmon spawn in lower Columbia River subbasins. Until recently, Columbia River coho salmon were managed as a hatchery stock. In some cases, coho salmon returning to Columbia River hatcheries in excess of brood stock needs are allowed to bypass the collection facility and allowed to spawn naturally. Spawning likely occurs in most areas accessible to coho, although production from naturally-spawning hatchery fish is likely low.

Table 2. Life history and population characteristics of coho salmon originating in Washington portions of the Lower Columbia.

Characteristic	Racial Features: Early – Type S (south migrating)	Racial Features: Late – Type N (north migrating)
Number of extant populations	18	
River entry timing	mid-August – September	late September – December
Spawn timing	mid-October – early November	November – January
Spawning habitat type	Higher tributaries	Lower tributaries
Emergence timing	January – April	January – April
Duration in freshwater	12-15 months	12-15 months
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	Smaller tributaries, river edges, sloughs, off-channel ponds
Ocean migration	Coastal Washington, Oregon, Northern California	Coastal British Columbia, Washington, Oregon
Age at return	3 years, some 2-year jacks	3 years, some 2-year jacks
Estimated historical spawners	250,000	
Recent natural spawners	6,000 – mostly of hatchery origin	
Recent hatchery adults	4,800 (1987) - 91,407 (2001)	11,800 (1995) - 177,900 (2001)

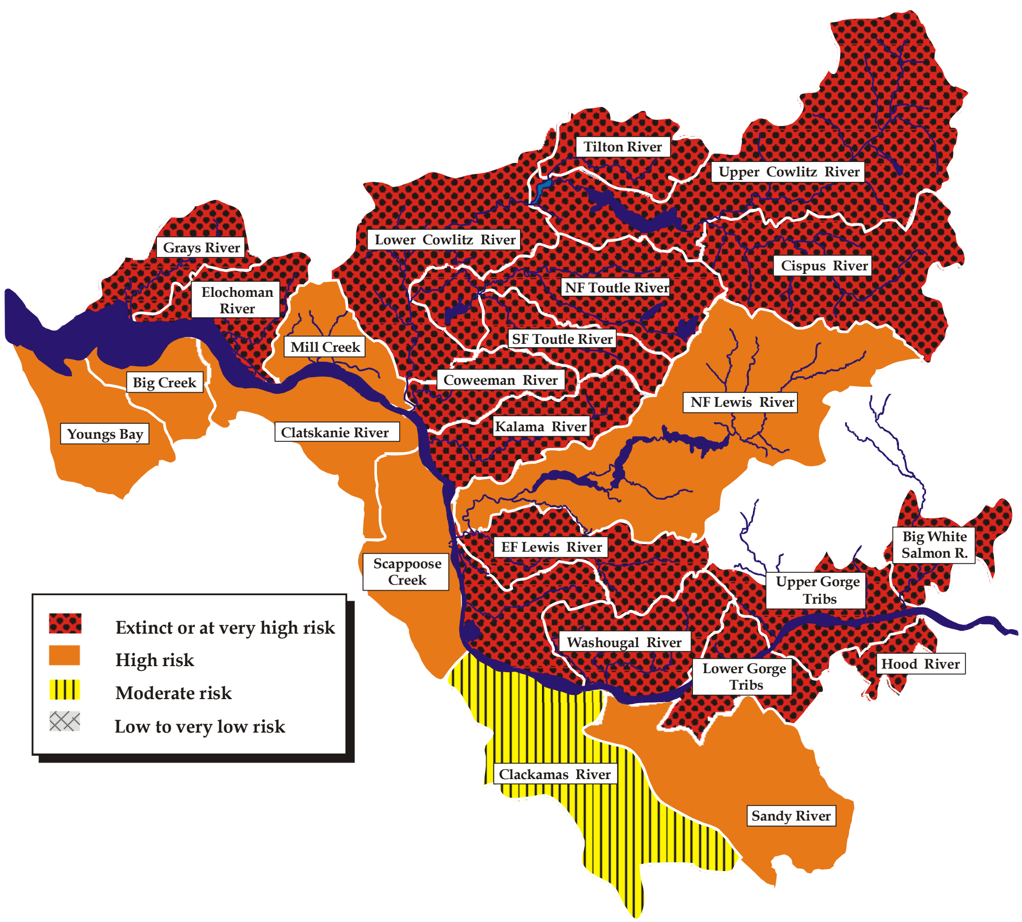


Figure 3. Distribution of historical coho salmon populations among Washington lower Columbia River subbasins.

2.2.2 ESU Definition and Status

Coho salmon genetic diversity has largely been lost in the lower Columbia River because of widespread hatchery production with many out-of-basin (but mostly within-ESU) stock transfers. As a result, the NMFS BRT concluded it could not identify any remaining natural populations of coho salmon in the lower Columbia River (excluding the Clackamas and Sandy rivers in Oregon) or along the Washington coast south of Point Grenville that warrant protection under the ESA. In a 1995 status review of coho salmon, 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 indicating that a listing may be warranted, but that 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.

2.3 Chum Salmon (*Oncorhynchus keta*)

Chum salmon once migrated more than 310 miles (500 km) up the Columbia River to spawn in the Walla Walla River and were productive in many lower Columbia River tributaries. Runs of nearly 1.4 million fish are believed to have returned annually to the Columbia River. Today, chum production is generally limited to areas downstream of Bonneville Dam. In 2002, approximately 19,000 chum returned to the lower Columbia River, about 1% of the historical run size.

2.3.1 Life History, Abundance, and Distribution

Lower Columbia chum salmon life history attributes are listed in Table 1. Chum salmon returning to the Columbia River are considered a fall run. Adult chum salmon return to the Columbia River from mid-October through November, but apparently enter the Grays River in late October-early December.

Chum salmon spawn primarily in the lower reaches of rivers, digging their redds mostly along the edges of the mainstem or tributaries or in side channels of rivers, from just above tidal influence to nearly 60 miles (100 km) from the sea. They spawn in shallower, slower-running streams and side channels more frequently than do other salmonids. Many Columbia River chum have been found to select spawning sites in areas of upwelling groundwater.

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

Characteristic	Chum salmon features
Number of extant populations	15
River entry timing	mid-October – December
Spawn timing	November – March
Spawning habitat type	Shallow, slow-moving mainstem, tributaries, or side channels
Emergence timing	February – April
Duration in freshwater	About 1 month
Rearing habitat	Edges/side channels of tributaries, mainstem, estuary
Estuarine use	Up to 4 months
Ocean migration	North Pacific and Bering Sea
Age at return	Primarily 3 & 4 years, a few 5 years
Estimated historical spawners	410,000
Recent natural spawners	3,000 – 19,000 (range over past 10 years)
Recent hatchery adults	300 (in 2002)

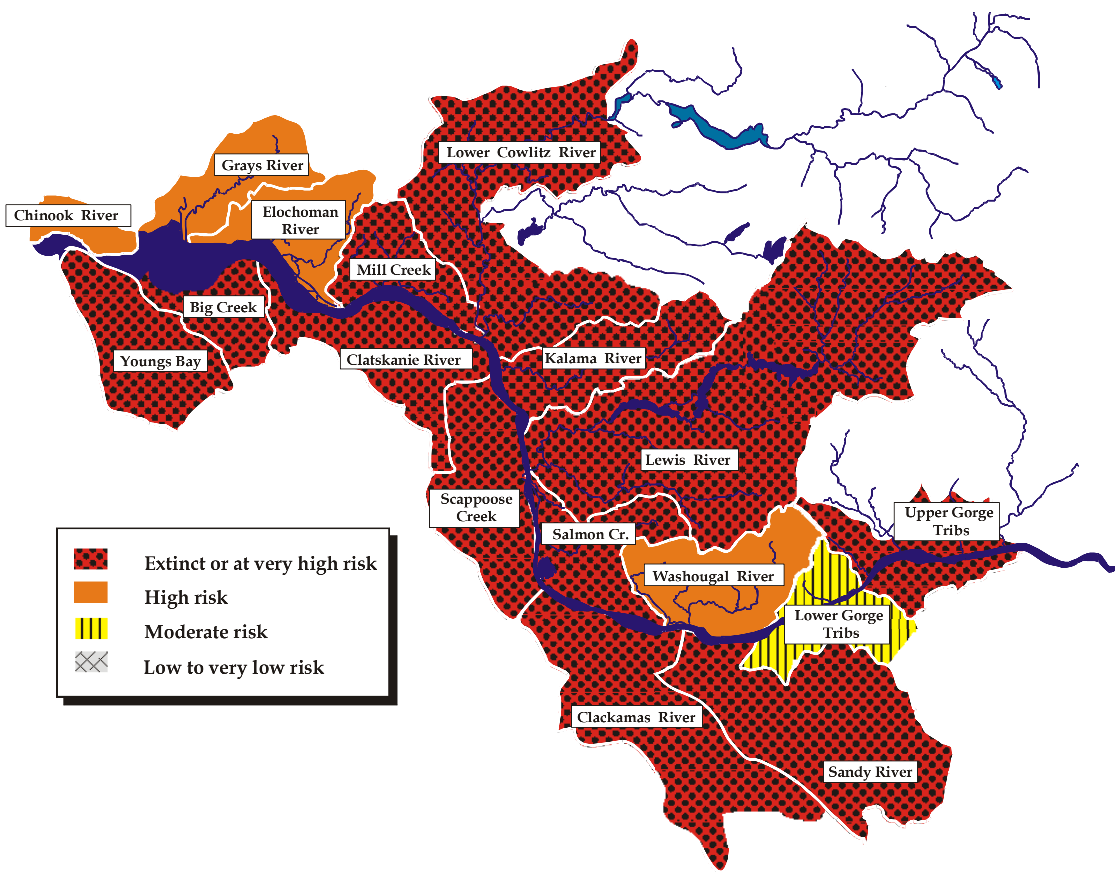


Figure 4. Historical demographically independent chum salmon populations in the Lower Columbia River ESU.

Fry emigration occurs from March through May and peaks from mid-April to early May. Because chum fry generally emigrate shortly after emergence, predation mortality during downstream emigration can be significant. Chum salmon juveniles use estuaries to feed before beginning long-distance oceanic migrations, more so than other anadromous salmonids. The period of estuarine residence appears to be the most critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult run back to fresh water. Chum salmon spend more of their life history in marine waters than other Pacific salmonids. There is little information on stock- or population-specific migration patterns and ocean distributions of chum salmon.

After substantial declines in the 1950s, annual chum returns were small but remained relatively stable from 1956 to 2000. There were significant increases in returns to Washington waters during 2001-2002 as indicated in index area peak counts in Grays River, Hardy Creek, Hamilton Creek, and mainstem spawning areas. Chum salmon have also been observed in Cowlitz, Lewis, Elochoman, Kalama, and Washougal rivers, and in Skamokowa, Germany, and Abernathy creeks. New spawning grounds for chum were recently discovered near the Pierce/Ives Island complex and along the northern Columbia River shoreline near the I-205 Glen Jackson Bridge where groundwater upwelling occurs.

2.3.2 ESU Definition and Status

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

2.4 Steelhead (*Oncorhynchus mykiss*)

Steelhead are rainbow trout that migrate to and from the ocean. Lower Columbia River steelhead include summer and winter runs. Because steelhead grow to a large size by feeding in the ocean, they attract significant sport fishing effort in several major lower Columbia River basins. The overall status of lower Columbia steelhead populations is generally poor, but natural production has been maintained in most areas in which steelhead were historically present. The most notable exceptions include areas in the Cowlitz and Lewis rivers where hydro development has blocked passage to historical spawning areas, and areas of the NF Toutle River drainage where habitat was devastated by the eruption of Mt. St. Helens in 1980.

2.4.1 Life History, Abundance, and Distribution

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.

Steelhead exhibit tremendous variability in life history, with juveniles rearing for 1 to 3 years in freshwater before migrating seaward and adults spending 1 to 3 years in the ocean (Table 4). Steelhead generally migrate northward along the coast of Canada and Alaska and then follow a counterclockwise migration pattern far into the North Pacific; they are believed to migrate further offshore than most salmonids.

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, based on preliminary information developed in the process of Lewis River hydro relicensing, 10,000 or more may have been produced in the Lewis Basin. The production potential of most lower Columbia River basins is substantially reduced from historical conditions as a result of habitat degradation resulting mostly from human activity, such as development or logging. Major hydro projects in the Cowlitz and Lewis basins have blocked access to approximately 80% of the historical steelhead spawning and rearing habitat within each basin.

Table 4. **Life history and population characteristics of steelhead trout originating in Washington portions of the lower Columbia.**

Characteristic	Racial Features	
	Summer steelhead	Winter steelhead
Number of extant populations	5	14
River entry timing	May – November	November – April
Spawn timing	January – June	March – early June
Spawning habitat type	Clear water rivers and tributaries in upper watersheds	Clear water rivers and tributaries
Emergence timing	8-9 weeks after spawning, March – July	8-9 weeks after spawning, March – July
Duration in freshwater	1-3 years (mostly 2), smolt in April – June	1-3 years (mostly 2), smolt in April – June
Rearing habitat	River and tributary main channels	River and tributary main channels
Estuarine use	Briefly in the spring, peak abundance in May	Briefly in the spring, peak abundance in May
Ocean migration	North to Canada and Alaska, and into the North Pacific, along the continental shelf	North to Canada and Alaska, and into the North Pacific, along the continental shelf
Age at return	3 – 5, occasionally 6 years	3 – 5, occasionally 6 years
Estimated historical spawners	50,500	19,300
Recent natural spawners	2,300	1,300
Recent hatchery adults	1,900 (approximate average annual total returns to six lower Columbia hatcheries, 1995-2002)	9,200 (approximate average annual total returns to six lower Columbia hatcheries, 1995-2002)

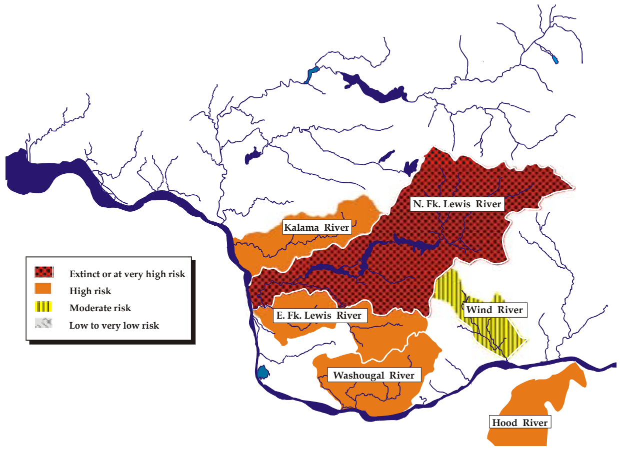
Watersheds that historically supported summer steelhead include the Kalama, North Fork Lewis, East Fork Lewis, Washougal, and Wind. Winter steelhead returned to the Cowlitz, Kalama, NF and EF Lewis, Washougal, and Wind rivers (

Figure 5). Steelhead also returned to the Grays, Elochoman, Big White Salmon, and Little White Salmon rivers and Skamokawa, Mill, Abernathy, and Germany creeks.

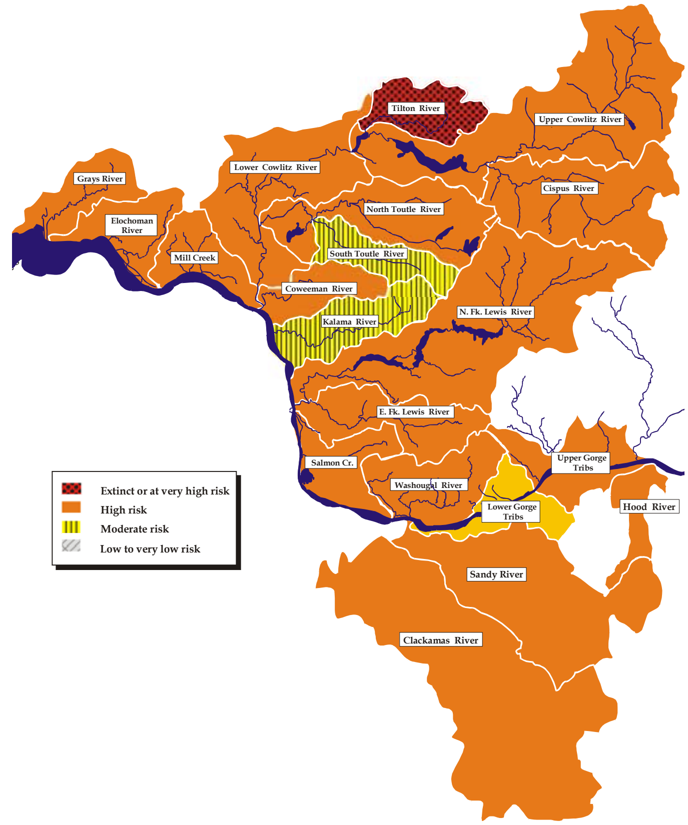
2.4.2 ESU Definition and Status

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, and
- The Middle Columbia ESU includes steelhead from the Little White Salmon and Big White Salmon rivers.



Summer Steelhead



Winter Steelhead

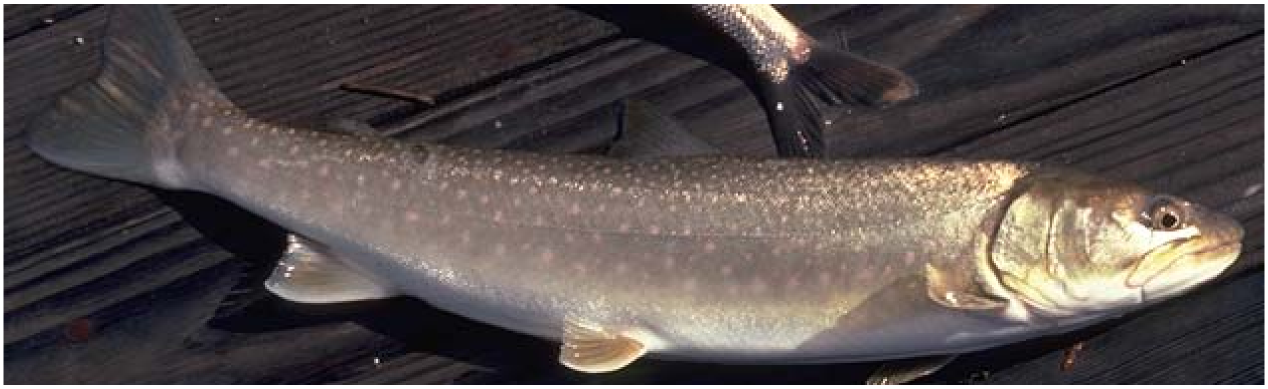
Figure 5. **Historical demographically independent steelhead populations in the lower Columbia River ESU.**

On March 19, 1998, NMFS issued a formal notice listing the Lower Columbia Steelhead ESU as threatened under ESA. The listed ESU includes only naturally-spawned populations of steelhead residing below natural and man-made impassable barriers (e.g., impassable waterfalls and dams). The populations that have been identified as comprising the Lower Columbia ESU are shown in Figure 5.

The NMFS BRT concluded that the Southwest Washington Steelhead ESU is not currently in danger nor is it likely to become endangered in the foreseeable future. Therefore, the Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany populations are not listed under the ESA. However, the BRT decision reflects the overall condition of the entire ESU and does not necessarily reflect the condition of each lower Columbia population within the ESU. 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.

Steelhead of the Middle Columbia ESU were listed as a threatened species on March 25, 1999. The ESU includes all naturally spawned populations of steelhead in streams from above Wind River, Washington, and Hood River, Oregon (exclusive), upstream to, and including, the Yakima River, Washington. Excluded are steelhead from the Snake River Basin.

2.5 Bull Trout (*Salvelinus confluentus*)



In the lower Columbia River, bull trout may exhibit resident or freshwater migratory life history patterns; anadromous bull trout are present elsewhere, but have not been observed in the lower Columbia.

2.5.1 Life History, Abundance, and Distribution

Bull trout are found primarily in cold streams. Researchers consistently find that water temperature is 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.

Status of bull trout is difficult to ascertain because data are scarce. The Lewis River bull trout population was classified as depressed because of chronically low numbers. Adfluvial populations exist in Yale and Swift reservoirs in the Lewis River system. No fish passage is in place at the dams impounding these reservoirs; bull trout have been displaced downstream during spill events. Bull trout have also been reported in the Little White Salmon basin but never above Little White Salmon National Fish Hatchery.

2.5.2 ESU Definition and Status

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. On June 10, 1998, the USFWS issued a final rule announcing the listing of bull trout in the Columbia and Klamath river basins as threatened under the ESA. According to WDFW, the bull trout populations in the Lewis River basin are considered at moderate risk of extinction.

Within the Columbia River Basin Bull Trout DPS, the Lower Columbia River Recovery Unit includes the Lewis River and Klickitat River core areas in Washington. The Lewis River Core Area consists of the mainstem Lewis River and tributaries downstream to the confluence with the Columbia River, with the exclusion of the East Fork of the Lewis River. The Klickitat River Core Area includes the Klickitat River and all tributaries downstream to the confluence with the Columbia River. In the two core areas, local populations of bull trout exist in Cougar, Pine, and Rush creeks (tributaries of the Lewis River) and the West Fork of the Klickitat River. No local populations have been identified in the White Salmon River, but that area contains core habitat and, after migratory obstructions are addressed, could support bull trout that migrate from the Columbia River.

Table 5. Life history and population characteristics of bull trout originating in Washington portions of the lower Columbia.

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

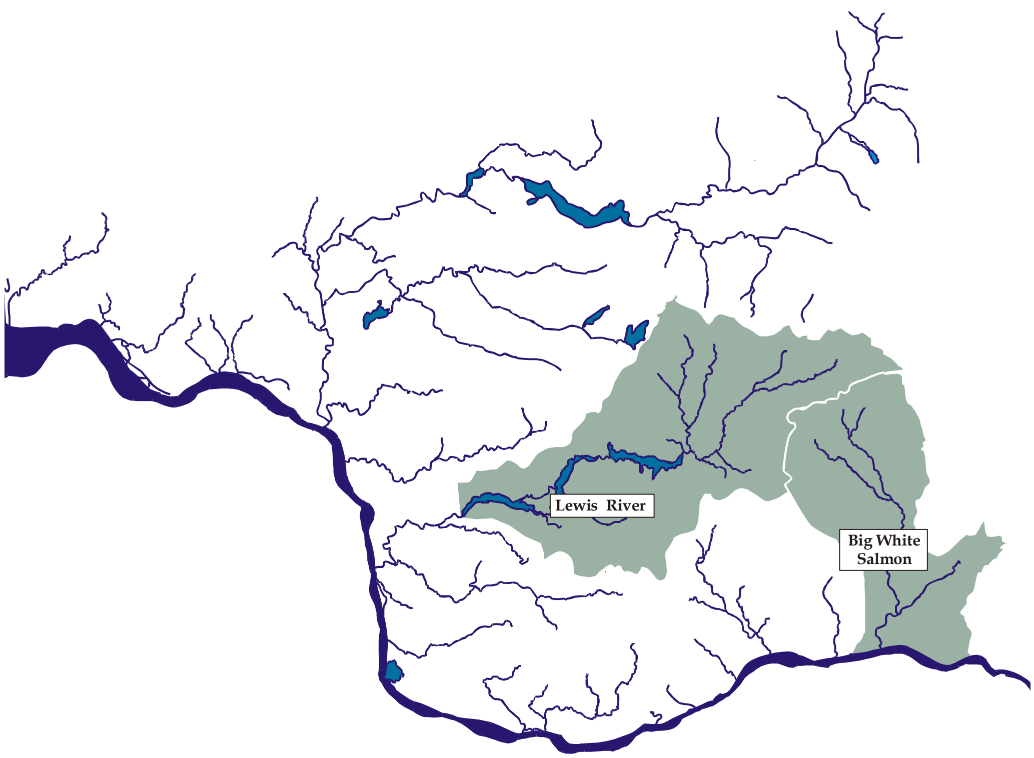


Figure 6. Distribution of historical bull trout populations among lower Columbia River subbasins.

2.6 Cutthroat Trout (*Oncorhynchus clarki clarki*)

Cutthroat trout are widely distributed in Washington lower Columbia River tributary systems and exist in both sea-run and resident forms. 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. They are not federally listed at this time.

2.6.1 Life History, Abundance, and Distribution

The life history of the coastal cutthroat subspecies is probably the most complex and flexible of any Pacific salmonid. Cutthroat trout are generalists—they exhibit several life histories and exist in many small streams not suitable for other salmonids. The flexibility of coastal cutthroat subspecies allows the expression of many life history patterns, which have been generalized in Table 6. They 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.

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

	Life History Form	
Characteristic	**Migratory**	**Resident**
Number of extant populations	Up to 1,300	
Upstream spawning migration	June – April	
Spawn timing	December – June	December – June
Spawning habitat type	Pool tail-outs in small streams	Pool tail-outs in small streams
Emergence timing	March – June	March – June
Natal area rearing	2-4 years	2-4 years
Downstream migration	Migrate to estuary/ocean, March – July, back upstream in fall	Reside locally or migrate to rivers/lakes, upstream in fall
Rearing habitat	Small to large streams (progressively with age)	Small to large streams (progressively with age)
Estuarine/marine residence	Several months	NA
Age at first spawning	4-6 years	2-3 years

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, widespread distribution, and poor data availability. Returns of both naturally spawned and hatchery-produced fish are believed to have declined in almost all lower river tributaries over the past 10–15 years.

Anadromous, fluvial, or resident life history forms of coastal cutthroat are reported in all Lower Columbia River drainages; anadromous individuals are either documented or thought to be present in all Washington tributaries of the Columbia downstream of Bonneville Dam (Figure 7). Cutthroat have been documented in over 1,300 locations within the lower Columbia DPS.

2.6.2 ESU Definition and Status

In April 1999, NMFS and the USFWS issued a joint proposed rule for the listing of southwestern Washington/Columbia River sea-run cutthroat trout. The ESU includes populations of coastal cutthroat trout in the Columbia River and its tributaries downstream from the Klickitat River in Washington and Fifteenmile Creek in Oregon (inclusive) and the Willamette River and its tributaries downstream from Willamette Falls. Cutthroat trout found in the Lewis River are included in this ESU, although the status of Lewis River cutthroat trout is currently unknown because of insufficient quantitative information to identify a trend in abundance or survival.

On July 5, 2002, the USFWS issued a withdrawal of the Proposed Rule to List the Southwestern Washington/Columbia River Distinct Population Segment of the Coastal Cutthroat Trout as Threatened because their latest information indicated relatively healthy populations in a large portion of the DPS, and their improved understanding of the ability of freshwater forms to produce anadromous progeny, lead them to conclude that the DPS did not meet the definition of a threatened species (in danger of becoming endangered in the foreseeable future). 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.

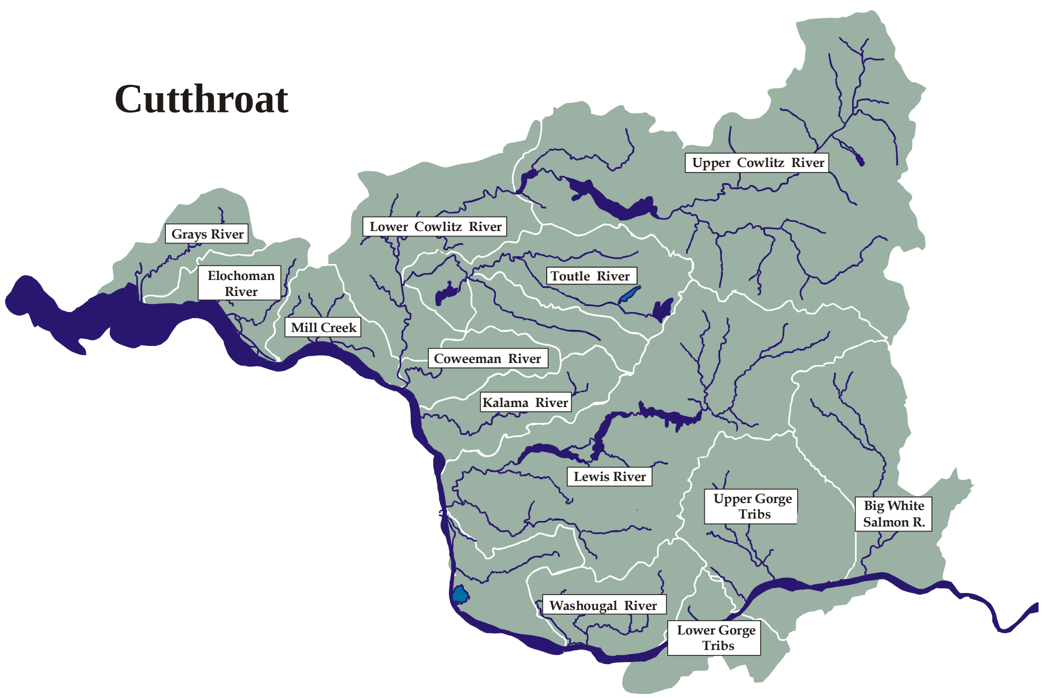


Figure 7. Distribution of historical cutthroat trout populations among lower Columbia River subbasins.

3.0 Limiting Factors

The third chapter of Volume I is focused on the specific limiting factors of fishing, hatcheries, and subbasin, mainstem Columbia River, estuarine, and ocean conditions that affect fishery resources of the Lower Columbia Planning Area. The chapter provides an overview of the types and extent of limiting factors that will be considered when recovery strategies are developed in the management plan.

3.1 Fishing

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

Fishing generally affects salmon populations through direct and incidental harvest, catch and release mortality, and size, age, and run timing alterations because of disproportionate fishing on different run components. From a population biology perspective, this most obviously causes reduced survival (fewer spawners) as well as chronic alteration of age, size, run timing, fecundity, and genetic characteristics. Fewer spawners result in fewer eggs for future generations and diminishes marine-derived nutrients delivered to freshwater systems via dying adults, recently found to be an important factor in the growth and survival of juvenile salmon in some aquatic ecosystems.

Because of their exposure to fisheries across large geographic regions of the West Coast, and because of complex jurisdictional issues, lower Columbia salmon and steelhead management is governed by a wide array of federal, state, tribal, and local jurisdictions. 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 salmon and steelhead, especially since the 1970s (Figure 8). Selective fisheries for fin-marked hatchery spring Chinook, coho, and steelhead have led to further decreases in wild fish exploitation while maintaining fisheries targeted on hatchery fish (Figure 8).

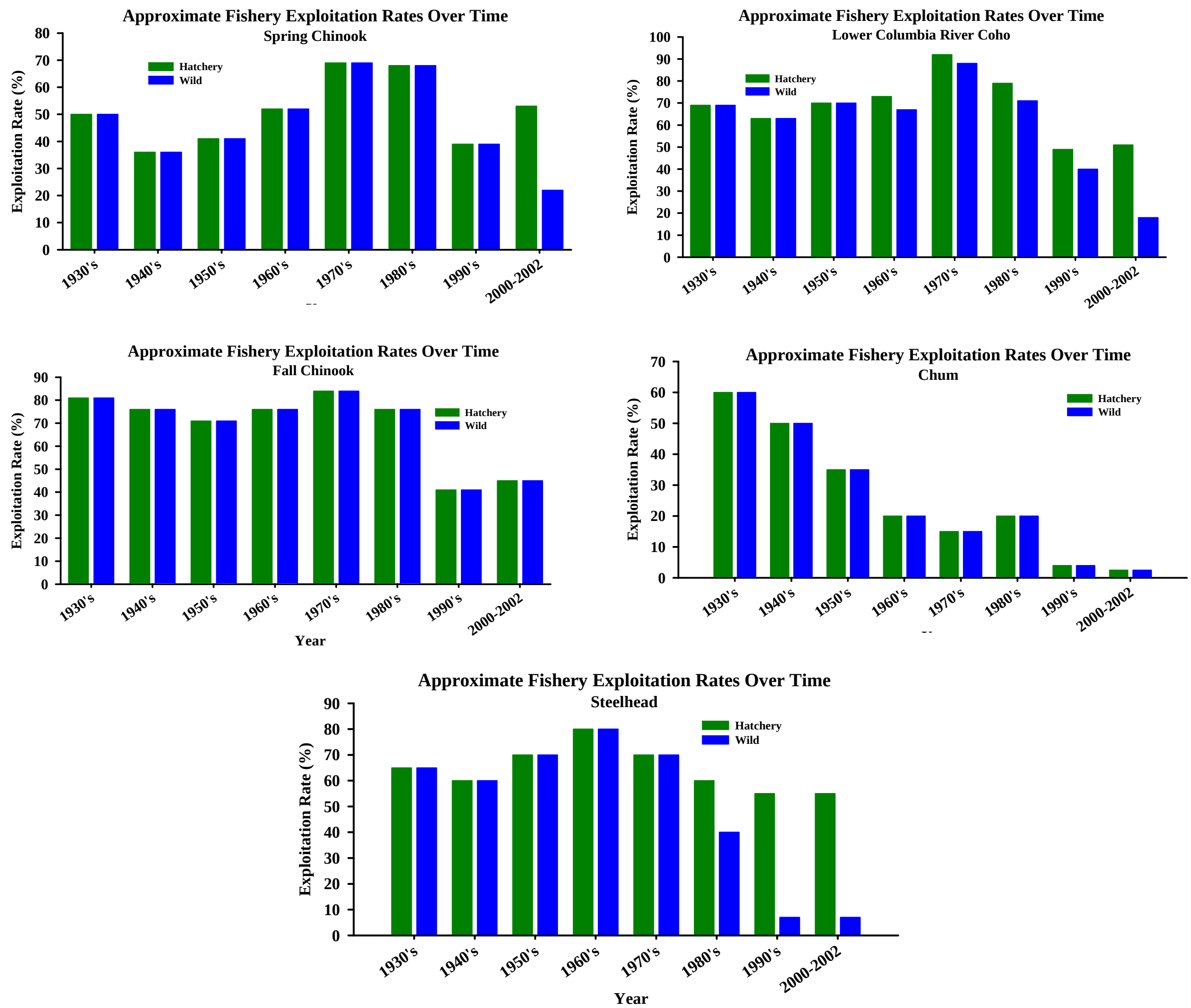


Figure 8. Approximate hatchery and wild fishery exploitation rates, 1930s to present.

3.1.1 Spring Chinook Fishery

Before 1974, over 50% of the mainstem Columbia River spring Chinook run was harvested (Figure 8), primarily in April and May. After 1977, target fisheries for upriver spring Chinook were eliminated and, as a result, lower Columbia River commercial fisheries ended by early March and sport fisheries closed before April. No lower Columbia fisheries during the April/May run peak occurred until 2001 when adipose fin-clipped hatchery adults returned, enabling fisheries to selectively retain hatchery fish and release wild fish. The 1985–2002 lower Columbia total harvest of spring Chinook ranged from zero in 1995 to 32,800 in 2002. Fisheries harvest bottomed out during 1994–2000, but increased in 2001 and 2002 when runs continued to improve and selective fisheries were implemented. The mainstem Columbia sport harvest of spring Chinook has exceeded the commercial harvest in the two most recent years. Approximate harvest rates of spring Chinook distributed among fisheries are displayed in Table 7.

Table 7. Recent harvest rates of spring Chinook by area.

Spring Chinook Fishery	Hatchery*	Wild**
Alaska	4%	4%
Canada	9%	9%
Washington/Oregon/California ocean	5%	5%
Columbia River	15%	2%
Tributary	20%	2%
Total	53%	22%

*Columbia River fisheries managed for commercial/sport allocation and hatchery escapement.

**Columbia River fisheries managed to meet ESA standards for wild Willamette and upriver spring Chinook.

3.1.2 Fall Chinook Fishery

The current harvest of lower Columbia fall Chinook is significantly reduced from past harvest levels. Reductions in the Columbia River harvest actually began by the 1950s, but coincided with increased ocean harvest, resulting in relatively high total harvest rates until the 1990s (Figure 8). The current harvest levels average about 45% for the three fall Chinook stocks (tule, lower river wild, and fall bright) present in the lower Columbia. Recent commercial harvest of lower Columbia fall Chinook peaked during 1987–88 when record fall Chinook numbers returned to the Columbia River. Harvest of lower river hatchery stock (tules) was almost 180,000 adults and lower river wild stock was nearly 19,000 adults.

Columbia River fall Chinook (brights) are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, as well as the Columbia River commercial gill-net and sport fisheries (Table 8). 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. Unlike spring Chinook, hatchery fall Chinook are not marked so harvest rates are the same for hatchery and wild fish.

Table 8. Recent harvest rates of fall Chinook by area.

Fishery	Tule*	LRW**	URB[§]
Alaska	3%	10%	10%
Canada	12%	9%	15%
Washington/Oregon/California Ocean	15%	3%	2%
Columbia River	10%	8%	20%
Tributary	5%	10%	1%
Total	45%	40%	48%

*Lower river tule harvest driven by 49% limit for Coweeman fall Chinook.

**Lower river wild harvest driven by 5,700 minimum natural escapement to North Lewis.

[§]Upriver harvest driven by Snake River wild ESA constraint and *US v. Oregon* Indian /non-Indian allocation agreement

3.1.3 Coho Fishery

Impacts to lower Columbia River coho salmon occur in ocean commercial, sport, and tribal fisheries, in Columbia River sport, commercial, and treaty Indian fisheries, and in tributary sport fisheries. Combined ocean and in-river harvest rates of Columbia River-produced coho ranged from 70-90% during 1970-1983 (Figure 8). During this time, naturally produced coho were managed like hatchery stocks and were subject to similar harvest rates. In the mid-1980s, ocean harvest was reduced to protect several Puget Sound and Washington coastal wild coho stocks. In the 1990s, ocean and Columbia River management strategies included considerations for Oregon Coastal and Columbia River wild coho.

Like other salmon stocks in the Columbia River, integrating the management of coho ocean and Columbia River fisheries is essential to meeting conservation requirements for ESA-listed or critical stocks and to promote fishery opportunity on hatchery populations. Inside the Columbia River, early and late coho are managed separately; differences in the timing of fish runs enable managers to structure seasons to meet separate harvest objectives for the stocks.

Columbia River coho do not migrate as far north as Columbia River Chinook; consequently, few Columbia River coho are harvested in Alaska or Canadian fisheries. Ocean troll coho harvest can be significant in years of large hatchery abundance. Selective fisheries for adipose fin-marked hatchery coho have been implemented in most ocean and sport fisheries since 1999. Current coho harvests are generally distributed as identified in Table 9.

Table 9. Recent harvest rates of coho by area.

Fishery	Hatchery	Wild
Alaska	0%	0%
Canada	<1%	<1%
WA/OR/CA Ocean	30%	9%
Columbia River	15%	8%
WA Tributaries	6%	1%
Total Exploitation	51%	18%

3.1.4 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. Commercial chum landings gradually diminished during the 1940s and 1950s to less than 50,000 pounds annually. Currently, there are no recreational or commercial fisheries for chum salmon in the Columbia River. Some chum are taken incidentally in gill-net fisheries for coho and Chinook salmon, but commercial landings have been 500 pounds or less since 1993. Total chum exploitation has declined dramatically over time (Figure 8).

NOAA Fisheries' biological opinions limit the incidental impact of Columbia River fisheries targeting other species to 5% of the annual return of chum listed under the ESA. Since Columbia River chum salmon were listed in 1999, fisheries impacts have remained below the ESA limit.

3.1.5 Steelhead Fishery

Generally, steelhead are not caught in commercial or recreational fisheries in the ocean, mainly because the migration pattern of most steelhead is seaward of ocean salmon fisheries. Summer steelhead are targeted in in-river treaty Indian commercial, ceremonial, subsistence, and non-Indian sport fisheries. The vast majority of lower Columbia winter steelhead harvest occurs in tributary recreational fisheries. Non-Indian commercial harvest of steelhead in the Columbia River has been prohibited since 1975. Mainstem Columbia sport fisheries have been regulated for selective harvest of adipose fin-marked hatchery fish and have required the release of wild steelhead since 1984 (Figure 8). The current distribution of fishery harvest impacts on steelhead is presented below (Table 10).

Table 10. Recent harvest rates of steelhead by area.

Steelhead Fishery	Hatchery	Wild
Ocean	< 1%	
Columbia River	15%	2%
Tributary	55%	5%
Total Exploitation	70%	7%

Summer steelhead treaty Indian fishery impacts are limited to a maximum of 15% according to a *US v. Oregon* Fall Management Agreement and ESA requirements. Limited numbers of winter steelhead are harvested annually in the treaty Indian winter commercial fishery that targets sturgeon.

3.1.6 Bull Trout Fishery

Sport fishing for bull trout was eliminated in the Lewis and White Salmon drainages in 1992. 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.

3.1.7 Cutthroat Trout Fishery

There is no direct commercial harvest of coastal cutthroat trout, and commercial gill net mesh size is too large to cause much incidental handling mortality of cutthroat in in-river fisheries. Angler harvest of coastal cutthroat trout has declined significantly since the implementation of more restrictive sport regulations in 1985 aimed at protecting wild anadromous salmonids. Tributaries in all subbasins in the lower Columbia region are closed to retention of wild (non-finclipped) cutthroat. Open fishing periods differ from subbasin to subbasin but many have spring closures to protect spawning cutthroat and steelhead. Hooking mortality does occur, particularly during steelhead/salmon seasons, but the extent of wild cutthroat mortality from hooking and illegal harvest is believed to be low. In 1985, the daily bag limit on the Columbia River was reduced from eight to two trout with a 12 in (30 cm) minimum size (subsequently raised to 14 in [36 cm]). The change was aimed at allowing most female cutthroat to spawn at least once before harvest.

3.2 Hatcheries

There are 20 salmon and steelhead production hatcheries in the Lower Columbia Basin (Figure 9) and a number of smaller rearing facilities and acclimation sites. These hatcheries have played a major role in producing salmon for harvest. They have also negatively impacted wild populations, including overharvest of wild fish in mixed population fisheries targeted on hatchery populations. Other detriments of hatchery fish stem from predation, competition, disease contagion, reduced survival of wild fish that interbreed with hatchery strays, and long-term genetic effects. Fisheries managers and the public are struggling to find the balance between hatchery facilities that can; 1) produce excess fish for harvest, 2) augment natural production, 3) help to rebuild depleted wild populations, and/or 4) serve as conservation banks for severely reduced populations, all while minimizing impacts on natural production.

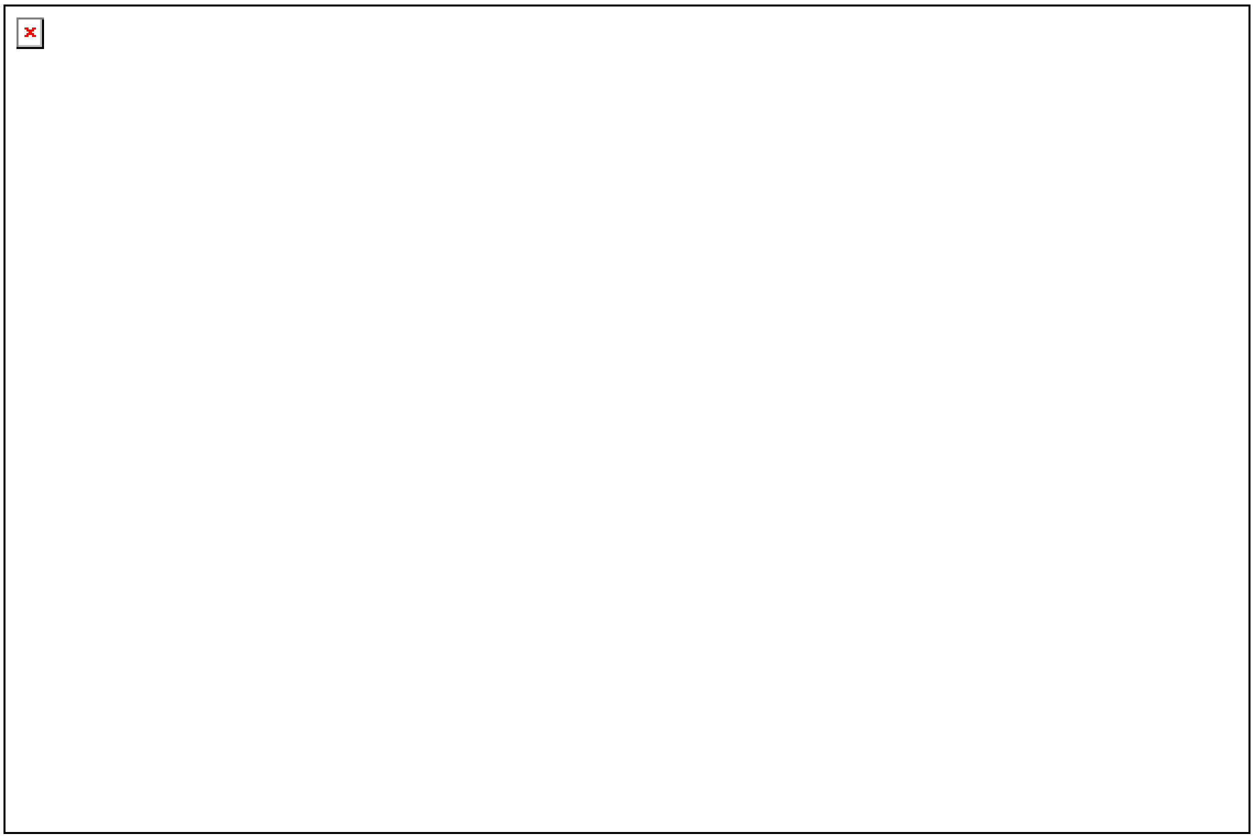


Figure 9. Major lower Columbia region salmon and trout hatchery facilities.

Lower Columbia hatcheries are used to produce spring Chinook, fall Chinook, coho, chum, steelhead, and cutthroat trout. Current (2003) total release goals for all Washington hatcheries in the lower Columbia region exceed 53 million fry, fingerlings, and yearlings combined (Table 11). Contributions from hatchery programs to ocean, estuary, river, and sport fisheries have been substantial.

Table 11. 2003 total release goals for lower Columbia hatchery programs, by species (subyearling and yearlings).

Species	Juvenile Releases
Spring Chinook	5,437,000
Fall Chinook	35,707,000
Coho	9,627,500
Chum	547,500
Summer Steelhead	980,000
Winter Steelhead	1,550,000
Sea-run Cutthroat	250,000
Total Lower Columbia Releases	53,119,000

3.3 Subbasin Fish Habitat

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 effects such as dams, logging, agriculture, urban development, road building, gravel mining, channelization, and water withdrawals. Section 3.3 of the Technical Foundation Volume I addresses these issues from the viewpoint of the fishes' needs for critical, limiting habitat features. The section provides a general overview of how fish are impacted by each limiting factor and how the factor is influenced by biophysical processes and land-use. A synopsis of current conditions throughout the region is also presented for each category. This broad-scale view of current conditions represents the aggregate of the detailed, subbasin-by-subbasin information presented in Volume II of the Technical Foundation.

3.3.1 Passage Obstructions

Fish passage barriers that limit access to spawning and rearing habitats are a significant factor affecting salmon populations in lower Columbia watersheds. Barriers primarily refer to dams and culverts, but also include water diversion structures, fish weirs, beaver dams, road crossings, tide gates, 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 has been severely reduced.

3.3.2 Stream Flow

Streamflows have been changed in many areas, especially through logging, agriculture, and urbanization. These practices alter land cover and affect runoff by decreasing soil infiltration rates, interrupting subsurface flow, and increasing snow accumulation and melt rates. Greater winter and spring flows can affect incubation, rearing, and emigration survival by increasing the likelihood of scouring eggs and alevins from the gravel or displacing juveniles from rearing habitats. Decreased summer low flow volumes can impact aquatic habitats through loss of available habitat area and increased risk of elevated stream temperatures. Alterations to summer and fall flows may impact spawner distributions and juvenile rearing success.

3.3.3 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. Several sources of information, including the WDOE 303(d) list of stream impairments, were used to document specific problems. Stream temperature is of particular concern in the Lower Columbia because of its importance to fish and its response to land use activities. Other concerns arise from dissolved oxygen, fecal coliform bacteria, suspended sediment, DDT, arsenic, lead, and others, but they comprise only a small portion of the listed streams.

3.3.4 Critical Habitats

The distribution, dimensions, and quality of stream channel habitat units greatly affects the health of fish populations. Although fish use a variety of habitat types to different degrees depending on lifestage, pools and backwater habitats are often regarded as the most crucial. Functional connectivity between the various critical habitats for each life history stage is also critical. The creation and maintenance of stream channel habitats is a function of the interaction between the underlying geology and the dynamics of flow, sediment, and large woody debris. Disrupting these physical processes may result in habitat unit types that are outside of natural ranges of quality and quantity. The greatest impacts on stream habitat units have been practices that have directly altered stream channels such as dam building, splash dam logging, stream clean-outs, gravel mining, and diking and channelization for agricultural, industrial, and residential uses. Upland and riparian land use practices that alter flow, sediment, and wood recruitment are less direct, but equally important, impacts.

3.3.5 Substrate and Sediment

Proper substrate and sediment conditions are necessary for spawning, egg incubation, and early rearing of salmonids. Substrate and sediment are delivered to spawning and rearing areas during natural disturbance events, mediated by LWD and existing habitat complexity. However, excessive fine sediment suspended in the water column can decrease feeding success and increase physiological stress, while sediment delivered to channels can suffocate salmonid eggs, inhibit emergence of fry from gravels, and facilitate the transport and persistence of chemical contaminants. Fine sediment is one of the primary factors limiting salmonid populations in the Lower Columbia region, as a result of land use activities within the subbasins. Heavy sediment loads have been a continual problem in the Toutle River watershed and other streams impacted by the Mt. St. Helens eruption, although conditions have been improving.

3.3.6 Woody Debris

Woody debris is an important component of stream ecosystems. Removal of large riparian trees can decrease wood entering the stream, reduce bank stability, increase sedimentation of pools and increase width to depth ratios, thus reducing the quality and quantity of pool habitat. Juvenile and adult salmonids rely directly on large woody debris for shade, protection from disturbance, and protection from predation. Woody debris also retains organic matter, provides sites for macroinvertebrate colonization, and traps salmon carcasses. Stream surveys show that large wood conditions are poor across much of the Lower Columbia region. Stream habitat modeling indicates that habitat diversity, normally enhanced by large wood, is the primary habitat factor that is depressing population performance.

3.3.7 Channel Stability

Unstable streambanks increase mass wasting and have subsequent effects on channel morphology and sediment loads. The results are increased suffocation of salmonid eggs, inhibited fry emergence from gravels, decreased feeding success, and increased physiological stress. Bank stability processes vary depending on location in a catchment. Channels lower in the watershed tend to have greater bank erosion, with channel sources contributing far more sediment than upslope sources. Timber harvesting, agriculture, and urban development reduce vegetative cover on stream banks. Bank stability problems, especially from livestock grazing, timber harvests, and road building, have been identified in most basins throughout the lower Columbia region.

3.3.8 Riparian Function

Riparian areas are an important interface between upland and aquatic systems because vegetation directly and indirectly affects fish habitat suitability through influences on water temperature, habitat diversity, sedimentation, wood recruitment, and bank stability. Reaches with less canopy cover tend to exhibit higher maximum temperatures and larger diurnal temperature fluctuations than reaches with more canopy. Riparian canopies are also an important source of carbon and nitrogen to the stream system. Riparian conditions are generally considered poor across the lower Columbia region. The worst impairments are located in the lowest elevations, especially around the urbanized Vancouver, WA, metropolitan area.

3.3.9 Floodplain Function

The interaction of rivers with their floodplain is important for flood flow dampening, nutrient exchange, sub-surface flow, and maintenance of stream and off-channel juvenile rearing habitats. As a stream accesses its floodplain during high flows, the increase in cross-sectional area decreases the flow velocity, reducing downstream flow volumes and limiting erosion. Floodplains are isolated from rivers through diking, dredging, channelization, and at road crossings. The effects on aquatic biota have been especially severe in Coast Range basins such as the Chinook and Grays rivers, and the lower reaches of many other streams, where dikes were constructed and floodplain channels were filled to create land for residential, commercial, and agricultural purposes.

3.4 Mainstem Conditions

Lower Columbia region salmon use the mainstem Columbia River primarily as a corridor for juvenile and adult migrations between spawning and rearing streams and the ocean where they grow and mature. Mainstem margins and backwaters are also important for juvenile salmonid rearing, particularly ocean-type salmonids that emigrate as subyearlings. The lower Columbia River mainstem has also recently become an important spawning area for some chum and fall Chinook in areas near Pierce and Ives islands, near the mouths of creeks in the lower Columbia Gorge area, and along the Washington shore near the I-205 Bridge.

The mainstem Columbia River has been dramatically altered by extensive dam construction for hydropower, flood control, navigation, and irrigation. Hydropower regulation throughout the system influences water levels in Bonneville Pool and flow releases from Bonneville Dam, which both affect lower Columbia salmon populations. The hydropower infrastructure and flow regulation has implications for adult migration, juvenile migration, mainstem spawning success, estuarine rearing, water temperature, water clarity, gas supersaturation, and predation.

3.4.1 Flow

Columbia River spring flows are greatly reduced from historical levels as water is stored for power generation and irrigation, while summer and winter flows have increased (Figure 10).

Flow regulation and reservoir construction has influenced smolt travel times and survival, as well as passage of adults at dams.

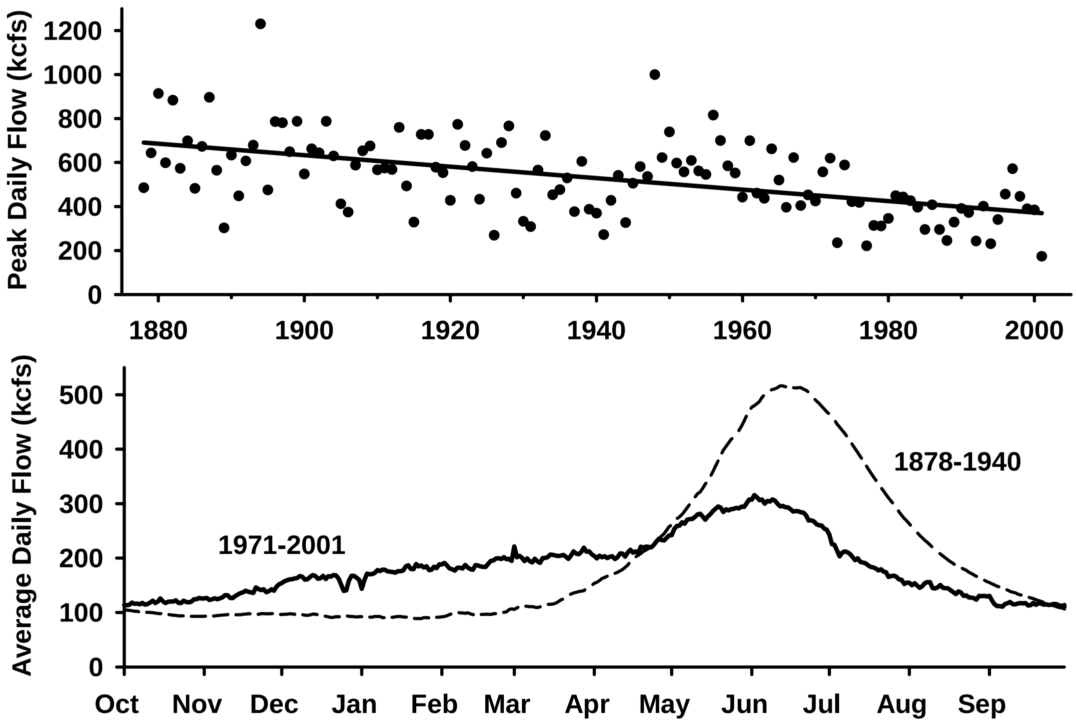


Figure 10. Historical changes in average daily flow patterns and flood frequency in the Columbia River at The Dalles.

3.4.2 Water Temperature and Clarity

Flow regulation and reservoir construction have increased average water temperature in the Columbia River mainstem. Summer water temperatures now regularly exceed optimums for salmon. High water temperatures can cause migrating adult salmon to stop their migrations or seek cooler water that may not be in the direct migration route to their spawning grounds. In the lower Columbia, many summer and fall migrating adults typically pull into the cooler Cowlitz, Lewis, and Wind river mouths before continuing up the Columbia. Warm temperatures can increase the fishes' susceptibility to disease, but the overall effects of migration delay because of high water temperature are unknown. Flow regulation and reservoir construction also have increased water clarity which can affect salmon through food availability and susceptibility to predation.

3.4.3 Gas Supersaturation

Supersaturation of water with atmospheric gases, primarily nitrogen, can occur when water is spilled over high dams. These high concentrations of gases are absorbed into the fishes' bloodstream during respiration. When the gas comes out of solution, bubbles may form and subject the fish to gas bubble disease, similar to the bends suffered by human divers. Measures implemented over the last 40 years include increasing headwater storage during spring, installing additional turbines, and installing flip-lip flow deflectors to reduce plunging and air entrainment of spilled water. Monitoring demonstrates that salmonid mortality continues to be associated with exceptionally high flows. Gas supersaturation poses the greatest risk for lower Columbia basin salmon stocks that must pass Bonneville Dam. Gas levels equilibrate slowly; thus, injurious gas levels at Bonneville Dam may extend for long distances downstream.

3.4.4 Predation

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation likely has always been a significant source of mortality but has been exacerbated by habitat changes. Other fishes—including northern pikeminnow, walleye, smallmouth bass, and salmonids—prey on juvenile salmonids. For example, pikeminnow have been estimated to consume millions of juveniles per year in the lower Columbia. Piscivorous birds congregate near dams and in the estuary around man-made islands where they consume large numbers of emigrating juvenile salmon and steelhead. Marine mammals prey on adult salmon, but the significance is unclear. Seals and sea lions are common in the Columbia River estuary and are regularly observed up to Bonneville Dam.

3.4.5 Adult Dam Passage

Fish ladders provide for upstream dam passage of adult salmon but are not 100% effective. Salmon may have difficulty locating ladder entrances and fish also may fall back over the dam after exiting from the fish ladder. Average per dam survival rates in the lower Columbia River mainstem are approximately 89% for spring Chinook, 94% for fall Chinook, and 95% for steelhead. Fallback of adult salmon and steelhead after dam passage can be significant, especially during periods of high flow and spill. Fallback rates at Bonneville Dam have been estimated to be 12-15% for Chinook and 5-10% for steelhead; fallback does not translate into complete losses, as some fallback fish re-enter the fish ladder and continue their upstream migration.

3.4.6 Juvenile Dam Passage

Delay and mortality of juvenile salmon at mainstem dams has proved to be one of the most difficult and contentious problems associated with hydropower development. Smolts typically migrate near mid-channel in the upper water column where water velocities are greatest. Delay results as juveniles stack up in dam forebays during daylight, when they are reluctant to enter turbine or spillway intakes. Fish passage at Bonneville Dam is particularly complex, with two passage routes at each of the two powerhouses, plus an unattached spillway. The turbines are the most hazardous passage route, estimated to kill about 10% of smolts that pass through intakes. Spillways are much safer than turbines: survival at Bonneville Dam spillways was 96-97%. Juvenile bypass systems to divert fish from turbine intakes are now in place at most mainstem dams in the Columbia River system, including Bonneville.

3.5 Lower River and Estuary

Estuaries are important for juvenile salmonid survival because they provide an opportunity to achieve the critical growth necessary for ocean survival. Estuarine habitats provide young salmonids with a productive feeding area, free of marine pelagic predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment. Proximity of high-energy areas, ample food availability, and sufficient refuge habitat is essential for salmonid growth and survival in the estuary. In particular, tidal marsh habitats, tidal creeks, and complex dendritic channel networks may be especially important to subyearlings as areas of both high prey density and as potential refuge from predators.

3.5.1 Habitat Change

The primary human factors that have determined estuary and lower mainstem habitat conditions include mainstem flow regulation, channel confinement and diking, channel dredging, floodplain development, and water withdrawal for urbanization and agriculture. Generally, these activities 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 and are difficult to separate from concurrent natural variation.

Altered river flows have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes. Winter drawdown of reservoirs and subsequent filling during the spring runoff season has decreased spring freshet magnitude and increased flows over the rest of the year (Figure 10). Reduction of maximum flow levels, dredged material deposition, and diking have all but eliminated overbank flows, resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary.

Channel confinement (e.g., diking) is particularly detrimental to estuary habitat capacity because it entirely removes habitat from the estuarine system. Floodplains have been reduced in size and off-channel habitat has been lost or disconnected from the main channel. It is estimated that the historical estuary had 75% more tidal swamps and 43% more tidal marshes than the current. In total, an estimated 36,970 acres (23.7%) of estuarine habitat has been lost from 1870 to 1983.

Development and maintenance of the shipping channel has greatly affected the morphology of the estuary. The extensive use of dredging, jetties, and pile dikes to maintain the shipping channel has impacted natural flow patterns. By concentrating flow in one deeper, main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays.

3.5.2 Ecological Interactions

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during their passage through the Columbia River estuary. Predation likely has always been a significant source of mortality but has been exacerbated by habitat changes. Caspian terns, cormorants, and gull species congregate in the estuary around man-made islands and consume large numbers of emigrating juvenile salmon and steelhead. Native fishes, particularly northern pikeminnow, prey on juvenile salmonids. Marine mammals prey on adult salmon, but the significance is unclear.

Competition may be occurring between American shad and juvenile salmonids in the estuary and lower river. For example, one study found that, in the Columbia River estuary and lower mainstem (up to RKm 62), American shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Estuaries may also be “overgrazed” when large numbers of both wild and hatchery ocean-type juveniles enter the estuary *en masse*, suggesting possible density dependant mechanisms affecting salmonid survival.

3.6 Ocean Conditions

Just 7 years after record low returns that many feared were the last gasps of endangered salmon and steelhead populations, record high numbers of salmon and steelhead were counted at Bonneville Dam.[1] Have fears of salmon extinction been overblown? Are the increases in response to two decades of costly protection and restoration? Have salmon recovered and is ESA listing no longer warranted? At least partial answers to these questions can be found by examining ocean productivity patterns and their effects on salmon survival. Salmon management traditionally assumed relatively constant—or at least randomly variable—ocean conditions. However, large fluctuations in smolt-to-adult survival over the last three decades have demonstrated that ocean conditions are much more dynamic than previously thought.

Salmon numbers naturally ebb and flow as ocean conditions vary. Healthy salmon populations are productive enough to withstand these natural ocean fluctuations. Weak salmon populations may be severely stressed during periods of poor ocean survival and may disappear or lose the genetic diversity needed to withstand the next cycle of low ocean productivity.

Recently increasing awareness of the influence of inter-decadal climate patterns on salmon population dynamics do not fundamentally alter recent assessments of status and extinction risks. Likelihood of extinction increases during extended periods of poor ocean conditions like those coincident with the ESA listing of many West Coast salmon and steelhead during the 1990s. Large salmon returns in the last few years are a temporary response to improved ocean conditions following the 1997–98 El Niño conditions; they are not likely to represent the average future condition. The respite provides us with the opportunity to continue protection and restoration to forestall extinction until ocean conditions again become poor—as they inevitably will. The risk is that temporary increases in survival and abundance may erode the sense of urgency for salmon recovery efforts.

[1] 403,000 in 1994 and 411,000 in 1995; 1.9 million in 2001 and 1.4 million in 2002.

4.0 Conceptual Framework and Recovery Standards

Chapter 4 of Volume I describes the conceptual framework for restoring healthy salmon populations through analysis of recovery planning questions and defining specific recovery goals and objectives. This framework provides a context for development of a recovery plan based on information in this technical foundation.

4.1 Conceptual Framework for Recovery

Developing an effective recovery plan will require systematic analysis of questions related to goals, status, strategies, and proposed actions based on the best available scientific methods and data. Analytical approaches that systematically relate fish status to underlying causal factors and actions can be extremely powerful tools for evaluating recovery goals and actions. Various analytical approaches and tools are available for evaluating fish recovery planning questions and complex habitat, harvest, hydro, and hatchery relationships. The acronyms for several of these tools are in wide usage (e.g., EDT, VSP, PVA, PCC) but the thicket of technical details pertaining to their capabilities, information bases, and weaknesses can be difficult to penetrate. The selection of an analytical approach is further complicated by the realities that no single tool comprehensively addresses recovery planning, many relationships are not fully understood, and the data needed to drive the tools are inconsistent across the planning area.

4.1.1 Planning Questions

Effective fish recovery planning depends on our ability to answer the five fundamental questions: 1) where are we now; 2) how did we get here; 3) where do we want to go; 4) how do we get to where we want to go; and 5) how do we know when we get there? While general planning questions can be simply stated, answers can be difficult and complicated. Fish are affected by a complex array of factors and our understanding of the relationships among these factors is incomplete. Efforts are further complicated by the need to consider multiple species, a large and diverse area, and a patchwork of overlapping jurisdictions and constituencies. The planning process must describe how fishing, hatcheries, and agricultural, energy, industrial, and urban development activities have influenced key fish species in the past and do so now, as well as to project a trajectory for these influences. Specific questions also exist within each area of impact. For instance, with reference to habitat, it is important to understand the relationships between land use practices, watershed processes, stream habitat conditions, and their effects on the life stages of each species. The recovery planning process must weigh human-induced effects on mortality at different life stages throughout the life cycle, identify how mortality can be reduced overall, and determine how mortality should be allocated to meet delisting and other social goals.

4.1.2 Viability and Use Recovery Goals

Recovery planning analyses must address both population viability goals related to ESA objectives and requirements, and broad goals related to a desire to support opportunities for other fish uses such as fishing. Population viability goals generally represent minimum standards for fish restoration where unique groups of populations are no longer in danger of extinction. Broader goals correspond to more expansive fish restoration that maintains population viability while providing additional fish for other uses (see Section 4.2 on Biological Reference Points below).

4.1.3 All Fish-Limiting Factors Addressed

Recovery planning analyses must equitably address all human-induced factors that limit fish status and have contributed to fish declines. These factors are sometimes generally referred to as the four Hs (hatcheries, harvest, hydropower, and habitat). The "4-H" reference highlights the need to treat all factors limiting recovery similarly and comprehensively, although the label oversimplifies the complicated direct and indirect relationships, the relative impacts of the different factors that affect fish, and previous fish protection efforts within each impact factor. Without a comprehensive, balanced approach for assessing impacts, discussions of site and action-specific recovery actions are easily confounded by counterproductive finger-pointing. Additionally, the effects of human-caused mortality and restoration measures must also be considered in the context of highly variable natural survival rates.

4.1.4 Life Cycle Focus

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 11). 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.

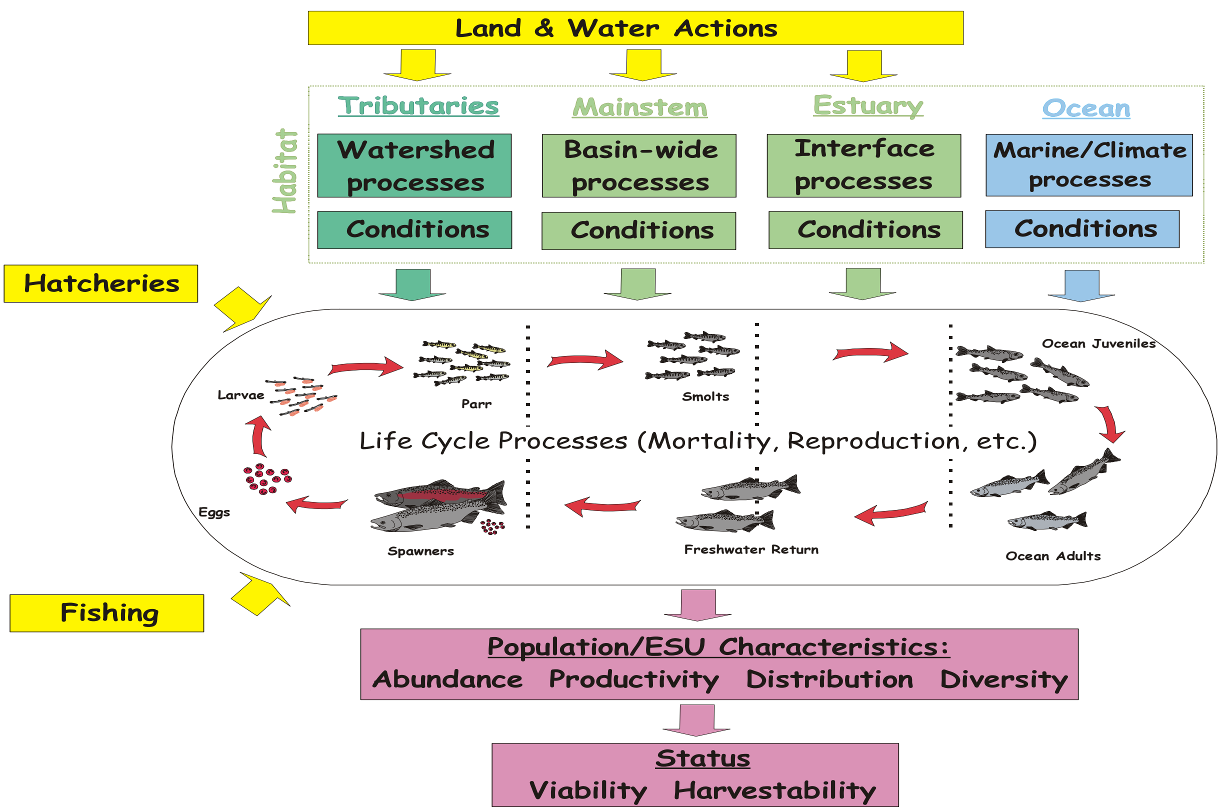


Figure 11. Conceptual depiction of the relationships between fish and factors limiting recovery.

4.1.5 Action-Specific

Recovery planning analyses must relate fish goals and status to specific actions, areas, and time periods. Analyses can identify the relative contributions of habitat, hydro, hatchery, and harvest impacts but should also relate necessary changes to specific activities that can produce the desired effect. Specific programs and activities need to be identified because that is the level at which changes will be implemented. Analyses that are not specific will fail to provide a clear blueprint for recovery implementation and risk failure of accountability.

4.1.6 Flexibility

Analyses with the flexibility to incorporate a variety of information, approaches, and tools will provide the most robust assessments for difficult recovery planning. Similar results from different analytical approaches to the same problem can provide corroboration for conclusions and substantially reduce uncertainty. Contrasting results can highlight critical uncertainties that should be addressed with future investigations. By design, different analytical tools may reflect smaller or larger pieces of the puzzle, may vary in the specificity or detail with which different components of the system are described, and may vary widely in the precision by which specific elements are quantified. Data demands often limit the breadth of analysis by any given tool. Attempts to develop analytical approaches across very broad swaths of a system are almost invariably constrained by information availability. The broader the analysis, the more likely it is to be confounded by unknown interactions in relationships.

Available analytical tools represent the spectrum of breadth, specificity, and precision. In ideal recovery planning, we would use a very detailed and data-rich mechanistic description of our system to maximize the specificity for exploring actions. However, analytical and data limitations often require us to work with less specific and less quantitative approaches to provide defensible results. The Recovery Standards and Assessments chapters (summarized below and in detail in the Technical Foundation) describe the approaches selected for establishing recovery goals and identifying remedial actions required.

4.1.7 Measuring and Managing Uncertainty

Expectations for analysis must be tempered by our imperfect understanding of the complex interaction of fish, limiting factors, and human activities, and the incomplete nature of available data. All models and analytical approaches are abstractions of reality subject to varying degrees of uncertainty. Systematic scientific analyses will reduce but not eliminate uncertainty. 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. Analyses will provide insight for decisions and will identify important data gaps and/or weaknesses, but the conundrum of decisions without full information will continue. Thus, science provides a firm footing for recovery planning but will not supplant the need to make difficult policy decisions with less than complete information.

The key to effective analysis in the recovery planning process is to frame an approach that recognizes and manages uncertainty by:

- 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;

- Incorporating corroborative analyses to validate key conclusions independently;
- Using sensitivity analyses to identify the risks associated with key uncertainties; and
- Identifying conclusions based on the weight of all evidence, rather than any specific analytical result, and with appropriate safety margins to buffer risks.

4.2 Biological Basis for Recovery Standards: Extinction, Viability, and Use

Extinction results from the interaction of fish population processes and external factors to reduce population size to critical low levels that are no longer self-sustaining. Population processes regulate how salmon respond to factors for decline. Characterization of population processes can also provide useful standards for the recovery process.

4.2.1 Definitions

Recovery efforts can aspire to restore salmon to various degrees across a continuum of status levels (Figure 12). Of course, *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 resources can support.

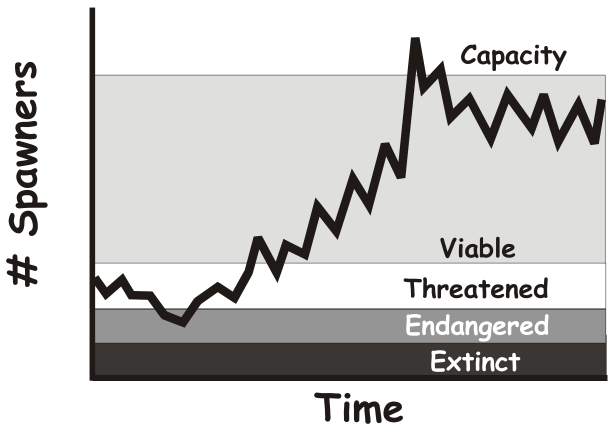


Figure 12. Continuum of abundance levels corresponding to various fish recovery standards.

Fish *recovery* refers to the restoration of fish status to some level at or above viability. Specific recovery goals may be defined anywhere within the range between minimum viability and the hypothetical capacity of a fully restored habitat. 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.

4.2.2 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 that provide fish for the marketplace. 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. 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.

4.2.3 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 including abundance, productivity, diversity, and spatial distribution are intimately related and are the ultimate determinants of whether populations are viable or doomed. NOAA fisheries has incorporated these parameters into a Viable Salmonid Population (VSP) concept that provides a useful framework for analysis of population viability.

Abundance refers to the population size 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 population's ability to replace itself and reflects a population's 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.

4.2.4 Ocean and Climatic Variability

Recovery planning can only address factors within human control, but 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 in ocean productivity is the one from which the population cannot recover.

4.2.5 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 because of 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 are not considered sustainable if they might become extinct whenever the subsidy is removed.

4.2.6 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. The real pitfall occurs when the biological and social tradeoffs implicit in various standards are not clearly articulated and/or distinguished. These pitfalls can lead to unrecognized conflicts of interest, especially when social values are represented in purely biological terms.

4.3 Recovery Standards

Recovery standards identify where we need to go relative to where we are now. The gap between current and desired conditions determines the nature, magnitude, and costs of actions required to achieve fish recovery. This information will provide a context for definition in the next phase of recovery planning: the setting of specific recovery goals by the LCFRB consistent with the Washington legislative mandate of this recovery planning effort and federal ESA requirements.

4.3.1 Definitions

Recovery standards can be expressed in a hierarchy of increasing specificity. *Recovery Goals* capture the biological and social purpose or vision for fish restoration efforts. The overarching goal of this recovery planning effort is *to restore viable fish populations under selected levels of utilization.* This broad recovery goal simultaneously addresses: 1) Washington's legislated mandate for "healthy and harvestable" salmon populations, 2) federal requirements under the ESA to protect populations from extinction, and 3) Magnuson Act requirements to manage for optimum sustainable harvests.

Criteria are biological expressions of objectives consistent with Recovery Goals. For instance, general criteria have been defined by the Willamette/Lower Columbia Technical Recovery Team and endorsed by the Executive Committee to describe fish numbers, population processes, and conditions consistent with viability. *ESU and Strata Level Criteria* describe acceptable probabilities of persistence or risk for groups of populations needed to assure that acceptable probabilities are achieved. *Population Level Criteria* include factors related to individual population status and viability including abundance, productivity, diversity, and spatial distribution. They may also include related factors such as habitat quantity and quality.

Recovery Targets are biologically based numerical expressions of recovery goals that reflect both biological and social factors.

4.3.2 Biological Viability Criteria

The Willamette/Lower Columbia TRT has identified a series of hierarchical ESU, Strata, and Population Persistence Criteria consistent with a viability recovery goal (Figure 13). Criteria were based on the VSP concept developed by NOAA fisheries.

An ESU is viable only where ESU and Strata criteria are all met. Each ESU consists of one or more strata that represent different life history and ecological zone combinations. For example, the lower Columbia River Chinook salmon strata includes Coast fall, Cascade fall, Gorge fall, Cascade late fall, Cascade spring, and Gorge spring. ESU criteria prescribe the following:

- Every stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence.
- Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence.
- 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 prescribe preservation of multiple populations within each stratum at levels sufficient to maintain normal species processes.

- Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence.
- Within a stratum, the populations restored/maintained at viable status or above should be selected to:
  - Allow for normative metapopulation processes, including the viability of "core" populations, which are defined as the historically most productive populations.
  - Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historical gene pools.
  - Minimize susceptibility to catastrophic events.

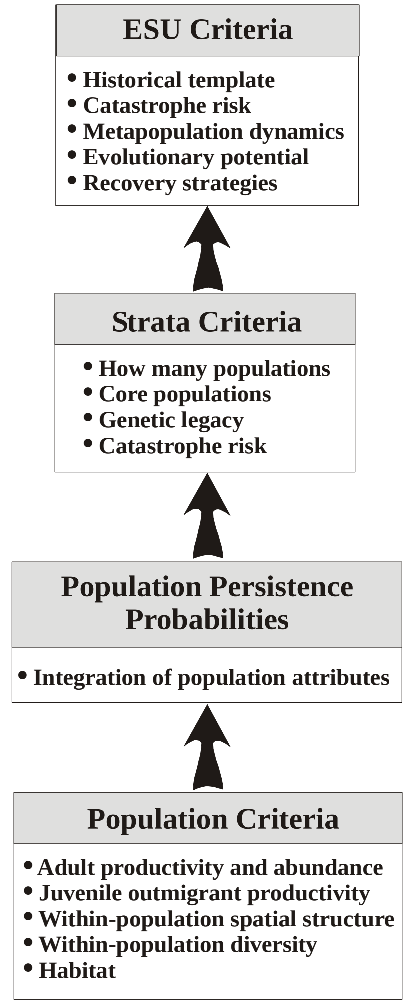


Figure 13. Willamette/Lower Columbia approach to viability criteria.

Population criteria are based on population size, population quality, and fish habitat metrics and are increasingly specific relative to ESU and Strata criteria. They ensure that no populations are sacrificed until viability is assured and identify aggressive recovery efforts that recognize the uncertain outcome of population-specific efforts. Adult productivity criteria are based on an annual rate of population increase and recruits per spawner. Juvenile emigrant productivity criteria are based on an increasing trend in emigrant numbers. Spatial structure and diversity criteria provide sufficient diversity to support desired levels of productivity, abundance, and diversity. Habitat criteria prescribe stable or increasing trends in quantity and quality.

TRT standards also provide an integrated scoring 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.

4.3.3 Planning Ranges: Balancing Biological and Social Goals

Technical Foundation recovery targets are expressed as a planning range. The lower bound is a minimum consistent with population viability. The upper bound is the realistic maximum based on the capacity of a restored system. Methods for setting target planning ranges for abundance were developed by the LCFRB and are based on guidelines identified by the Willamette/Lower Columbia Technical Recovery Team (see Volume I, Chapter 5).

Planning ranges are species- and population-specific. Planning ranges 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 (Figure 14). Recovery will require moving future abundance into the planning target range for a significant number of all historical populations for each species and ESU. The exact numbers that constitute a "significant proportion" were identified in criteria prescribed by the Willamette/Lower Columbia Technical Recovery Team.

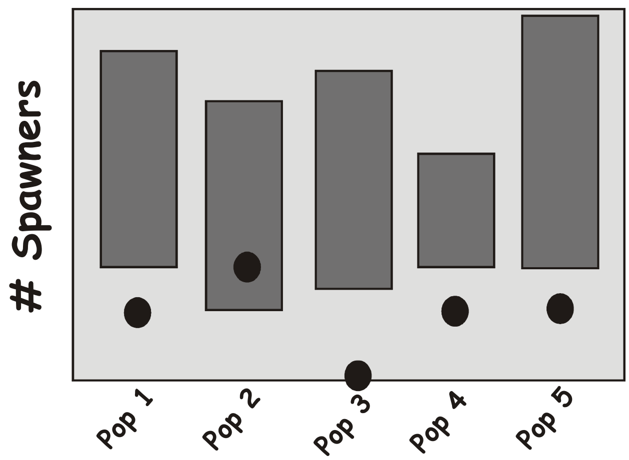


Figure 14. Example comparison of current status with planning target ranges for Washington lower Columbia River salmon recovery (Note: top and bottom of bars are the maximum and minimum planning ranges; points are current status).

Specific goals within this planning range will be selected through a collaborative process led by the LCFRB during subsequent phases of the recovery planning process. The lower end of the range is the minimum conservation standard that must be achieved in a critical number of populations. The upper end of the range sets a realistic maximum for expectations. Average population sizes need only to exceed the low bound of the target planning range within a specified period to ensure long-term population viability and meet federal ESU delisting requirements. Higher average numbers will be required to meets state and federal requirements for healthy harvestable populations; exactly how high will depend on the desired balance of fisheries, other human impacts, and ecosystem values. Numbers near the low end of the planning range would provide only limited opportunity for harvest and would be more susceptible to ocean/climate variation, but would require smaller changes in water or land use. Conversely, numbers near the upper end of the planning range would provide optimum harvest opportunity and could withstand variability in ocean conditions, but would require greater habitat changes.

5.0 Assessments of Current Status and Limiting Factors

Chapter 5 of the Technical Foundation includes assessments of current population status relative to potential recovery benchmarks for each focal fish species. It also describes analyses of the relative significance of six factors for decline; fishing, hatcheries, stream habitat, mainstem and estuary habitat, dams, and predation. (Only factors within the realm of human management were included.) These evaluations provide a road map of possible avenues for recovery and a basis for more detailed assessments of recovery scenarios and strategies in the next phase of the recovery planning process.

For effective interpretation by both highly technical scientific professionals and an informed lay audience, descriptions of current status and factors for decline must be technically defensible, based on the best available data, as well as intuitively easy to interpret. A sound technical approach was needed to provide effective guidance and to withstand intense scientific scrutiny. “Best available data” is the standard for evaluating Endangered Species assessments. In many cases, the “best available” may be less than ideal but scientific information can support informed decisions, provide direction, reduce uncertainty, and generate testable hypotheses even where the data are not definitive. Finally, descriptions need to be intuitively easy to understand by a mix of technical and non-technical people who will be called upon to make scientific and policy decisions based on these data.

Specific assessments for each species include: 1) estimates of current viability for each population, 2) comparisons of current fish numbers with recovery planning ranges, 3) descriptions of the biological significance of each population, 4) indices of the relative effects of each limiting factor for each fish population, and 5) subjective summaries of the recovery prospects for each focal fish species.

5.1 Approach

5.1.1 Current Viability

We evaluated viability based on standards developed by the Willamette/Lower Columbia TRT, consisting of a committee of scientists convened by NOAA Fisheries to provide technical guidance in fish recovery. As detailed in Chapter 5 of the Technical Foundation, TRT viability guidelines are based on scores assigned to viability attributes each fish population within an ESU. Attributes include spawner abundance, productivity, juvenile outmigrant numbers, diversity, spatial structure, and habitat conditions. The rating scale corresponds to 100-year persistence probabilities: 0 = 0-40%, 1 = 40-75%, 2 = 75-95%, 3 = 95-99%, 4 > 99%. Population scores were then counted and averaged across a geographic strata for each species for comparison with recovery benchmarks established by the TRT. The lower Columbia region includes Coast, Cascade, and Gorge strata identified by the TRT to capture within-ESU differences in population characteristics related to differences in geographical and environmental conditions. The benchmarks include a strata average persistence probability greater than 2.25 with at least two populations at high persistence probabilities ($\geq$3.0).

Population trends and extinction risks are also reported based on analyses of population time series data by NOAA Fisheries, where abundance trends were described with median annual growth rates (λ) based on slopes fit to 4-year running sums of abundance. Extinction risks were based on two different models that make slightly different assumptions about future patterns from recent abundance time series data.

Current population sizes were also compared with historical "template" numbers to provide a perspective on differences that have contributed to current viability. Historical numbers were available from the EDT Model analyses, as described in Chapter 5 of the Technical Foundation, based on assumed habitat conditions.

5.1.2 Recovery Planning Ranges

Planning ranges, as generally described in Section 4 above, were estimated both in terms of spawner numbers and population productivity. 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.

Comparisons of current numbers and planning ranges provide an index of the difference between current, viable, and potential values (Figure 15). The low bound of the planning range is equivalent to a high level of viability as described by the Willamette/Lower Columbia TRT. 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.

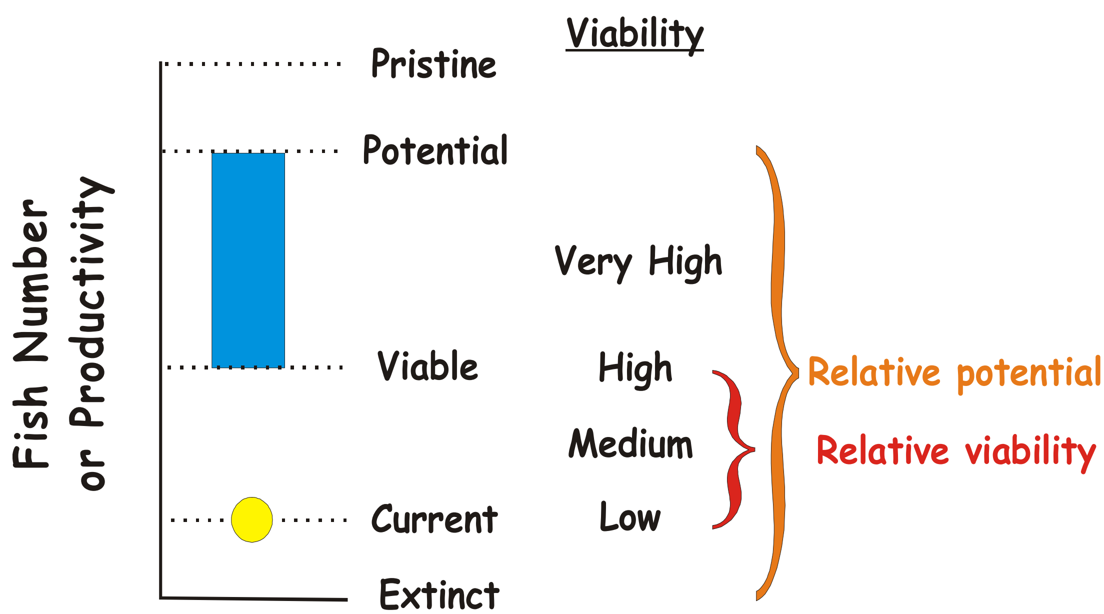


Figure 15. Depiction of generic recovery planning ranges relative to viability levels identified by the Willamette/Lower Columbia Technical Recovery Team.

The low bound of the planning range was generally based either on: 1) Population Change Criteria (PCC) developed by NOAA Fisheries, the population growth rate and average abundance after 20 years that would minimize risks of falling below critically low population sizes over 100 years, 2) default PCC values of 600, 1,100, and 1,400 spawners, for steelhead, chum, and Chinook, respectively, where sufficient data were unavailable or populations were thought to average less than 150 spawners, or 3) current abundance, for populations that have insignificant extinction risks (i.e., less than 5% within 100 years). Where PCC numbers exceed potential habitat capacity under properly functioning habitat conditions (PFC) estimated using EDT, the PFC+ EDT value was used as a minimum.

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 PFC, assuming no removal of existing dams, no fishing, and the estuary at historical productivity levels. Both abundance and productivity at PFC was estimated using EDT analysis. The upper bound of the abundance planning range was defined in terms of long-term equilibrium spawner numbers. Where EDT was unavailable, we conservatively assumed an upper bound of two times the lower abundance bound.

Planning range productivity values at viability were expressed as median annual population growth rates, estimated from current escapement time series data analyses. Default PCC values of 9%, 14%, and 15% population growth per year were used for steelhead, chum, and Chinook, respectively, when population-specific PCC estimates were unavailable. The upper bound of the productivity planning range was based on EDT values, expressed as the asymptotic Beverton-Holt recruit per spawner parameter which describes maximum adult spawner per spawner values at low spawner numbers.

Recovery scenarios based on TRT guidelines prescribe biological objectives that target different recovery levels for different populations. Some populations need to be restored to high levels of viability, others need to be improved to contribute to ESU viability but need not reach high levels of viability, and others need to reach very high levels of viability to compensate for recovery uncertainties and to provide opportunities for other uses such as harvest. Comparisons of current status with recovery planning ranges provide a means of estimating improvement increments necessary to reach any given population level. Increments based on productivity differences also provide a means for relating necessary improvements to manageable impact factors. Proportional improvements in population productivity were estimated for recovery of each population.

5.1.3 Population Significance

To facilitate future development of recovery scenarios consistent with biological guidelines for recovery, we developed a simple index to systematically rate the biological significance of each population based on the available data. The biological significance of each fish population can be described in terms of:

Current viability: Likelihood that a population will not go extinct within a given time frame. The healthiest, most robust current populations are the most viable.

Core potential: Number of fish that could be produced in a given area if favorable historical conditions could be at least partially restored.

Genetic character: Current resemblance to historical characteristics that were intended to be preserved.

Specific guidelines related to each of these attributes are the basis for population viability criteria identified by the Willamette/Lower Columbia TRT. Biological significance ratings were calculated for each population based on the simple arithmetic average of scores for the three elements. Details on the calculations for each attribute are fully described in Chapter 5 of the Technical Foundation.

5.1.4 Current Limiting Factors

5.1.4.1 Net Effect of Manageable Factors

To inform the development of recovery scenarios and strategies by technical and policy groups, we needed to inventory key factors and place them in perspective relative to each other. The factors currently limiting Washington lower Columbia River salmon and steelhead populations were evaluated based on a simple index that incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g., predation). This is referred to as the Adult Equivalent Impacts Occurring Unconditionally (AEIOU) Index.

This approach represents the relative order of magnitude of key limiting factors. It does not constitute a fine-scaled mechanistic analysis of limiting factors and dynamics of every listed population. The question was not whether a factor might be responsible for a 50% or 55% impact with a confidence interval of 5%. Rather, we needed to know whether a factor represented a 5% or 50% or 90% impact. The relative importance of each factor guides both technical decisions on what combinations of recovery measures can prove effective and policy decisions on where to focus efforts and how to balance the responsibilities and costs of recovery. Only the subset of factors we can potentially manage were included in the AEIOU Index – natural mortality factors beyond our control (e.g., naturally occurring ocean mortality) are excluded (Figure 16).

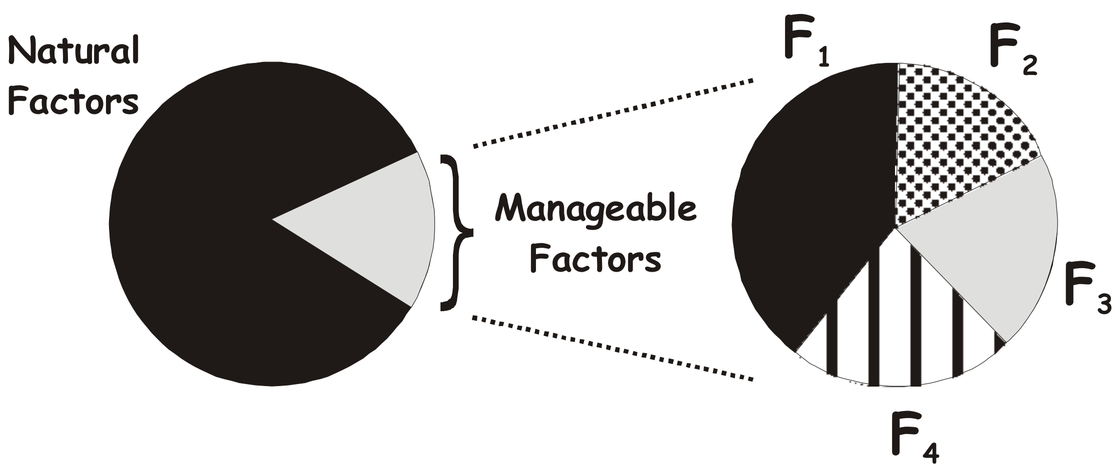


Figure 16. Manageable human factors affecting salmon mortality, productivity, and numbers represented as a portion of all factors and as their own pie.

Factor level effects are most easily thought of as mortality rates. Analyses included losses associated with fishing, dam passage of juveniles and adult migrants, loss of tributary rearing capacity because of blockage and habitat degradation, reduced estuary survival because of habitat changes, reduced natural population productivity because of interbreeding with less-fit hatchery fish, and predation by fish, birds, and marine mammals. The factor reduction is relative to the potential number of that specific life stage rather than relative to numbers at an earlier or later life stage. Each factor level effect translates into an equivalent reduction in fish numbers or productivity (e.g., a 50% reduction in habitat quality reduces adult numbers by 50% just as a 25% harvest mortality reduces adult numbers by 25%). In our simple example, with a 50% habitat quality reduction and a 25% harvest mortality, the net impact would be 1-[(1-0.5)(1-0.25)] or a 62.5% reduction because of habitat and harvest impacts (only 37.5% of the historical number remains). Details on the calculations for each limiting factor impact (fisheries, hatcheries, dams, stream habitat, mainstem and estuary habitat, and predation) are fully described in Chapter 5 of the Technical Foundation.

The impact factors described in Chapter 5 are a beginning rather than an end of the recovery scenario and strategy development process. Estimated or assumed values for impact factors represent a reasonable first approximation and may be later refined by more detailed evaluations of each individual factor. There are caveats because of lack of specific data, general inferences, indirect analyses, uncertainty, but these impact factors provide a unified basis for addressing actions required for recovery.

Once the relative significance of various factors for decline is understood, the obvious next questions are: 1) how big a change is needed to achieve recovery, 2) what combinations of factor changes will be effective, and 3) how difficult or costly will it be to affect each individual limiting factor by any given amount. A general sense of effective changes in any given factor can be gained by comparing specific impacts with increases in population growth rate or productivity. For instance, if population growth rates need to increase by 10% to reach desired population persistence probabilities, then we would need to collectively decrease impact factors by an absolute value of 10% per year.

5.1.5 Summary Assessments

For each species discussed below, we assessed the prospects and constraints for recovery by subjectively reviewing and synthesizing the results of the four methods described above. We did not finalize quantitative assessments; rather we chose to leave those final determinations for the recovery planning process. The information provided in the following sections sets the stage for recovery planners to determine the most appropriate summary method to support their decision-making.

5.2 Chinook

5.2.1 Current Viability

Current Chinook population sizes and productivities are only a small fraction of conservatively estimated historical numbers (averaged from Table 5-3, Technical Foundation).

Table 12. Current and potential Chinook population size in the lower Columbia River, by species.

Species Group	Current wild escapements	Habitat-based potential
Spring Chinook	1,115	54,271
Tule fall Chinook	5,454	91,275
Bright fall Chinook	6,493	16,089

Current run sizes are also significantly less than projected viability levels and equilibrium potential, as inferred with EDT (Table 13). Based on interim TRT population criteria, 100-year persistence probabilities for five Washington populations are very low or already extinct (0-39%), 22 populations are low (40-74%), three populations are moderate (75-94%), and only one population is relatively high (95-99%) (Table 13). All strata currently fall short of integrated TRT recovery criteria.

Of ten Washington Chinook populations modeled for extinction risk, eight exhibited greater than a 90% extinction likelihood under current population trajectories (Table 13). However, model-derived estimates may be overly pessimistic because of the limited time period of available data coincident with population declines following the ocean regime shift in the late 1970s, as well as very large post-1983-84 El Niño returns which occur in the first half of most available time series. Future estimates revised to consider longer-term cyclical patterns in ocean survival may project much lower extinction risks.

5.2.2 Recovery Planning Ranges

Planning ranges are presented in Table 13. Minimum viability abundance values vary among populations from 1,400 to 6,500 based primarily on PCC viability targets. Maximum planning numbers range from 1,400 to 33,200 based on subbasin potentials estimated with EDT for PFC. Consistent with their current threatened population status, recent natural spawning escapements have almost universally averaged less than the lower viability bound of the planning range.

5.2.3 Populations Significance

The population significance rank provides a simple sorting device to group populations in each strata based on current viability, core potential, and genetic legacy (Table 13). Based on this ranking method, no Coast Strata Washington tule Chinook population is distinguishable from any other; the Elochoman population was designated as a core population by the TRT. In the Cascade strata, tules in the Coweeman, Lewis/Salmon, and lower Cowlitz sort to the top by virtue of their current viability, genetic legacy designations, or large historical population sizes. No Gorge tule population is distinguished from the others by this index. Late fall bright Chinook are represented by only one Cascade population each in Washington and Oregon. Upper Cowlitz and Cispus spring Chinook rank at the top of the Cascade strata by virtue of their genetic legacy designation and high historical core potential.

5.2.4 Current Limiting Factors

The net effects of quantifiable human impacts and potentially manageable predation on Chinook salmon translates into an 85-100% reduction in productivity among Washington lower Columbia populations (Figure 17). Thus, current fish numbers are only 0-15% of what they would be if all manageable impacts were removed.

No single factor accounts for the majority of the reduction in fish numbers. Loss of habitat quantity and quality in the tributaries and the estuary account for significant shares of the impact. Dam construction constitutes the largest single impact for upper Cowlitz and Lewis populations of spring Chinook and tule fall Chinook. Dam construction is also a significant factor for Gorge Chinook populations. Fishing causes significant losses for fall Chinook but less so for spring Chinook. Hatchery effects vary among populations but are generally less than 20% of the total impact. Predation is among the lesser impacts we considered.

Table 13. Recent average run sizes, viability, persistence probability, extinction risk, planning ranges, and recovery potential of lower Columbia River Chinook, grouped by recovery strata.

					Planning ranges		Recovery potential			
Population	Recent avg number	Current viability	Persistence prob.[1]	Extinct risk model 2[2]	At viability	EDT potential	Genetic legacy[3]	Core population[4]	Biological significance[5]	Rank[6]
Coast Fall										
Grays/Chinook	73	**Low+**	60%	1.00	1,400	1,400			0.17	C
Eloch/Skam	140	**Low+**	60%	0.98	1,400	4,500		1	0.21	C
Mill/Aber/Germ	250	**Low**	50%	0.98	2,000	3,200			0.19	C
Youngs Bay (OR)	--	**Low**	50%		1,400	2,800			0.18	--
Big Creek (OR)	--	**Low**	60%		1,400	2,800		1	0.20	--
Clatskanie (OR)	--	**Low**	60%		1,400	2,800			0.21	--
Scappoose (OR)	--	**Low**	50%		1,400	2,800			0.18	--
Cascade Fall										
Lower Cowlitz	602	**Low+**	60%	0.97	3,900	33,200		1	0.51	A
Upper Cowlitz	0	**V Low**	30%		1,400	10,800			0.18	C
Toutle	1,000	**Low**	50%		1,400	14,100		1	0.29	C
Coweeman	425	**Med**	80%	0.54	3,000	4,100	1		0.63	A
Kalama	1,192	**Low+**	70%	0.90	1,300	3,200			0.24	C
Lewis/Salmon	235	**Med**	80%	0.80	1,900	3,900	1		0.60	A
Washougal	1,225	**Low+**	70%	0.90	5,800	5,800			0.24	C
Clackamas (OR)	56	**Low**	50%	1.00	1,400	2,800		1	0.18	--
Sandy (OR)	208	**Low**	60%		1,400	2,800			0.22	--
Gorge Fall										
L Gorge	--	**Low**	50%		1,400	2,800			0.16	C
U. Gorge (Wind)	138	**Low**	50%		1,400	2,400		1	0.17	C
White Salmon	174	**Low**	50%	0.99	1,600	3,200		1	0.17	C
Hood (OR)	--	**Low**	60%		1,400	2,800			0.19	--
Cascade L Fall										
Lewis NF	6,493	**Med+**	100%	0.60	6,500	16,600	1	1	0.96	A
Sandy (OR)	445	**Low**	60%		5,100	10,200	1	1	0.72	--

Population	Recent avg number	Current viability	Persistence prob.[1]	Extinct risk model 2[2]	Planning ranges: At viability	Planning ranges: EDT potential	Recovery potential: Genetic legacy[3]	Recovery potential: Core population[4]	Recovery potential: Biological significance[5]	Rank[6]
Cascade Spring										
Upper Cowlitz	365	**Low**	40%		2,800	8,100	1	1	0.78	A
Cispus	150	**Low**	40%		1,400	2,300		1	0.59	A
Tilton	150	**V Low**	0%		1,400	2,800			0.12	C
Toutle	150	**V Low**	20%		1,400	3,400			0.21	C
Kalama	105	**Low**	40%		1,400	1,400			0.16	C
Lewis NF	300	**V Low**	40%		2,200	3,900		1	0.26	C
Sandy (OR)	2,649	**Med**	80%	0.03	2,600	5,200	1	1	0.78	--
Gorge Spring										
White Salmon	0	**V Low**	0%		1,400	2,800		1	0.12	C
Hood (OR)	0	**V Low**	20%		1,400	2,800			0.17	--

[1] *Persistence probability corresponding to net population score (interpolated from corresponding persistence ranges).*
[2] *Population projection interval extinction risks (PPI E) estimated from abundance time series by NOAA Fisheries using Population Change Criteria model.*
[3] *Genetic legacy designation by the Technical Recovery Team. Genetic legacy populations are relatively unchanged by hatchery influences or represent unique life histories.*
[4] *Core population designation by Technical Recovery Team. Core populations were the largest historical populations and were key to metapopulation processes.*
[5] *Average of current viability, core population potential, and genetic legacy scores.*
[6] *Strata ranking based on average population score of viability potential, genetic legacy, and core population.*

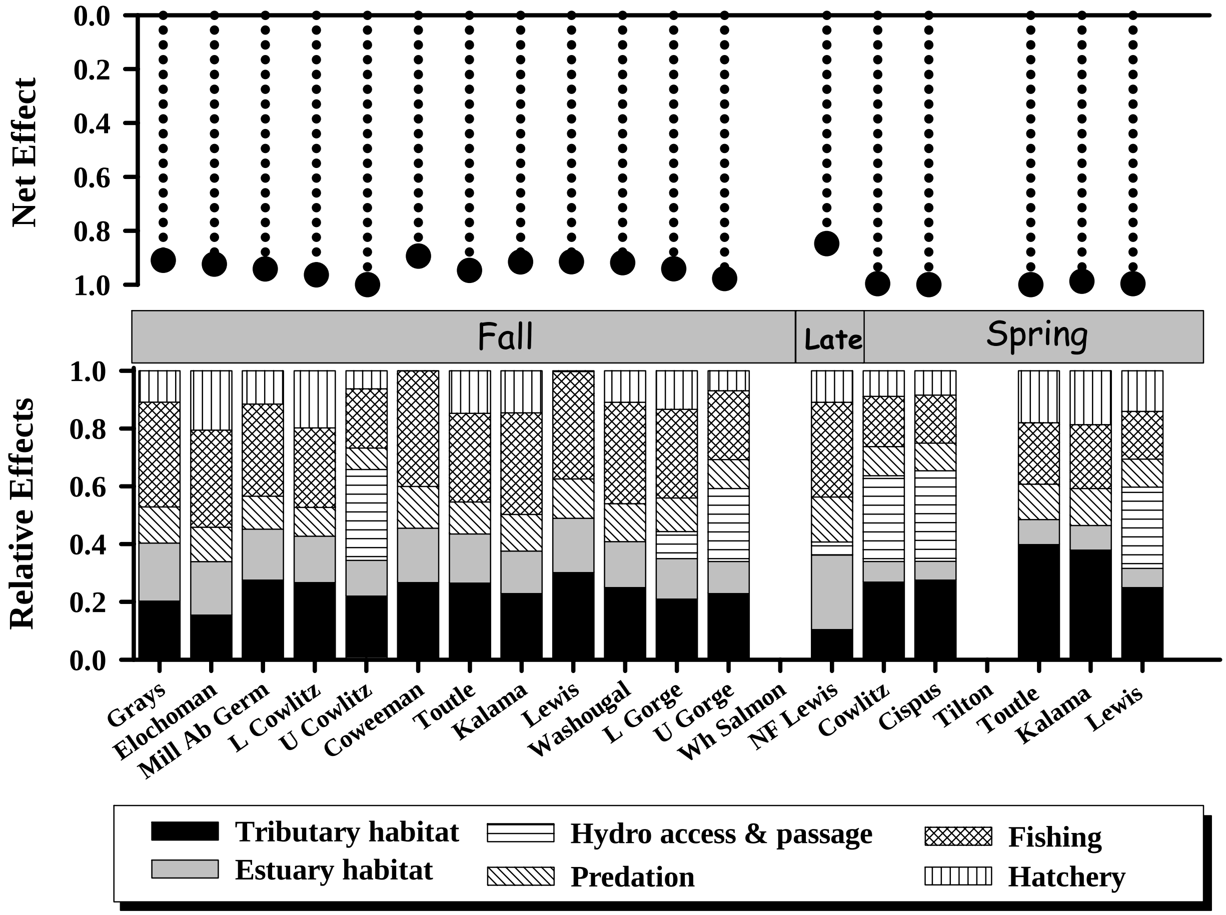


Figure 17. **Net effect and relative contribution of potentially manageable impact factors on Chinook salmon in Washington lower Columbia River subbasins. Net effect is the approximate reduction from historical fish numbers as a result of manageable factors included in this analysis.**

5.3 Chum Salmon

5.3.1 Current Viability

The Willamette/Lower Columbia Technical Recovery Team identified 16 historical populations of chum salmon in the Columbia River ESU. Eight occur only in Washington, six occur only in Oregon, and two are shared between states. Significant populations presently exist only in the Grays River and the lower Columbia River Gorge tributaries and mainstem.

Current Washington chum population sizes (around 3,500, Table 14) are much less than historical numbers, which ranged from 6,600 to 479,800 based on EDT estimates. TRT population criteria indicate that 100-year persistence probabilities are very low or already extinct (0-39%) for 12 populations, low (40-74%) for 3 populations, and moderate (75-94%) for 1 population. No chum population was judged to be currently at a high probability of persistence. All strata currently fall short of recovery criteria.

Population trends and extinction risks have been estimated for two chum populations based on abundance time series data and two different models. Population trends were negative for one of the two estimates and extinction risks averaged for both models were 50-60% per population. Differences between score-derived persistence probabilities and trend-derived extinction risks reflect different assumptions and uncertainties in these methods.

5.3.2 Recovery Planning Ranges

Planning ranges are available only for Washington populations (Table 14). Minimum values vary among populations from 1,100 to 4,300 according to PCC numbers. Maximum planning range numbers range from 2,200 to 135,700 based on subbasin potentials estimated with EDT for Properly Functioning Conditions. Consistent with their current threatened population status, recent natural spawning escapements have universally averaged less than the low viability bound of the planning range. Recent numbers have averaged fewer than 300 naturally produced fish in eight of ten chum populations that occur in Washington.

Substantial improvements in productivity are required in most populations to reach viable levels. Chum populations in the Grays River and lower Gorge were estimated to require an 8% to 12% improvement in productivity to reach a level of high viability. Other chum populations would require a 25% to 2,000% increase in productivity to reach viable levels.

5.3.3 Population Significance

The population significance rank provides a simple sorting device to group populations in each strata based on current viability, core potential and genetic legacy (Table 14). In the Coast stratum, Grays River chum sort to the top by virtue of their current viability and genetic legacy designations; the Elochoman population was designated as a core population by the TRT. In the Cascade stratum, Cowlitz chum sort to the top by virtue of their genetic legacy designations; all other Cascade chum are grouped in a low tier. The lower Gorge chum populations are distinguished by core and legacy designations, as well as currently greater numbers than other populations.

Table 14. Recent average run sizes, viability, persistence probability, extinction risk, planning ranges, and recovery potential of lower Columbia River chum salmon, grouped by recovery strata.

					Planning ranges		Recovery potential			
Population	Recent avg number	Current viability	Persistence prob.[1]	Extinct risk model 2[2]	At viability	EDT potential	Genetic legacy[3]	Core population[4]	Biological significance[5]	Rank[6]
Coast										
Grays/Chinook	960	**Low+**	70%	0.006	4,300	7,800	1	1	0.56	A
Eloch/Skam	150	**Low**	40%		1,100	8,200		1	0.13	C
Mill/Ab/Germ	150	**V Low**	30%		1,100	3,000			0.10	C
Youngs (OR)	150	**V Low**	20%		1,100	2,200			0.07	--
Big Creek (OR)	150	**V Low**	20%		1,100	2,200			0.07	--
Clatskanie (OR)	150	**V Low**	20%		1,100	2,200			0.07	--
Scappoose (OR)	150	**V Low**	20%		1,100	2,200			0.07	--
Cascade										
Cowlitz	150	**V Low**	30%		1,100	135,700	1	1	0.76	A
Kalama	150	**V Low**	30%		1,100	12,200			0.11	C
Lewis	150	**V Low**	30%		1,100	71,000		1	0.26	C
Salmon	150	**V Low**	10%		1,100	4,200			0.05	C
Washougal	150	**Low**	50%		1,100	9,400			0.17	C
Clackamas (OR)	150	**V Low**	10%		1,100	2,200		1	0.04	--
Sandy (OR)	150	**V Low**	20%		1,100	2,200			0.05	--
Gorge										
Lower Gorge	542	**Med+**	80%	0.717	2,600	3,100	1	1	0.58	A
Upper Gorge	100	**V Low**	30%		1,100	5,900			0.09	C

[1] *Persistence probability corresponding to net population score (interpolated from corresponding persistence ranges).*
[2] *Population projection interval extinction risks (PPI E) estimated from abundance time series by NOAA Fisheries using Population Change Criteria model.*
[3] *Genetic legacy designation by the Technical Recovery Team. Genetic legacy populations are relatively unchanged by hatchery influences or represent unique life histories.*
[4] *Core population designation by Technical Recovery Team. Core populations were the largest historical populations and were key to metapopulation processes.*
[5] *Average of current viability, core population potential, and genetic legacy scores.*
[6] *Strata ranking based on average population score of viability potential, genetic legacy, and core population.*

5.3.4 Current Limiting Factors

The net effects of quantifiable human impacts and potentially manageable predation on chum salmon translates into a 92-100% reduction in productivity among Washington lower Columbia populations (Figure 18). Thus, current fish numbers are only 0-8% of what they would be if all manageable impacts were removed.

Spawning and rearing habitat degradation accounts for half or more of the manageable impacts in all populations except for the Gorge where direct hydropower impacts are significant (Figure 18). Estuary habitat changes are also thought to be significant for chum salmon. Fishing and hatchery impacts are very small.

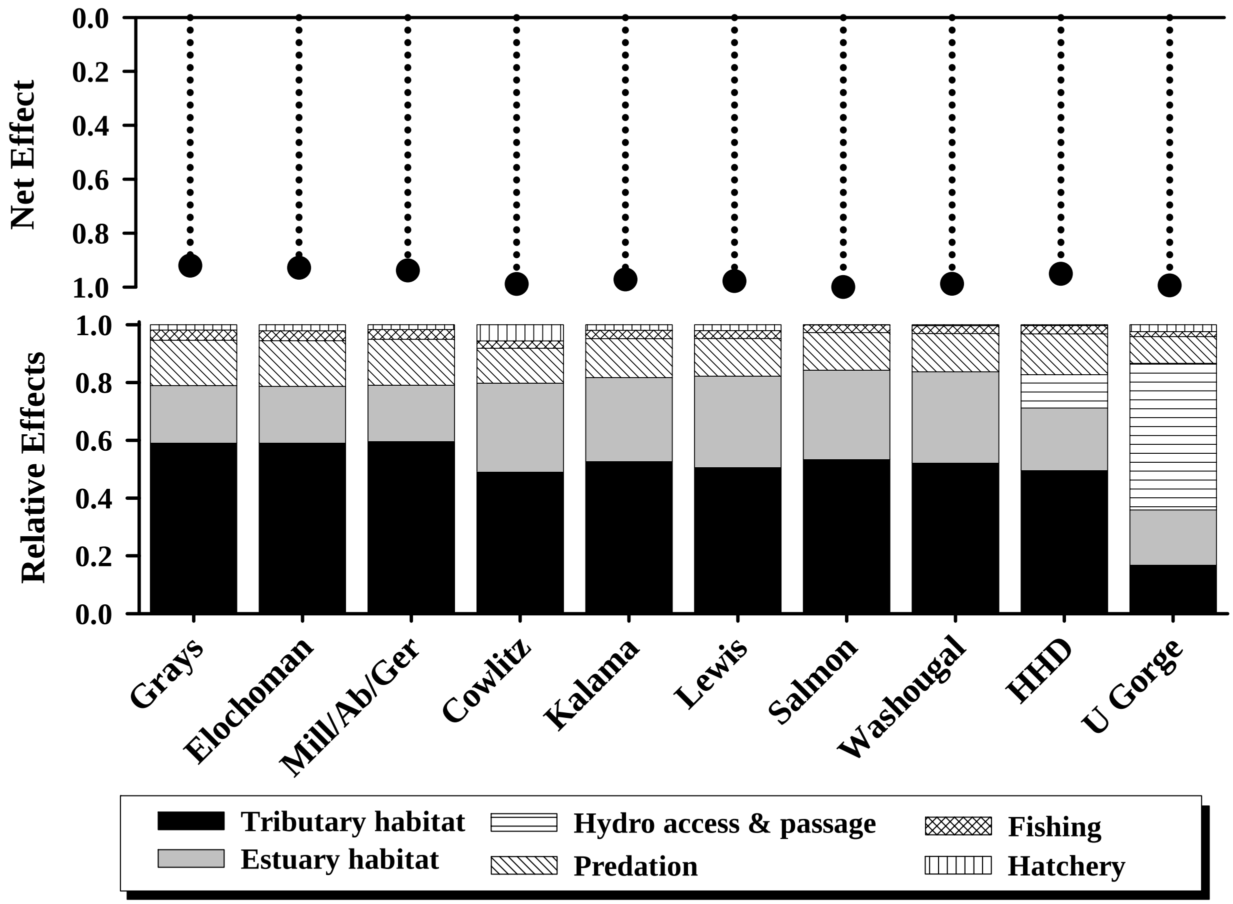


Figure 18. Net effect and relative contribution of potentially manageable impact factors on chum salmon in Washington lower Columbia River subbasins. Net effect is the approximate reduction from historical fish numbers as a result of manageable factors included in this analysis.

5.4 Coho

5.4.1 Current Viability

Because coho are not currently listed under the ESA, the Willamette/Lower Columbia TRT has not designated populations of coho in the lower Columbia River. However, as part of the Status Review process for ESA-listed ESUs, the NOAA Fisheries BRT tentatively identified 25 historical LCR coho populations: 18 populations in Washington and seven in Oregon (Table 15).

Recent numbers have averaged fewer than 300 naturally-produced fish in 16 of 18 Washington coho salmon populations, including several populations where no current spawning escapement estimate has been provided (Table 15). Recent natural escapements of Washington lower Columbia coho exceeded an average of 1,000 fish only in the lower Cowlitz and NF Lewis basins. The recent average escapements have also been consistently less than EDT equilibrium numbers based on current stream habitat conditions and dramatically below anticipated numbers estimated with EDT under PFC (Table 15). EDT underestimated coho numbers because current analyses do not include many of the smaller streams used by coho.

Based on interim TRT population criteria, 100-year persistence probabilities are very low or already extinct (0-39%) for 17 populations, low (40-74%) for seven populations, and moderate (75-94%) for only one population; no coho populations had a relatively high (95-99%) 100-year persistence probability (Table 15). All strata currently fall short of integrated TRT recovery criteria.

5.4.2 Population Significance

The population significance rank provides a simple sorting device to group populations in each strata based on current viability, core potential, and genetic legacy considerations (Table 15). The TRT has not designated “core” or “legacy” coho populations based on the abundance and genetic criteria utilized for other ESA-listed salmonids. NOAA Fisheries “Back of the Envelope” (BOE) abundance estimates was used as a surrogate to generate a relative index for the “core” population designation by comparing each population’s BOE abundance to the largest BOE–derived Columbia coho population (i.e., lower Cowlitz). There was no simple surrogate for the genetic legacy criteria utilized by the TRT for other salmonids; thus, effects on the average population score and relative ranking were uniform across all coho populations.

Based on the population significance index, Washington coho salmon populations in the Coast strata are ranked in the same group (Table 15). In the Cascade strata, the lower Cowlitz and NF Lewis sort to the top by virtue of their current viability and core potential designations. The second tier in the Cascade strata includes NF Toutle, upper Cowlitz, and EF Lewis populations; these populations had moderately large historical populations. A third Cascade tier includes Washougal, Kalama, Salmon, Coweeman, SF Toutle, Tilton, and Cispus populations; these populations were all relatively small and all currently have low viability. No Gorge coho population is distinguished from the others by this index.

Table 15. Recent average run sizes, viability, persistence probability, extinction risk, planning ranges, and recovery potential of Lower Columbia River coho salmon, grouped by recovery strata.

Population	4-yr Avg number	Current viability	Persistence Prob.[1]	Planning ranges: Min EDT potential[2]	Planning ranges: EDT PFC+ potential[3]	Recovery potential: Core population [4]	Recovery potential: Genetic legacy [5]	Recovery potential: Biological Significance [6]	Rank[7]
Coast									
Grays/Chinook	28	--	30%	1,239	4,593	0.33	0.00	0.20	B
Eloch/Skam	32	--	30%	2,396	7,045	0.36	0.00	0.20	B
Mill/Aber/Germ	24	--	40%	2,045	3,664	0.25	0.00	0.20	B
Youngs Bay (OR)	403	--	40%	--	--	0.48	0.00	0.28	--
Big Creek (OR)		--	40%	--	--	0.28	0.00	0.22	--
Clatskanie (OR)	92	--	50%	--	--	0.46	0.00	0.29	--
Scappoose (OR)	458	--	60%	--	--	0.10	0.00	0.20	--
Cascade									
L Cowlitz	1,015	--	30%	4,144	19,058	1.00	0.00	0.42	A
Coweeman	15	--	30%	1,873	7,579	0.21	0.00	0.16	C
Toutle SF	44	--	30%	3,860	32,901	0.14	0.00	0.13	C
Toutle NF	190	--	30%	--	--	0.52	0.00	0.25	B
U Cowlitz	--	--	10%	11,039	28,770	0.56	0.00	0.21	B
Cispus	--	--	10%	3,752	6,612	0.10	0.00	0.06	C
Tilton	--	--	10%	261	4,011	0.20	0.00	0.08	C
Kalama	18	--	30%	484	1,282	0.22	0.00	0.16	C
Lewis NF	3,778	--	40%	2,367	5,917	0.71	0.00	0.35	A
Lewis EF	43	--	30%	1,066	4,101	0.35	0.00	0.20	B
Salmon	--	--	20%	772	5,731	0.30	0.00	0.16	C
Washougal	14	--	30%	824	4,170	0.30	0.00	0.17	C
Clackamas (OR)	1,684	--	80%	--	--	0.49	0.00	0.39	--
Sandy (OR)	587	--	70%	--	--	0.51	0.00	0.38	--
Gorge									
L Gorge	28	--	30%	57	153	0.11	0.00	0.11	C
U. Gorge	233	--	30%	418	1,114	0.09	0.00	0.11	C
White Salmon	129	--	20%	--	--	0.14	0.00	0.09	C
Hood (OR)	<50	--	30%	--	--	0.17	0.00	0.13	--

1 Persistence probability corresponding to net population score (interpolated from corresponding persistence ranges).
2 Current population number inferred with EDT from estimated and assume, current habitat conditions.
3 Estimate if habitat conditions are restored to "properly functioning" standards defined by NOAA Fisheries and predevelopment estuary conditions are restored.
4 Normalized core population potential used in biological significance ranking. The TRT has not designated core populations for coho; the score is based on BOE abundance.
5 Genetic legacy score used in biological significance ranking. The TRT has not assigned genetic legacy designations for coho; no surrogate is available for this metric.
6 Average of current viability, core population potential, and genetic legacy scores.
7 Strata ranking based on average population score of viability potential, genetic legacy, and core population.

5.4.3 Current Limiting Factors

The net effects of quantifiable human impacts and potentially manageable predation on coho salmon translates into a 92-100% reduction in productivity among Washington lower Columbia populations (Figure 19). Thus, current fish numbers are only 0-8% of what they would be if all manageable impacts were removed.

Loss of tributary habitat quantity and quality generally account for significant shares of the impact, particularly in the NF Toutle population where tributary habitat loss accounts for over half of the total impact. Dam construction constitutes the largest single impact for upper Cowlitz, Cispus, Tilton, and NF Lewis populations but does not appear to be a primary limiting factor for other coho populations, including the upper Gorge. Fishing and hatchery effects vary among populations but approach 30% of the total impact in some populations. Predation and estuary habitat conditions were among the lesser impacts we considered.

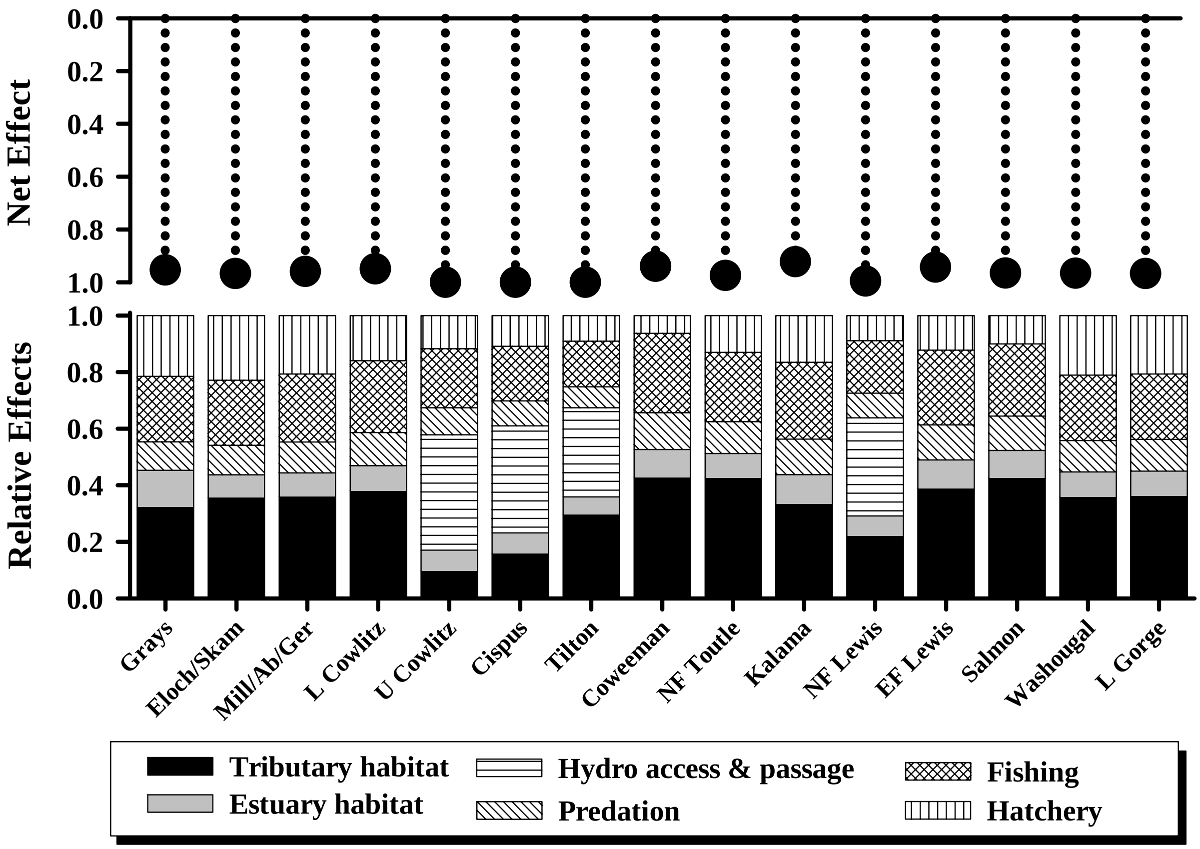


Figure 19. Net effect and relative contribution of potentially manageable impact factors on coho salmon in Washington lower Columbia River subbasins. Net effect is the approximate reduction from historical fish numbers as a result of manageable factors included in this analysis.

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5.5 Steelhead

5.5.1 Current Viability

Current steelhead population sizes are only a small fraction of historical numbers inferred from the average of five methods (see Table 5-21 of Technical Foundation).

Table 16. Current and potential steelhead population size in the lower Columbia River, by species.

Species Group	Current wild escapements	Habitat-based potential
Winter steelhead	2,346	50,452
Summer steelhead	1,281	19,321

EDT estimates of equilibrium numbers range from 60 to 2,300 per population under current conditions, but recent population estimates were typically much less than EDT estimates in part because of poor ocean survival conditions. Recent numbers have averaged fewer than 300 naturally produced fish in six of nine Washington winter steelhead populations and two of four Washington summer steelhead populations where data are available (Table 17). Historical steelhead population sizes in Washington ranged from 300 to 7,400 based on EDT estimates.

Based on interim TRT population criteria, 100-year persistence probabilities are very low or already extinct (0-39%) for two populations, low (40-74%) for 21 populations, and moderate (75-94%) for three populations (Table 17). All strata currently fall short of integrated TRT recovery criteria.

Population trends and/or extinction risks have been estimated for 12 steelhead populations based on abundance time series data and two different models. Population trends were negative for seven of 12 populations. Extinction risks averaged for both models were 80% or greater for seven of nine populations. Noteworthy exceptions include NF Toutle winter steelhead (recovering from volcanic effects) and Washougal summer steelhead. We assume that future estimates revised to consider cyclical patterns in ocean survival like those that have produced recent large returns will project much lower extinction risks consistent with persistence scores based on specific population attributes.

5.5.2 Recovery Planning Ranges

Minimum abundance planning range values vary among populations from 100 to 1,800 (Table 17). Populations with larger current numbers generally require greater minimum numbers to reach viable levels according to Population Change Criteria. Maximum planning range numbers range from 100 to 3,500 based on subbasin potentials estimated with EDT for PFC. Consistent with their current threatened population status, recent natural spawning escapements have averaged less than the low viability bound of the planning range for all populations except for EF Lewis summer steelhead. Substantial improvements in productivity are required in most populations to reach viable levels.

5.5.3 Population Significance

The population significance rank, based on current viability, core potential, and genetic legacy (Table 17), was used to rank population viability within strata. In the Coast strata, the Grays and Mill/Abernathy/Germany winter steelhead were categorized in a middle group and the Elochoman/Skamokawa populations were slightly lower. In the Cascade stratum, Upper Cowlitz, Cispus, and NF Toutle populations sorted to the top by virtue of their current viability, genetic legacy designations, or large historical potential. North Fork Lewis, South Toutle, Kalama, EF

Lewis, and Coweeman rank in a middle tier. Lower Cowlitz, Washougal, Salmon, and Tilton populations sort to the bottom rank. The two Gorge stratum winter steelhead populations are similarly low in their ranking.

Cascade summer steelhead populations include the Washougal and East Fork Lewis in the top tier by virtue of their legacy status. Kalama summer steelhead fall in a middle tier distinguishable from North Fork Lewis in a third tier. Only one Gorge summer steelhead population occurs in Washington, and it ranks near the top Cascade populations.

5.5.4 Current Limiting Factors

The net effects of quantifiable human impacts and potentially manageable predation on steelhead translate into a 40-100% reduction in productivity among Washington lower Columbia populations (Figure 20). Thus, current fish numbers are only 0-60% of what they would be if all manageable impacts were removed.

No single factor consistently accounts for the majority of the reduction in fish numbers. Loss of tributary habitat quantity and quality is in many cases the most significant impact. Dam construction constitutes the largest single impact for upper Cowlitz and Lewis populations. Dam construction is also a factor for Gorge steelhead populations. Fishing is a minor impact, especially for winter steelhead. Hatchery effects vary among populations but are generally less than 20% of the total impact. Estuary habitat and predation are among the lesser impacts we considered.

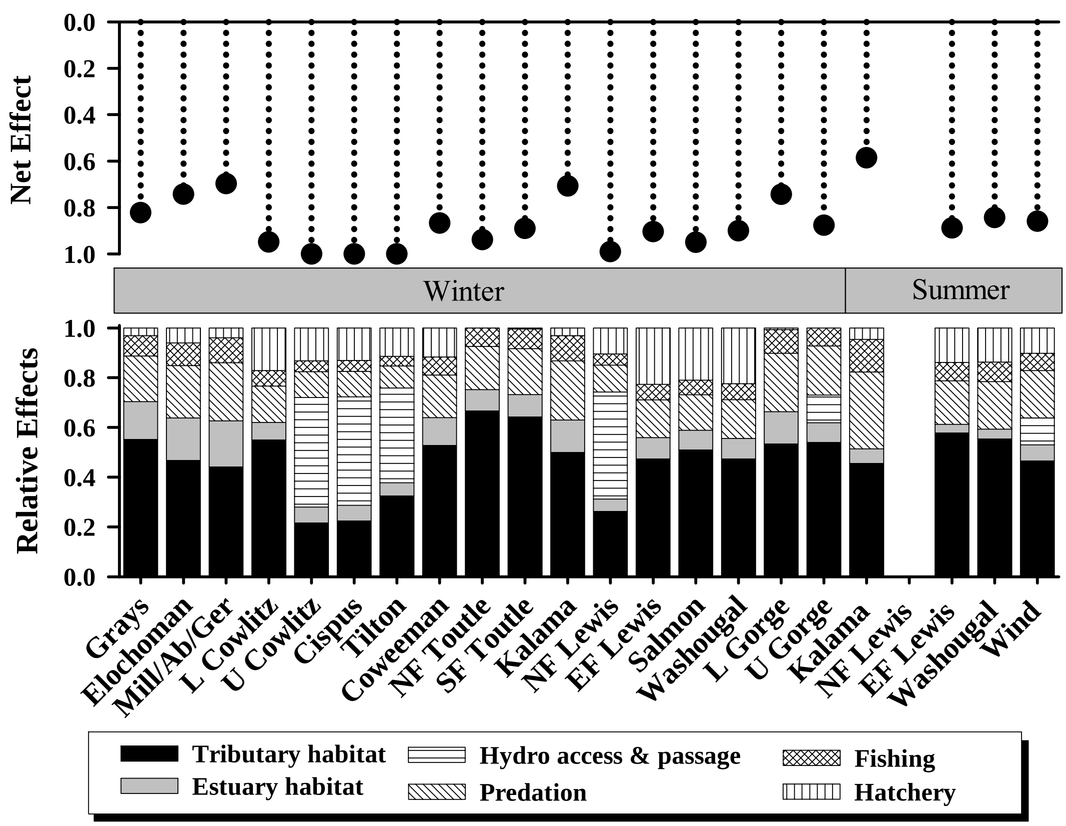

Figure 20. Net effect and relative contribution of potentially manageable impact factors on steelhead in Washington lower Columbia River subbasins. Net effect is the approximate reduction from historical fish numbers as a result of manageable factors included in this analysis.

Table 17. Recent average run sizes, viability, persistence probability, extinction risk, planning ranges, and recovery potential of lower Columbia River steelhead, grouped by recovery strata.

					Planning ranges		Recovery potential			
Population	**Recent avg number**	**Current viability**	**Persistence prob.[1]**	**Extinct risk model 2[2]**	**At viability**	**EDT potential**	**Genetic legacy[3]**	**Core population[4]**	**Biological significance[5]**	**Rank[6]**
Coast Winter										
Grays/Chinook	150	**Low+**	70%		600	2,300			0.41	B
Eloch/Skam	150	**Low+**	60%		600	1,000			0.26	C
Mill/Aber/Germ	150	**Low+**	60%		600	1,500			0.33	B
Cascade Winter										
Lower Cowlitz		**Low**	50%		600	1,500			0.29	C
Coweeman	228	**Low+**	70%		800	1,200			0.31	B
Toutle SF	453	**Med**	80%	0.85	1,400	1,900			0.41	B
Toutle NF	176	**Low**	70%	0.03	700	3,500		1	0.53	A
Upper Cowlitz	0	**V Low**	40%		600	1,600	1	1	0.59	A
Cispus	0	**V Low**	40%		600	1,200	1	1	0.55	A
Tilton	0	**V Low**	30%		600	1,300			0.21	C
Kalama	541	**Med+**	90%	0.75	600	700			0.32	B
Lewis NF		**Low**	50%		600	3,400		1	0.46	B
Lewis EF	77	**Low+**	60%	0.97	600	1,300			0.31	B
Salmon		**Low**	50%		600	1,200			0.26	C
Washougal	421	**Low+**	60%		600	1,000			0.27	C
Clackamas (OR)	277	**Low**	60%	0.85	1,000	2,000		1	0.36	--
Sandy (OR)	589	**Low**	60%	0.99	1,800	3,600		1	0.52	--
Gorge Winter										
L. Gorge (HHD)		**Low+**	60%		200	300			0.21	C
U. Gorge (Wind only)		**Low+**	60%		100	100			0.17	C
Hood (OR)	436	**Low**	70%		1,400	2,800	1	1	0.79	--
Cascade Summer										
Kalama	291	**Low+**	70%	0.99	700	1,000		1	0.39	B
Lewis NF		**V Low**	20%		600	1,200			0.27	C
Lewis EF	463	**Low+**	70%		200	400	1		0.60	A
Washougal	136	**Low+**	70%	0.72	500	900	1	1	0.70	A
Gorge Summer										
Wind	391	**Med+**	90%	0.78	1,200	1,900		1	0.59	A
Hood (OR)	154	**Low**	50%		600	1,200			0.37	--

[1] *Persistence probability corresponding to net population score (interpolated from corresponding persistence ranges).*

[2] *Population projection interval extinction risks (PPI E) estimated from abundance time series by NOAA Fisheries using Population Change Criteria model.*
[3] *Genetic legacy designation by the Technical Recovery Team. Genetic legacy populations are relatively unchanged by hatchery influences or represent unique life histories.*
[4] *Core population designation by Technical Recovery Team. Core populations were the largest historical populations and were key to metapopulation processes.*
[5] *Average of current viability, core population potential, and genetic legacy scores.*
[6] *Strata ranking based on average population score of viability potential, genetic legacy, and core population.*

5.6 Bull Trout

5.6.1 Current Viability

The USFWS formulated a draft bull trout recovery plan, identifying 27 recovery units for bull trout. One is the Lower Columbia recovery unit, which has two core areas (the Lewis River and the Klickitat River). While no local populations have been identified in the White Salmon, the subbasin contains core habitat, and could support bull trout. Recent natural escapements in two upper Lewis River spawning areas currently average several hundred fish per year.

5.6.2 Recovery Planning Ranges

At present, recovery standards for bull trout have only been partially identified. However, USFWS has compiled a list of research criteria to gather the data necessary to assess whether management actions are resulting in the recovery of bull trout in the Lower Columbia recovery unit. Distribution and abundance of bull trout in the Lower Columbia recovery unit is unknown and considered a research need. Until additional information is obtained, at a minimum, the existing local populations in the recovery unit need to be maintained. The development of a standardized monitoring and evaluation program to accurately describe trends in bull trout abundance has been identified as a priority research need. Barriers to bull trout migration in the Lower Columbia recovery unit need to be addressed (Swift 1 and 2 and Yale Dams on the Lewis River, and Condit Dam on the White Salmon River).

5.6.3 Summary Assessment

- The historical distribution and abundance of bull trout in the lower Columbia region are unknown. Bull trout are known to exist in the Lewis drainage and some Gorge tributaries.
- Hydropower development has negatively affected bull trout populations in the Lewis River system, where three hydroelectric dams block fish passage and eliminate connectivity of subpopulations. The USFWS has recommended providing passage to re-connect the Yale and Swift reservoir populations.
- The USFWS has recommended installing a means of fish passage at Condit Dam on the White Salmon River, although no bull trout are known to currently occupy that system. Suitable habitat exists and bull trout are believed to have existed in the White Salmon historically.
- Fishing for bull trout is closed in Washington. Bycatch has been reported in the Lewis River watershed kokanee fishery but its impacts are believed to be very low.
- There are no hatchery programs to produce bull trout. Interactions between bull trout and hatchery-produced salmonids have not been studied, and impacts are unknown.

5.7 Cutthroat

5.7.1 Current Viability

Lower Columbia River coastal cutthroat trout are not listed under the federal ESA. The subspecies was a candidate for listing as "threatened," but the USFWS found on July 2002 that a listing was not warranted. Coastal cutthroat trout are widely distributed throughout suitable habitats of lower Columbia River subbasins and historical distribution has not contracted appreciably. Cutthroat occur at over 1,300 documented locations within the lower Columbia distinct population segment.

The USFWS also found that populations in the Washington part of the distinct population segment under review "remained at levels comparable to healthy-sized populations, indicating that large-scale, long-term declines have not occurred at the landscape level". Available density data for tributaries below Bonneville Dam were comparable to those from Olympic Peninsula and Puget Sound populations that were not considered to be in danger of extinction. While numbers of sea-run cutthroat appeared to have declined, the USFWS found that resident and anadromous forms were not segregated, and that because resident forms could give rise to anadromous progeny, the presence of healthy subpopulations of resident trout mitigated risks to anadromous forms to some degree.

5.7.2 Summary Assessment

- Cutthroat trout are widely distributed in Washington lower Columbia River tributary systems and are not federally listed. Numbers of sea-run cutthroat appear to have declined but risks are ameliorated by the presence of healthy subpopulations of resident trout.
- Current fishing impact is low and additional restrictions are not warranted given the current status of the species.
- Some hatchery production of sea-run cutthroat occurs. Relative risks and benefits have not been quantified.
- Cutthroat are a generalist species that exist in many small streams not suitable for other salmonids. Thus, cutthroat are susceptible to habitat changes that do not directly affect other anadromous species in Washington lower Columbia tributaries; suitable habitat conditions continue to be widely available.
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5.8 Conclusions

Human activities, including fishing, hatchery operation, alteration of stream, river, and estuary habitats, hydropower development and operation, and potentially manageable predation, have collectively reduced productivity of salmonid populations significantly below historical levels. Recovery efforts will require significant improvements in multiple areas because no single factor accounts for the majority of the reduction in fish numbers.

Subbasin Habitat - Stream habitat conditions significantly limit salmonid populations in all Washington lower Columbia River subbasins. Substantial stream habitat improvements will be necessary to reach optimum conditions (i.e., PFC) in all subbasins and to achieve recovery. The significance of stream habitat suggests that recovery may not be feasible without substantial improvements in tributary habitat quantity and quality.

Estuary and Mainstem Habitat - Estuary and mainstem habitats are critical to fall Chinook and chum salmon life history, with assumed habitat impacts ranging from 30 to 40%. Estuary and mainstem habitats are of lesser importance to spring Chinook salmon, coho salmon, and steelhead life history, with assumed habitat impacts of ~10%.

Hydropower - Tributary hydropower development is currently the most significant factor limiting spring Chinook populations and recovery may not be feasible without effective passage measures at Cowlitz and Lewis River dams. Hydropower development in the Cowlitz and Lewis has also blocked 50-95% of the historical steelhead and coho salmon habitat. Significant hydropower impacts on chum include passage mortality at Bonneville Dam, the inundation of Columbia River Gorge lower tributary reaches by Bonneville Reservoir, and changes to mainstem spawning habitat downstream from Bonneville Dam. Flood control by Cowlitz and Lewis dams has altered habitat-forming processes in lower subbasin reaches favored by chum. Mainstem dam passage affects all upper Gorge populations, but can be only partially addressed by passage improvements.

Fishing - Fishing impacts on fall Chinook provide some opportunity for increasing numbers through additional fishery constraints, although reductions would require changes in U.S. ocean, Canada ocean, Alaska ocean, and Columbia River fisheries. Since Lower Columbia fall Chinook and coho comprise only a small portion of the catch in many fisheries, additional constraints for their protection will forgo harvest of larger numbers from healthy wild and especially hatchery populations. Intensive fishery management processes provide significant opportunities for limiting fishing risks by tailoring annual harvests to fish availability. Current fishing impacts on spring Chinook and coho are modest and provide limited opportunities for increases through additional regulation of fisheries. Current fishing impacts on chum salmon and steelhead are very low and additional fisheries regulations provide limited opportunity for increasing their numbers. Steelhead fishing impacts occur almost exclusively in Columbia basin sport fisheries.

Hatcheries - Reduced productivity of wild fish from interbreeding with less-fit hatchery fish is a significant concern, although these negative effects may be at least partially offset by the demographic benefits of additional spawners. Potential negative impacts increase with the proportion of hatchery spawners and the genetic and phenotypic disparity between wild and hatchery fish. Potential fitness impacts among Washington lower Columbia salmonid populations are: fall Chinook (0 to 34%), spring Chinook (27 to 70%), coho salmon (11 to 50%), and steelhead (0 to 65%). Potential impacts are greatest where out-of-basin stocks continue to be used for broodstock. Existing chum salmon hatchery programs pose no significant risk of reduced wild productivity as a result of interbreeding with less-fit hatchery fish. Inter-specific hatchery predation impacts on juvenile fall Chinook and chum salmon are generally absent in basins without significant releases of coho, steelhead, or spring Chinook. In subbasins where large hatchery programs are underway (i.e. Lewis and Cowlitz), inter-specific hatchery predation impacts can be substantial: fall Chinook (15 to 27%) and chum (11%).

Predation - For all salmonid species, natural predation was among the lesser impacts we considered.

VOLUME II – SUBBASINS

1.0 Introduction

Subbasin Chapters 2-17 in Volume II provide specific information on fish populations and the factors affecting them. These chapters include a review of existing information as well as the results of technical assessments including partitioning of mortality factors (4-H analysis), fish habitat modeling, and watershed process assessment. Subbasin Chapters 3-17 contain the following sections: 1) Subbasin Description, 2) Focal Fish Species, 3) Potentially Manageable Impacts, 4) Hatchery Discussion, 5) Fish Habitat Conditions, 6) Fish/Habitat Assessments, and 7) Integrated Watershed Assessment.

The lower Columbia River mainstem and estuary subbasin description (Chapter 2) follows a different format than all other subbasins for three primary reasons: 1) a lack of habitat data consistent with the other subbasins, 2) the unique role of the lower mainstem and estuary for all salmonid populations in the Columbia River basin, and 3) the joint planning and recovery effort with the State of Oregon.

2.0 Subbasin Description

The subbasin description presents an overview of subbasin geography, including topography, geology, climate, land cover, and land use characteristics. Subbasin information was obtained from a variety of existing reports and agency data. Methods used for describing subbasin land cover are describe in detail in Volume II.

3.0 Focal Fish Species

Information on focal fish species are presented in a Fact Sheet format, beginning with fish distribution maps followed by bulleted descriptions of fish distribution, life history traits, diversity, abundance, productivity and persistence, hatchery practices, and harvest rates. Fish distribution maps were created from GIS data compiled by Washington State's Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP) program; fish distribution maps were updated where better or more recent information was available.

4.0 Potentially Manageable Impacts

In Volume I of this Technical Foundation, we evaluated factors currently limiting Washington lower Columbia River salmon and steelhead populations based on a simple index of potentially manageable impacts (see Section 5.0 above). For the purposes of Volume I, the results of the mortality factor analyses were presented for each species across all subbasins to evaluate ESU-level mortality factors and identify those factors where survival improvements would have the greatest effect on ESU recovery. For the purposes of Volume II, the mortality factors analyses have been re-organized for consistency with the subbasin analyses.

5.0 Hatchery Discussion

A brief summary of species-specific hatchery programs is presented for each subbasin, based on the most recent available Hatchery and Genetic Management Plan (HGMP) for each program. The hatchery discussions are divided into the following sections: genetics, interactions, water quality/disease, mixed harvest, passage, and supplementation.

6.0 Fish Habitat Conditions

This section presents a background of the general condition of stream habitat and watershed processes within subbasins. Stream habitat and landscape conditions that are believed to be potentially impacting aquatic resources are described. This section does not include an analysis of the relative importance of habitat conditions or the significance to fish at the population scale, which is the focus of the following 3 sections (see descriptions below).

6.1 Fish Habitat Assessments

Fish Habitat Assessments present the results and analysis of EDT fish habitat modeling. The section is divided into 3 sub-sections: 1) Population Analysis, 2) Restoration and Preservation Analysis, and 3) Habitat Factor Analysis.

6.2 Population Analysis

EDT describes fish population levels in terms of productivity, abundance, and diversity. Estimation of fish population levels under a given set of habitat conditions is one of several EDT applications, whether EDT has been corroborated with specific fish census data or if census data are not available. This application is particularly useful in recreating a historical baseline and relating changes in fish population levels to changes in habitat conditions.

EDT estimates were generated for historic (template), current (patient), and "Properly Functioning" habitat conditions (PFC). The historical/template condition is defined as pre-non-Native American/European influence and represents a hypothetical optimum. The current/patient condition represents the immediate past few years. PFC represents favorable habitat conditions for salmonids throughout the basin based on criteria identified by NMFS.

6.3 Restoration and Preservation Analysis

Restoration and preservation analysis is based on the same fish abundance, productivity, and diversity information derived for the population analysis. Restoration and preservation analysis provides a greater level of detail as it identifies reaches based on their preservation value and restoration potential. Restoration and preservation analysis results are specific to each fish species because of the different fish habitat requirements of each.

Restoration value is estimated as the percent increase in salmon performance if a reach is completely restored. Addressing degraded habitat conditions in a reach with a high restoration potential would provide a greater benefit to the population than in a reach with low restoration potential. Preservation value is estimated as the percent decrease in salmon performance if a reach was thoroughly degraded. Reaches with a high preservation value should be protected because of the disproportionately high negative impact on the population that would result from degradation.

6.4 Habitat Factor Analysis

The Habitat Factor Analysis assesses the relative impact of various stream channel attributes on a particular fish population. Key limiting habitat conditions are identified by comparing EDT current/patient habitat conditions with optimum conditions in the historical/template baseline. This analysis illustrates the specific habitat factors that, if restored, would yield the greatest benefit to population abundance. The habitat factor analysis depicts a greater level of detail than the reach analysis in that it looks at the specific habitat factors rather than the aggregate effect of all habitat factors.

6.5 Integrated Watershed Assessment

The Integrated Watershed Assessment (IWA) is a GIS-based screening tool used to examine the current condition of key watershed processes (sediment supply, hydrology, and riparian condition) that directly or indirectly influence habitat conditions affecting fish populations in the lower Columbia Region. The focus on watershed processes allows for both an understanding of likely current conditions, and prediction of future conditions based on projected trends in land use or landscape condition. Because the functionality or impairment of watershed processes and additional contributing factors are identified at local as well as watershed scales, the results of this analysis are suggestive of the general categories of habitat protection and restoration measures that could be applied in recovery planning.

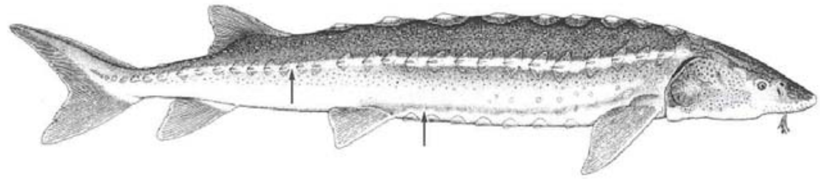
VOLUME III - OTHER FISH AND WILDLIFE SPECIES

Volume III of this Technical Foundation addresses selected anadromous and resident fish and wildlife of interest under the NPCC subbasin planning process; these species include sturgeon (white and green), Pacific lamprey, eulachon, northern pikeminnow, American shad, introduced gamefish (walleye, smallmouth bass, and channel catfish), dusky Canada goose, Caspian terns, Columbian white-tailed deer, sandhill crane, western pond turtle, selected neo-tropical birds (red-eyed vireo and yellow warbler), sea lions, and harbor seal. Each species chapter provides life history information, identifies populations and distribution, describes species status and abundance trends, and discusses the known factors affecting current population status.

1.0 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 1800s prior to the adoption of significant fishery restrictions and recovery required decades. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey. The lower Columbia population is 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. Bonneville Reservoir continues to support a significant white sturgeon population although numbers and sizes are substantially less than in the lower river. Only the Kootenai River subpopulation of white sturgeon has been listed under the Endangered Species Act (endangered).

2.0 Green Sturgeon



Green sturgeon (*Acipenser medirostris*) also occur in the lower Columbia River but do not typically 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 are a candidate species.

3.0 Pacific Lamprey

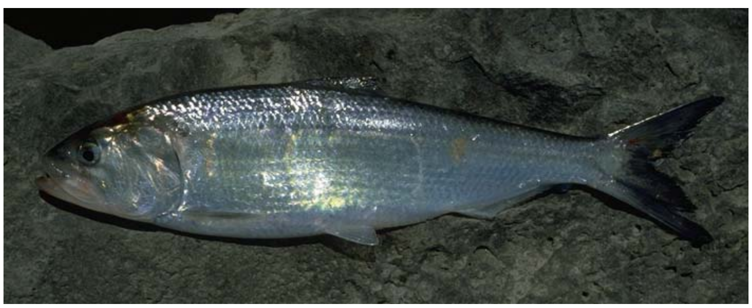
Pacific lamprey (*Entosphenus tridentatus*) are a native anadromous inhabitant Pacific Northwest rivers including the Columbia. Lamprey spawn in small tributaries historically as far upstream as Idaho and British Columbia, and die after spawning. Young lamprey, called ammocoetes, are algae filter feeders 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. Suffering in part for their unique appearance and parasitic reputation, relatively little is known about status and biology of Pacific lamprey. Most data suggests that populations in the Columbia Basin have been declining concurrent with hydroelectric development and other habitat changes.

4.0 Eulachon

Eulachon is the official common name for smelt (*Thaleichthys pacificus*) which 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 huge numbers by other fishes including sturgeon, birds, and marine mammals. Smelt numbers and run patterns can be quite variable and low runs during the 1990's were a source of considerable concern by fishery agencies.

5.0 Northern Pikeminnow

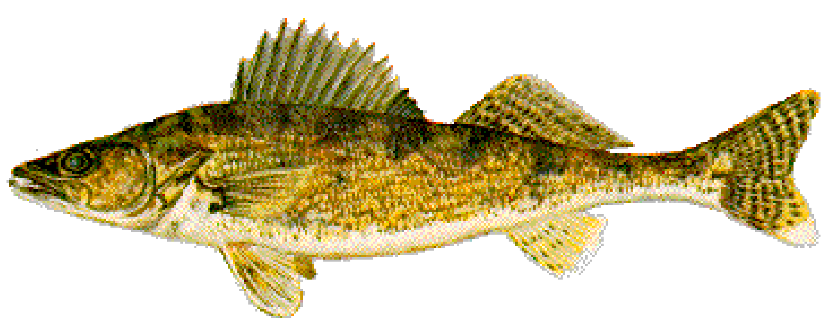
The northern pikeminnow *(Ptychocheilus oregonensis)* is native to freshwater lakes and rivers of the Pacific slope of western North America from Oregon to northern British Columbia. Northern pikeminnow are large (10-20 inches), long-lived (10-15 years), predaceous minnows. This opportunistic species has flourished with habitat changes in the mainstem Columbia River and its tributaries. Salmonids are an important food for 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 in an attempt to reduce predation mortality by reducing numbers of the large, old pikeminnow that account for most of the losses.



6.0 American Shad

Millions of American shad (*Alosa sapidissima*) have colonized the Columbia River after their introduction from the East Coast to California's Sacramento River during the 1870s. Two to four million shad are counted at dam fish ladders 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.

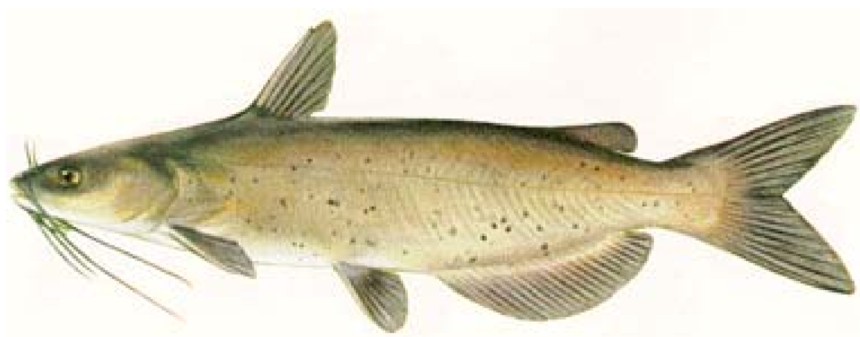
7.0 Walleye



Walleye (*Stizostedium vitreum*) were introduced from the Mississippi River basin into the Grand Coulle area over the last 30 years and 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.

8.0 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).



9.0 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.

10.0 Dusky Canada Goose

The dusky Canada goose (*Branta canadensis occidentalis*) is a distinctive race of medium size (about 6 lbs) 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. The mild, wet climate during winter and extensive agriculture, provide ideal habitat for wintering Canada geese. A network of federal and state waterfowl refuges established in the mid-1960s also provide additional attraction and security for wintering. Dusky Canada geese numbers began an abrupt decline after the 1964 Alaska earthquake raised the elevation nesting area wetlands, which precipitated a series of successional vegetation changes and also increased predation. This race of geese is subject to continuing measures to restore and protect key habitat areas and to limit hunting mortality.

11.0 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. Populations are recovering from historic harvest and habitat effects have been controlled. The species is not listed but is of conservation concern because of the concentration of breeding terns at relatively few sites and 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 rather than Rice Island in order to reduce predation on salmonids.

12.0 Columbian White-tailed 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 the low productivity of the population are the most important threats now to the population. Recovery goals identify the need to secure additional habitat for population re-introduction.

13.0 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 1916. 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. 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 recreationists.

14.0 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. Wetland draining, filling, and development eliminated much habitat during the past century. Habitat effects are compounded by the long life span and low rate of recruitment. The vagaries of Pacific Northwest weather probably result in high variation in hatching success. As significant predators on hatchling and small juvenile western pond turtles, non-native species such as bullfrogs and warm water fish seem to reduce survivorship and alter recruitment patterns.

15.0 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 an function.

16.0 Yellow Warbler

Within Washington, yellow warblers (*Dendroica petechia*) are apparently secure and are not of conservation concern. However, yellow warbler 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. Factors affecting continued existence include habitat loss and degradation.

17.0 Seals & Sea Lions

Harbor seals and sea lions are seasonal residents of the lower Columbia River. Most are concentrated in or near the estuary but individuals regularly range as far upstream as Bonneville Dam. 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 widely 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 passage problem where fish are artificially concentrated in the vicinity of locks, dams, and fish ladders.

VOLUME IV - EXISTING PROGRAMS

Volume IV describes of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning. These include fish and wildlife protection and restoration activities. This information helps demonstrate current management directions, existing and imminent protections, and the means by which recovery strategies and measures will be implemented. These program descriptions form the basis for a "gap analysis" in the recovery/management plan. The gap analysis identifies programmatic needs in each subbasin, activities underway to address them, the value and efficacy of current activities, and modifications or needed consistent with recovery objectives.

VOLUME V - ECONOMIC ASSESSMENT

Volume V describes potential costs and economic considerations for recovery and subbasin planning. The recovery planning process will yield a preferred scenario, strategies to accomplish the scenario, and recovery measures to implement the strategy. Evaluation and selection of a scenario depends, in part, upon a coarse-scale analysis of the relative costs of implementing potential strategies and the economic effects of these actions. The economics volume of the Technical Foundation does not analyze costs and benefits of specific scenarios and actions but does summarize the background information needed to do so in later phases of recovery and management planning.

- The economic modeling and explanations are at a summary level commensurate with expected sub-basin plan content recommended by the NPPC Independent Economic Analysis Board (see IEAB, Recommendations and Guidance for Economic Analysis in Subbasin Planning, January 2003).

Summaries include:

- Economic base descriptions at a regional level of current economies in the study area. Describe causes and influences for recent economic trends. Description factors to include demographic variables (age, gender, housing information, etc.) and economic variables (employment, income, production, etc.).
- General descriptions of the relationship between plan actions and effects to the economy both adverse and beneficial. These include explanations of how actions can be modeled and their effects measured based on qualitative descriptions and quantitative modeling.
- Descriptions of stakeholder types who might suffer adverse impacts if actions are implemented and qualitatively describe nature and magnitude of impacts.
- Estimates of unit cost and benefit information for the range of anticipated actions so that readers will have some sense of action cost and action's economic impacts and valuation.
- Descriptions of an approach that can be used in a cost effective analysis so that packaged actions (i.e., plan alternatives) can be ranked, and compared to other programs that may attain the same results. For example, hatchery production versus fish resource habitat improvements for natural production.

VOLUME VI - TECHNICAL APPENDICES

Numerous assessments and analyses were performed in the process of completing this Technical Foundation. These assessments and analyses are important to the recovery and subbasin planning process, however, in many cases, they do not cleanly fit within the organizational structure of this Technical Foundation. Each of these assessments or analyses have been included as a separate Appendix within Volume VI of this Technical Foundation. Each Appendix addresses a specific topic or tool used during recovery and subbasin planning and is developed in more detail than was appropriate for the primary chapters.

1.0 POPULATION RANKING

A summary of viability scores and rationales assigned to salmon and steelhead population status based on Technical Recovery Team criteria.

2.0 RUN RECONSTRUCTION

Reconstructions of annual salmon returns and spawning escapement by year of origin used for estimates of survival and productivity rates. These rates are useful for validating model estimates of basin capacities and viable population sizes.

3.0 COHO CAPACITY ESTIMATION

Empirical estimates of subbasin capacities for producing coho salmon used to evaluate Ecosystem Diagnosis and Treatment (EDT) inferences from habitat conditions.

4.0 INTEGRATED WATERSHED ASSESSMENT

Description of the method and rationale for IWA analyses of the degree of impairment of key habitat forming processes in Washington Lower Columbia River Subwatersheds.

5.0 INTEGRATED WATERSHED ASSESSMENT RESULTS

Detailed descriptions and discussions of the results of IWA analyses of the degree of impairment of key habitat forming processes in Washington Lower Columbia River Subwatersheds.

6.0 APPLICATION OF THE EDT MODEL

Discussion of the application of the EDT model in habitat assessments in this Technical Foundation.

7.0 EDT FOR GERMANY, ABERNATHY, MILL, ELOCHOMAN, AND SKAMOKAWA WATERSHEDS

Descriptions of input data and assumptions for EDT analyses in Washington Lower Columbia River Subbasins.

8.0 EDT FOR COWLITZ, COWEEMAN, KALAMA, LEWIS, AND GORGE WATERSHEDS

Descriptions of input data and assumptions for EDT analyses in Washington Lower Columbia River Subbasins.

9.0 ANADROMOUS FISH BARRIER ASSESSMENT

Analysis of barriers to fish passage and accessible habitat in Washington Lower Columbia River Subbasins.

ACRONYMS

AABM	abundance-based management agreements
ACOE	US Army Corps of Engineers
ADFG	Alaska Department of Fish and Game
AEQ	adult equivalent
ARP	aggregate recovery percentage
ATV	all terrain vehicle
BBS	Breeding Bird Survey
BC	British Columbia
BCWD	bacterial cold water disease
B-IBI	Benthic Index of Biotic Integrity
BKD	bacterial kidney disease
BMPs	Best Management Practices
BPA	Bonneville Power Administration
BPH	Bonneville Pool Hatchery
BRT	biological review team
C&S fisheries	commercial and subsistence fisheries
CBFWA	Columbia Basin Fish and Wildlife Authority
CCC	ESA-listed (1998) central California coast coho
CCD	Cowlitz Conservation District
CCD/WCD	Cowlitz and Wahkiakum Conservation District
CDFG	California Department of Fish and Game
CFD	computational fluid dynamics
CFFCF	Cowlitz Falls Fish Collection Facility
CPUE	catch per unit of effort
CRFMP	Columbia River Fish Management Plan
CRITFC	Columbia River Inter-Tribal Fish Commission
CRRL	Columbia River Research Lab
CWT	coded-wire tag
DART	data access real time
DD	degree days
DDAC	didecyldimethylammonium chloride
DDE	dichloro-diphenyl-ethane
DDT	dichloro-diphenyl-trichlorethane
DFO	Department of Fisheries and Oceans of Canada
DNR	Washington Department of Natural Resources
DO	dissolved oxygen
DPS	distinct population segment

EA	environmental assessment
EDT	ecosystem diagnosis and treatment
ENSO	El Nino Southern Oscillation Index
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
ETM	Estuary Turbidity Maximum
FERC	Federal Energy Regulatory Commission
FGE	fish guidance efficiency
FHC	Fish Health Center
FL	fork length
FMP	Fish Management Plan
FMMPA	Federal Marine Mammal Protection Act
GDU	genetically distinct unit
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IFIM	Instream Flow Incremental Methodology
IFMP	Integrated Fisheries Management Plan
IHNV	Infectious Hematopoeitic Necrosis Virus
IMA	Interim Management Agreement
INPFC	International North Pacific Fisheries Commission
IPC	Idaho Power Company
ISBM	individual stock base management
LCN	lower Columbia natural
LC50	Lethal Concentrate 50
LFA	Limiting Factors Analysis
LOA	Letter of Agreement negotiated as part of the Pacific Salmon Treaty
LRH	lower river hatchery
LRW	lower river wild
LWD	large woody debris
MCB	mid-Columbia bright
MMOP	Marine Mammal Observer Program
MSY	maximum sustainable yield
mtDNA	mitochondrial deoxyribose nucleic acid
NBS	National Biological Service
NF	National Forest
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service

NOAA	Fisheries Division of National Oceanic and Atmospheric Administration
NPMP	Northern Pikeminnow Management Plan
NPPC	Northwest Power Planning Council, now called Northwest Power and Conservation Council
NRC	Natural Resource Council
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
NPCC	Northwest Power and Conservation Council (formerly Northwest Power Planning Council)
OC	Oregon coast
OCN	ESA-listed (1998) Oregon coast coho
OCNL	Oregon coastal natural lake
OCNR	Oregon coastal natural river
ODFW	Oregon Department of Fish and Wildlife
OFC	Oregon Fish Commission
OFWC	Oregon Fish and Wildlife Commission
OPI	Oregon Production Index
OPIA	Oregon Production Index Area
OPIH	Oregon Production Index Hatchery
OSY	optimum sustained yield
PCB	polychlorienated biphenyls
PCC	Population change criteria
PDO	Pacific Decadal Oscillation
PFC	Properly Functioning Condition
PFMC	Pacific Fisheries Management Council
PNFHPC	Pacific Northwest Fish Health Protection Committee
PRIH	private hatchery
PSC	Pacific Salmon Commission
PSMFC	Pacific States Marine Fishery Commission
PST	Pacific Salmon Treaty
PUD	Public Utility District
RCW	Revised Code of Washington
REAP	Regional Ecosystem Assessment Project
RM	river mile
SAFE	Select Area Fishery Enhancement
SAS	Salmon Advisory Subpanel
SaSi	Salmonid Stock Inventory
SASSI	Salmon and Steelhead Stock Inventory
SCH	Spring Creek Hatchery
SF	square foot

SFMP	Salmon Fishery Management Plan
SMTF	Sturgeon Management Task Force
SONC	Southern Oregon/Northern California
SRS	sediment retention structure
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment
STEP	Salmon Trout Enhancement Program
STT	Salmon Technical Team
T	temperature
TAG	Technical Advisory Group
TDG	total dissolved gases
303d list	State of Washington's list of impaired water bodies
TL	total length
TMDL	total maximum daily load
TRT	Technical Review Team
TSS	total suspended solid
TU	thermal units
UCD	Underwood Conservation District
UCM	unit characteristic method
UPGMA	unweighted pair group method with arithmatic mean
URB	upriver bright
US	United States
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
USGS	US Geological Service
VSP	Viable Salmonid Population
WA/OR	Washington/Oregon
WAC	Washington Administrative Code
WAU	Watershed Administrative Unit
WCC	Washington Conservation Commission
WCD	Wahkiakum Conservation District
WDF	Washington Department of Fish and Wildlife
WDFG	Washington Department of Fish and Game
WDFW	Washington Department of Fish and Wildlife
WDG	Washington Department of Game
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDW	Washington Department of Wildlife
WF	west fork

WFC	Washington Fish Commission
WQRP	Water Quality Restoration Plan
WRCC	Western Regional Climate Center
WRIA	Water Resource Inventory Area
WSCC	Washington State Conservation Commission
YIN	Yakama Indian Nation
YOY	young of the year

GLOSSARY

adfluvial	Possessing a life history trait of migrating between lakes or rivers and streams.
16°C (61°F)	State water temperature standard for class AA ("extraordinary") streams.
18°C (64°F)	State water temperature standard for for class A ("excellent") streams.
303d list	State list of impaired water bodies.
abiotic	Non-living.
adsorption	Physical binding of one substance to another.
aestivation	Temporary state of inactivity.
aggradation	The accumulation of stratigraphic sequences by deposition that stacks beds atop each other, building upwards during periods of balance between sediment supply and accommodation.
alevins	Earliest life stage in the life history of salmon following the hatching of eggs in the redds. Characterized as tiny fish living within the redd subsisting off a yolk sac attached to their bellies. Also know as yolk-sac larvae.
allele	An allele is any one of a number of alternative forms of the same gene occupying a give location on a chromosome.
allochthonous	Material that is formed or introduced from somewhere other than the place it is presently found.
allozyme data	Data pertaining to the form of an enzyme that differs in amino acid sequence from other forms of the same enzyme and is encoded by one allele at a single location on a chromosome.
allozyme electrophoresis	The identification of one of the different forms of an enzyme found in individuals of the same species, via the movement of charged particles through a fluid following the application of an electric field.
ammocoetes	Juvenile life stage of Pacific Lamprey during their freshwater residency.
amphidromy	Bi-directional, non-reproductive migration between fresh and saltwater.
anadromy	Spawn in fresh water, spend non-reproductive periods in marine environment
anaerobic respiration	Respiration without the use of oxygen, e.g., microbes.
andesite	A gray to black volcanic rock with 52-63% silica content.
angler trips	A measure of recreational fish harvest effort. One angler trip is equivalent to one person angling for one day.
annulus	Annual variations in growth ring patterns on a scale.
anthropogenic	Human induced.
asymptote	A line that is considered to be the limit to a curve. As the curve approaches the asymptote, the distance separating the curve and the asymptote continues to decrease, but the curve never actually intersects the asymptote.
avulsion	Lateral displacement of a stream from its main channel into a new course across its floodplain.
bedload	The quantitiy of large particles including rocks and pebbles mobilized along the bottom of a stream bed.
benthic invertebrates	Invertebrates whose habitat is in the substrate of a body of water.
bioenergetics modeling	Tracking the flow of energy through trophic levels of an ecosystem.
biotic	Living.
breccia	A *clastic rock* composed of particles more than 2 millimeters in diameter and marked by the angularity of its component grains and rock fragments.
BRT	Biological review team.
buccal cavity	Mouth cavity.
Ceratomyxa Shasta	Agent causing ceratomyxosis, an intenstinal disease in salmonids resulting in high mortality rates.
cfs	Cubic feet per second. A unit commonly used to quantify discharge rate.

char	Common name for several species of fish of the genus *Salvelinus* of the family Salmonidae; these fish have small scales and a red belly.
chromosomal karyotypes	Pictures of chromosomes cut out from a microphotograph of a cell and rearranged into homologous pairs according to size and other physical characteristics. The standardized arrangement of karyotypes allows researchers to discover if an individual is a male or female and if he/she has any gross chromosomal abnormalities.
coarse-scale	General; broad scale as opposed to fine scale or detailed.
cobble	Naturally rounded rock fragment between 64-256 mm (2.5-10 inches) in diameter. Typically compose a portion a streams substrate along with fine sediments, gravel, boulders and bedrock.
Columbia River Compact	Joint Oregon & Washington regulating form for mainstem Columbia River Fisheries.
cottids	Members of the family cottidae, also known as sculpins. A family of fishes common to streams throughout the Pacific Northwest.
CPUE	Catch per unit effort .
CWT	Coded-wire tag.
cyprinid	Members of the family cyprinidae, also known as minnows.
DDT	A chlorinated organic pesticide highly toxic to fish.
degree-days	A measure of cumulated temperature units. Two days at 10°C is equal to 20 degree days. Usually used to measure incubation periods.
demersal	Relating to the bottom, or substrate of a body of water.
diadromy	Migrating between fresh and saltwater.
diel	A day and an adjoining night.
DNA variations	Potential combinations or expressions of genetic material.
DO	Dissolved oxygen.
Early-seral	Early stage in the development of an ecosystem from an undisturbed, un-vegetated state. Vegetation is dominated by shade intolerant species.
ecosystem diagnosis and treatment (EDT)	
El Nino Southern Oscillation Index (ENSO)	
embedded substrates	Substrates partially or completely covered by fine sediment layers.
emydid	Family of turtle species
Eocene	Early epoch of the Tertiary period lasting from approximately 55 million to 40 million years ago.
Escapement	The number of salmon returning to the spawning grounds.
ESU criteria	
Evolutionarily significant unit (ESU)	
facultative potadromy	When dams keep fish that are historically anadromous or amphidromous from migrating, some fish (e.g. sturgeon) can migrate entirely within freshwater.
FGE	Fish guidance efficiency
fish of the year	Could not find to reference
flashy flow	Flow regime marked by a high frequency of high flows.
fluvial	Migrating between main rivers and tributaries.
fork length (FL)	Fish measured from the tip of its nose to the fork in its tail.
fry	The young of various fishes
furunculosis	A bacterial disease of salmonids usually characterized by boils on the skin of infected fish. When allowed to develop to advanced stages the disease is fatal.

handle	Having a fish in hand. Usually referring to when a fish is caught and released, as opposed to harvest which is caught and retained.
heterozygosity	The presence of different alleles of a gene at one or more locations on a chromosome.
Holoarctic region	The northern tier of the hemisphere.
HUC	Hydrologic Unit Code. Number coding system used to identify watersheds.
hyporheic zone	Subsurface areas beside and beneath streams where ground and surface waters mix.
hypoxia	Oxygen limitation.
inter-specific	Between different species.
interstitial	Occurring in small spaces or cracks.
intra-specific	Within the same species.
introgressed	To combine; to become a part of
iodophor	A substance consisting of iodine and a solubilizing agent that releases free iodine when in solution. Used as a cleaner/sanitizer.
iteroparous	Has more than one reproductive cycle in its lifetime (e.g., sturgeon).
jacks	Small reproductively mature male salmon that return to spawn after spending only one winter in the marine environment.
kg	kilogram; 1 kilogram = 2.2046 pounds
km	kilometer; 1 kilometer = 3,280 feet
lateritic	A suborder of soils found in warm, temperate, and tropical regions.
lentic	“Standing” water such as a lake or pond.
lithology	Description of rock composition and texture.
lotic	“Moving” water such as a stream.
macrothalmia	Pacific lamprey juveniles (ammocoetes) in the process of metamorphosis to their marine tolerant physiology. The equivalent of a salmon smolt.
mass failure, mass wasting	General term for a variety of processes by which large masses of rock or earth material are moved downslope by gravity, either slowly or quickly.
metrics	Measurements
mm	millimeter; 1 millimeter = .03937 inches
morphometry	The measurement of shape.
mtDNA	Mitochondrial DNA
neritic	Describing the environment and conditions of the marine zone between low tide and the edge of the continental shelf, a depth of roughly 200 m.
NTU	Nephelometric Turbidity Unit. A unit describing light penetration in water.
orographic	Related to or caused by physical geography.
osmoregulation	The process of controlling the amount of water in tissues and cells.
OSY	Optimum sustained yield.
Pacific Decadal Oscillation (PDO)	
PCBs	Poly-chlorinated bi-phenyls. Popular electrical insulator that was determined in the late 1970’s to be a probable agent causing cancer and neurological and liver damage.
pelagic	In ornithology, sea-birds that come to land only to breed; in marine ecology, organisms (e.g. plankton) that inhabit open water.
piscivorous	Fish-eating.
poikilotherms	Cold-blooded
pools	A geomorphic stream channel unit characterized by little to no surface turbulence or slope, low flow rate, and residual depth.
Population change criteria	

Population persistence criteria	
potadromy	All feeding and reproductive migrations within a freshwater river system.
predaceous	Predatory
reach	A length of stream defined by some functional characteristic. May be defined simply by length, distance between tributaries, or changes in land forms, land use, etc.
recovery strategy criteria	
redd	Nest made in gravel dug by a fish for egg deposition (and then filled) and associated gravel mounds.
scute	Large bony scale such as that found on sturgeon.
second-feet	Unit measuring discharge, usually in association with reservoirs.
semelparous	Has only one reproductive cycle in its lifetime (e.g. salmon).
seral-stage	Stage in the development of an ecosystem from an undisturbed, un-vegetated state towards a climax state. Stages are often classified as early, middle, or late.
sexually dimorphic	Species has two forms, one for each sex.
smolt	A young salmon or steelhead before it has swum to the sea, typically in its second year
smoltification	Process of physiologically changing from fry or parr to smolt.
SRS	Sediment Retention Structure. Earthen dam on the N. Fk. Toutle designed to protect the lower Toutle and Cowlitz from inundation from Mt. St. Helens sediment after the eruption.
Strata criteria	
stream power	A product of the stream's discharge and slope.
substrates	Layers of sediment particles comprising the bottom of a body of water. The bed of a body of water.
subyearling	Fish that are less than 1 year old
swim bladders	A bladder of gas possessed by certain fishes that allows them to maintain a particular depth in the water column.
sympatric	Individuals, species, populations, etc. that share a common habitat.
TMDL	Total Maximum Daily Load.
toe-width methodology	Measures the width of a stream from the toe of the bank on one side of the stream to the toe of the bank on the other side.
trash racks	Screens at flow diversions or fish diversions that filter debris from the water at the diversion intake.
Trichodina	A protozoan parasite affecting the gills of fish. Only pose a serious threat to fish health under high infestations.
trophic	Having to do with the processes of nutrition.
TSS	Total suspended solid (TSS).
tule	
turbidity	A measure of light penetration in a body of water. Higher turbidity indicates "murkier" water conditions.
unexploited	Not fished. Absence of harvest.
volitional	Acting of free will. Voalitional releases from hatcheries allow the juveniles to move downstream from the facility on their own accord.
Water Resources Inventory Area (WRIA)	
yearling	Fish that are 1–2 years old
YOY	Young of the year.