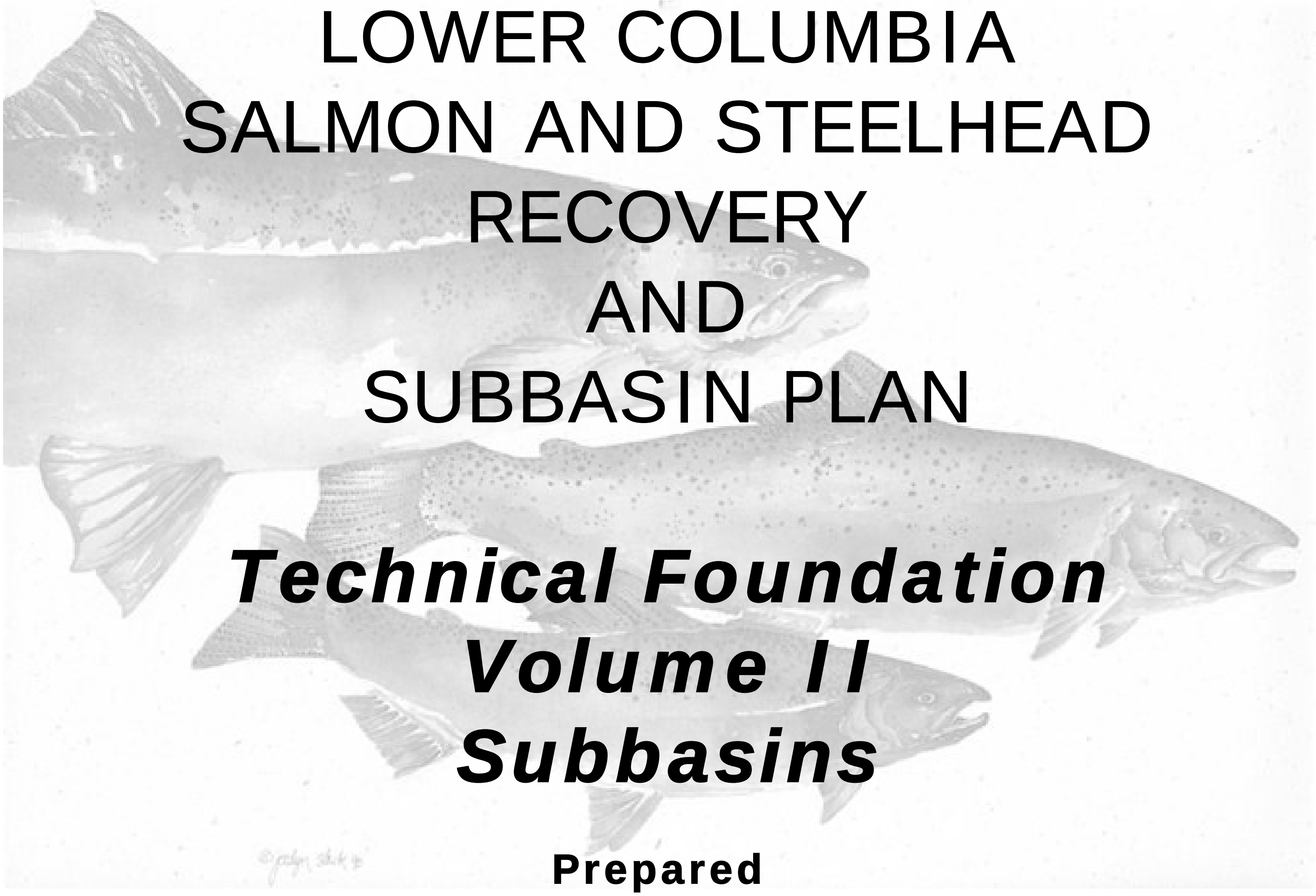

LOWER COLUMBIA
SALMON AND STEELHEAD
RECOVERY
AND
SUBBASIN PLAN

Technical Foundation
Volume II
Subbasins

Prepared
For
Northwest Power
And
Conservation Council

MAY 28, 2004
DRAFT

Prepared By:
Lower Columbia Fish Recovery Board

Preface

This is number two of six volumes of a 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 an 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. A separate Executive Summary document provides an overview of the entire Technical Foundation.

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 II, Chapter 1
Introduction

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1.0 Introduction to Subbasin Chapters

1.1 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. This information contributes to our understanding of limiting factors and threats affecting focal species. The information presented in these chapters is summarized in the Management Plan in the form of working hypotheses from which subbasin actions are then identified. 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. Detailed descriptions of each of these sections, their interrelationships among each other, and their relationship to recovery planning objectives are provided below.

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. The lower Columbia River mainstem and estuary subbasin description presents the following information: a subbasin description/overview, focal fish and wildlife species descriptions, mainstem and estuary habitat forming processes, mechanisms of habitat change, comparisons of historical and current habitat conditions, interaction between focal species and subbasin habitats, ecological relationships with native and nonnative species, recognition of current knowledge gaps, and a series of hypothesis statements that attempt to describe our current understanding of the lower mainstem and estuary ecosystem.

1.1.1 Subbasin Description

The subbasin description presents an overview of subbasin geography, including topography, geology, climate, land cover, and land use characteristics. Information on topography and geology was obtained from a variety of existing reports, including WDFW reports, USFS reports, WDOE Watershed Planning documents, and Washington Conservation Commission Limiting Factors Analyses (LFAs). Climate information was obtained from existing reports as well as from the Western Regional Climate Center database (http://www.wrcc.dri.edu/). Information on land ownership that is displayed in the pie chart and in the land ownership map was originally compiled by the Department of Natural Resources (WDNR). Land cover presented in the land cover pie chart was originally derived from Landsat imagery following the methods described in Lunetta et al. (1997). This information was summarized by 7th field watershed (referred to as subwatersheds in our discussions) and then aggregated up to the subbasin scale for presentation purposes. The 6 land cover categories are defined in Table 0-1. Land use maps were compiled using data from the National Land Cover Dataset (NLCD) (Vogelmann et al. 2001).

Table 0-1. Definition of land cover categories presented in Subbasin Description sections.

Land Cover Category	Description
Late Seral	Coniferous crown cover greater than 70%. Greater than 10% crown cover in trees greater then or equal to 21 inches diameter breast height (dbh).
Mid-Seral	Conferous crown cover greater than 70%. Less than 10% crown cover in trees greater then or equal to 21 inches diameter breast height (dbh).
Early Seral	Conferous crown cover greater than or equal to 10% and less than 70%. Less than 75% of total crown cover in hardwood tree/shrub cover.
Other Forest	Less than 10% coniferous crown cover (can contain hardwood tree/shrub cover; cleared forest land, etc.)
Non-Forest	Urban, agriculture, rangeland, barren, glaciers
Water	Lakes, large rivers, and other water bodies

Adapted from Lunetta et al. 1997.

1.1.2 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. Edits were performed on fish distributions where better or more recent information was available. Information contained in the fish fact sheet descriptions was obtained from a variety of published reports by the WDFW and other various sources.

1.1.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries.

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% or 50%. Rather, we needed to know whether a factor represented a 5% or 50% or 90% impact.

Only the subset of factors we can potentially manage were included in the analyses – natural mortality factors beyond our control (e.g. naturally occurring ocean mortality) are excluded. For instance, tributary habitat changes, estuary habitat changes, fishing, hydro and hatchery effects are all obviously human impacts. Natural mortality in freshwater, the estuary, and the ocean that occurs independent of human effects was factored out. Although it can only minimally be managed by humans, predation by fish, birds, and marine mammals was included in the analysis because of the widespread public interest in the magnitude of the predation effect relative to human factors.

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.

1.1.4 Hatchery Discussion

A brief summary of species-specific hatchery programs is presented for each subbasin; the primary source of information was 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. The genetic section identifies what is known about the broodstock source of each hatchery program as well as the occurrence of egg, fry, or smolt transfers to or from other hatcheries. The interactions section discusses possible interaction scenarios between hatchery-hatchery juveniles, hatchery-wild juveniles, and hatchery-wild spawners. The water quality/disease section identifies the water source for the hatchery, operational controls used to maintain water quality, and the disease monitoring procedures utilized by the hatchery to minimize disease transmission within and outside of the hatchery. The mixed harvest section describes the specific fisheries that hatchery programs contribute to and indicates how hatchery fish are targeted in the presence of wild fish. The passage section describes the collection systems at each hatchery and discusses passage challenges for returning broodstock. The supplementation section identifies how each hatchery program aligns with species-specific supplementation programs within the subbasin.

1.1.5 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). Information has been obtained from a variety of sources, including Limiting Factor Analyses (LFAs) conducted by the Washington State Conservation Commission, US Forest Service watershed analyses, Washington Deptarment of Ecology Watershed Planning documents, as well as from the assessments described in the following 2 sections.

1.1.6 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. A more thorough description of the functions of the EDT model, its application to recovery planning, and sources for additional information are presented in Vol. VI.

1.1.6.1 Population Analysis

Estimation of fish population levels under a given set of habitat conditions is one of several EDT applications. EDT provides an effective alternative for estimating fish population levels where census data is incomplete. This is particularly useful in recreating a historical baseline. EDT results have been corroborated with specific fish census data where available. Even where census data is unavailable for a species or subbasin, EDT provides a robust means of relating changes in fish population levels to changes in habitat conditions.

EDT describes fish population levels in terms of productivity, abundance, and diversity. Productivity is a population's capacity to replace itself (represented in EDT as the inherent number of adults produced in the next generation per spawner). Abundance is the realized habitat capacity (represented in EDT as the equilibrium number of adult spawners produced when the available habitat is fully seeded). Diversity in EDT is an index based on the percentage of theoretically possible life history pathways that are viable under the specified habitat conditions. Because EDT is fish life cycle-based, it also provides estimates of smolt productivity and abundance that are useful for describing effects of subbasin spawning and rearing habitats independent of out-of-basin fishery, mainstem, estuary, and ocean concerns. Smolt abundance reflects the equilibrium (realized) number of smolts produced and smolt productivity reflects the number of smolts produced per spawner.

EDT estimates were generated for historic (template), current (patient), and "Properly Functioning" (PFC) habitat conditions. 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 in NMFS (1996). PFC conditions are less optimum than the pristine historical template but are assumed to ensure population persistence (i.e. avoid extinction).

1.1.6.2 Restoration and Preservation Analysis

This section presents the results of the EDT restoration and preservation analysis. Restoration and preservation analysis is based on the same fish abundance, productivity, and diversity information derived for population analysis from historical/template and current/patient habitat conditions. 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.

Results are typically displayed in a graphical format that is often referred to as a ladder or tornado diagram. For each reach, there is a preservation value and a restoration value for each of the three population performance parameters – productivity, abundance, and life history diversity. The values presented are normalized by reach length and represent the change in population performance per 1000 meters stream length. Values were normalized to avoid potential bias due to reach length. 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. 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. Many reaches have both high preservation and high restoration value. These tend to be highly productive reaches, where relatively modest changes in habitat quality can have a significant effect on population performance. In these reaches, management strategies should work to both preserve existing functional attributes and restore degraded attributes.

Reaches have been ranked and categorized into High (H), Medium (M), and Low (L) groupings based on their potential to contribute to population viability. Reach rankings were determined by summing the potential change values for preservation and restoration across the 3 performance measures (i.e. summing the values for all bars of the ladder diagram for each reach). Reach rankings therefore reflect the contribution of the reach to current AND potential population performance.

Reaches were also given a recovery emphasis designation. A designation of P indicates that preservation measures should be emphasized within the reach. A designation of R indicates that restoration measures should be emphasized. A designation of PR means that both preservation and restoration are equally important.

1.1.6.3 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 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.

The standard EDT habitat factor output, which is NOT presented in this volume, presents the effect of habitat attributes on life stage survival for each life stage and each reach. These results are displayed in what are commonly termed “consumer report diagrams”. While this level of detail is useful for practitioners who are implementing specific recovery measures in specific reaches, it is too detailed for an effective comparison of habitat impairments across reaches in a basin. In order to expand the analysis to the population-scale, we combined all life stages within a reach and weighted the reach values according to the relative contribution of the reach to overall population abundance. The result is a chart with sized dots representing the relative degree to which habitat factors within a reach are serving to suppress population abundance. This chart can be used to determine the degree of population-scale impact of a particular habitat factor in a particular reach. Habitat factor impacts can be compared within and among reaches.

1.1.7 Integrated Watershed Assessment

The Integrated Watershed Assessment (IWA) is a GIS-based screening tool used to examine the current condition of key watershed processes 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.

While multiple watershed processes are important determinants of watershed health and instream habitat quality, the delivery and routing of sediment, water, and woody debris into and through the stream channel are viewed to be fundamental. The condition of these watershed processes can be measured by modeling sediment supply, hydrology, and riparian condition within the watershed. These three measures form the core of the IWA for the following reasons:

- They are fundamental drivers of watershed health
- Their condition can be inferred from available GIS data
- Additional natural and human-derived factors affecting these processes, readily derived from available GIS data sets, can be rated against known thresholds

The IWA is conducted at the subwatershed level, with process conditions identified as Functional (F), Moderately Impaired (M), or Impaired (I). Subwatersheds are 3,000-12,000 acre drainage areas defined as management units by the LCFRB for recovery planning purposes. A rating of F indicates that the current condition of that subwatershed process is comparable to natural conditions and is most likely providing beneficial conditions for fish habitat. A rating of M indicates that current conditions may be a source of limiting factors for fish habitat. A rating of I indicates highly degraded conditions that are most likely to be a source of limiting factors. Hydrology, sediment and riparian conditions are analyzed at the local level (i.e., within the subwatershed, not including upstream drainage area), and at the watershed level (i.e., integrating the entire drainage area upstream of each subwatershed). This information, in combination with predicted future trends of land use conditions in the watershed, can be used to prioritize actions in the context of recovery planning.

1.1.8 References

Lunetta, R. S., B. L. Cosentino, D. R. Montgomery, E. M. Beamer, and T. J. Beechie. 1997. GIS-based evaluation of salmon habitat in the Pacific Northwest. Photogrammetric Engineering & Remote Sensing. Vol. 63, No. 10. pp. 1219-1229.

National Marine Fisheries Service (NMFS). 1996. Making endangered species act determinations of effect for individual or grouped actions at the watershed scale. Prepared by the National Marine Fisheries Service (now NOAA Fisheries) Environmental and Technical Services Division – Habitat Conservation Branch.

Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, N. Van Driel, 2001. Completion of the 1990s National Land Cover Data Set for the Conterminous United States from Landsat Thematic Mapper Data and Ancillary Data Sources, Photogrammetric Engineering and Remote Sensing, 67:650-652.

Volume II, Chapter 2
Columbia River Estuary and Lower Mainstem Subbasins

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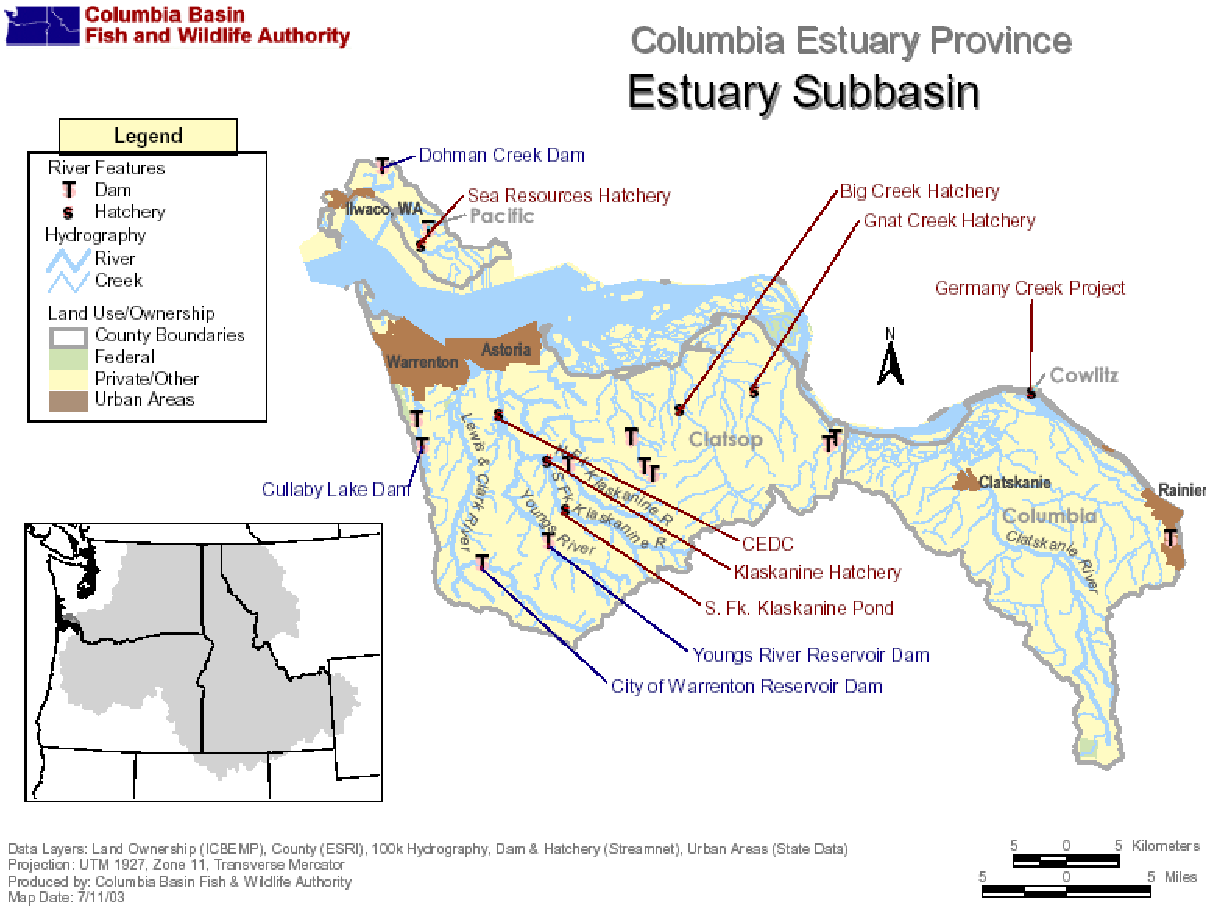
2.0 Columbia River Estuary and Lower Mainstem

This chapter describes physical processes, habitat, fish and wildlife species, and ecological relationships within the lower Columbia River mainstem (i.e. below Bonneville Dam) and estuary. A balanced and complete ecosystem-based approach was desired for this assessment, however, was not possible based on currently available data. Certain topics are discussed in far greater detail than others because of this difference in data availability. For example, the estuary is discussed in detail throughout the chapter, while specific discussions regarding the lower mainstem are not presented, simply because the data do not exist. In the same regard, considerable research has focused on salmonid species in the Columbia River while much less is known about the other species presented here.

Another necessary point of clarification is the use of the word *estuary*, which was not standardized across all previous research efforts. For our purposes, the Columbia River estuary was defined as the tidally influence portion of the Columbia River from the mouth to Bonneville Dam (rm 146) as well as the Columbia River plume. However, many other studies have defined the estuary differently. For example, some define the estuary upper boundary as the extent of salt water intrusion (typically Harrington Point at rm 23) while others define the upper boundary as the extent of river flow reversal (up to Oak Point at rm 53). Also, recent research suggests that the Columbia River plume environment should also be considered as part of the estuary. Thus, when presenting the work of others, *estuary* refers to the estuary boundaries described by the research and the reader is encouraged to review the original publication to alleviate any confusion as to which part of the estuary is being discussed. Where possible, clarification was provided to indicate if the information being presented applied to the tidal freshwater portion of the lower mainstem (i.e. rm 46-146), the lower portion of the river (rm 0-46), or the Columbia River plume.

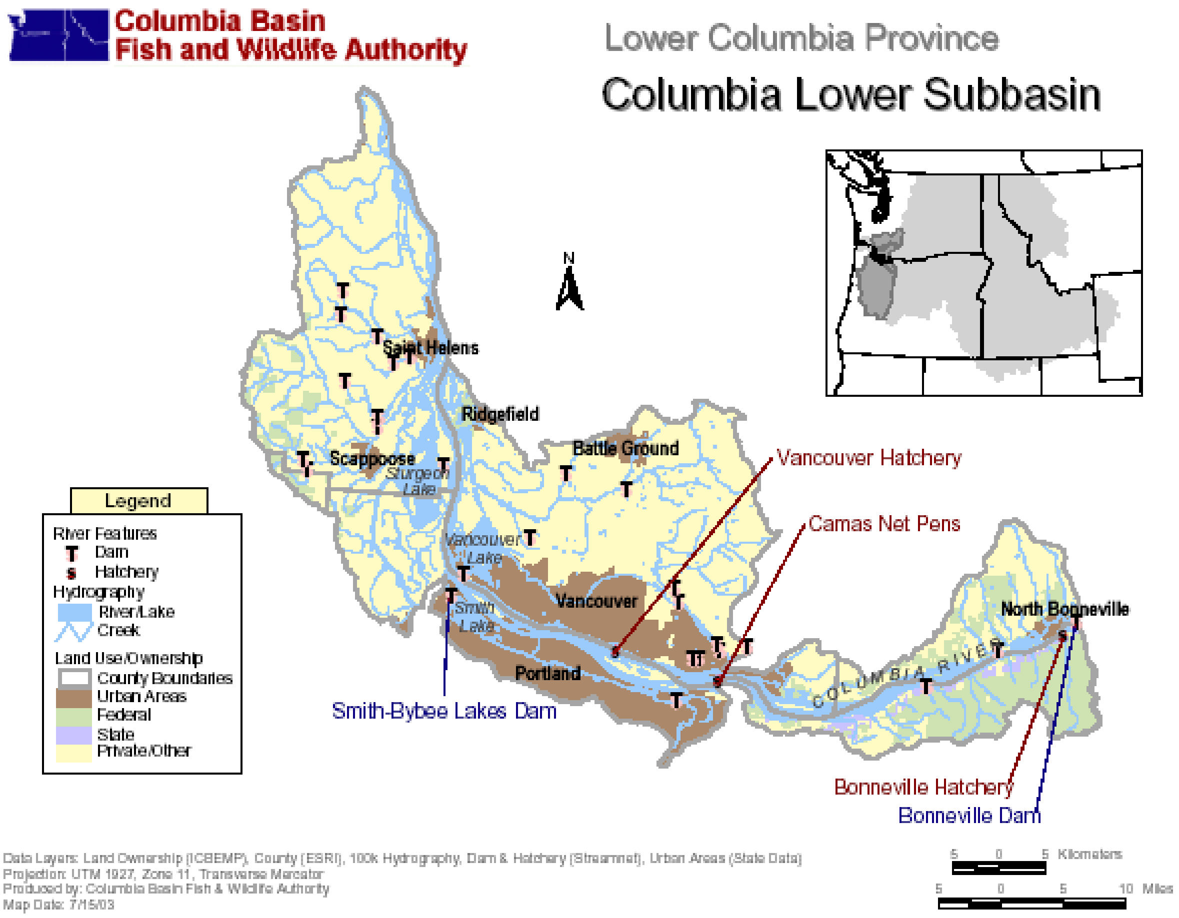
The geographic area covered in this subbasin assessment and qualitative analysis includes the Columbia River estuary and the lower Columbia River up to Bonneville Dam (Figure 2-1, Figure 2-2, and Figure 2-3); the major tributaries are not included in this analysis as they have been designated as subbasins by the Northwest Power and Conservation Council (NPCC) and are addressed separately in this Technical Foundation. The description and analysis, however, focuses on the Columbia River estuary by default; far more research to date has focused on the estuary and not the tidal freshwater portion of the lower mainstem. Where possible, data specific to the lower Columbia River mainstem were included; elsewhere, assumptions where made as to whether the habitat conditions, habitat-forming processes, and species-habitat interactions in the estuary were also applicable to the lower Columbia River mainstem.

Figure 2-1. Large-scale map of the lower Columbia River mainstem and estuary, depicting major tributaries and population centers (R2 2003).



Data Layers: Land Ownership (ICBEMP), County (ESRI), 100k Hydrography, Dam & Hatchery (Streamnet), Urban Areas (State Data)
Projection: UTM 1927, Zone 11, Transverse Mercator
Produced by: Columbia Basin Fish & Wildlife Authority
Map Date: 7/11/03

Figure 2-2. Boundaries of the Columbia Estuary Subbasin as defined by the Northwest Power and Conservation Council.



Data Layers: Land Ownership (ICBEMP), County (ESRI), 100k Hydrography, Dam & Hatchery (Streamnet), Urban Areas (State Data)
Projection: UTM 1927, Zone 11, Transverse Mercator
Produced by: Columbia Basin Fish & Wildlife Authority
Map Date: 7/15/03

Figure 2-3. Boundaries of the Lower Columbia Subbasin as defined by the Northwest Power and Conservation Council.

This chapter is organized into the following sections: 2.1 Subbasin Description, 2.2 Focal Species, 2.3 Habitat, 2.4 Species/Habitat Interactions, 2.5 Ecological Relationships, 2.6 Knowledge Gaps, 2.7 Hypothesis Statements. Section 2.1 Subbasin Description provides the context for the subbasin assessment as well as an overview of the physical setting, fish and wildlife resources, and habitats in the lower Columbia River mainstem and estuary subbasin. Section 2.2 Focal Species describes the selection process for identifying focal species and provides a brief description of each species status and abundance trends as well as life history as it relates to the potential use of lower mainstem and estuary habitats. Section 2.3 Habitat discusses the physical processes that create habitats in the lower mainstem and estuary, identifies the natural and anthropogenic factors that have affected habitat change in the lower mainstem and estuary, and compares the historical and modern day acreage of specific habitat types. Section 2.4 Species/Habitat Interactions presents the association of focal species with lower mainstem and estuary habitats. Further, this section discusses potential relationships between lower mainstem and estuary habitat change and focal species, particularly salmonids. Section 2.5 Ecological Relationships briefly discusses potential ecological interactions among native and exotic species in the Columbia River estuary and lower mainstem . Section 2.6 Knowledge Gaps identifies and prioritizes critical areas where we lack adequate understanding of linkages between lower mainstem and estuary habitats and focal species; the section also acknowledges the on-going development of tools designed to describe physical and biological processes in the estuary. Finally, Section 2.7 Hypothesis Statements presents a series of hypotheses that are intended to summarize our current knowledge of estuary processes, habitat condition, and focal species; collectively, the hypotheses constitute the working hypothesis of the subbasin assessment as defined by the Northwest Power Planning Council (2001).

2.1 Subbasin Description

The subbasin description is divided into the following sections: 2.1.1 Purpose, 2.1.2 History, 2.1.3 Physical Setting, 2.1.4 Fish and Wildlife Resources, 2.1.5 Habitat Classification, 2.1.6 Estuary and Lower Mainstem Zones, 2.1.7 Major Land Uses, and 2.1.8 Areas of Biological Significance. Section 2.1.1 Purpose describes the purpose of this subbasin assessment in the context of the Northwest Power and Conservation Council (NPCC; formerly Northwest Power Planning Council) subbasin planning process and how the chapter integrates with the Washington Lower Columbia River Fish Recovery Plan Technical Foundation. Section 2.1.2 History provides a brief description of the rich history of the subbasins. Section 2.1.3 Physical Setting describes the general physical of the subbasins. Section 2.1.4 Fish and Wildlife Resources provides a species list of the fish and wildlife species known to occur in the subbasins. Section 2.1.5 Habitat Classification describes estuary and mainstem habitat types, the abundance of habitat classification systems available to describe habitat, the habitat classification systems utilized in this analysis, and the potential relationship among each habitat classification system. Section 2.1.6 Estuary and Lower Mainstem Zones describes geographic estuary and mainstem areas utilized to facilitate subsequent discussions of habitat change. Section 2.1.7 Major Land Uses identifies the variety of human activities that occur within the subbasins. Section 2.1.8 Areas of Biological Significance identifies areas that provide critical natural habitats and help maintain the delicate balance of the ecosystem.

2.1.1 Purpose

In the context of the NPCC subbasin planning process, this chapter is intended to serve as the Subbasin Assessment portion of the Columbia River Estuary and Lower Mainstem Subbasin Plan. As such, this subbasin assessment will provide an overview of the subbasins (Section 2.1), describe focal species (Section 2.2), environmental conditions (Section 2.3), and ecological relationships (Sections 2.4 and 2.5), identify limiting factors (Sections 2.3, 2.4, and 2.6), and provide a synthesis of the information (Section 2.7). This subbasin assessment will not include a complete inventory of existing activities in the lower Columbia River mainstem and estuary nor will it present a Management Plan for the subbasins; these are both future activities in the subbasin planning process. Thus, components of a Management Plan, such as biological objectives or a research, monitoring, and evaluation plan, will not be developed here. From the perspective of subbasin planning, the most important outcome of the subbasin assessment is the development of the working hypothesis (Section 2.7); all of the other information presented in the assessment provides a means to that end. The working hypothesis provides a metric of our current understanding of the subbasins and serves as the link between the subbasin assessment and the future management plan.

This chapter describes two of the eleven subbasins considered in the Washington Lower Columbia River Fish Recovery Plan Technical Foundation. To avoid repetition, references are used throughout this chapter if the topic has been discussed in more detail in the Technical Foundation. Primary reference to the Technical Foundation occurs in the abundance trends and life history description of focal species. Additionally, the Technical Foundation includes a detailed discussion of the salmonid limiting factors common across the subbasins.

2.1.2 History

By the early 1800s, approximately 50,000 Native Americans (primarily the Chinooks) inhabited villages scattered along the banks of the Columbia River (Cone and Ridlington 1996, Thompson 2001). Paleological records indicate that people in the region harvested Pacific salmon as early as 9,000 years ago (Lichatowich 1999). The Chinook peoples were skilled traders and the Columbia River served as a major trade route; tribes came from inland valleys and as far away as the Great Plains to trade for salmon and other valuable resources (Thompson 2001). Estimates indicate that the Chinookan peoples harvested almost 41 million pounds of salmon annually, much of which was traded to interior tribes (Cone and Ridlington 1996).

As early as 1543, European explorers ventured along the Oregon coast, but failed to find the mouth of the Columbia River. Finally, in 1792, Captain Robert Gray of the United States sailed across the bar at the mouth of the river and explored the vicinity of Astoria. Later, William Robert Broughton, a Spanish lieutenant, mapped and named many features of the lower Columbia River as far upriver as the Portland area (Miller 1958).

In 1803, Meriwether Lewis and William Clark began an expedition in St. Louis with the intent of finding a trade route across the continent to the Orient. By 1805, the expedition reached the lower Columbia River, making contact with the native people. After this expedition, European settlement in the region advanced rapidly; the Hudson Bay Company played a substantial role in establishing trade with the native people. In 1840, ‘Oregon Fever’ brought many settlers from the Mid-West; timber and fisheries became the driving forces behind European settlement of the region.

Earliest accounts of European exploitation of salmon date around 1830, when salmon were dried and salted for storage and distribution. The salmon industry began to realize its full potential when the first cannery began operating in Eagle Cliff, WA, in 1867; many other canneries began operating over the next decade and by 1883, there were 55 canneries on or near the Columbia River. Initially, chinook salmon were the primary catch, but fisheries began harvesting other salmon by the late 1800s; catch of all species peaked at 47 million pounds in 1911 (Cone and Ridlington 1996).

Introductions of exotic fish species had substantial impacts on early fisheries. For example, American shad were introduced to San Francisco in 1871; by 1903, Columbia River fisherman reported that shad had become so numerous they were a nuisance. Other species (i.e. warm-water fish such as bluegill, crappie, and bass) were becoming increasingly abundant in the lower reaches of many Columbia River tributaries and slough habitats of the lower mainstem Columbia River; these sloughs are ideal habitats for these warm water species (Fies 1971).

Concomitant to the growth of the fishing industry, the timber industry was experiencing a boom. Timber industry practices included the removal of stream debris, temporary construction of splash dams to store timber, and log drives that flushed timber through the system as freshet flows blasted the splash dams (Farnell 1980). Although efficient and inexpensive, such practices destroyed instream and riparian habitat. Log drive practices were eliminated by 1914, but other logging practices (such as the lack of riparian buffers) continued to negatively affect fish and wildlife habitat, including that of salmonids.

Early settlers maintained farms for subsistence; initially, commercial farming was not a major industry. By the late 1800s, a substantial amount of acreage in the subbasin had been cleared of trees, burned, and converted to agricultural land; much of this land conversion was occurring in the lower Columbia River floodplain and the interior valleys. Many of these floodplain areas remain in agricultural use today.

Since the late 1800s, the US Army Corps of Engineers has been responsible for maintaining navigation safety on the Columbia River. In 1878, Congress directed the Corps to maintain a 20-foot minimum channel depth, authorizing the Columbia River navigation channel project. To maintain this channel depth, periodic dredging was required in a few shallow reaches where controlling depths ranged from 12-15 feet (USACE 1999). At the mouth of the Columbia River, construction of the south jetty began in 1885; an extension to the original south jetty began in 1903 and was completed in 1914 (Sherwood et al. 1990). Meanwhile, construction of the north jetty began in 1913 and was completed in 1917 (Sherwood et al. 1990). Additionally, use of pile dikes to assist in channel depth maintenance began in the lower Columbia River in 1885 at St. Helens Bar; other early dikes included Martin Island Bar and Walker Island Bar in 1892-93. Over time, Congress continually authorized increases to the minimum navigation channel depth and width: 1899 – depth authorized to 25 ft; 1912 – depth authorized to 30 ft, width established at 300 ft; 1930 – depth authorized to 35 ft, width authorized to 500 ft, channel course was realigned in some reaches; 1936-1957 – periodic channel alignment adjustments; 1962 – depth authorized to 40 ft; 1999 – depth authorized to 43 ft. Most of the current pile dike system was during the periods 1917-1923 and 1933-1939; the existing system consists of 256 dikes totaling 240,000 linear feet (USACE 2001).

In the early 1930s, the Columbia River was slated for development of the next major federal hydropower project; Bonneville Dam began operation in the late 1930s, affecting salmonid access to spawning habitat above Bonneville Dam. With extensive hydroelectric development, the lower Columbia River was quickly viewed as a production zone for salmon. Mitigation for the loss of habitat caused by dams came in the Mitchell Act of 1948, which created a system of hatcheries on the Columbia River. Although the some of the first hatcheries where generally unsuccessful, hatcheries were viewed as the solution to overfishing, habitat loss, and hydroelectric development.

2.1.3 Physical Setting

The Columbia River estuary has formed over geologic time by the forces of glaciation, volcanism, hydrology, and erosion and accretion of sediments. Circulation of sediments and nutrients throughout the estuary are driven by river hydrology and coastal oceanography. Sea levels have risen since the late Pleistocene period, which has submerged river channels and caused deposition of coarse and fine sands (Marriott et al. 2001).

The Columbia River estuary and lower mainstem span over 2 ecological provinces as defined by the NPCC: Columbia River Estuary (river mouth, including nearshore waters and Columbia River plume, to rm 34) and the Lower Columbia River (rm 34 to Bonneville Dam). The historical (circa 1880) total surface area of the Columbia River estuary has been estimated from 160-186 square miles (Thomas 1983, Simenstad et al. 1984), with extensive sand beds and variable river flow. The current estuary surface area has been estimated as 101,750 acres, which is equivalent to 159 square miles (Marriott et al. 2002). The Willamette River is the largest tributary to the lower Columbia River. Major tributaries originating in the Cascades include the Sandy River in Oregon and the Washougal, Lewis, Kalama and Cowlitz Rivers in Washington. Major Coast Range tributaries include the Elochoman and Grays Rivers in Washington and the Lewis and Clark, Youngs and Clatskanie Rivers in Oregon. Numerous other minor tributaries drain small watersheds but do not have substantial influence on the Columbia River because of their small size (Marriott et al. 2002).

In the Columbia River, tidal impacts in water level have been observed as far upstream as Bonneville Dam (RM 146) during low flow, reversal of river flow has been measured as far upstream as Oak Point (RM 53), and intrusion of salt water is typically to Harrington Point (RM 23) at the minimum regulated monthly flow, although at lower daily flows saltwater intrusion can extend past Pillar Rock (RM 28) (Neal 1972). The lowest river flows generally occur during

September and October, when rainfall and snowmelt runoff are low. The highest flows occur from April to June, resulting from snowmelt runoff. High flows also occur between November and March, caused by heavy winter precipitation. The discharge at the mouth of the river ranges from 100,000 to 500,000 cfs, with an average of about 260,000 cfs. Historically, unregulated flows at the mouth ranged from 79,000 cfs to over 1 million cfs, with average flows about 273,000 cfs (Neal 1972, Marriott et al. 2002).

The estuarine shoreline in both Washington and Oregon consist primarily of rocky, forested cliffs or low elevation, gently sloping floodplain areas. The topography of the riverine portion of the two ecological provinces does not vary considerably (Marriott et al. 2001).

The climate conditions vary across the subbasins; in general, coastal areas receive more precipitation and experience cooler summer temperatures and warmer winter temperatures than inland areas. In the lower part of the subbasin, climate data has been collected in Astoria, Oregon, since 1953 (WRCC 2003). Total average annual precipitation is 68 inches, ranging from 1.04 inches in July to 10.79 inches in December. January is the coldest month in Astoria with an average maximum temperature of 48.2°F and an average minimum temperature of 36.5°F; August is the warmest month with an average maximum temperature of 68.7°F and an average minimum temperature of 52.8°F. In the middle part of the subbasin, climate conditions have been recorded at St. Helens, Oregon, since 1976 (WRCC 2003). Total average annual precipitation is 44 inches, ranging from 0.79 inches in July to 6.77 inches in December. January is the coldest month in St. Helens with an average maximum temperature of 46.9°F and an average minimum temperature of 33.5°F; August is the warmest month with an average maximum temperature of 82.7°F and an average minimum temperature of 55.6°F. In the upper part of the subbasin, climate conditions have been recorded at Bonneville Dam since 1948 (WRCC 2003). Total average annual precipitation is 77 inches, ranging from 0.90 inches in July to 12.91 inches in December. January is the coldest month at Bonneville with an average maximum temperature of 42.4°F and an average minimum temperature of 32.7°F; August is the warmest month with an average maximum temperature of 78.7°F and an average minimum temperature of 56.4°F.

2.1.4 Fish and Wildlife Resources

An abundance of fish and wildlife species are known to occur in the Columbia Estuary and Columbia Lower Subbasins, either as year-round residents, seasonal residents, or migratory visitors. Early species survey work in the estuary was performed for aquatic species (Gaumer et al. 1973, Bottom et al. 1984, Dawley et al. 1985), birds (Hazel 1984), mammals (Howerton et al. 1984), and marine mammals (Jeffries et al. 1984). More recently, Marriott et al. (2002) provided an excellent summary of the aquatic species, birds, mammals, reptiles, and amphibians found in the Columbia River estuary and lower mainstem. A species list adapted from Marriott et al. (2002) and IBIS (2003) has been included here to demonstrate the variety of species present in the subbasins (Table 2-1).

Table 2-1. List of fish and wildlife species known to occur in the Columbia Estuary and Columbia Lower Subbasins.

Species Group	Common Name	Scientific Name
FISH	Pacific lamprey	*Lampetra tridentata*
	River lamprey	*Lampetra ayresi*
	Spiny dogfish	*Squalus acanthias*
	Big skate	*Raja binoculata*
	Green sturgeon	*Acipenser medirostris*
	White sturgeon	*Acipenser transmontanus*
	American shad	*Alosa sapidissima*
	Pacific herring	*Clupea harengus pallasi*
	Northern anchovy	*Engraulis mordax*
	Chum salmon	*Oncorhynchus keta*
	Coho salmon	*Oncorhynchus kisutch*
	Sockeye salmon	*Oncorhynchus nerka*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Steelhead	*Oncorhynchus mykiss*
	Cutthroat trout	*Oncorhynchus clarki clarki*
	Mountain whitefish	*Prosopium williamsoni*
	Whitebait smelt	*Allosmerus elongates*
	Surf smelt	*Hypomesus pretiosus*
	Night smelt	*Spirinchus starksi*
	Longfin smelt	*Spirinchus thaleichthys*
	Eulachon	*Thaleichthys pacificus*
	Common carp	*Cyprinus carpio*
	Peamouth	*Mylocheilus caurinus*
	Northern pikeminnow	*Ptychocheilus oregonensis*
	Largescale sucker	*Catostomus macrocheilus*
	Yellow bullhead	*Ictalurus natalis*
	Brown bullhead	*Ictalurus nebulosus*
	Channel catfish	*Ictalurus punctatus*
	Pacific hake	*Merluccius productus*
	Pacific tomcod	*Microgadus proximus*
	Walleye Pollock	*Theragra chalcogramma*
	Threespine stickleback	*Gasterosteus aculeatus*
	Bay pipefish	*Syngnathus leptorhynchus*
	Pumpkinseed	*Lepomis gibbosus*
	Warmouth	*Lepomis gulosus*
	Bluegill	*Lepomis macrochirus*
	Walleye	*Stizostedium vitreum*
	Smallmouth bass	*Micropterus dolomeiui*
	Largemouth bass	*Micropterus salmoides*
	White crappie	*Pomoxis annularis*
	Black crappie	*Pomoxis migromaculatus*
	Yellow perch	*Perca flavenscens*
	Redtail surfperch	*Amphistichus rhodoterus*
	Shiner perch	*Cymatogaster aggregata*

Species Group	Common Name	Scientific Name
	Striped seaperch	*Embiotoca lateralis*
FISH CONT.	Spotfin surfperch	*Hyperprosopon anale*
	Walleye surfperch	*Hyperprosopon argenteum*
	Silver surfperch	*Hyperprosopon ellipticum*
	White seaperch	*Phanerodon furcatus*
	Pile perch	*Rhacochilus vacca*
	Pacific sandfish	*Trichodon trichodon*
	Snake prickleback	*Lumpenus sagitta*
	Saddleback gunnel	*Pholis ornata*
	Pacific sand lance	*Ammodytes hexapterus*
	Bay goby	*Lepidogobius lepidus*
	Black rockfish	*Sebastes melanops*
	Kelp greenling	*Hexogrammus decagrammus*
	Lingcod	*Ophiodon elongatus*
	Padded sculpin	*Artedius fenestralis*
	Coastrange sculpin	*Cottus aleuticus*
	Prickly sculpin	*Cottus asper*
	Buffalo sculpin	*Enophyrs bison*
	Red Irish lord	*Hemilepidotus hemilepidotus*
	Pacific staghorn sculpin	*Leptocottus armatus*
	Cabezon	*Scorpaenichthys marmoratus*
	Warty poacher	*Ocella verrucosa*
	Tubenose poacher	*Pallasina barbata*
	Pricklebreast poacher	*Stellerina xyosterna*
	Slipskin snailfish	*Liparis fucencis*
	Showy snailfish	*Liparis pulchellus*
	Ringtail snailfish	*Liparis rutteri*
	Pacific sanddab	*Citharichthys sordidus*
	Speckled sanddab	*Citharichthys stigmaeus*
	Butter sole	*Isopsetta isolepis*
	English sole	*Parophrys vetulus*
	Starry flounder	*Platichthys stellatus*
	C-O sole	*Pleuronichthys coenosus*
	Sand sole	*Psettichthys melanostictus*
	Larval smelt	
	Larval flatfish	
	Other larval fish	
AMPHIBIANS	Northwestern Salamander	*Ambystoma gracile*
	Long-toed Salamander	*Ambystoma macrodactylum*
	Cope's Giant Salamander	*Dicamptodon copei*
	Pacific Giant Salamander	*Dicamptodon tenebrosus*
	Columbia Torrent Salamander	*Rhyacotriton kezeri*
	Cascade Torrent Salamander	*Rhyacotriton cascadae*
	Rough-skinned Newt	*Taricha granulosa*
	Dunn's Salamander	*Plethodon dunni*
	Larch Mountain Salamander	*Plethodon larselli*
	Van Dyke's Salamander	*Plethodon vandykei*

Species Group	Common Name	Scientific Name
	Western Red-backed Salamander	*Plethodon vehiculum*
AMPHIBIANS CONT.	Ensatina	*Ensatina eschscholtzii*
	Clouded Salamander	*Aneides ferreus*
	Oregon Slender Salamander	*Batrachoseps wrighti*
	Tailed Frog	*Ascaphus truei*
	Western Toad	*Bufo boreas*
	Pacific Chorus (Tree) Frog	*Pseudacris regilla*
	Red-legged Frog	*Rana aurora*
	Cascades Frog	*Rana cascadae*
	Oregon Spotted Frog	*Rana pretiosa*
	Columbia Spotted Frog	*Rana luteiventris*
	Bullfrog	*Rana catesbeiana*
BIRDS	Red-throated Loon	*Gavia stellata*
	Pacific Loon	*Gavia pacifica*
	Common Loon	*Gavia immer*
	Yellow-billed Loon	*Gavia adamsii*
	Pied-billed Grebe	*Podilymbus podiceps*
	Horned Grebe	*Podiceps auritus*
	Red-necked Grebe	*Podiceps grisegena*
	Eared Grebe	*Podiceps nigricollis*
	Western Grebe	*Aechmophorus occidentalis*
	Clark's Grebe	*Aechmophorus clarkii*
	Sooty Shearwater	*Puffinus griseus*
	Short-tailed Shearwater	*Puffinus tenuirostris*
	Fork-tailed Storm-petrel	*Oceanodroma furcata*
	Leach's Storm-petrel	*Oceanodroma leucorhoa*
	Brown Pelican	*Pelecanus occidentalis*
	Brandt's Cormorant	*Phalacrocorax penicillatus*
	Double-crested Cormorant	*Phalacrocorax auritus*
	Pelagic Cormorant	*Phalacrocorax pelagicus*
	American Bittern	*Botaurus lentiginosus*
	Great Blue Heron	*Ardea herodias*
	Great Egret	*Ardea alba*
	Cattle Egret	*Bubulcus ibis*
	Green Heron	*Butorides virescens*
	Black-crowned Night-heron	*Nycticorax nycticorax*
	Turkey Vulture	*Cathartes aura*
	Greater White-fronted Goose	*Anser albifrons*
	Snow Goose	*Chen Ccaerulescens*
	Ross's Goose	*Chen rossii*
	Canada Goose	*Branta canadensis*
	Dusky Canada Goose	*Branta canadensis occidentalis, Baird*
	Brant	*Branta bernicla*
	Trumpeter Swan	*Cygnus buccinator*
	Tundra Swan	*Cygnus columbianus*
	Wood Duck	*Aix sponsa*

Species Group	Common Name	Scientific Name
	Gadwall	*Anas strepera*
BIRDS CONT.	Eurasian Wigeon	*Anas penelope*
	American Wigeon	*Anas americana*
	Mallard	*Anas platyrhynchos*
	Blue-winged Teal	*Anas discors*
	Cinnamon Teal	*Anas cyanoptera*
	Northern Shoveler	*Anas clypeata*
	Northern Pintail	*Anas acuta*
	Green-winged Teal	*Anas crecca*
	Canvasback	*Aythya valisineria*
	Redhead	*Aythya americana*
	Ring-necked Duck	*Aythya collaris*
	Greater Scaup	*Aythya marila*
	Lesser Scaup	*Aythya affinis*
	Harlequin Duck	*Histrionicus histrionicus*
	Surf Scoter	*Melanitta perspicillata*
	White-winged Scoter	*Melanitta fusca*
	Black Scoter	*Melanitta nigra*
	Long-tailed Duck	*Clangula hyemalis*
	Bufflehead	*Bucephala albeola*
	Common Goldeneye	*Bucephala clangula*
	Barrow's Goldeneye	*Bucephala islandica*
	Hooded Merganser	*Lophodytes cucullatus*
	Common Merganser	*Mergus merganser*
	Red-breasted Merganser	*Mergus serrator*
	Ruddy Duck	*Oxyura jamaicensis*
	Osprey	*Pandion haliaetus*
	White-tailed Kite	*Elanus leucurus*
	Bald Eagle	*Haliaeetus leucocephalus*
	Northern Harrier	*Circus cyaneus*
	Sharp-shinned Hawk	*Accipiter striatus*
	Cooper's Hawk	*Accipiter cooperii*
	Northern Goshawk	*Accipiter gentilis*
	Red-tailed Hawk	*Buteo jamaicensis*
	Rough-legged Hawk	*Buteo lagopus*
	Golden Eagle	*Aquila chrysaetos*
	American Kestrel	*Falco sparverius*
	Merlin	*Falco columbarius*
	Gyrfalcon	*Falco rusticolus*
	Peregrine Falcon	*Falco peregrinus*
	Prairie Falcon	*Falco mexicanus*
	Gray Partridge	*Perdix perdix*
	Ring-necked Pheasant	*Phasianus colchicus*
	Ruffed Grouse	*Bonasa umbellus*
	White-tailed Ptarmigan	*Lagopus leucurus*
	Blue Grouse	*Dendragapus obscurus*
	Wild Turkey	*Meleagris gallopavo*
	Mountain Quail	*Oreortyx pictus*

Species Group	Common Name	Scientific Name
	California Quail	*Callipepla californica*
BIRDS CONT.	Northern Bobwhite	*Colinus virginianus*
	Virginia Rail	*Rallus limicola*
	Sora	*Porzana carolina*
	American Coot	*Fulica americana*
	Sandhill Crane	*Grus canadensis*
	Black-bellied Plover	*Pluvialis squatarola*
	American Golden-Plover	*Pluvialis dominica*
	Pacific Golden-Plover	*Pluvialis fulva*
	Snowy Plover	*Charadrius alexandrinus*
	Semipalmated Plover	*Charadrius semipalmatus*
	Killdeer	*Charadrius vociferus*
	Black Oystercatcher	*Haematopus bachmani*
	Greater Yellowlegs	*Tringa melanoleuca*
	Lesser Yellowlegs	*Tringa flavipes*
	Solitary Sandpiper	*Tringa solitaria*
	Spotted Sandpiper	*Actitis macularia*
	Willet	*Catoptrophorus semipalmatus*
	Wandering Tattler	*Heteroscelus incanus*
	Whimbrel	*Numenius phaeopus*
	Long-billed Curlew	*Numenius americanus*
	Marbled Godwit	*Limosa fedoa*
	Ruddy Turnstone	*Arenaria interpres*
	Black Turnstone	*Arenaria melanocephala*
	Surfbird	*Aphriza virgata*
	Red Knot	*Calidris canutus*
	Sanderling	*Calidris alba*
	Semipalmated Sandpiper	*Calidris pusilla*
	Western Sandpiper	*Calidris mauri*
	Least Sandpiper	*Calidris minutilla*
	Baird's Sandpiper	*Calidris bairdii*
	Pectoral Sandpiper	*Calidris melanotos*
	Sharp-tailed Sandpiper	*Calidris acuminata*
	Rock Sandpiper	*Calidris ptilocnemis*
	Dunlin	*Calidris alpina*
	Stilt Sandpiper	*Calidris himantopus*
	Buff-breasted Sandpiper	*Tryngites subruficollis*
	Ruff	*Philomachus pugnax*
	Short-billed Dowitcher	*Limnodromus griseus*
	Long-billed Dowitcher	*Limnodromus scolopaceus*
	Common Snipe	*Gallinago gallinago*
	Wilson's Phalarope	*Phalaropus tricolor*
	Red-necked Phalarope	*Phalaropus lobatus*
	Red Phalarope	*Phalaropus fulicaria*
	South Polar Skua	*Catharacta maccormicki*
	Pomarine Jaeger	*Stercorarius pomarinus*
	Parasitic Jaeger	*Stercorarius parasiticus*
	Bonaparte's Gull	*Larus philadelphia*

Species Group	Common Name	Scientific Name
	Heermann's Gull	*Larus heermanni*
BIRDS CONT.	Mew Gull	*Larus canus*
	Ring-billed Gull	*Larus delawarensis*
	California Gull	*Larus californicus*
	Herring Gull	*Larus argentatus*
	Thayer's Gull	*Larus thayeri*
	Western Gull	*Larus occidentalis*
	Glaucous-winged Gull	*Larus glaucescens*
	Glaucous Gull	*Larus hyperboreus*
	Sabine's Gull	*Xema Sabini*
	Black-legged Kittiwake	*Rissa tridactyla*
	Caspian Tern	*Sterna caspia*
	Elegant Tern	*Sterna elegans*
	Common Tern	*Sterna hirundo*
	Arctic Tern	*Sterna paradisaea*
	Forster's Tern	*Sterna forsteri*
	Black Tern	*Chlidonias niger*
	Common Murre	*Uria aalge*
	Pigeon Guillemot	*Cepphus columba*
	Marbled Murrelet	*Brachyramphus marmoratus*
	Ancient Murrelet	*Synthliboramphus antiquus*
	Cassin's Auklet	*Ptychoramphus aleuticus*
	Rhinoceros Auklet	*Cerorhinca monocerata*
	Tufted Puffin	*Fratercula cirrhata*
	Rock Dove	*Columba livia*
	Band-tailed Pigeon	*Columba fasciata*
	Mourning Dove	*Zenaida macroura*
	Barn Owl	*Tyto alba*
	Flammulated Owl	*Otus flammeolus*
	Western Screech-owl	*Otus kennicottii*
	Great Horned Owl	*Bubo virginianus*
	Snowy Owl	*Nyctea scandiaca*
	Northern Pygmy-owl	*Glaucidium gnoma*
	Burrowing Owl	*Athene cunicularia*
	Spotted Owl	*Strix occidentalis*
	Barred Owl	*Strix varia*
	Long-eared Owl	*Asio otus*
	Short-eared Owl	*Asio flammeus*
	Northern Saw-whet Owl	*Aegolius acadicus*
	Common Nighthawk	*Chordeiles minor*
	Black Swift	*Cypseloides niger*
	Vaux's Swift	*Chaetura vauxi*
	White-throated Swift	*Aeronautes saxatalis*
	Black-chinned Hummingbird	*Archilochus alexandri*
	Anna's Hummingbird	*Calypte anna*
	Calliope Hummingbird	*Stellula calliope*
	Rufous Hummingbird	*Selasphorus rufus*
	Belted Kingfisher	*Ceryle alcyon*

Species Group	Common Name	Scientific Name
	Lewis's Woodpecker	*Melanerpes lewis*
BIRDS CONT.	Acorn Woodpecker	*Melanerpes formicivorus*
	Williamson's Sapsucker	*Sphyrapicus thyroideus*
	Red-naped Sapsucker	*Sphyrapicus nuchalis*
	Red-breasted Sapsucker	*Sphyrapicus ruber*
	Downy Woodpecker	*Picoides pubescens*
	Hairy Woodpecker	*Picoides villosus*
	Three-toed Woodpecker	*Picoides tridactylus*
	Black-backed Woodpecker	*Picoides arcticus*
	Northern Flicker	*Colaptes auratus*
	Pileated Woodpecker	*Dryocopus pileatus*
	Olive-sided Flycatcher	*Contopus cooperi*
	Western Wood-pewee	*Contopus sordidulus*
	Willow Flycatcher	*Empidonax traillii*
	Hammond's Flycatcher	*Empidonax hammondii*
	Dusky Flycatcher	*Empidonax oberholseri*
	Pacific-slope Flycatcher	*Empidonax difficilis*
	Say's Phoebe	*Sayornis saya*
	Ash-throated Flycatcher	*Myiarchus cinerascens*
	Western Kingbird	*Tyrannus verticalis*
	Eastern Kingbird	*Tyrannus tyrannus*
	Loggerhead Shrike	*Lanius ludovicianus*
	Northern Shrike	*Lanius excubitor*
	Cassin's Vireo	*Vireo cassinii*
	Hutton's Vireo	*Vireo huttoni*
	Warbling Vireo	*Vireo gilvus*
	Red-eyed Vireo	*Vireo olivaceus*
	Gray Jay	*Perisoreus canadensis*
	Steller's Jay	*Cyanocitta stelleri*
	Western Scrub-Jay	*Aphelocoma californica*
	Pinyon Jay	*Gymnorhinus cyanocephalus*
	Clark's Nutcracker	*Nucifraga columbiana*
	Black-billed Magpie	*Pica pica*
	American Crow	*Corvus brachyrhynchos*
	Northwestern Crow	*Corvus caurinus*
	Common Raven	*Corvus corax*
	Horned Lark	*Eremophila alpestris*
	Purple Martin	*Progne subis*
	Tree Swallow	*Tachycineta bicolor*
	Violet-green Swallow	*Tachycineta thalassina*
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
	Cliff Swallow	*Petrochelidon pyrrhonota*
	Barn Swallow	*Hirundo rustica*
	Black-capped Chickadee	*Poecile atricapillus*
	Mountain Chickadee	*Poecile gambeli*
	Chestnut-backed Chickadee	*Poecile rufescens*
	Bushtit	*Psaltriparus minimus*
	Red-breasted Nuthatch	*Sitta canadensis*

Species Group	Common Name	Scientific Name
	White-breasted Nuthatch	*Sitta carolinensis*
BIRDS CONT.	Brown Creeper	*Certhia americana*
	Rock Wren	*Salpinctes obsoletus*
	Canyon Wren	*Catherpes mexicanus*
	Bewick's Wren	*Thryomanes bewickii*
	House Wren	*Troglodytes aedon*
	Winter Wren	*Troglodytes troglodytes*
	Marsh Wren	*Cistothorus palustris*
	American Dipper	*Cinclus mexicanus*
	Golden-crowned Kinglet	*Regulus satrapa*
	Ruby-crowned Kinglet	*Regulus calendula*
	Western Bluebird	*Sialia mexicana*
	Mountain Bluebird	*Sialia currucoides*
	Townsend's Solitaire	*Myadestes townsendi*
	Veery	*Catharus fuscescens*
	Swainson's Thrush	*Catharus ustulatus*
	Hermit Thrush	*Catharus guttatus*
	American Robin	*Turdus migratorius*
	Varied Thrush	*Ixoreus naevius*
	Wrentit	*Chamaea fasciata*
	Northern Mockingbird	*Mimus polyglottos*
	European Starling	*Sturnus vulgaris*
	American Pipit	*Anthus rubescens*
	Cedar Waxwing	*Bombycilla cedrorum*
	Orange-crowned Warbler	*Vermivora celata*
	Nashville Warbler	*Vermivora ruficapilla*
	Yellow Warbler	*Dendroica petechia*
	Yellow-rumped Warbler	*Dendroica coronata*
	Black-throated Gray Warbler	*Dendroica nigrescens*
	Townsend's Warbler	*Dendroica townsendi*
	Hermit Warbler	*Dendroica occidentalis*
	Palm Warbler	*Dendroica palmarum*
	Macgillivray's Warbler	*Oporornis tolmiei*
	Common Yellowthroat	*Geothlypis trichas*
	Wilson's Warbler	*Wilsonia pusilla*
	Yellow-breasted Chat	*Icteria virens*
	Western Tanager	*Piranga ludoviciana*
	Green-tailed Towhee	*Pipilo chlorurus*
	Spotted Towhee	*Pipilo maculatus*
	California Towhee	*Pipilo crissalis*
	Chipping Sparrow	*Spizella passerina*
	Brewer's Sparrow	*Spizella breweri*
	Clay-colored Sparrow	*Spizella pallida*
	Vesper Sparrow	*Pooecetes gramineus*
	Savannah Sparrow	*Passerculus sandwichensis*
	Grasshopper Sparrow	*Ammodramus savannarum*
	Fox Sparrow	*Passerella iliaca*
	Song Sparrow	*Melospiza melodia*

Species Group	Common Name	Scientific Name
	Lincoln's Sparrow	*Melospiza lincolnii*
BIRDS CONT.	Swamp Sparrow	*Melospiza georgiana*
	White-throated Sparrow	*Zonotrichia albicollis*
	Harris's Sparrow	*Zonotrichia querula*
	White-crowned Sparrow	*Zonotrichia leucophrys*
	Golden-crowned Sparrow	*Zonotrichia atricapilla*
	Dark-eyed Junco	*Junco hyemalis*
	Lapland Longspur	*Calcarius lapponicus*
	Black-headed Grosbeak	*Pheucticus melanocephalus*
	Snow Bunting	*Plectrophenax nivalis*
	Lazuli Bunting	*Passerina amoena*
	Red-winged Blackbird	*Agelaius phoeniceus*
	Tricolored Blackbird	*Agelaius tricolor*
	Western Meadowlark	*Sturnella neglecta*
	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
	Brewer's Blackbird	*Euphagus cyanocephalus*
	Brown-headed Cowbird	*Molothrus ater*
	Bullock's Oriole	*Icterus bullockii*
	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*
	Pine Grosbeak	*Pinicola enucleator*
	Purple Finch	*Carpodacus purpureus*
	Cassin's Finch	*Carpodacus cassinii*
	House Finch	*Carpodacus mexicanus*
	Red Crossbill	*Loxia curvirostra*
	Common Redpoll	*Carduelis flammea*
	Pine Siskin	*Carduelis pinus*
	Lesser Goldfinch	*Carduelis psaltria*
	American Goldfinch	*Carduelis tristis*
	Evening Grosbeak	*Coccothraustes vespertinus*
	House Sparrow	*Passer domesticus*
MAMMALS	Virginia Opossum	*Didelphis virginiana*
	Masked Shrew	*Sorex cinereus*
	Vagrant Shrew	*Sorex vagrans*
	Montane Shrew	*Sorex monticolus*
	Baird's Shrew	*Sorex bairdi*
	Water Shrew	*Sorex palustris*
	Pacific Water Shrew	*Sorex bendirii*
	Trowbridge's Shrew	*Sorex trowbridgii*
	Shrew-mole	*Neurotrichus gibbsii*
	Townsend's Mole	*Scapanus townsendii*
	Coast Mole	*Scapanus orarius*
	California Myotis	*Myotis californicus*
	Western Small-footed Myotis	*Myotis ciliolabrum*
	Yuma Myotis	*Myotis yumanensis*
	Little Brown Myotis	*Myotis lucifugus*
	Long-legged Myotis	*Myotis volans*
	Fringed Myotis	*Myotis thysanodes*

Species Group	Common Name	Scientific Name
	Long-eared Myotis	*Myotis evotis*
MAMMALS CONT.	Silver-haired Bat	*Lasionycteris noctivagans*
	Big Brown Bat	*Eptesicus fuscus*
	Hoary Bat	*Lasiurus cinereus*
	Townsend's Big-eared Bat	*Corynorhinus townsendii*
	American Pika	*Ochotona princeps*
	Brush Rabbit	*Sylvilagus bachmani*
	Eastern Cottontail	*Sylvilagus floridanus*
	Nuttall's (Mountain) Cottontail	*Sylvilagus nuttallii*
	Snowshoe Hare	*Lepus americanus*
	Black-tailed Jackrabbit	*Lepus californicus*
	Mountain Beaver	*Aplodontia rufa*
	Yellow-pine Chipmunk	*Tamias amoenus*
	Townsend's Chipmunk	*Tamias townsendii*
	Yellow-bellied Marmot	*Marmota flaviventris*
	California Ground Squirrel	*Spermophilus beecheyi*
	Golden-mantled Ground Squirrel	*Spermophilus lateralis*
	Cascade Golden-mantled Ground Squirrel	*Spermophilus saturatus*
	Eastern Gray Squirrel	*Sciurus carolinensis*
	Eastern Fox Squirrel	*Sciurus niger*
	Western Gray Squirrel	*Sciurus griseus*
	Douglas' Squirrel	*Tamiasciurus douglasii*
	Northern Flying Squirrel	*Glaucomys sabrinus*
	Northern Pocket Gopher	*Thomomys talpoides*
	Western Pocket Gopher	*Thomomys mazama*
	Camas Pocket Gopher	*Thomomys bulbivorus*
	American Beaver	*Castor canadensis*
	Western Harvest Mouse	*Reithrodontomys megalotis*
	Deer Mouse	*Peromyscus maniculatus*
	Columbian Mouse	*Peromyscus keeni*
	Pinon Mouse	*Peromyscus truei*
	Dusky-footed Woodrat	*Neotoma fuscipes*
	Bushy-tailed Woodrat	*Neotoma cinerea*
	Southern Red-backed Vole	*Clethrionomys gapperi*
	Western Red-backed Vole	*Clethrionomys californicus*
	Heather Vole	*Phenacomys intermedius*
	White-footed Vole	*Phenacomys albipes*
	Red Tree Vole	*Phenacomys longicaudus*
	Montane Vole	*Microtus montanus*
	Gray-tailed Vole	*Microtus canicaudus*
	Townsend's Vole	*Microtus townsendii*
	Long-tailed Vole	*Microtus longicaudus*
	Creeping Vole	*Microtus oregoni*
	Water Vole	*Microtus richardsoni*
	Muskrat	*Ondatra zibethicus*
	Black Rat	*Rattus rattus*
	Norway Rat	*Rattus norvegicus*

Species Group	Common Name	Scientific Name
	House Mouse	*Mus musculus*
MAMMALS CONT.	Western Jumping Mouse	*Zapus princeps*
	Pacific Jumping Mouse	*Zapus trinotatus*
	Common Porcupine	*Erethizon dorsatum*
	Nutria	*Myocastor coypus*
	Coyote	*Canis latrans*
	Red Fox	*Vulpes vulpes*
	Gray Fox	*Urocyon cinereoargenteus*
	Black Bear	*Ursus americanus*
	Raccoon	*Procyon lotor*
	American Marten	*Martes americana*
	Fisher	*Martes pennanti*
	Ermine	*Mustela erminea*
	Long-tailed Weasel	*Mustela frenata*
	Mink	*Mustela vison*
	Wolverine	*Gulo gulo*
	American Badger	*Taxidea taxus*
	Western Spotted Skunk	*Spilogale gracilis*
	Striped Skunk	*Mephitis mephitis*
	Northern River Otter	*Lutra canadensis*
	Mountain Lion	*Puma concolor*
	Bobcat	*Lynx rufus*
	Elk	*Cervus elaphus*
	Mule Deer	*Odocoileus hemionus*
	White-tailed Deer	*Odocoileus virginianus*
	Columbian White-tailed Deer	*Odocoileus virginianus leucurus*
	Mountain Goat	*Oreamnos americanus*
MARINE MAMMALS	Northern (Steller) Sea Lion	*Eumetopias jubatus*
	California Sea Lion	*Zalophus californianus*
	Harbor Seal	*Phoca vitulina*
REPTILES	Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
	Western Pond Turtle	*Clemmys marmorata*
	Red-eared Slider Turtle	*Trachemys scripta*
	Northern Alligator Lizard	*Elgaria coerulea*
	Southern Alligator Lizard	*Elgaria multicarinata*
	Western Fence Lizard	*Sceloporus occidentalis*
	Western Skink	*Eumeces skiltonianus*
	Rubber Boa	*Charina bottae*
	Racer	*Coluber constrictor*
	Ringneck Snake	*Diadophis punctatus*
	California Mountain Kingsnake	*Lampropeltis zonata*
	Gopher Snake	*Pituophis catenifer*
	Western Terrestrial Garter Snake	*Thamnophis elegans*
	Northwestern Garter Snake	*Thamnophis ordinoides*
	Common Garter Snake	*Thamnophis sirtalis*

Species Group	Common Name	Scientific Name
	Western Rattlesnake	*Crotalus viridis*

2.1.5 Habitat Classification

The estuary includes a complex mosaic of interconnected and interacting habitat types. One of the difficulties in describing these habitat types is choosing a habitat classification system that adequately describes the habitats used by focal species and is acceptable to all stakeholders in the subbasin. For example, habitat type descriptions differ as a result of the resolution of the methods utilized to map and classify the habitat. Further, habitat mapping methods are designed to describe aquatic or terrestrial habitat types, but generally are not capable of adequately mapping both. Choosing the appropriate habitat classification system is further complicated by the diversity of habitats found throughout the lower Columbia River mainstem and estuary or by different area coverage of each habitat mapping effort. For the purposes of this subbasin assessment, a habitat classification was needed that could: describe aquatic habitats, describe terrestrial habitats, and provide a historical context for evaluating the change in estuary and mainstem (to Bonneville Dam) habitat types over time. There is not one habitat classification system that provides for all these needs; thus, we chose to utilize multiple habitat classification systems to describe estuary and mainstem habitat types as described below. The use of multiple habitat classification systems creates additional challenges because the habitat types among different classification systems are rarely directly comparable. However, we evaluated each habitat classification system to determine potential groupings of specific habitat types from each classification system, limiting the comparison to habitat types known to occur in the lower Columbia River and estuary.

2.1.5.1 Bathymetric Mapping

Bathymetry is a low resolution method that provides coarse delineations of habitat types. Habitat classification using bathymetry provides a means to segregate aquatic habitat based on depth criteria; additionally, published bathymetric mapping efforts provide a historical context for evaluating Columbia River estuary habitat change. Using bathymetric survey maps of the U.S. Coast Survey (now U.S. Geodetic Survey), five major types of estuary (i.e. rm 0-46.5) habitat were defined by the Columbia River Estuary Data Development Program (Thomas 1983) according to elevation and the dominant vegetation: tidal swamps, tidal marshes, shallow water/flats, medium depth water, and deep water. A cross-sectional view of these habitat types is depicted in Figure 2-4. Tidal swamps are those areas where the dominant vegetation is mostly shrub and woody species with elevations varying between mean high high water (MHHW) and the line of non-aquatic vegetation. Tidal marshes vary considerably depending on dominant low shrubs or emergent herbaceous vegetation and have been recorded slightly above mean low low water (MLLW) to slightly above MHHW. Shallow water/flats are defined as being between an elevation slightly above the MLLW mark to -6 ft MLLW. Medium depth water is between 6 ft and 18 ft below MLLW, while deep water is defined as 18 ft and deeper. Further, at a given elevation, there is an overriding influence of time and salinity in development of specific types of habitat. For example, tidal marsh habitat may be classified as a saltwater or freshwater marsh and each is characterized by distinctive vegetation as driven by salinity levels. Additionally, shallows/flats habitat may be present in an area formerly classified as medium depth water as a result of accretion; given time and further accretion, shallows/flats habitat may transition to tidal marsh.

Thomas (1983) also investigated five categories of non-estuarine habitat (i.e. developed floodplain, natural and filled uplands, non-tidal swamps, non-tidal marshes, and non-tidal water) to identify the fate of floodplain areas that were removed from the estuarine system. Developed floodplain habitat was defined as all diked floodplain converted to agriculture, residential, or other land use. Natural and filled uplands included those areas where measurable acreages have been filled, primarily through disposal of dredge material. Non-tidal swamps were areas of the diked floodplain that were never cleared or were cleared and converted back to swamp. Non-tidal marshes included areas of the diked floodplain that support emergent wetland vegetation; these were typically abandoned pastures dominated by rush and sedge. Non-tidal water was those areas of former tidal sloughs that were separated from the river by dikes and tidegates.

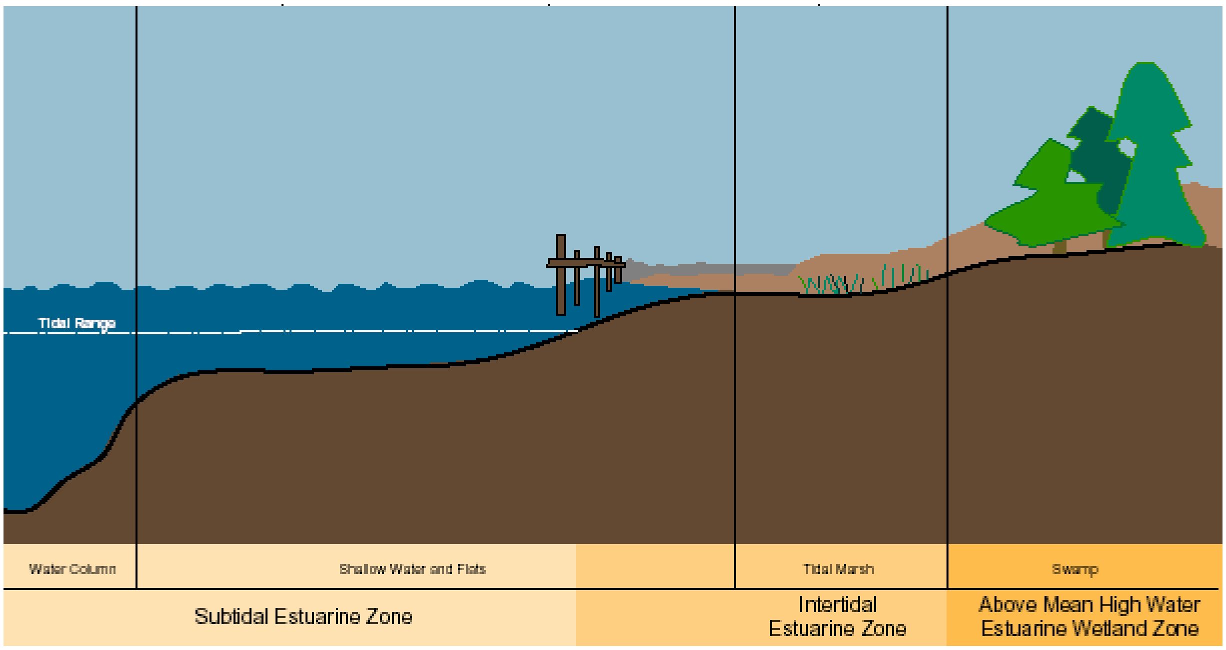


Figure 2-4. Cross-sectional depiction of general estuary habitat types (USACE 2001).

2.1.5.2 Satellite Imagery Habitat Mapping

Satellite imagery provides a high resolution habitat mapping method that principally uses vegetative communities to describe habitat types. Because of the use of vegetation, satellite imagery is generally not capable of distinguishing different types of aquatic habitats. Different satellite imagery technology are available that provide different levels of resolution; two of these technologies are compared in Garono et al. (2003b).

A widely accepted habitat classification system developed from satellite imagery is that of Johnson and O'Neil (2001); this habitat classification system describes wildlife habitats present in Washington and Oregon and provides a historical context for evaluating habitat change in lower Columbia River mainstem and estuary habitats. A total of 32 wildlife habitat types are delineated in this classification system (Table 2-2); each habitat type is further described based on geographic distribution, physical setting, landscape setting, structure, and composition. Johnson and O'Neil (2001) also provide information on other classification systems and key references, natural disturbance regimes, succession and stand dynamics, management and anthropogenic impacts, and status and trends to provide further insight for each habitat type. This habitat classification system has been utilized by the Northwest Habitat Institute for producing maps comparing historical and current wildlife habitat types in the lower Columbia River mainstem and estuary as part the NPCC subbasin planning process (IBIS 2003).

Table 2-2. Wildlife habitat types in Washington and Oregon determined by Johnson and O'Neil (2001).

Wildlife Habitat Types	Vegetative/Land Use/Marine Groupings
Westside Lowland Conifer-Hardwood Forest	*Alnus rubra-Acer macrophyllum* Upland Forests
	Picea sitchensis-Tsuga heterphylla Forests
	Pseudotsuga menziesii-Alnus rubra-Acer macrophyllus Forests
	Maritime *Tsuga heterphylla-Thuja plicata* Forests
	Forested Dunes
Westside Oak and Dry Douglas-fir Forest and Woodlands	Westside *Quercus garryana* Forests and Woodlands
	Westside *Quercus garryana-Pseudotsuga menziesii* Forests
	Westside Dry *Pseudotsuga menziesii* Forests
	Pseudotsuga menziesii-Arbutus menziesii Forests
Southwest Oregon Mixed Conifer-Hardwood Forests	*Abies concolor* Mixed conifer Forests
	Pinus jefferii Woodlands
	Pseudotsuga menziesii-Lithocarpus densiflorus Forests
	Southwest Oregon Low Elevation Mixed Conifer Forests
Montane Mixed Conifer Forests	*Abies amabilis-Tsuga heterophylla* Forests
	Abies lasiocarpa-Picea englemannii Forests
	Abies magnifica var. shastensis Forests and Woodlands
	Tsuga mertensiana Forests
	Tsuga mertensiana-Abies amabilis Forests
Eastside (Interior) Mixed Conifer Forest	Eastside *Abies grandis- Pseudotsuga menziesii* Forest
	Eastside *Pseudotsuga menziesii- Pinus ponderosa* Forest
	Eastside *Tsuga heterphylla-Thuja plicata* Forests
Lodgepole Pine Forests and Woodlands	*Pinus contorta* Grass understory
	Pinus contorta Shrub understory
	Pinus contorta Subalpine Forests
	Pinus contorta Woodlands and Forests on Pumice
Ponderosa Pine Forests and Woodlands	*Pinus ponderosa* Woodlands
	Eastside *Pinus ponderosa -Quercus garryana* Forest and Woodlands
Upland Aspen Forests	*Populus tremuloides* Upland Forests
Subalpine Parklands	Subalpine and Alpine Wetlands
	Pinus albicaulis-Abies lasiocarpa Woodlands and Parklands
	Tsuga mertensiana Parklands
Alpine Grasslands and Shrublands	Subalpine and Alpine Grasslands
	Alpine Dwarf Shrublands-Fellfields and Sedge Turf
Westside Grasslands	Westside *Festuca idahoensis var. romeri-Danthonia californica*
Ceanothus-Manzanita Shrublands	Chaparral
Western Juniper and Mountain Mahogany Woodlands	*Juniperus occidentalis* Scablands
	Juniperus occidentalis-Artemisia tridentata Tall Shrublands
	Juniperus occidentalis/ Bunchgrass
	Cercocarpus ledifolius
Eastside (Interior) Canyon Shrublands	Eastside Moist Deciduous Shrublands
Eastside (Interior) Grasslands	*Pseudoroegneria spicata* Grasslands
	Eastside Low-to-Mid-elevation *Festuca idahoensis* Grasslands
	Eastside Modified Grasslands
	Sporobolus cryptandrus-Aristida puppurea var.longiseta Grasslands
Shrub-steppe	*Artemisia tripartita* Shrub-steppe
	Artemisia cana Shrub-steppe
	Artemisia tridentata ssp. tridentata and ssp. wyomingensis Shrub-steppe
	Artemisia tridentata ssp. vaseyana Shrublands
	Purshia tridentata Shrub-steppe
	Sandy steppe and Shrub-steppe
Dwarf Shrub-steppe	*Artemisia rigida/Eriogonum spp./Poa secunda* Dwarf-Shrub Scabland
	Artemisia arbuscula Dwarf-Shrub-steppe

Eastside *Quercus garryana* Woodlands

Artemisia nova Dwarf-Shrublands

Wildlife Habitat Types	Vegetative/Land Use/Marine Groupings
Desert Playa and Salt Scrub	Alkali Grasslands and Wetlands
	Atriplex confertifolia Shrublands
	Mixed Saltdesert Shrub-Non-Playa
	Mixed Saltdesert Shrub-Playa
	Sarcobatus vermiculatus Shrublands
Agriculture, Pasture, and Mixed Environs*	Cultivated Croplands
	Improved Pasture
	Modified Grasslands
	Orchard/Vineyard/Nursery
	Unimproved Pasture
Urban and Mixed Environs*	High Density
	Moderate Density
	Low Density
Open Water-Lakes, Rivers, Streams	Riverine
	Lacustrine-Open Water
Herbaceous Wetlands	Graminoid Wet Meadow
	Freshwater Aquatic Beds
	Herbaceous and Sedge Wetlands
Westside Riparian - Wetlands	*Alnus viridis ssp. sinuata-Acer circinatum* Shrublands
	Westside Riparian and Wetland Deciduous Forests
	Picea sitchensis Wetland Forests and Woodlands
	Tsuga heterophylla-Thuja plicata coniferous wetlands
	Westside Riparian/Wetland Shrublands
	Shrub/herbaceous Sphagnum Bogs
	Wooded Bogs
Montane Coniferous Wetlands	Westside Montane Coniferous Wetlands
	Picea engelmannii Forested Wetlands
Eastside (Interior) Riparian - Wetlands	Eastside Midmontane *Alnus incana-Salix ssp.* Riparian Shrublands
	Eastside Lowland Riparian Shrublands
	Eastside *Populus balsamifera ssp. trichocarpa*
	Alnus rhombifolia Riparian
	Pinus ponderosa Riparian Woodlands
	Populus tremuloides Riparian/Wetland Forests and Woodlands
Coastal Dunes and Beaches	Coastal Dune Grasslands
	Coastal Dune Shrublands
Coastal Headlands and Islets	Coastal Headland Shrublands and Grasslands
Bays and Estuaries*	Bays and Estuaries (includes Intertidal Marshes)
Inland Marine Deeper Waters*	Puget Sound to Strait of Juan de Fuca
Marine Nearshore*	Marine environment from shore line to 20m depth
Marine Shelf*	Marine environment from 20m to 200m depth
Oceanic*	Marine environment greater than 200m depth

* Wildlife habitats were determined by an expert panel process.

The Lower Columbia River Estuary Partnership (LCREP) was interested in producing spatial data sets describing the location and distribution of estuarine and tidal freshwater habitat cover types along the Columbia River from the mouth to Bonneville Dam using a consistent method and data source (Garono et al 2003c). The habitat mapping focused on estuarine and tidal freshwater habitats; areas not located along the river and >175 ft elevation (for the eastern dataset) or >100 ft elevation (for the western dataset) were deleted from the habitat classification(Garono et al 2003c). The habitat types designated in this research differed from that of Thomas (1983) and Johnson and O'Neil (2001). In general, the vegetated habitat types are more specific than that of Thomas (1983) but less specific than that of Johnson and O'Neil (2001); the aquatic habitat types were less specific than Thomas (1983) and similar to that of Johnson and O'Neil (2001). However, in order to compare the habitats mapped in 2000 with a National Oceanic and Atmospheric Administration (NOAA) mapping dataset from1992, a more generalized list of habitat types were derived to achieve consistency between the two datasets (Garono et al. 2003a). This habitat change analysis provided a recent context for evaluating lower Columbia River mainstem and estuary habitat change.

The resulting habitat types from the merge of the 1992 and 2000 datasets include: herbaceous wetland, scrub-shrub wetland, forested wetland, herbaceous upland, scrub-shrub upland, deciduous forest upland, coniferous forest upland, mixed forest upland, unconsolidated shoreline, water, urban, and other (Garono et al 2003a). The following general guidelines defined the major habitat classes: herbaceous habitat types had >70% herbaceous cover, scrub-shrub habitat types had >70% woody vegetation <8 ft high, forest habitat types had >60% conifers of broad-leaved vegetation, mixed forest habitat types were defined based on the proportion of conifers/deciduous ranging from 40/60 to 50/50, and unconsolidated shoreline habitat had at least 70% of the area as exposed substrate (Garono et al. 2003c). It is not clear what criteria Garono et al. (2003a,c) utilized to distinguish between wetland and upland habitat.

2.1.5.3 WDFW Priority Habitats

WDFWs Priority Habitats and Species Program was initiated in 1989 and remains in use today. WDFW priority habitats are generally defined as habitat types with unique or significant value to many species. An area identified and mapped as priority habitat has one or more of the following attributes: comparatively high fish and wildlife density, comparatively high fish and wildlife species diversity, important fish and wildlife breeding habitat, important fish and wildlife seasonal ranges, important fish and wildlife movement corridors, limited availability, high vulnerability to habitat alteration, or unique or dependent species. A priority habitat may be described by a unique vegetation type or by a dominant plant species that is of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows). A priority habitat may also be described by a successional stage (e.g., old growth and mature forests). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

Specific descriptions of the four WDFW Priority Habitats considered in this subbasin assessment follows. Old growth forest west of the Cascade crest are generally defined as stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings, with at least 8 trees/acre that are >81 cm diameter at breast height (dbh) or >200 years old. Mature forests are defined as stands with average tree diameter >53 cm dbh; decay, number of snags, and quantity of large downed material is generally less than old growth forests. Riparian habitats are a general grouping that includes all areas adjacent to aquatic systems with flowing water that contain elements of both aquatic and terrestrial ecosystems. Freshwater wetlands are defined as transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water; no vegetation is specified other than the presence of hydrophytic plants. Numerous conditions may satisfy the designation as rural natural open space: an area where a priority species resides or uses for breeding or regular feeding, a corridor connecting other priority habitats, or an isolated remnant of natural habitat larger than 10 acres and surrounded by agricultural development. Rural natural open space is a general habitat type that may or may not possess wetland, riparian, aquatic, or forested habitat attributes; thus, specific descriptions of habitat attributes and relationship to focal species habitat requirements is fairly subjective.

Little data are available regarding the relationship between historical and current habitat conditions of WDFW priority habitats; thus, we have no context in which to evaluate habitat change of WDFW priority habitats in the lower Columbia River mainstem and estuary.

Because of the general nature of these habitat designations, there may be considerable overlap among the characteristics of each habitat; thus, analysis of the specific relationships between these habitats and the focal species is problematic. For example, riparian habitats are a general grouping that include elements of aquatic and terrestrial environments; freshwater wetland habitats associated with flowing water may be a subset of the riparian category. Within the freshwater wetland category, there is uncertainty as to whether the wetland is dominated by herbaceous vegetation, shrubs, or trees; each of these wetlands provides very different habitat opportunities for the focal species. Additionally, the rural natural open space is also a general habitat type; unless some knowledge of a specific rural natural open space habitat is available, it is difficult to distinguish whether the habitat includes forest, riparian, wetland, or any combination of these habitat characteristics.

2.1.5.4 Relationship Among Habitat Classification Systems

Each habitat classification system described above was developed with a specific purpose; each system only partially satisfies the needs for this subbasin assessment (i.e. describe aquatic habitats, describe terrestrial habitats, and provide a historical context for evaluating the change in estuary and mainstem habitat types over time). For example, each system differs in the specificity of habitat types and the area covered by those habitat types. In order to completely describe the aquatic and terrestrial habitats throughout the lower Columbia River mainstem and estuary, the habitat classification systems were compared to establish similarities among them. However, because each habitat classification system was developed with different methods, there is no direct relationship among the habitat types used in each system and we relied heavily on professional judgment to determine the relationship among each classification system. We evaluated each habitat classification system to determine possible groupings of specific habitat types from each classification system (Table 2-3); we limited the comparison to habitats known to occur in the lower Columbia River and estuary. For example, wildlife habitats from Johnson and O’Neil (2001) that only occur in eastern regions of Washington or Oregon were not included in the comparison.

Table 2-3. Potential relationship of specific habitat types among the different habitat classification

systems.

Estuarine Habitat Types (Thomas 1983)	Wildlife Habitat Types (Johnson and O'Neil 2001)	LCREP Estuary and Tidal Freshwater Habitats (Garono et al. 2003a)	WDFW Priority Habitats
Deep Water	Open Water – Lakes, River, and Streams	Water	NA
Medium Depth Water	Open Water – Lakes, River, and Streams	Water	NA
Shallow Water/Flats	Open Water – Lakes, River, and Streams Bays and Estuaries	Water	NA
Tidal Marsh	Herbaceous Wetlands	Herbaceous Wetlands Scrub-Shrub Wetlands	Riparian
Tidal Swamp	Westside Riparian-Wetlands	Forested Wetland	Riparian
Non-estuarine Water	Open Water – Lakes, River, and Streams	Water	NA
Non-estuarine Marsh	Herbaceous Wetlands	Herbaceous Wetlands Scrub-Shrub Wetlands	Freshwater Wetland Riparian
Non- estuarine Swamp	Westside Riparian-Wetlands	Forested Wetland	Riparian Freshwater Wetland
Developed Floodplain	Agriculture, Pastures, and Mixed Environs Urban and Mixed Environs	Urban	Rural Natural Open Space
Natural and Filled Uplands	Coastal Dunes and Beaches	Unconsolidated Shore	NA
NA	Westside Lowland Conifer-Hardwood Forest	Coniferous Forest Upland	Old Growth/Mature Forest
NA	Westside Oak and Dry Douglas-fir Forest	Deciduous Forest Upland	Old Growth/Mature Forest
NA	Montane Mixed Conifer Forest	Mixed Forest Upland Coniferous Forest Upland	Old Growth/Mature Forest
NA	Westside Grasslands	Herbaceous Upland	Rural Natural Open Space

2.1.6 Estuary and Lower Mainstem Zones

The Columbia River estuary and lower mainstem consists of two major physiographic subsystems: the estuarine subsystem and the tidal freshwater subsystem (Johnson et al. 2003b). The estuary and lower mainstem are dynamic subsystems, resulting partially from interactions between seasonal flow and salinity-tidal regimes. Subsystem designation was based on efforts of the Columbia River Estuary Data Development Program (Simenstad et al. 1984). The estuarine subsystem extends from the Columbia River mouth to Puget Island (rm 0-46) and includes 7 distinct areas based on habitat structure, salinity concentration, and sediment composition: Entrance, Mixing Zone, Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, and the Upper Estuary. A map of the estuarine subsystem boundaries is provided in Figure 2-5, however, a similar map was not available for the tidal freshwater subsystem. Boundary delineation of these areas is consistent with the estuary areas discussed by Thomas (1983). The freshwater subsystem extends from Puget Island to Bonneville Dam and is separated into 2 areas (i.e. rm 46-105 and rm 105-146). The distinct areas within the estuary and tidal freshwater subsystems are briefly described below based on Johnson et al. (2003b):

- **Entrance** – The area is dominated by subtidal habitat and has the highest salinity in the estuary. Historically, the Entrance was a high-energy area of natural fluvial land forms (e.g. Clatsop Spit, Trestle Bay), and a complex of channels, shallow water, and sand bars. The Entrance area supports the Columbia Plume, which creates a unique low-salinity, high productivity environment extending well into the ocean. The dynamic nature of the areas has changed as a result of dredging and jetty construction, which have limited wave action and the ocean-fed supply of sediment.

- **Mixing Zone** – The area is characterized by a network of mid-channel shoals and flats, such as Desdemona and Taylor Sands. The Mixing Zone has the highest variation in salinity within the estuary based on interactions between tide cycles and river flow. The estuary turbidity maximum (ETM), which is created through these interactions, is often located within the Mixing Zone. Urban development, primarily around Astoria, has moderately impacted intertidal and subtidal habitats in the area.

- **Youngs Bay** – The area is characterized by a broad flood plain and was historically abundant in tidal marsh and swamp habitat. Diking and flood control structures were used to convert floodplain habitat in the area to pasture. The remaining fragmented tidal marsh and tidal swamp habitats in Youngs Bay are thought to be different in structure and vegetative community than the historical condition of these habitats.

- **Baker Bay** – The area was historically a high energy area from ocean currents and wave action, which have been altered as a result of dredging and jetty construction. Additionally, migration of mid-channel islands toward the interior of Baker Bay has sheltered the area from wave action. As a result, tidal marsh habitat has recently started to develop in some areas while much of the historical tidal marsh and tidal swamp habitat has been lost because of dike construction in the floodplain. Because of proximity to the river mouth, Baker Bay consists primarily of brackish water.

- **Grays Bay** – Historically, water circulation in the area was a result of interactions between river flow and tidal intrusion. Pile dikes constructed adjacent to the main Columbia River navigation channel have decreased circulation in Grays Bay; this circulation change has caused flooding problems in the Grays and Deep River valley bottoms and has promoted tidal marsh habitat development in the accreting bay. Dike construction, primarily for pasture conversion, has isolated the main channel from its historical floodplain and eliminated much of the historical tidal swamp habitat.

- **Cathlamet Bay** – The area is characterized by some of the most intact and productive tidal marsh and swamp habitat remaining in the estuary; a large portion of Cathlamet Bay is protected by the Lewis and Clark National Wildlife Refuge. The western edge of Cathlamet Bay contains part of the brackish oligohaline zone, which is thought the be important during juvenile anadromous fish transition from fresh to salt water. Portions of Cathlamet Bay have lost substantial acreage of tidal swamp habitat as a result of dike construction; conversely, tidal marsh habitat has formed along the fringe of dredge disposal locations.
- **Upper Estuary** – The area is characterized by deep channels and steep shorelines on both sides of the river. The narrow channel structure produces an area dominated more by tidal swamp habitat and less edge habitat (tidal marsh). The Upper Estuary is typically dominated by freshwater, except during low river flow or large flood tides. Dike construction and clearing of vegetation has resulted in a substantial loss of tidal marsh habitat on Puget Island and within the Skamokawa and Elochoman floodplain.
- **Tidal Freshwater** – The tidal freshwater subsystem is distinct from the estuarine subsystem based on geology, vegetation, and climate. This region is influenced by major tributaries such as the Willamette, Cowlitz, Lewis, and Kalama Rivers. This area of the Columbia River mainstem is characterized by elongate islands that divide the river and form oxbow lakes, sloughs, and side channels (e.g. Sauvie Island and Scappoose Bay). The tidal freshwater subsystem was historically dominated by a combination of tidal plant communities, ash riparian forests, and marshy lowlands.

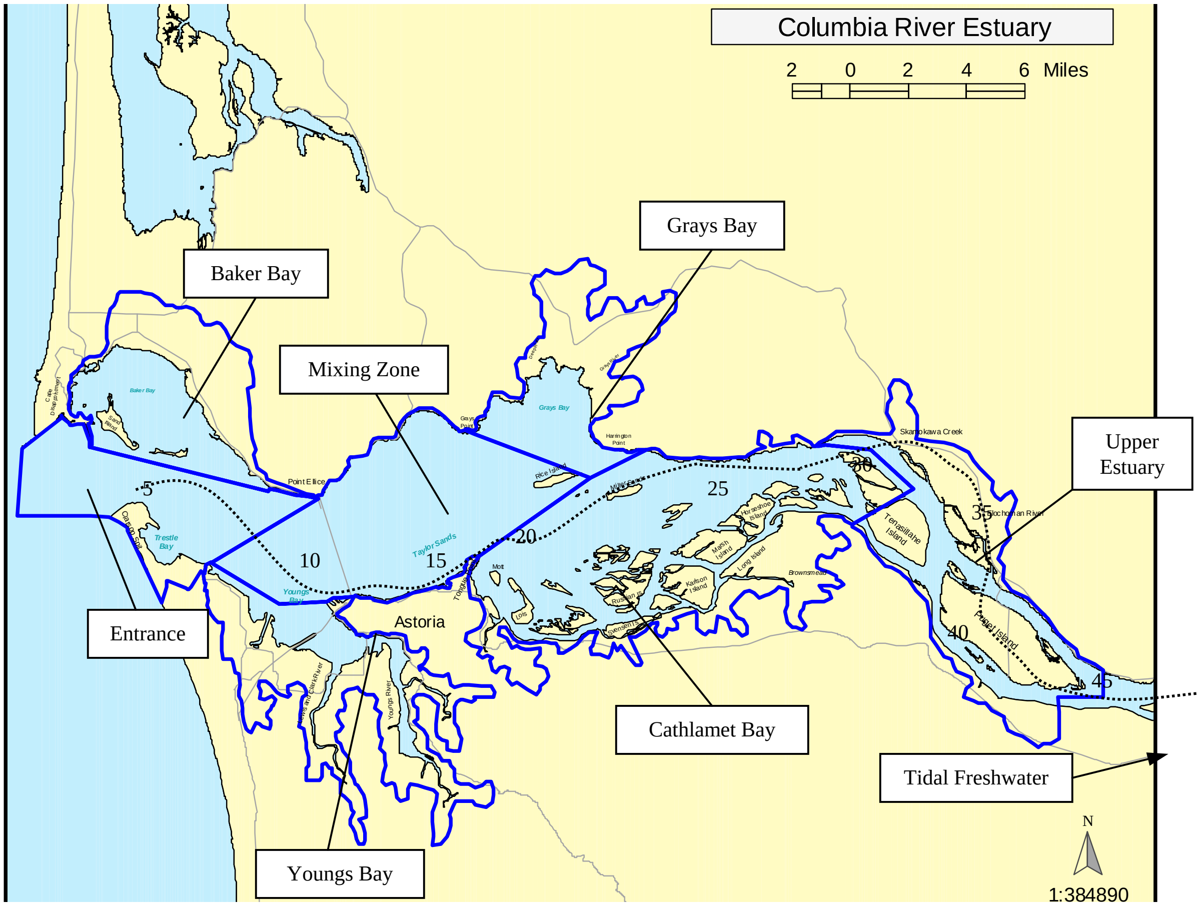


Figure 2-5. Approximate area boundaries of distinct physiographic areas within the Columbia River estuary based on Thomas (1983) and Johnson et al. (2003b). Dashed line represents an approximation of the main channel; numbers along this channel are approximate river mile measurements.

2.1.7 Major Land Uses

The size of the subbasin lends itself to an abundance of possible land uses. The area contains multiple population centers and political jurisdictions, including the largest Oregon population center (Portland) and the fourth largest in Washington (Vancouver; Figure 2-1). Nine counties are located wholly or partially within the subbasin as well as 14 port districts. Jurisdictional boundaries of many of these entities overlap. The following list is a brief description of the major land uses within the lower Columbia River mainstem and estuary subbasin (Marriott et al. 2001):

- Approximately 2.5 million people live in the basin; many others visit for recreation or business.
- Hundreds of fish and wildlife species reside in or migrate through the estuary; more than a dozen rare and endangered species utilize the lower river and estuary.
- Bonneville Dam generates power for the region and beyond as part of the Federal Columbia River Power System.
- Five deep-water ports support a shipping industry that transports 30 million tons of goods annually.
- Timber harvest occurs throughout the basin; six major pulp and paper mills contribute to the regions economy.
- Aluminum plants along the river produce 43% of the U.S.'s aluminum.
- Agriculture is widespread throughout the floodplain, including many fruit and vegetable crops as well as beef and dairy cattle.
- Although commercial fishing activity has declined in recent years, the industry continues to play a significant role in the region.
- Primary recreational activities include fishing, boating, hiking, and windsurfing.

2.1.8 Areas of Biological Significance

Numerous areas of special biological significance provide critical natural habitats and help maintain the delicate balance of the ecosystem. Since 1870, more than half of the tidal swamp and marsh areas in the lower river have been lost as a result of diking, draining, filling, dredging, and flow regulation. Since 1948, tidal wetland habitats in the lower 46 miles of the river have decreased by as much as 70%. Much of the remaining wetlands are protected by inclusion in the Lewis and Clark and the Julia Butler Hansen National Wildlife Refuges. In addition to the feeding, spawning, nursery, and migratory habitat they provide, these wetlands are critical to flood control and water quality. Specific areas of special biological significance in the Lower Columbia River Estuary Program include:

- Clatsop Spit in Fort Stevens State Park is a significant migratory shorebird feeding and nesting area for sanderlings
- Baker Bay, Youngs Bay, Trestle Bay, Grays Bay and Cathlamet Bay are especially productive areas for benthic organisms, anadromous fish and waterfowl
- Bald eagle nesting sites in the lower estuary
- High-quality wetlands in Pacific County

- Lewis and Clark National Wildlife Refuge, which includes most of the islands and the open water between RM 18 and 25; managed primarily for waterfowl
- Julia Butler Hansen National Wildlife Refuge, which includes the lower Elochoman River area in Washington
- Tenasillahee Island Research Natural Area; the upstream tip of the island consists of a spruce swamp that is a remnant of a once widespread habitat type in the program study area
- Puget Island Natural Area Preserve
- White Island Natural Area Preserve, black cottonwood-willow community, and high-quality surge-plain wetlands in Wahkiakum County
- Ridgefield National Wildlife Refuge
- Vancouver Lake Lowlands, including Shillapoo Wildlife Recreation Area
- Sauvie Island Wildlife Management Area
- Steigerwald Lake Wildlife Refuge
- Franz Lake Wildlife Refuge
- Pierce Island Natural Area Preserve and a high-quality, black cottonwood-Oregon ash community, both in Skamania County
- Pierce Ranch Wildlife Refuge

Other areas of special biological significance include: Bradwood Cliffs; Kerry Island; Big and Little Creek Estuary; Tansy Point; Tongue Point; Cooperage Slough; Russian Point Marsh; East Sand Island; Gnat Creek Marsh; Blind Slough Spruce Swamp; Burnside Marsh; Deer Island; Wallace Island; Prescott and Carr Slough; Wapato Bay; Scappoose Flats; Sandy Island; Burlington Bottom; Smith and Bybee Lakes; Virginia Lake; McGuire Island; Sandy River Delta; Gary, Flat, and Chatham Islands; Horsetail Creek Wetlands; and Rooster Rock State Park wetlands.

2.2 Focal Species

Focal species are those species that have special legal, ecological, cultural, or local status and are used to evaluate the health of the ecosystem and the effectiveness of management actions. In this section, we describe the process by which the focal species list was created (Section 2.2.1) and provide a brief description of each focal species life history and abundance trends (Sections 2.2.2 through 2.2.15).

2.2.1 Selection Process

Focal species selection followed the NPCC's *Technical Guide for Subbasin Planners* (NPCC 2001). The *Technical Guide* indicates that the assessment of focal species serves two functions:

- It provides insight on the status of species that warrant legal consideration because of Endangered Species Act (ESA) or treaty right considerations; and
- It serves a diagnostic function, with certain species used as an indicator of broad ecological health.

Further, focal species are used to evaluate the effectiveness of management actions and the health of the ecosystem. The *Technical Guide* offers four criteria for selecting focal species (in order of importance):

- Designation as Federal endangered or threatened species;
- Ecological significance;
- Cultural significance; and
- Local significance.

Within the Lower Columbia and Estuary subbasins, identification and selection of species has been a thoughtful and deliberative facet of the subbasin planning process. Early in 2001, the Lower Columbia Fish Recovery Board (LCFRB), together with the Washington Department of Fish and Wildlife, considered an initial set of 21 species for the 11 subbasins on the Washington State side of the Lower Columbia Region, including the mainstem and estuary. In 2003, the Lower Columbia River Estuary Program (LCREP; now called the Lower Columbia River Estuary Partnership) entered into an agreement with Oregon to participate with the LCFRB in the co-development of a subbasin plan for the Columbia Estuary and Columbia Lower Subbasins. A Planning Group[1] was formed to guide this effort. The Planning Group added three additional species not contemplated by the LCFRB (i.e. river otter, osprey, and bald eagle). Table 2-4 depicts the selection of species for the estuary/mainstem subbasin assessment and their relationship to selection criteria.

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

Table 2-4. Species Selection and Planning Context.

Species	ESA	Ecological[1]	Cultural	Economic[2]	Recreation[3]
Species of Primary Interest (Focal Species)					
Fall Chinook	X	X	X	X	X
Chum	X	X	X	X	X
Spring Chinook	X	X	X	X	X
Winter Steelhead	X	X	X	X	X
Summer Steelhead	X	X	X	X	X
Coho	X	X	X	X	X
Pacific Lamprey	X	X	X		
Bald Eagle	X	X	X		
CWT Deer	X	X[4]	X		
Green Sturgeon		X	X		
White Sturgeon		X	X	X	X
Species of Ecological Significance					
N. Pikeminnow		X		X[8]	X
Shad		X[7]		X	X
River Otter		X[9]			
Eulachon		X	X	X	X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
Species of Management Interest					
Dusky Canada Goose				X[5]	
Sandhill Crane	X			X[5]	
Species of Recreational Significance					
Walleye		X[7]			X
Smallmouth Bass		X[7]			X
Channel Catfish		X[7]			X

1 May be positive or negative ecological impact; this column only indicates relative significance.

2 May be positive or negative economic impact; this column only indicates relative significance.

3Active recreation potential (e.g., harvest).

4 Likely ecologically important historically.

5 Seasonal crop damage.

6 Historically not present in estuary.

7 Non-native species.

8 Some economic importance for control program.

9 Indicator of ecosystem health.

10 Indicator of habitat type.

In the species selection process, it became evident that individual species were important to the subbasin planning process for different purposes and significance at the subbasin- and Columbia River Basin-scale. Some species, like summer steelhead, have basin-wide significance in terms of their legal, ecological, cultural, economic, and recreational significance. Other species, like the river otter, are of interest because of their value as an indicator of ecosystem health. Still others, like yellow warblers, are indicators of a specific habitat type.

The Planning Group decided to organize the list of species into broad categories that help convey the purpose and significance that individual species play in the planning process. All species will be addressed in the management plan and will have biological objectives and strategies developed for them, although the structure of the biological objectives and strategies may take different form due to inherent differences in their significance, ecological interactions, information available, and management structures in place.

Species of Primary Interest (Focal Species). This category of species will receive the highest level of attention and are considered the focal species for purposes of developing a subbasin plan that adheres to the standards of the Council. The ocean-type and stream-type salmonids play a major role in structure and content of the subbasin assessment because of their importance to all of the selection criteria, the absence of management plans in the estuary/mainstem, and the far-reaching implications of their life cycle requirements to various landscape-level processes and habitat conditions within and outside of the subbasins. Well developed recovery or management plans exist for bald eagle, CWT deer, pacific lamprey, and the green/white sturgeon. The plans augment this assessment and provide the basis for developing biological objectives and strategies for these species. The subbasin management plan will address the integration of the various species-specific management plans into a balanced approach for all focal species.

Species of Ecological Interest: This category of species is intended to inform subbasin planners on the general health of the estuary/mainstem in terms of quality of the environment, habitat diversity, or management issues. Each of these species will be addressed in the management plan. Native species include: Northern Pikeminnow, River Otter, eulachon, Caspian terns, Osprey, yellow warbler, and red-eyed vireo; non-native species include shad.

Species of Management Interest: This category of species is important from a management perspective and are indicative of a habitat type that is not represented elsewhere in the planning process (e.g., agricultural lands). Species include the Dusky Canada Goose and the Sandhill Crane (federally listed).

Species of Recreational Interest: This category of non-native species has recreational interest in the estuary/mainstem, as well as poorly understood ecological interactions with salmonids. They include walleye, smallmouth bass, and channel catfish.

Detailed descriptions of the biology and life history of each species are found elsewhere in the Technical Foundation (i.e. Volume I [for salmonids] or Volume III [for other species; except for river otter, bald eagle, and osprey, which were not part of the Technical Foundation]). The following sections are intended to briefly describe the life history of each focal species as it relates to potential use of lower Columbia River mainstem and estuary habitats.

2.2.2 Ocean-type Salmonids

Ocean-type salmonids represent the life history strategy that migrates downstream from the spawning area within days to months of emergence from the gravel. Early migrants may only be 30-40 mm fork length, while later migrants are usually larger, ranging from 50-80 mm fork length; subyearling migrants from the mid-Columbia and further up the basin tend to be considerably larger, ranging from 70-100 mm fork length (NMFS 2002). Ocean-type salmonid populations in the lower Columbia River include fall chinook and chum salmon. Ocean-type juvenile salmon commonly spend weeks to months rearing in the lower mainstem and estuary prior to reaching the requisite size for ocean entry and survival. Ocean-type salmon are oriented to low velocity, near-shore habitats; riparian/wetland areas in the mainstem and tidal marsh habitats in the estuary that are connected to the lower river (i.e. access not blocked via dikes) provide essential cover and feeding requirements of ocean-type juvenile salmon (Simenstad and Cordell 2000 as cited in USACE 2001, Bottom et al. 2001). They are often associated with substrates consisting of fines and sands, although this may be an artifact of the low velocity preference rather than a partiality for fine-grained substrates. As fish grow, ocean-type juvenile salmon utilize other habitat types (e.g. water column habitat) and are not as strongly associated with near-shore habitats.

2.2.2.1 Fall Chinook

Chinook salmon (*Oncorhynchus tshawytscha*) are the largest and most diverse of the Pacific salmon. Two runs of fall chinook return to Washington lower Columbia River tributaries: “tule” fall chinook, and “bright” late fall chinook. Tule fall chinook return from August through November to spawn almost immediately, typically in large tributary mainstems. Fall chinook have ocean-type life histories where juveniles gradually migrate downstream as subyearlings during their first spring and summer. Most tule fall chinook adults return after 2 to 3 years in the ocean where they range along the coasts of Washington, Oregon, and British Columbia. Bright late fall chinook return from August through October and spawn November through January. Life history is otherwise similar to tule fall chinook except the lower river bright fall run migrates farther north, and may spend up to 4 years in the ocean before returning.

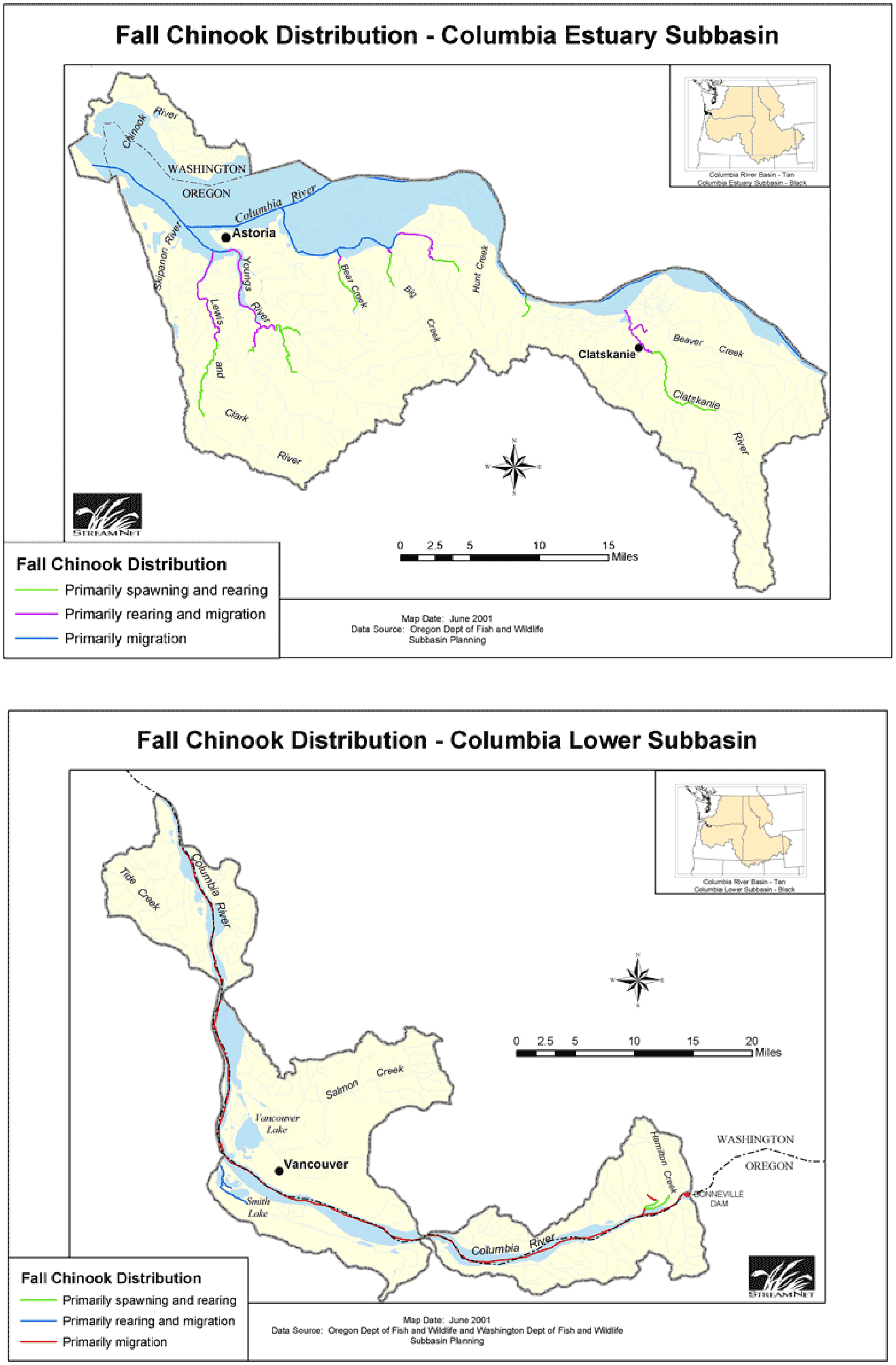
Lower Columbia River chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries. Tule fall chinook were widely distributed while bright fall chinook were limited to the Lewis River, and perhaps the mainstem Columbia near the present Bonneville Dam site. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of chinook salmon in the Columbia River ESU. Washington accounts for 13 of 20 tule fall and 1 of 2 late fall chinook populations in this ESU; the other chinook populations originate in Oregon waters. All Washington lower Columbia chinook populations are below proposed recovery targets with the possible exceptions of Lewis late fall, Coweeman fall, and East Fork Lewis fall population. Current runs of tule fall chinook are dominated by hatchery-produced fish.

Fall chinook exhibit some variability in their timing of migration to the estuary. Some fall chinook fry migrate to the ocean soon after yolk resorption at 30-45 mm in length (Lister et al. 1971, Healey 1991). In most river systems, however, fry migrate at 60–150 days post-hatching or as fingerling in the late summer or autumn of their first year. When environmental conditions are not conducive to subyearling emigration, ocean-type chinook salmon may remain in fresh water for their entire first year.

In the Columbia River estuary, subyearling chinook salmon were captured in every month of the year and were distributed throughout freshwater, estuarine, and marine regions (Bottom et al. 1984). Reimers (1973), working in the Sixes River, Oregon, suggested that estuarine rearing is critical to fall chinook survival. Subyearling chinook were one of the most abundant species collected in the Columbia River estuary; Bottom et al. (1984) suggested that subyearling chinook abundance was partially related to their slow migration through the estuary (i.e. subyearling chinook were available for long periods of time in a variety of estuarine habitats). For example, subyearling chinook tagged and released in April and May were captured in the estuary through October (Bottom et al. 1984). Subyearling chinook moved through the estuary slower than other salmonids; in fact, migration rate appeared to decrease for about half the hatchery groups when they entered the estuary (Bottom et al. 1984). Generally, juvenile hatchery subyearling chinook released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984). Subyearling chinook abundance was highest in the spring and summer months; during spring and summer, subyearling chinook were most frequently associated with water column and nearshore habitats while in the winter, they were more frequently associated with nearshore, shoals, and bay habitats (Bottom et al. 1984). Subyearling chinook represented 68% of the total catch of juvenile salmonids in the estuary (Bottom et al. 1984).

Diet of juvenile fall chinook varies considerably based on fish size and location in the river, estuary, and nearshore habitats (see Craddock et al. 1976, McConnell et al. 1978, Levy and Northcote 1982, McCabe et al. 1983, Bottom et al. 1984, Dawley et al. 1986, McCabe et al. 1986, Bottom and Jones 1990, Sherwood et al. 1990, Brodeur 1992, Miller and Simenstad 1997, Simenstad and Cordell 2000). For young chinook in the lower mainstem, Craddock et al. (1976) determined that diptera were the primary prey species during the winter and spring while zooplankton (primarily *Daphnia*) were the major prey item from July to October; similarly, Bottom et al. (1984) and Bottom and Jones (1990) reported that young chinook in the estuary primarily ate amphipods (*Corophium*), cladocerans (*Daphnia*), and diptera, with *Corophium* dominant in winter and spring and *Daphnia* dominant in summer.

Adult fall chinook primarily use the Columbia River estuary and lower mainstem as a migratory route to spawning areas (Figure 2-6). There is evidence of fall chinook spawning and subsequent rearing in Oregon tributaries in the estuary region and in Washington tributaries in the tidal freshwater region near Bonneville Dam (Figure 2-6). Recent spawning surveys indicate fall chinook spawning in the Columbia River mainstem below Bonneville Dam; however, these fish are expected to be hatchery strays and the National Marine Fisheries Service (NMFS) does not consider them to be part of the lower Columbia River fall chinook ESU. (For more information regarding the fall chinook life cycle, refer to the Technical Foundation, Volume I, section 3.2)


Fall Chinook Distribution - Columbia Estuary Subbasin

Map Date: June 2001
Data Source: Oregon Dept of Fish and Wildlife
Subbasin Planning

Fall Chinook Distribution - Columbia Lower Subbasin

Map Date: June 2001
Data Source: Oregon Dept of Fish and Wildlife and Washington Dept of Fish and Wildlife
Subbasin Planning

Figure 2-6. Adult fall chinook distribution in the Columbia Estuary and Columbia Lower

Subbasins.

2.2.2.2 Chum Salmon

Chum salmon (*Oncorhynchus keta*) return during fall (generally October/November) to spawn in the lowermost reaches of the Columbia River tributaries often just above tidewater. Chum fry migrate downstream almost immediately after emergence and spend most of their life in the estuary or ocean. Runs of over 1 million chum are believed to have once returned to the Columbia River. Annual runs now average 4,000 fish, about 3% of the historical run size. All naturally produced chum populations in the Columbia River and its tributaries in Oregon and Washington were listed as threatened in August 1999.

Chum salmon once migrated as far upstream as the Walla Walla River. Today, production is generally limited to areas downstream of Bonneville Dam, including Grays River, Hardy Creek, and Hamilton Creek, and in the mainstem Columbia River near Ives Island. The latter three populations are located immediately downstream of Bonneville Dam. The Willamette/Lower Columbia Technical Recovery Team has identified 16 historical populations of chum salmon in the Columbia River ESU. Of these, eight occur only in Washington, six occur only in Oregon, and two are shared between states. Chum populations have been largely extirpated for 14 of 16 historical populations. Significant populations exist only in the Grays River and the lower Columbia River Gorge tributaries and mainstem. All chum populations are below the lower bound of proposed recovery planning targets with the possible exception of the lower Gorge population.

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 (Mazer and Shepard 1962, Bakkala 1970, Mathews and Senn 1975, Fraser et al. 1978, Peterman 1978, Sakuramoto and Yamada 1980, Martin et al. 1986, Healey 1982, Bax 1983, Salo 1991).

Chum fry generally emigrate shortly after emergence; several factors influence the timing of downstream migration, including time of adult spawning, stream temperatures during egg incubation and after hatching, fry size and nutritional condition, population density, food availability, stream discharge volume and turbidity, physiological changes in the fry, tidal cycles, and day length (Simenstad et al. 1982, Salo 1991). In Washington, chum may reside in fresh water for as long as a month (Salo and Noble 1953, Bostick 1955, Beall 1972).

In the Columbia River estuary, juvenile chum salmon were a minor portion of the catch during sampling efforts of Bottom et al. (1984); chum, sockeye, and cutthroat collectively represented 1% of the total juvenile salmonid catch. Chum salmon juveniles were captured in the estuary during April and May during both years of the study; chum salmon were present in the estuary from February through June (Bottom et al. 1984). Juvenile chum salmon were primarily distributed within the freshwater or estuarine regions of the estuary, although there was one occurrence in the marine region (Bottom et al. 1984).

Diet varies considerably based on fish size and location in the river, estuary, and nearshore habitats (see Craddock et al. 1976, McConnell et al. 1978, Levy and Northcote 1982, McCabe et al. 1983, Bottom et al. 1984, Dawley et al. 1986, McCabe et al. 1986, Bottom and Jones 1990, Sherwood et al. 1990, Brodeur 1992, Miller and Simenstad 1997, Simenstad and Cordell 2000).

Chum salmon adults utilize the Columbia River estuary and lower mainstem for migration to spawning areas. Chum salmon are known to spawn in Washington tributaries associated with the Columbia Estuary and Columbia Lower Subbasins, such as the Chinook River or Hamilton Creek (Figure 2-7). Further, spawning and outmigration surveys have documented successful chum spawning in the lower mainstem Columbia River below Bonneville Dam along the north bank near the I-205 bridge. (For more information regarding the chum salmon life cycle, refer to the Technical Foundation, Volume I, section 3.1.)

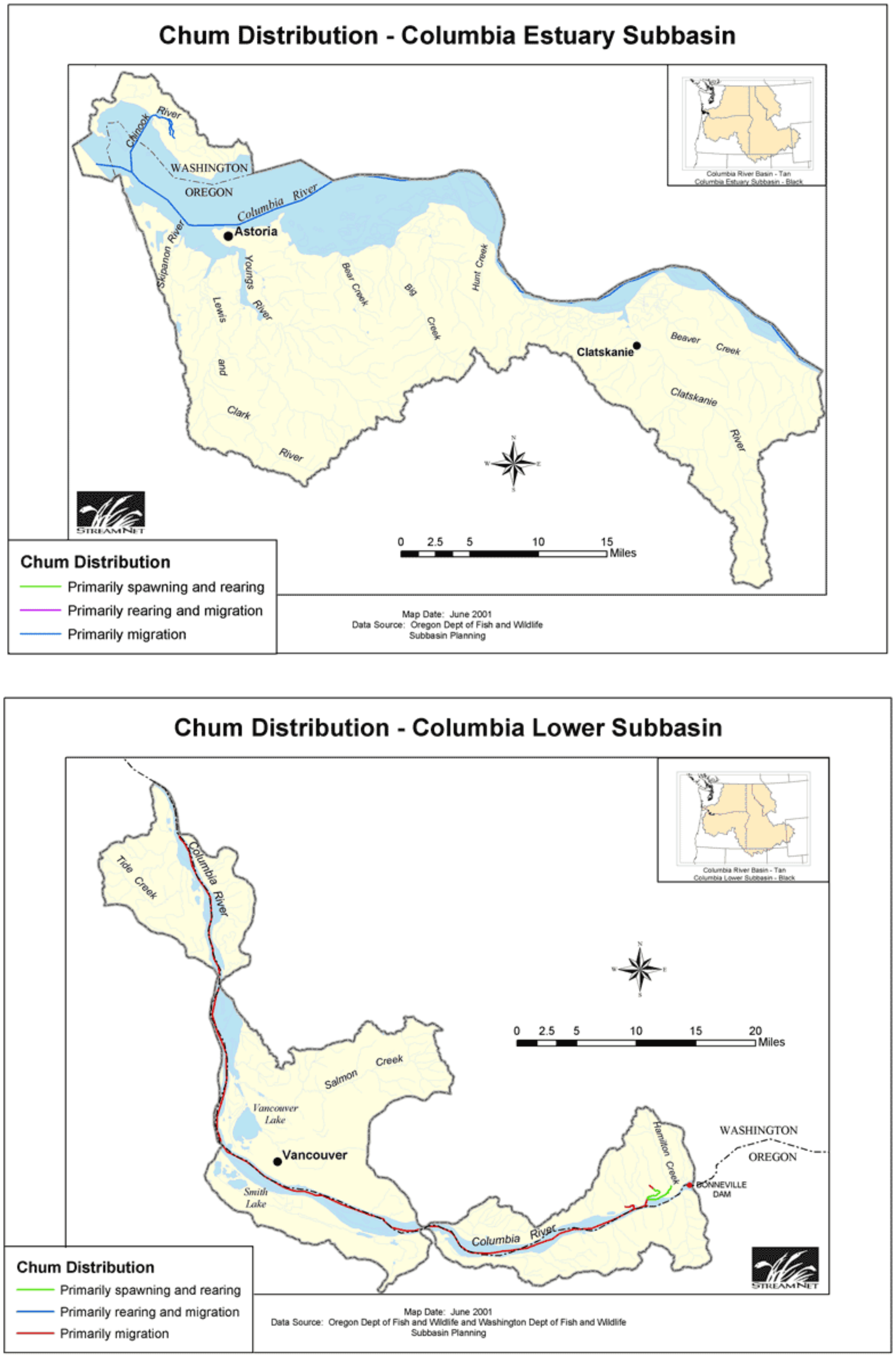


Figure 2-7. Adult chum salmon distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.2.3 Stream-Type Salmonids

Stream-type salmonids represent the life history strategy that rear within the natal stream for months or years after emergence from the gravel and outmigrate during their second year of life. In general, stream-type juvenile salmon reach the lower mainstem and estuary at a relatively large size (> 80mm) and commonly spend less time than ocean-type salmonids rearing in the lower mainstem and estuary. Stream-type juvenile salmonids actively migrate through the lower Columbia River mainstem and estuary. Stream-type salmon are oriented to water column habitats and are typically found throughout the near surface water column (i.e. top 6 m); they tend to avoid low-velocity areas and are not associated with any specific substrate type. Stream-type salmonid populations in the lower Columbia River include spring chinook, winter steelhead, summer steelhead, and coho salmon.

Yearling salmonids have been documented eating the same types of organisms as subyearlings, although the composition and specific diet items likely differs. For example, Bottom et al. (1984) noted that adult *Diptera* and *Corophium spp*. were major prey items of both yearling and subyearling chinook; however, *Diptera* accounted for about 55% of yearling chinook diet while it accounted for about 8% of the diet of subyearling chinook. In the lower Columbia River and estuary, Dawley et al. (1986) and Bottom and Jones (1990) observed yearlings salmonids consuming diptera, cladocerans, and amphipods.

2.2.3.1 Spring Chinook

Chinook salmon (*Oncorhynchus tshawytscha*) are the largest and most diverse of the Pacific salmon. Spring chinook typically return to freshwater in March and April and migrate into small headwater streams to spawn in late summer. Spring chinook exhibit a stream-type life history where juveniles rear in tributary streams for one year before rapidly migrating downstream on the spring freshet. Most adults return after 2 to 4 years in the ocean where they migrate far to the north off Canada and Alaska.

Lower Columbia River chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries; spring chinook were present in the larger Cascade subbasins. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of chinook salmon in the Columbia River ESU. Washington accounts for 7 of 9 spring chinook populations in this ESU; the other chinook populations originate in Oregon waters. All Washington lower Columbia spring chinook populations are below proposed recovery targets. Current runs of spring chinook are dominated by hatchery-produced fish.

Yearling chinook salmon were present in the estuary most months of the year and were distributed throughout the freshwater, estuarine, and marine regions (Bottom et al. 1984). Yearling chinook abundance was highest in April and May and was relatively low for most other months; they represented 8% of the catch of juvenile salmonids (Bottom et al. 1984). Yearling chinook were most frequently associated with water column and nearshore habitats; they were most susceptible to purse seine harvest in main channel sampling stations, indicating an affinity to water column habitat (Bottom et al. 1984). Yearling chinook migrated through the estuary faster than subyearlings but slower than steelhead (Bottom et al. 1984). More than half of the hatchery groups of yearling chinook appeared to decrease their migration rate through the estuary, however, only about a third increased in mean fork length (Bottom et al. 1984). As with other salmonids, juvenile hatchery yearling chinook released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

Adult spring chinook utilize the estuary and lower mainstem primarily as a migration route to spawning locations. There is no evidence of spring chinook spawning in the lower mainstem or in tributaries of the Columbia Estuary and Columbia Lower subbasins (Figure 2-8). (For more information regarding the spring chinook life cycle, refer to the Technical Foundation, Volume I, section 3.2.)

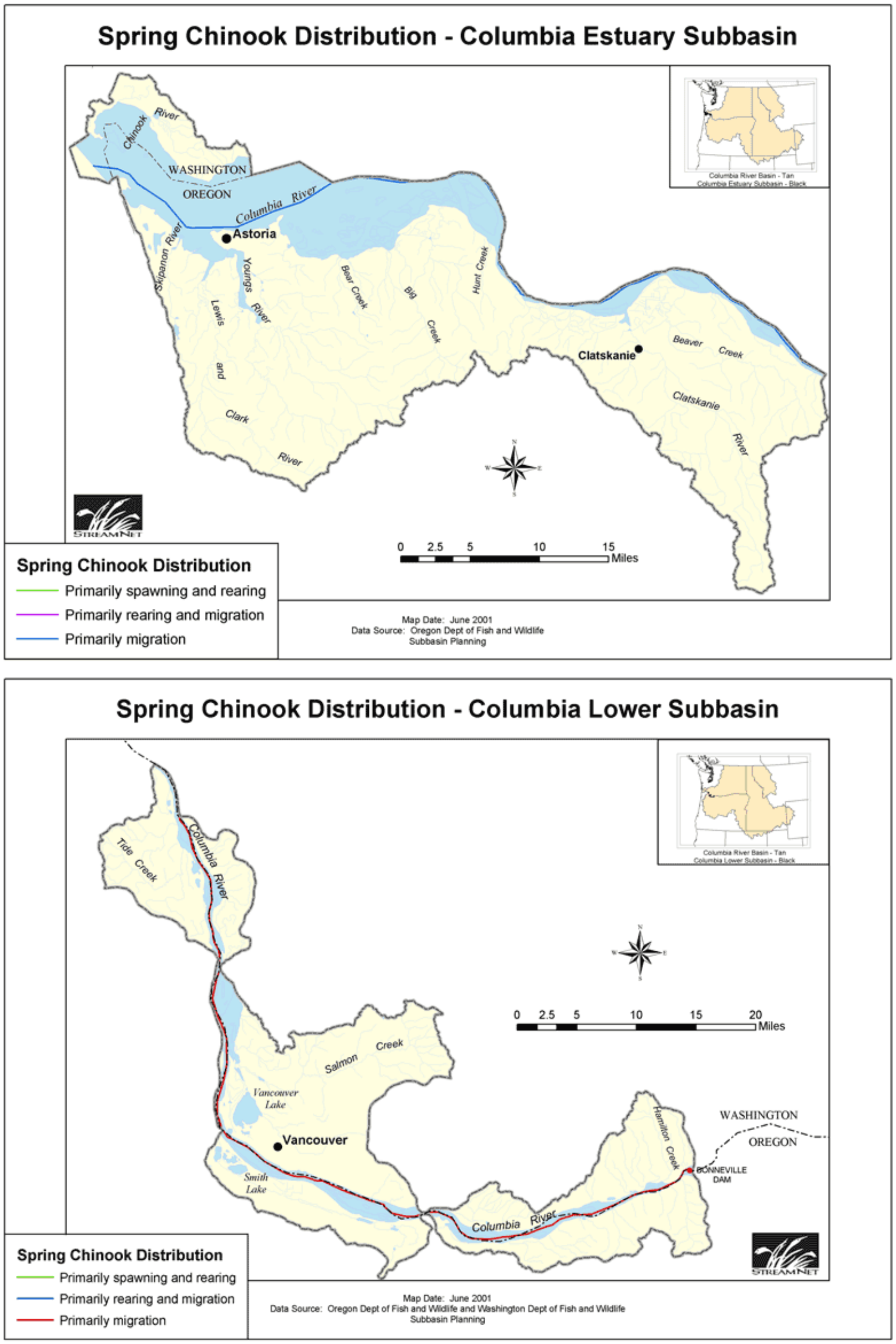


Figure 2-8. Adult spring chinook distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.2.3.2 Steelhead

Steelhead (*Oncorhynchus mykiss*) are rainbow trout that migrate to and from the ocean. Resident and anadromous life histories are often found in the same population. Steelhead exhibit tremendous variability in life history with juveniles rearing for 1 to 4 years in freshwater before migrating seaward and as adults spending 1 to 3 years in the ocean. Steelhead generally migrate northward along the coast of Canada and Alaska before dispersing far out into the North Pacific.

Lower Columbia River steelhead are listed as threatened under the ESA. The Willamette/Lower Columbia Technical Recovery Team has identified 23 historical populations of steelhead in the Columbia River ESU. Washington accounts for 14 of 17 winter run steelhead and 5 of 6 summer run steelhead populations in this ESU. Three additional winter run populations of the unlisted Washington Coast ESU occur in lower Columbia subbasins included in this planning process. Small but significant steelhead populations remain in most Washington subbasins where they were historically present. All Washington lower Columbia winter steelhead populations are below proposed recovery planning targets with the possible exception of the Kalama winter steelhead population. All Washington lower Columbia summer steelhead populations are below proposed recovery planning targets with the possible exception of the Wind summer population.

Steelhead in the Columbia River estuary consumed a relatively even proportion of *Corophium salmonis* (amphipod), *Corbicula manilensis* (bivalve), and adult *Diptera* (Bottom et al. 1984).

Juvenile steelhead were present in the Columbia River estuary from February to July of each year of sampling by Bottom et al. (1984); steelhead abundance was greatest in May and relatively low for other months (Bottom et al. 1984). Juvenile steelhead constituted 5% of the total juvenile salmonid catch (Bottom et al. 1984). Steelhead juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary; they were most frequently associated with water column habitats (Bottom et al. 1984). Juvenile steelhead moved through the estuary more rapidly than other salmonids; based on catch data, they were present in the estuary for the shortest duration of any of the salmonid group (Bottom et al. 1984). Winter steelhead have been found to migrate at an average rate of 3.3 km/hr, traveling 134-143 km in 32 to 90 hours (Durkin 1982, Dawley et al. 1986 as cited in USACE 2001). Migration rate of many hatchery groups of juvenile steelhead increased through the estuary (Bottom et al. 1984). As with other salmonids, juvenile hatchery steelhead released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

2.2.3.2.1 Winter Steelhead

Winter steelhead return to fresh water between December and May and generally spawn in late April and early May. Winter steelhead returned to the Cowlitz, Kalama, NF and EF Lewis, Washougal, and Wind. Where winter and summer runs occur in the same stream, winter steelhead tend to spawn lower in the watershed than summer steelhead.

Adult winter steelhead use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, winter steelhead are known to spawn and rear in numerous small tributaries associated with the Columbia Estuary and Columbia Lower Subbasins (Figure 2-9). (For more information regarding the winter steelhead life cycle, refer to the Technical Foundation, Volume I, section 3.4.)

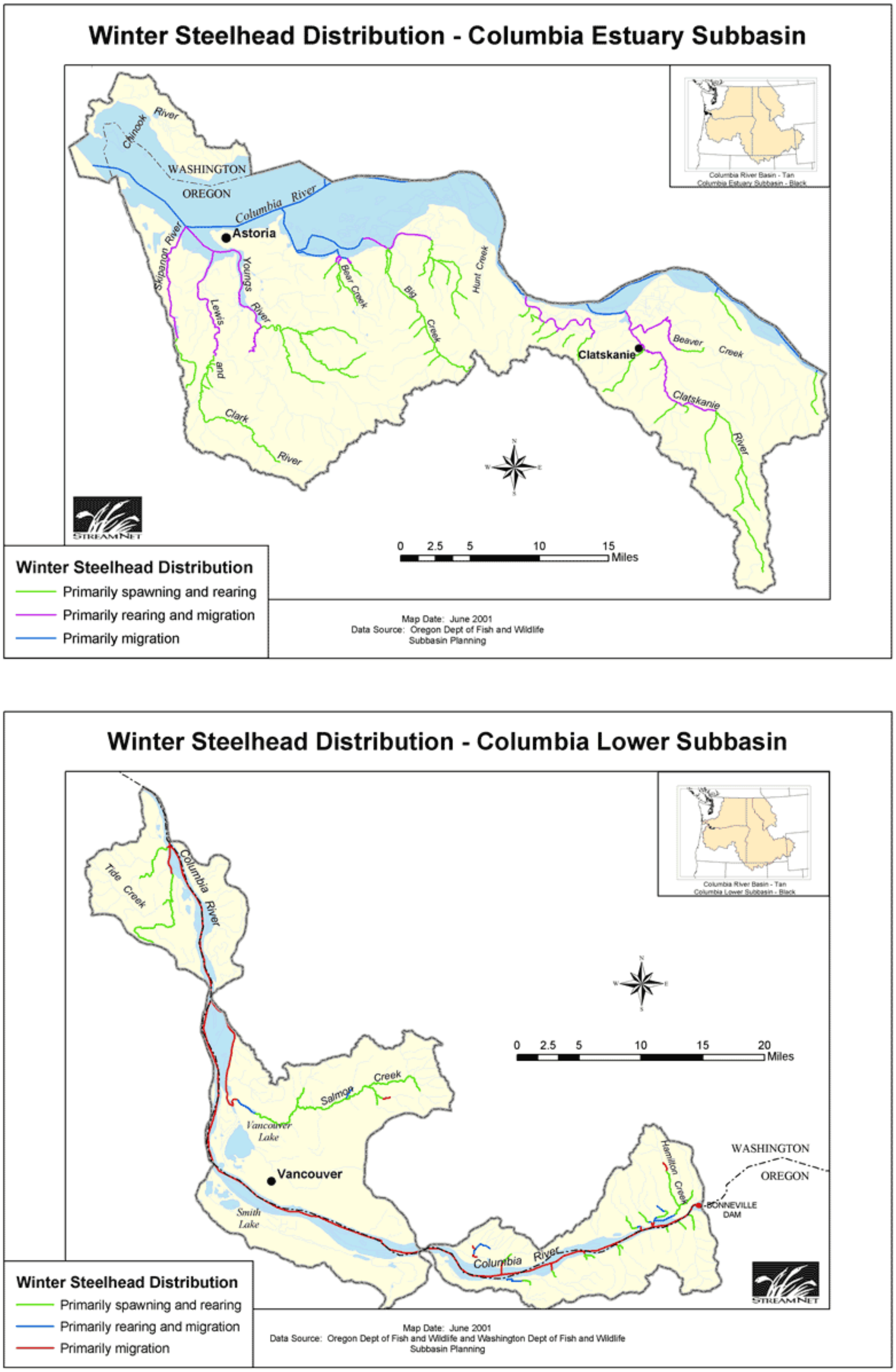


Figure 2-9. Adult winter steelhead distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.2.3.2.2 Summer Steelhead

Summer steelhead return from the ocean between May and October and generally spawn between late February and early April. Watersheds that historically supported summer steelhead included the Kalama, North Fork Lewis, East Fork Lewis, Washougal, and Wind. Where summer and winter runs occur in the same stream, summer steelhead tend to spawn higher in the watershed than winter steelhead.

Adult summer steelhead use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, there is evidence of summer steelhead spawning and rearing in small Oregon tributaries associated with the Columbia Lower Subbasin (Figure 2-10). (For more information regarding the summer steelhead life cycle, refer to the Technical Foundation, Volume I, section 3.4.)

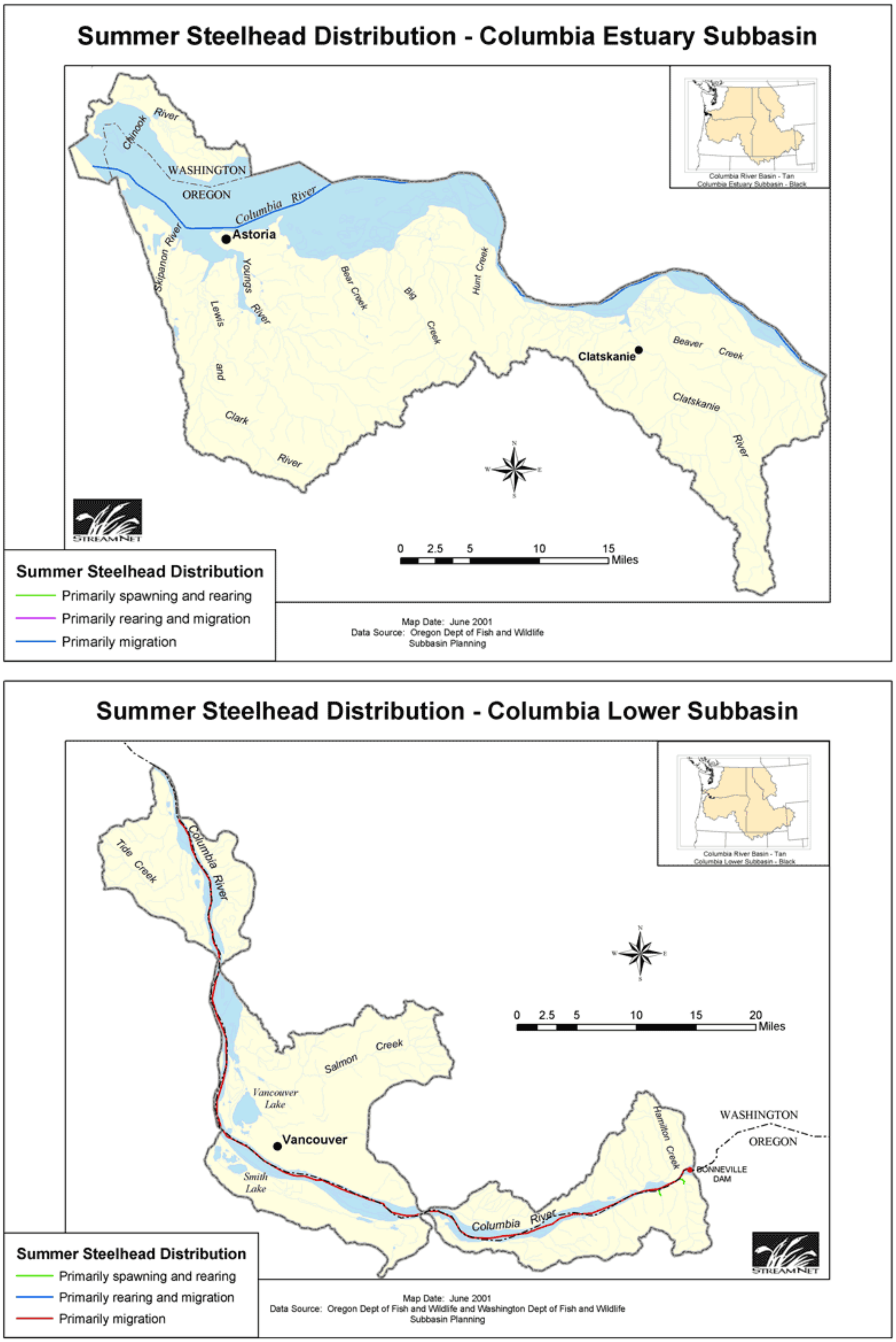


Figure 2-10. Adult summer steelhead distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.2.3.3 Coho Salmon

Coho (Oncorhynchus kisutch) salmon spawn during fall in small streams with the onset of spawning typically tied to fall freshets in September and October. Coho adults are almost entirely 3-year olds although a few jacks return at age 2. Juvenile coho rear in freshwater for one year prior to migration during spring. Lower Columbia River coho runs include early and late returning stocks. Most early-run fish migrate south to mature in coastal Oregon waters. Most late-run coho migrate north into Washington coastal waters.

Coho are currently a candidate for listing under the ESA. Coho salmon historically returned to spawn in all accessible tributary reaches in the lower Columbia River basin. Today, coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. Past fishery impacts were excessive for coho, however, current fishing impacts are relatively low as a result of implementation of selective fisheries. Tributary hydropower development has blocked significant coho habitat in the Cowlitz and Lewis basins. Current stream habitat conditions severely limit coho production.

Recent numbers of natural coho spawners are generally unknown although most wild populations are thought to have been extirpated or consist of no more than a few hundred fish. Approximately 13 Washington lower Columbia River subbasins were historically used by coho salmon according to the NOAA Fisheries status review and Washington's salmon stock inventory. Recovery targets have not yet been proposed for coho because of incomplete habitat and status information on which they could be based.

Most juvenile coho, in the region south of central British Columbia, migrate seaward as smolts in late spring, typically during their second year. Factors that tend to affect the time of migration include: the size of the fish, flow conditions, water temperature, dissolved oxygen levels, day length, and the availability of food (Shapovalov and Taft 1954). The size of coho smolts is fairly consistent over the species' geographic range; a FL of 100 mm seems to be the threshold for smoltification (Gribanov 1948).

Juvenile coho salmon were present in the Columbia River estuary from March to August of each year of sampling by Bottom et al. (1984); coho abundance was greatest in May and June and relatively low for other months (Bottom et al. 1984). Juvenile coho salmon comprised 18% of the total juvenile salmonid catch (Bottom et al. 1984). Coho juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary; they were most frequently associated with water column habitats, however, tagged hatchery coho released in the lower Columbia (i.e. Grays River (rm 34) and Big Creek (rm 29)) were more likely to be found in shallow bays and intertidal areas than upriver coho (Bottom et al. 1984). Juvenile coho salmon moved through the estuary relatively quickly and appeared to increase their migration rate through the estuary (Bottom et al. 1984). As with other salmonids, juvenile hatchery coho released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

The most common prey items of coho salmon in the Columbia River estuary were *Corophium salmonis* and *Corophium spinicorne* (amphipods) and adult *Diptera*; *Corophium salmonis* constituted over half of the coho diet (Bottom et al. 1984).

Adult coho salmon use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, coho salmon are known to spawn and rear in numerous small tributaries associated with the Columbia Estuary and Columbia Lower Subbasins (Figure 2-11).

(For more information regarding the coho salmon life cycle, refer to the Technical Foundation, Volume I, section 3.3.)

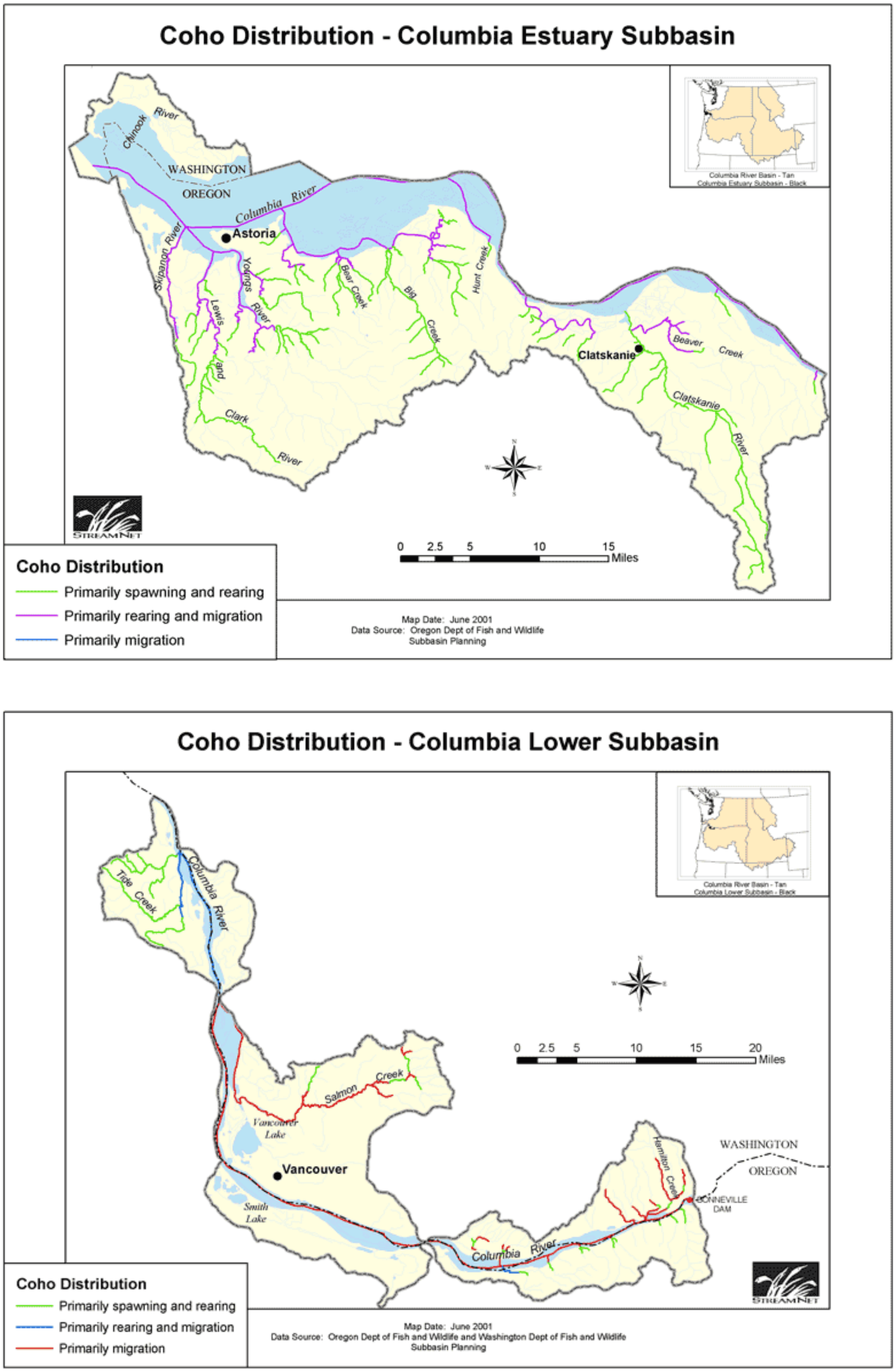


Figure 2-11. Adult coho salmon distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.2.4 Pacific Lamprey

Pacific lamprey (*Lampetra tridentata*) are a native anadromous inhabitant of Pacific Northwest rivers including the Columbia. Lamprey spawn in small tributaries, historically as far upstream as Idaho and British Columbia, and die after spawning. Young lamprey, called ammocoetes, are algae filter feeders that burrow in sandy stream margins and side channels for up to 6 years before downstream migration. Adults are predators that feed only in the ocean and attach themselves to their prey with suction mouths.

Lamprey were historically an important food source for native peoples and a significant component of the Columbia River ecosystem. Spawning adults are a source of marine-derived nutrients in the freshwater and an important prey item for sturgeon and marine mammals. In fresh water, at least 7 aquatic and five avian species prey on juvenile lamprey. 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. Although adult lamprey can negotiate waterfalls, they apparently have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile passage systems.

Adult Pacific lamprey entry into freshwater can vary from February (Kan 1975) to September (Beamish 1980, Scott and Crossman 1973). Habitat utilization of the lower Columbia River mainstem and estuary by adult lampreys is not known; likely, the lower Columbia River serves primarily as a migration corridor. Further, similar to most adult salmonids, lamprey feeding ceases during upstream migrations (Scott and Crossman 1973). The first juvenile life stage of lampreys, ammocoetes, burrow into sand and silt substrates after hatching where they filter feed on algae (Scott and Crossman 1973, Kostow 2002). Ammocoetes spend approximately 6 years rearing in freshwater; rearing begins downstream of the nest and, as ammocoetes grow, they gradually move downstream, generally at night, continuing to burrow and filter feed in fine substrates (Scott and Crossman 1973, Kostow 2002, Claire 2003). Because of this burrowing activity, ammocoetes may be an indicator of water quality or contaminants (Gustavo Bisbal, USFWS, personal communication). Older ammocoetes generally occupy the lower portions of river basins, and thus, may be found throughout the tidal freshwater portion of the lower Columbia. Pacific lamprey ammocoetes metamorphose into macrothalmia (physiological equivalent of a smolt) and begin the seaward migration; during this transformation, Pacific lamprey survive on lipid reserves and do not feed (Kostow 2002).

In the Columbia River estuary, juvenile Pacific lamprey were present from December to June; Pacific lamprey abundance was highest in December and was extremely low for the remainder of the year (Bottom et al. 1984). Juvenile Pacific lamprey abundance in the Columbia River estuary is relatively low compared to most other species captured (Bottom et al. 1984). Pacific lamprey juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary, however, presence in the marine region was limited. In an analysis of estuary feeding groups, juvenile Pacific lamprey were grouped with white sturgeon, however, no data were collected regarding lamprey diet composition. This is consistent with the life history data presented above that indicates Pacific lamprey do not feed during their downstream migration to saltwater. Pacific lamprey life history data suggests use of Columbia River estuarine habitats is limited. (For more information regarding the Pacific lamprey life cycle, refer to the Technical Foundation, Volume III, section 2.0.)

2.2.5 Sturgeon

2.2.5.1 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. Large sizes (over 12 feet and 1000 pounds) and long life spans (100 years or more) allow them to negotiate heavy current and outlast good and bad periods. These fish are bottom-oriented feeders that eat primarily shrimp and clams as young but graduate to a live fish diet as they get larger.

Sturgeon are an ancient order of fishes that have existed for hundreds of millions of years. Sturgeon species are found in most major river systems of the Northern Hemisphere but have been widely decimated by over fishing and dam construction. Their long lifespan and late age of maturity make sturgeon particularly susceptible to over fishing. Columbia River white sturgeon were severely over fished during the late 1800's prior to the adoption of significant fishery restrictions and recovery required decades. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey. Sturgeon rarely use fish ladders which were engineered to pass the more surface-oriented salmon.

White sturgeon historically ranged all the way to the Canadian headwaters of the Columbia River and to Shoshone Falls in the upper Snake River. 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).

White sturgeon move freely between fresh and saltwater environments (DeVore et al. 1999); as a result, individual white sturgeon in the Columbia River below Bonneville Dam may exhibit any number of life history strategies (Bemis and Kynard 1997, Kynard 1997). Movements of adult white sturgeon in freshwater vary considerably and appear to be a function of access and seasonal food availability (Beamesderfer et al. 1995). In the lower Columbia River, DeVore and Grimes (1993) reported that adults often migrated upstream during the fall, downstream during spring, and congregated at the Columbia River estuary during summer, presumably in relation to food availability, with such movements exceeding 62 miles (100 km). DeVore et al. (1999) reported of 471 white sturgeon were originally tagged in the unimpounded lower Columbia River downstream from Bonneville Dam, sturgeon were recaptured in 23 separate locations outside the Columbia River Basin from the Fraser River, B.C., to the Sacramento River, CA, from 1976–97. Thus, adult white sturgeon may be found anytime throughout the lower Columbia River mainstem and estuary; extensive seasonal use of the estuary during summer is likely. White sturgeon often concentrate in deep water habitats, but are known to freely feed in a wide range of habitats throughout its range.

White sturgeon are communal, broadcast spawners (Wang et al. 1985; Conte et al. 1988; Paragamian et al. 2001, and references therein) that generally spawn in high velocity areas associated with gravel and larger substrates (Wydowski and Whitney 1979; Simpson and Wallace 1981; RL&L 1994, 1996; Perrin et al. 1999; Parsley et al. 2002; Paragamian et al. 2001; Golder Associates 2003, IPC 2003). Hard-bottom, high-velocity, structured habitats with adequate interstitial space are critical as spawning and incubation substrate and predation refuge areas for broadcast-spawning white sturgeon (Parsley et al. 1993; Perrin et al. 1999; Parsley et al. 2002; Secor et al. 2002). In the lower Columbia River mainstem, white sturgeon are known to spawn in the free-flowing reach of the Columbia River Gorge below Bonneville Dam. Adhesive embryos settle to the substrate; white sturgeon larvae remain in the substrate until the yolk is absorbed (Brannon et al. 1985). White sturgeon that burrow into fine sediments commonly die as a result of suffocation. The larval swim-up dispersal stage of white sturgeon enter the water column and are subject to the influences of current (Brannon et al. 1985). Larvae seek substrates that provide cover and remain associated with these substrate until the yolk is absorbed and feeding is initiated (Brannon et al. 1985). Larvae begin exogenous feeding and metamorphose into juveniles at about 3-4 months after fertilization (Parsley et al. 2002). Juveniles feed on a variety of prey items, including chironomid larvae, amphipods, and mysis shrimp (Scott and Crossman 1973, Wydowski and Whitney 1979, Sprague et al. 1993). Thus, juvenile white sturgeon may also be found anytime throughout the lower Columbia River mainstem and estuary in a variety of different habitats.

In the Columbia River estuary, white sturgeon were part of a large group of benthic and epibenthic feeders present during the summer (Bottom et al. 1984). *Corophium salmonis* (amphipod) comprised the majority of the white sturgeon diet; other important diet items included *Neomysis mercedis* and *Macoma balthica* (Bottom et al. 1984).

In the Columbia River estuary, white sturgeon were captured all months of the year during sampling efforts by Bottom et al. (1984); catch was twice as high in the summer compared to the rest of the year. Although, white sturgeon catch was relatively low compared to other species present in the estuary (Bottom et al. 1984). White sturgeon distribution was limited to the freshwater and estuarine regions of the estuary; white sturgeon were not captured in the marine region of the estuary (Bottom et al. 1984). In the spring, white sturgeon were most frequently associated with channel bottom habitats in the freshwater region of the estuary; in the summer, white sturgeon were most frequently associated with water column and channel bottom habitats in the freshwater and estuarine regions of the estuary. (For more information regarding the white sturgeon life cycle, refer to the Technical Foundation, Volume III, section 1.0.)

2.2.5.2 Green Sturgeon

Green sturgeon (*Acipenser medirostris*) occur in the lower Columbia River but do not typically range far upstream from the estuary. NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted.

Green sturgeon is an anadromous species that spawn in several West Coast rivers but spend most of their life in near-shore marine and estuarine waters from Mexico to southeast Alaska (Houston 1988; Moyle et al. 1995). While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. Reasons for concentrations in the Columbia River are unclear; no spawning occurs in the system and all of the green sturgeon stomachs examined to date have been empty. These fish may be seeking warmer summer river waters in the northern part of their range.

Adult green sturgeon typically migrate into fresh water beginning in late February (Moyle et al. 1995). Spawning occurs in deep turbulent river mainstems. Klamath and Rogue River populations appear to spawn within 100 miles of the ocean, while the Sacramento spawning run may travel over 200 miles. Spawning occurs from March–July, with peak activity from April–June (Moyle et al. 1995).

Specific spawning habitat preferences are unclear, but eggs likely are broadcast over large cobble where they settle into the cracks (Moyle et al. 1995). The adhesiveness of green sturgeon eggs is poor compared to white sturgeon (Van Eenennaam et al. 2001), which may be explained by the reduced thickness of the outer layer of the chorion of green sturgeon eggs (approximately half the thickness of that in white sturgeon; Deng et al. 2002). Optimum flow and temperature requirements for spawning and incubation are unclear, but spawning success in most sturgeons is related to these factors (Dettlaff et al. 1993). Temperatures above 68°F (20ºC) were lethal to embryos in laboratory experiments (Cech et al. 2000).

Green sturgeon larvae are distinguished from other sturgeon by the absence of a swim-up or post-hatching pelagic stage. They can be distinguished from white sturgeon by their size (longer and larger), light pigmentation, and size and shape of the yolk-sac (Deng et al. 2002). Larvae hatched in the laboratory are photonegative, exhibiting hiding behavior (Deng et al. 2002), and after the onset of exogenous feeding, green sturgeon larvae and juveniles appear to be nocturnal (Cech et al. 2000). This development pattern and behavior may be an adaptation suited for avoiding downstream displacement. Juveniles appear to spend up from 1–4 years in fresh and estuarine waters and disperse into salt water at lengths of 1-2.5 feet. Green sturgeon are benthic feeders on invertebrates including shrimp and amphipods, small fish, and possibly mollusks (Houston 1988).

Time series data on green sturgeon abundance and size composition are limited to fishery landing statistics; these do not provide a consistent index of green sturgeon abundance. Columbia River harvest per unit effort and size composition data suggest an increasing rather than decreasing trend in green sturgeon abundance. Current data indicate that: green sturgeon still spawn in most systems where they were historically present, significant numbers of spawners are present in several systems, and geographic range of spawning green sturgeon is currently stable or increasing. The wide distribution of green sturgeon, large numbers seasonally observed in some areas, and projections based on demographic rates suggest that total green sturgeon numbers are at least in the tens of thousands.

2.2.6 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. This opportunistic species has flourished with habitat changes in the mainstem Columbia River and its tributaries. Pikeminnow are of particular interest for their predation on juvenile salmon. 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 where 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. A bounty fishery program for recreational anglers is aimed at balancing pikeminnow numbers rather than eliminating the species and has also stimulated development of a popular fishery.

Northern pikeminnow are large (10-20 inches), long-lived (10-15 years), slow-growing predaceous minnows (Cyprinidae). Northern pikeminnow have successfully evolved in a range of dynamic lentic and lotic ecosystems and successfully adapted to their varied habitat conditions; they are considered opportunistic generalists that inhabit slow to moderately flowing streams and lakes. Based on known distribution and habitat usage, all life stages of northern pikeminnow may be found in many habitat types throughout the lower Columbia River mainstem; however, usage of estuarine habitats is minimal because of low salinity tolerance. This is consistent with data collected by Bottom et al. (1984). Northern pikeminnow distribution was limited to the freshwater region of the estuary; pikeminnow were not captured in the marine or estuarine regions of the estuary. Northern pikeminnow were present in the freshwater region of the estuary from June to October; pikeminnow abundance in the estuary was very low relative to other species captured (Bottom et al. 1984).

Beamesderfer (1992) attributed the widespread distribution and resiliency of northern pikeminnow to their relatively broad spawning and rearing habitat requirements. In the Columbia River downstream from its confluence with the Snake River, northern pikeminnow abundance is highest in the approximately 186 miles (300 km) from the estuary to the Dalles Dam (2,580-3,020 fish/km) and decreases significantly in the 100 miles (161 km) from the Dalles Dam to McNary Reservoir (550-690 fish/km; Beamesderfer et al. 1996). Spawning generally occurs during June and July in large aggregations that broadcast eggs over clean rocky substrate in slow-moving water at a range of depths in rivers, lake tributaries, lake stream outlets, and shallow and deep littoral areas (Beamesderfer 1992). Wydoski and Whitney (1979) reported that eggs hatch in 7 days at 65°F water, and that the young become free swimming within 14 days. Newly-emerged larval northern pikeminnow in the Columbia River drift downriver during July, generally at night. Although pikeminnow adapted to a variety of habitats, age-0 northern pikeminnow rearing in littoral habitats of the upper John Day Reservoir had significantly greater growth and lower mortality in 1994, a year with low flows, abundant instream vegetation, and high near-shore water temperatures. Parker et al. (1995) observed a similar relationship in pikeminnow age 2 and older; sex-specific growth coefficients were higher and sex-specific annual mortality rates were lower for pikeminnow in Columbia River reservoirs compared the free-flowing reach below Bonneville Dam. However, this may be a function of greater density of northern pikeminnow in the lower mainstem compared to the mainstem reservoirs.

The diet of northern pikeminnow varies with their size (Ricker 1941; Falter 1969; Olney 1975; Buchanan et al. 1981). In the Columbia River, invertebrates dominate the diets of northern pikeminnow that are smaller than 11.8 in (300 mm) FL, with fishes and crayfish increasing in importance as fish size increases (Thompson 1959; Kirn et al. 1986; Poe et al. 1991, 1994). (For more information regarding the northern pikeminnow life cycle, refer to the Technical Foundation, Volume III, section 4.0.)

2.2.7 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. Adults are typically 5 to 8 inches long and 3-5 years old. Most eulachon die after spawning. 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 Rivers.

Smelt support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gillnet fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Smelt are also eaten in large numbers by other fishes including sturgeon, birds, and marine mammals. Smelt numbers and run patterns can be quite variable and low runs during the 1990's were a source of considerable concern by fishery agencies. Current patterns show a substantial increase in run size compared to the 1990's. The low returns in the 1990's are suspected to be primarily a result of low ocean productivity.

Eulachon typically enter the Columbia River system from December to May with peak entry and spawning during February and March (WDFW 2001). Eulachon spawn in the main tributaries of the Columbia River and in the mainstem of the Columbia River. Water temperature plays an important role in upstream migration for spawning eulachon. Past studies have shown that the optimum water temperature for upstream migration is 40F (Smith and Saalfeld 1955). The colder the water, the longer the delay for spawning runs.

Eulachon spawn primarily at night. Each female deposits approximately 17,000 to 60,000 eggs, depending on size of female (Morrow 1980). Fertilized eggs are adhesive and attach to particles of coarse sand or other river substrate like pea-sized gravel or sticks (Smith and Saalfeld 1955). Eulachon eggs have been observed in water from 8 to 20 feet in depth. Water temperature influences the length of time to hatching. In temperatures of 6.5-9.0°C, eggs will hatch in about 22 days. At colder temperatures of 4.4-7.2°C, as found in the Cowlitz River, eulachon eggs will hatch in 30 to 40 days (Garrison and Miller 1982).

Newly hatched larvae are transparent and 4-7 mm in length. They have poor swimming ability and migrate downstream at the mercy of river currents. Eulachon fry have been recorded to within 20 miles seaward of the Columbia River mouth. The result of several plankton hauls conducted in 1946 showed no fry had developed beyond yolk-sac stage; therefore, it is probable no feeding occurs in fresh water during outbound migration (Smith and Saalfeld 1955). After the yolksac is depleted eulachon will feed on pelagic plankton. Stomach samples of juvenile eulachon contained euphausiids (Barraclough 1964). Eulachon rear in near-shore marine areas from shallow to moderate depths. Eulachon will move into deeper water, up to depths of 625 m, as they grow (Allen and Smith 1988). Eulachon are an important link in the food chain between zooplankton and larger organisms.

Eulachon spend the majority of life in salt water and little is known about this saltwater phase. Eulachon feed on plankton in salt water, but stop feeding when returning to fresh water. The sex ratio of spawning adults is an average of 4.5 males to 1 female in the Columbia River and tributaries supporting eulachon. The male to female ratio has been recorded as high as 10.5 males to 1 female in the Cowlitz River (Smith and Saalfeld 1955).

2.2.8 River Otter

The river otter (*Lutra canadensis*) is a top predator of most aquatic food chains that has adapted to a wide variety of aquatic habitats, from marine environments to high mountain lakes of North America (Toweill and Tabor 1982, Melquist and Hornocker 1983, Melquist and Dronkert 1987). The river otter is a year-round resident of the lower Columbia River mainstem and estuary (Howerton et al. 1984, Henny et al. 1996), although field observations and trapper data indicate that population numbers are relatively low (Howerton et al. 1984). Otters on the lower Columbia River concentrate their time in shallow, tidal influenced back waters, sloughs, and streams throughout the estuary. River otters exhibit differing degrees of social and spatial structure based on available habitat, shelter, and food (Reid et al. 1994b). Otter home ranges (approximately 11 river miles) are largely defined by local topography and overlap extensively within and among sexes, exhibiting varying degrees of mutual avoidance and tolerance depending on seasonal dispersion and availability of food and shelter (Reid et al. 1994b). However, otters do maintain territories within home ranges that are delineated by scent marking and latrine sites. Areas within territories are used almost exclusively by the defending otter, who excludes other otters of the same sex (i.e., females otter excludes other females and family groups while males exclude other males). Female river otters mate immediately after parturition during the months of March and April, with estrous lasting up to 46 days (Wright 1963, Melquist and Hornocker 1983). Fertilized eggs develop to the blastocyst stage and are arrested in development (delayed implantation) for up to 10 months (Hamilton and Eadie 1964, Tabor and Wight 1977). The duration of pregnancy after implantation occurs is approximately 2 months. Otter diets vary seasonally and generally consist of a wide variety of fish species and aquatic invertebrates such as crabs, crayfish, and mussels (Toweill 1974, Toweill and Tabor 1982, Melquist and Dronkert 1987, Reid et al. 1994a).

2.2.9 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. The conversion of much of its habitat to agriculture and unrestricted hunting reduced its numbers to a just a few hundred in the early 20th century. A few scattered populations remain and numbers have climbed to approximately 300-500 in the lower Columbia and 5,000 in the Roseburg area. Habitat conversion and losses coupled with the low productivity of the population are the currently the most important threats to population viability. Recovery goals identify the need to secure additional habitat for population re-introduction.

Columbian white-tailed deer are present in low-lying mainland areas and islands in the Columbia River upper estuary and along the river corridor. They are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; however, Columbian white tails can be found breeding or feeding in any number of habitats (Westside lowland conifer-hardwood forest, Westside grasslands, Westside riparian wetlands, herbaceous wetlands, agriculture/pastures/mixed environments, urban/mixed environments; Johnson and O'Neil 2001). Columbian white-tailed deer are non-migratory; in the Columbian White-Tailed Deer National Wildlife Refuge, mean home range for females was about 390 acres and for males was 475 acres, with daily movements considerably smaller than these ranges (Gavin et al. 1984). The peak of breeding activity is generally around mid-November and peak of fawning is about mid-June (USFWS 1976). Columbian white-tailed deer diet consists of browse, forbs, and grasses; generally, browse is chosen in summer, fall, and winter, forbs are most heavily utilized in spring, summer, and early fall, while grasses are not preferred at any time of the year but are eaten in proportion to their availability only in the early spring (Dublin 1980). (For more information regarding the Columbia white-tailed deer life cycle, refer to the Technical Foundation, Volume III, section 11.0.)

2.2.10 Caspian Tern

Caspian terns (*Sterna caspia*) are highly migratory species that are distributed throughout the world and are currently present in large numbers in the Columbia River estuary. The species is not listed, but is of conservation concern because there are relatively few breeding sites and because of significant predation of listed Columbia River salmonids.

Caspian terns have become increasingly abundant in the Columbia River estuary in recent years, becoming the largest breeding colony in North America (Carter et al. 1995). Breeding colony preference is for newly formed, flat, sandy, mid-channel islands, such as those formed via dredge spoils or accretion. There is considerable concern regarding Caspian tern consumption of juvenile salmonids, however, we have no mechanism to measure whether current tern predation differs significantly from historical predation. Further, management actions to discourage breeding on Rice Island and encourage breeding on East Sand Island appears to be decreasing the amount of tern predation on juvenile salmonids.

Caspian terns are highly migratory and exhibit cosmopolitan distribution (Harrison 1984). There were no terns in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds moved to Rice Island in 1987; the area used by Caspian terns was created from dredge spoils from the navigational channel (Roby et al. 1998). The combined total of the reestablished East Sand Island colony and the Rice Island colony has since expanded to approximately 10,000 pairs (the largest colony in North America) (Caspian Tern Working Group 1999). Recent management actions have successfully discouraged breeding on Rice Island while encouraging breeding on other estuary islands. Spring migrants first arrive at breeding sites between mid-March to mid-May depending on latitude, elevation, and coastal or interior location (Cuthbert and Wires 1999). The timing of southward migration varies with region (Cuthbert and Wires 1999); typically, the peak of fall migration occurs between mid-July and mid-September (Cuthbert and Wires 1999) with stragglers leaving by the end of November (Gilligan et al. 1994, Peterjohn 2001).

Caspian terns breed in colonies and typically locate their colonies close to a source of abundant fish in relatively shallow estuarine or inshore marine habitats or in inland freshwater lakes, rivers, marshes, sloughs, reservoirs, irrigation canals, and (low-salinity) saline lakes (Cuthbert and Wires 1999). Nest substrates vary from sand, sand-gravel, spongy marshy soil, or dead or decaying vegetation to hard soil, shell banks, limestone, or bedrock, but terns seem to preferred sand (Quinn and Sirdevan 1998). Caspian terns have been reported to fly up to 38 miles from the breeding colony while foraging (Gill 1976, Ryan et al. 2001, 2002); the Columbia River estuary colony appear to feed within the estuary (Collis et al. 1999, Collis et al. 2001). Caspian terns are piscivorous (Harrison 1984); fish may constitute up to 98% of the diet, particularly during periods of high fish abundance such as the peak of smolt outmigration (Roby et al. 1998). Breeding Caspian terns require one-third of their body weight of fish per day during the nesting season, which also coincides with the peak of smolt migration. Diet of the Rice Island colony is dominated by juvenile salmonids (Roby et al. 1998, Roby et al. 2002) while diet of the East Sand Island colony was primarily non-salmonids (Roby et al. 2002). Studies in 1990 and 1991 revealed that eggs of Caspian terns nesting at Rice and East Sand Islands were contaminanted with organochlorine compounds, including PCBs, DDE, dioxins, and furans, suggesting that their food source (primarily juvenile salmonids) may be contaminated with these coumpounds as well (USFWS 2002). (For more information regarding the Caspian tern life cycle, refer to the Technical Foundation, Volume III, section 10.0.)

2.2.11 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) are distributed throughout North America, breeding in most of its range; abundance is highest along coastal areas of the northern conterminous states, Canada, Alaska, as well as Florida and South Carolina. Eagles have been observed to reach a maximum age of about 28 years in the wild (Schempf 1997 as cited in Stinson et al. 2001); captive birds have lived to age 47 (Stalmaster 1987 as cited in Stinson et al. 2001). In general, southern areas within this range are more important as wintering areas than breeding areas. In Washington, bald eagles are substantially more abundant in the cool, maritime region west of the Cascade Mountain range (Stinson et al. 2001).

Depending on the level of competition for food and nest sites, bald eagles may attempt to breed at age 3 or as late as age 8 (Gerrard et al. 1992, Bowman et al. 1995, Buehler 2000 as cited in Stinson et al. 2001). Bald eagles develop pair bonds that generally last until one eagle dies (Jenkins and Jackman 1993 as cited in Stinson et al. 2001). Eagles usually return annually to a nesting territory near a reliable food source; breeding adults will defend their territories from intruding eagles. As with breeding site fidelity, bald eagles seem to exhibit a relatively high annual fidelity to wintering areas (Harmata and Stahlecker 1993, Buehler 2000 as cited in Stinson et al. 2001). Communal night roosts are an important component of bald eagle wintering habitat. Eagles may also roost singly, in pairs or gather in large congregations of as many as 500 individuals at locations that are used year-after-year. Roosts may vary widely but studies have shown that communal night roosts provide a microclimate more favorable than available elsewhere in the vicinity (Keister et al. 1985, Stalmaster 1981, Knight et al. 1983, Stellini 1987 as cited in Stinson et al. 2001).

Bald eagle populations throughout its range exhibited a slow decline because of habitat loss, decreased abundance of winter foods, and harassment/hunting since the time of European settlement. Despite protection with the Bald Eagle Protection Act of 1940, harassment by humans continued because of misidentification with golden eagles, poisoning of bald eagles in conjunction with livestock predator control programs, and collection of bald eagle parts for black market collectors or native American ceremonial uses. The population decline accelerated dramatically after the early 1940s with the widespread use of organochlorine pesticides, particularly DDT (Elliot and Harris 2001-2002). By the 1960s, less than 700 breeding pairs were estimated to exist in the lower 48 states and bald eagles had been extripated from at least seven states within its historical range (Stinson et al. 2001).

The ban of DDT, habitat protection, reduced persecution, and reintroduction projects have aided in recovery of the North American population (Stinson et al. 2001). During the preceeding 25 years, the bald eagle population has doubled every 7-8 years. Most known populations have reached regional recovery goals where applicable, but populations remain below pre-European settlement abundance (Buehler 2000 as cited in Stinson et al. 2001). In Washington the most recent (1998) statewide survey recorded 664 occupied nest sites; this accounts for 12% of the known bald eagle territories across the lower 48 states (Stinson et al. 2001). A recent decline in nest occupancy rate and the occurrence of nest sites in developed areas suggests that nesting habitat in areas of western Washington is approaching saturation (Stinson et al. 2001).

Historically, bald eagles were common and locally abundant throughout Washington; accounts from 1890 indicate that bald eagles were especially abundant near the mouth of the Columbia River (Stinson et al. 2001). No historical population abundance or density estimates are available for bald eagles in Washington. The Washington and Oregon bald eagle populations were included for federal listing as endangered under the Endangered Species Act in 1978. Threats to the population identified at the time of listing included reproductive failure caused by organochlorine pesticides, widespread loss of suitable nesting habitat resulting from logging, housing development, and recreation, and persecution (primarily illegal shooting (USFWS 1978 as cited in Stinson et al. 2001). In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized.

Breeding bald eagles require large trees near open water that is not subject to intense human activity and will generally select one of the largest trees in a stand for nesting (Anthony et al. 1982 as cited in Stinson et al. 2001). In Washington, 99% of all bald eagle nests are within 1 mile of a lake, river, or marine shoreline. The distance to open water varies somewhat with shore type; nests tend to be closer to marine shores and rivers than to lake shores. Eagles also require perches distributed throughout their nest territories; perches are prominent points which provide a view of the common foraging area. Because eagles exhibit consistent daily foraging patterns, they often use the same perches (Stalmaster 1987, Gerrard and Bortolotti 1988 as cited in Stinson et al. 2001).

Bald eagles breeding in the lower Columbia River region are year-yound residents and do not migrate during the winter (Garrett et al. 1988). All bald eagle nest sites in this area have been monitored for productivity since the late 1970s, and in recent years there were 96 occupied breeding territories (Isaacs and Anthony 2003). In addition, the area supports an additional wintering population of over 100 eagles. Studies in the early 1980's in the Columbia River estuary indicated eagle diet consisted of 90% fish, 7% birds, and 3% mammals (Watson et al. 1991 as cited in Stinson et al. 2001). Waterfowl were the most common avian prey in nests, while suckers (*Catostomus spp*.), American shad (*Alosa sapidissima*), and carp (*Cyprinus carpio*) were the most common fish prey items. Bald eagles will often steal prey from osprey and gulls, and have even been observed stealing marine invertebrates from sea otters (Watt et al. 1995 as cited in Stinson et al. 2001), and fish from river otters (Taylor 1992 as cited in Stinson et al. 2001). Diet of bald eagles can vary considerably, depending on the geographic location or the methods used to determine diet composition (Knight et al. 1990 as cited in Stinson et al. 2001).

The lower Columbia River bald eagle population is one of only two regional populations in Washington that has exhibited low reproductive success representative of a decreasing population (the other regional population was in Hood Canal). Significant concentrations of DDE, PCB, and dioxins were found in bald eagle eggs on the lower Columbia River (Anthony et al. 1993, USFWS 1999b, Mahaffy et al. 2001 as cited in Stinson et al. 2001); concentrations of these contaminants were above no-effect levels estimated for the species. Despite low reproduction success, the lower Columbia River bald eagle population has increased, likely as a result of recruitment of new adults from other areas. Although, the reproductive health of the lower Columbia population appears to be improving based on recent linear trend analysis (Stinson et al. 2001), bald eagle productivity and breeding success of pairs nesting below river mile 60 remains low, especially for those pairs nesting between river mile 13 to 31 (USFWS 1999b, Isaacs and Anthony 2003).

The density of nesting eagles depends on many factors that determine habitat quality, such as prey populations, human disturbance, and perhaps the availability of nest and perch trees. Occupied nests of adjacent nesting pairs are generally spaced closer in areas of high quality habitat. The seasonal home range that contains the foraging and nesting habitat of a pair averages about 2.6 mi^2 in the Puget Sound region (Watson and Pierce 1998 as cited in Stinson et al. 2001) and about 8.5 mi^2 in the Columbia River Estuary (Garrett et al. 1993 as cited in Stinson et al. 2001). However, most eagle activity in the lower Columbia River occurs within 0.2 mi^2 of the nest site (Garrett et al. 1993).

2.2.12 Osprey

The osprey (*Pandion haliaetus*) is a large piscivorous bird of prey that nests and feeds along the lower Columbia River in spring and summer. Ospreys have nearly worldwide breeding distribution; birds that breed in the Pacific Northwest migrate to wintering grounds in southern

Mexico and northern Central America (Martell et al. 2001). Ospreys nest in forested riparian areas along lakes, rivers, or coastlines; nests are situated atop trees, rock pinnacles, or artificial structures such as channel markers or power/light poles (Poole et al. 2002, Henny et al. 2003a). Adult pairs are thought to mate for life and return to the same area annually for breeding (Poole et al. 2002). Generally, adults spend approximately one month on the breeding grounds before egg laying (Henny et al. 2003a); egg incubation takes about 5 weeks and nestlings are ready to fly approximately 7-8 weeks after hatching (Poole et al. 2002). Along the lower Columbia River during 1997 and 1998, osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population (Henny et al. 2003a). Ospreys feed almost exclusively on fish and are not particular about the species of fish they consume (Poole et al. 2002). In the lower Columbia and Willamette Rivers, largescale suckers are an important part of the osprey's diet; ospreys remain close to the nest for feeding (Henny et al. 2003a, 2003b).

The osprey has several advantages as a monitoring species for the health of the Columbia River. The osprey population was studied in detail in 1997 and 1998, and the population nests all along the river up to Umatilla. These earlier data (size of nesting population by river segment, reproductive performance, and residue concentrations in eggs) provide the baseline for comparison with similar data collected in the future to help address contaminant trends over time. Furthermore, residue concentrations in eggs can be compared among locations along the river, such as above and below dams, cities, or other point sources of contaminants. For example, higher PCB concentrations in osprey eggs were detected below Bonneville Dam compared to concentrations above the dam. Other advantages for having the fish-eating osprey as a contaminant monitoring species include:

- Osprey feed primarily on fish close to their nest sites and integrate contaminant exposure in the local area,
- Osprey are at the top of the food chain and are susceptible to biomagnification effects of contaminants (e.g. many contaminants biomagnify from 10 to 100 fold from fish to osprey eggs (Henny et al. 2003b)), and
- Productivity of conspicuous nesters can be monitored in an attempt to establish a response that is linked to population processes.

2.2.13 Sandhill Crane

Historically, sandhill cranes (*Grus canadensis*) occupied a larger North American range than they do today. In Washington, sandhill cranes were historically described as "not common summer resident both sides of the Cascades" (Dawson and Bowles 1909). Evidence of breeding sandhill cranes in Washington was absent from 1941 to 1972, when a paired appeared at Conboy Lake NWR. Sandhill crane breeding habitat in Washington is limited when compared to the large wetland complexes in southern Oregon, northern California, or elsewhere in its range; thus, the potential breeding production in Washington is relatively small compared to other breeding locations. Sandhill cranes have been a state listed endangered species in Washington since 1981. The Yakama Indian Nation has listed the sandhill crane as sensitive (BIA 1993); it is also considered a species of cultural importance. In Oregon, the greater sandhill crane is categorized as vulnerable on the sensitive species list and in California, the greater sandhill crane is listed as threatened.

Sandhill cranes are represented by three subspecies: greater, Canadian, and lesser. The greater sandhill crane is the only subspecies that nests in Washington. The only known breeding sites in Washington are: Conboy Lake NWR and Panakanic Valley, Klickitat County; Polo Field/Signal Peak on Yakama Indian Nation lands, Yakima County; and Deer Creek on WDNR lands in Yakima County (Engler and Brady 2000). The only wintering area for sandhill cranes in Washington is the lower Columbia bottomlands near Vancouver, Ridgefield, and Woodland. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February 2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas (Ivey et al. in prep.). Though not known to be a historical wintering area, an average of few hundred, but up to 1,000 cranes have wintered in the area during the last seven or eight years (J. Engler, personal communication). In winter, birds generally concentrate in agricultural regions with extensive areas of small grain crops. However, associated wetlands are still used for some feeding, as well as for nighttime roosting and midday loafing (Littlefield and Ivey 2000). Generally, the species can be categorized as an opportunistic omnivore (Armbruster 1987), feeding on a variety of food items including roots, bulbs, grains, berries, snails, earthworms, insects, amphibians, lizards, snakes, mice, and greens (Ridgway 1895, Barrows 1912, Bent 1926, Gabrielson and Jewett 1940, Brown 1942). (For more information regarding the sandhill crane life cycle, refer to the Technical Foundation, Volume III, section 12.0.)

2.2.14 Yellow Warbler

Within Washington, yellow warblers (*Dendroica petechia*) are apparently secure and are not of conservation concern. Yellow warblers are an excellent indicator of riparian zone structure and function.

The yellow warbler is a long-distance neotropical migrant; spring migrants begin to arrive in the Pacific Northwest region in April but the peak of spring migration in the region is in late May (Gilligan et al. 1994). Southward migration begins in late July, and peaks in late August to early September; very few migrants remain in the region in October (Lowther et al. 1999). The yellow warbler is a riparian obligate species most strongly associated with wetland habitats that contain Douglas spirea and deciduous tree cover (Rolph 1998). Biological objectives for this species in the lowlands of western Oregon and western Washington include providing habitats that meet the following definition: >70% cover in shrub layer (<3 m) and subcanopy layer (>3 m and below the canopy foliage) with subcanopy layer contributing >40% of the total; shrub layer cover 30-60% (includes shrubs and small saplings); and a shrub layer height >2 m (Altman 2001). Yellow warblers are a locally common breeder at lower elevations along rivers and creeks in the Columbia Basin, although only possible breeding evidence has been observed along the lower Columbia River mainstem and estuary (Smith et al. 1997). Yellow warblers capture and consume a variety of insect and arthropod species, as well as wild berries, by gleaning from subcanopy vegetation (Lowther et al. 1999). (For more information regarding the yellow warbler life cycle, refer to the Technical Foundation, Volume III, section 15.0.)

2.2.15 Red-eyed Vireo

The red-eyed vireo (*Vireo olivaceus*) is common in western Washington. This songbird has been one of the most abundant birds in North America, although its numbers seem to have declined recently, possibly as a result of the destruction of wintering habitat in the neotropics, fragmentation of northern breeding forests, or other causes. The red-eyed vireo is secure, particularly in the eastern United States. Within Washington, the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The red-eyed vireo is an excellent indicator of riparian zone structure and function.

The red-eyed vireo is a long-distance neotropical migrant; it breeds throughout North America and winters in South America (Bent 1965). The red-eyed vireo 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 (C. Chappell pers. comm.) and along the Columbia River in Clark, Skamania, and Klickitat Counties; presence in the Columbia River estuary is not well documented. Biological objectives for this species in the lowlands of western Oregon and western Washington include providing habitats that meet the following definition: mean canopy tree height >50 ft (15 m), mean canopy closure >60%, young (recruitment) sapling trees >10% cover in the understory, and riparian woodland >164 ft (50 m) wide (Altman 2001). Vireos are primarily insectivorous, with 85% of their diet composed of insects and only 15% of vegetable material, mostly fruits and berries eaten in August–October. (For more information regarding the red-eyed vireo life cycle, refer to the Technical Foundation, Volume III, section 14.0.)

2.3 Habitat

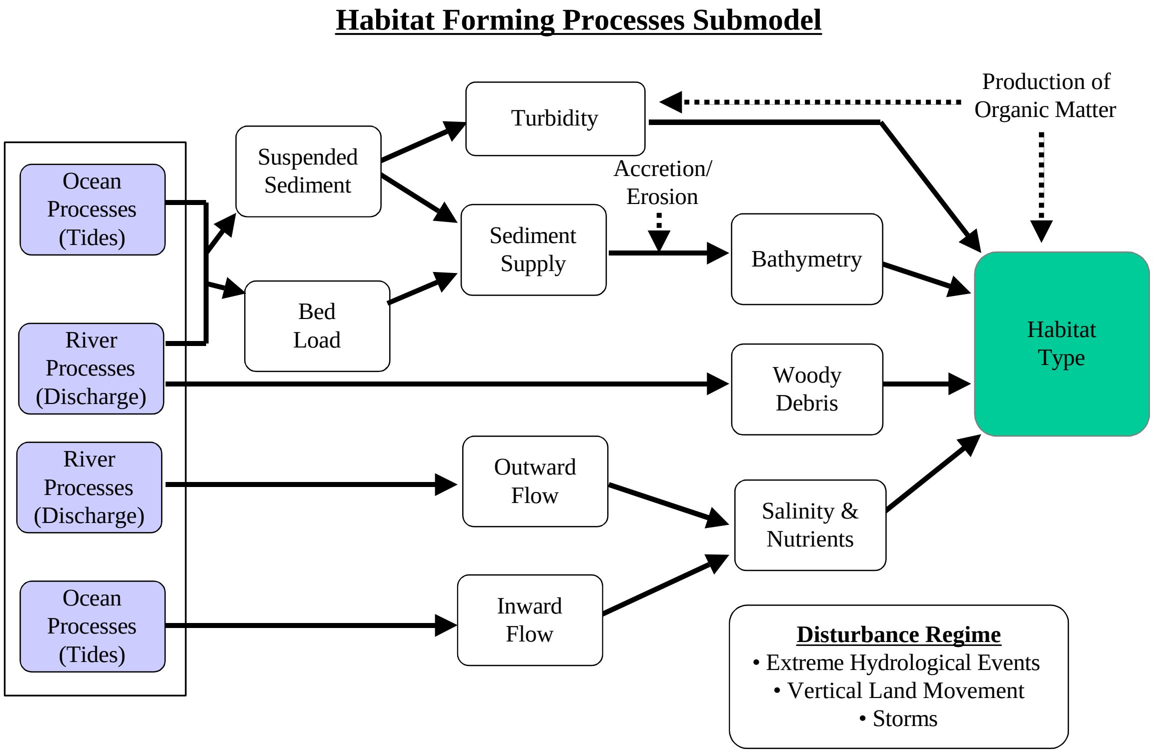
The habitat discussion is divided into three sections: 2.3.1 Habitat-Forming Processes, 2.3.2 Habitat Change, 2.3.3 Historical vs. Current Habitat Condition. Section 2.3.1 Habitat-Forming Processes describes the physical processes that determine habitat formation in the Columbia River estuary and lower mainstem. Section 2.3.2 Habitat Change identifies the natural and anthropogenic factors that have contributed to habitat changes in the subbasin. Section 2.3.3 Historical vs. Current Habitat Condition describes estimates of acreage change of specific estuary and lower mainstem habitats, presenting results from multiple habitat mapping efforts and discussing the similarities and differences among the mapping efforts.

2.3.1 Habitat-Forming Processes

An estuary is the portion of a river that is influenced by ocean tides. The estuary is a complex interaction of river and tidal forces, a high-energy and dynamic physical and biological system, with high temporal variability in circulation, sedimentation and biological processes (Sherwood and Creager 1990). Habitat formation in the lower Columbia River mainstem and estuary are controlled by opposing hydrologic forces of ocean processes (tides) and river processes (discharge) as depicted in the conceptual model (Figure 2-12). As each of these hydrologic processes interact, the habitats that form are a function of time. These processes may be disturbed by storms, extreme hydrologic events, or catastrophic events such as earthquakes or volcano eruptions. Tides introduce marine-derived sediments to the estuary while river discharge carries freshwater sediments via bedload and suspended sediment. This supply of sediments influences the bathymetry of the estuary through the processes of erosion and accretion. Suspended sediment, along with the production of organic matter, determine the degree of water turbidity. The opposing processes of estuary outflow (river discharge) and inflow (tides) determine the salinity gradient and the type and location of available nutrients. River discharge also directly affects the level of woody debris recruitment to the estuary. Finally, the main components of the habitat formation process (bathymetry, water turbidity, salinity, nutrients, and woody debris) determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

The habitat-forming processes of accretion, erosion, salinity, and turbidity affect the distribution of plants throughout the estuary. Vegetation within each habitat comprises the majority of primary production in the estuary, via the production of organic matter within plant tissue and the export of dissolved organic matter. Primary productivity is driven by light; as turbidity increases, light through the water column decreases, which can result in less phytoplankton growth and can limit the depth of submerged plants.

Elevation partially controls the types of habitat created and maintained through the various habitat-forming processes (USACE 2001). There is a continuous elevation gradient from tidal swamp to water column habitat, with some elevation overlap between each habitat type. Defined elevation ranges for each habitat type (tidal swamp, tidal marsh, tidal flats, water column) are presented in Thomas (1983). At a given elevation, there is an overriding influence of salinity in the development of each type of habitat which controls the vegetation assemblage.



Note: Sediment re-suspension can increase potential for contaminant transport if sediments were contaminated

Figure 2-12. Conceptual model of habitat-forming processes in the Columbia River estuary (adapted from USACE 2001). Note that the function of time is not included in this particular model and time is an important controlling factor in the formation of habitat.

2.3.1.1 Hydrological Conditions

Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes (ISAB 2000, Bottom et al. 2001, USACE 2001, Johnson et al. 2003b). Flow regulation in the Columbia River basin has been a major contributor to the changes that have occurred in the estuary from historical conditions. The 21 dams built in the Columbia and Snake Rivers since 1933 have caused river flows to be altered substantially. Water losses from irrigation, reservoir evaporation, and climate change have resulted in annual flows at The Dalles, Oregon that are about 17% less than 19th century virgin flows (Bottom et al. 2001). Thus, the predevelopment flow cycle of the Columbia River has been modified by hydropower water regulation and irrigation withdrawal (Thomas 1983, Sherwood et al. 1990 as cited in Nez Perce et al. 1995, Weitkamp 1994, NMFS 2000c, Williams et al. 2000, Bottom et al. 2001, USACE 2001).

Spring freshet properties have been more highly altered than mean flow. Spring freshets are very important to the outmigration of juvenile salmonids; freshet flows stimulate salmon downstream migration and provide a mechanism for rapid migrations. Also, spring freshets (especially overbank flows) provide habitat, increase turbidity thereby limiting predation, and maintain favorable water temperatures during spring and early summer. Further, organic matter supplied by the river during the freshet season is a major factor maintaining the detritus-based food web. Additionally, reductions in freshet flows combined with flood-control diking and wetland development have disconnected the lower river from its floodplain. Consequently, substantial over-bank flows are rare compared to predevelopment flooding frequency, resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Flow regulation in the Columbia has decreased spring freshet magnitude and increased flows over the rest of the year as a result of winter drawdown of reservoirs and filling of the reservoirs during the spring runoff season. The best historical record of Columbia River flow exists at the Dalles, Oregon, where a gauging station has recorded flow since 1878. About 97% of the flow of the total Columbia River flow passes the gauge at the Dalles. Average spring freshet flows at the Dalles since 1969 have been reduced by 50-55%, and winter flows (October–March) have increased by 35% (Bottom et al. 2001; Figure 2-13). This same pattern has been observed at Bonneville Dam (USACE 2001; Figure 2-14). Further, most of the spring freshet flow reduction is attributed to flow reduction, about 20% is a result of irrigation withdrawals, and only a small portion (5%) is connected to climatic change (Bottom et al. 2001).

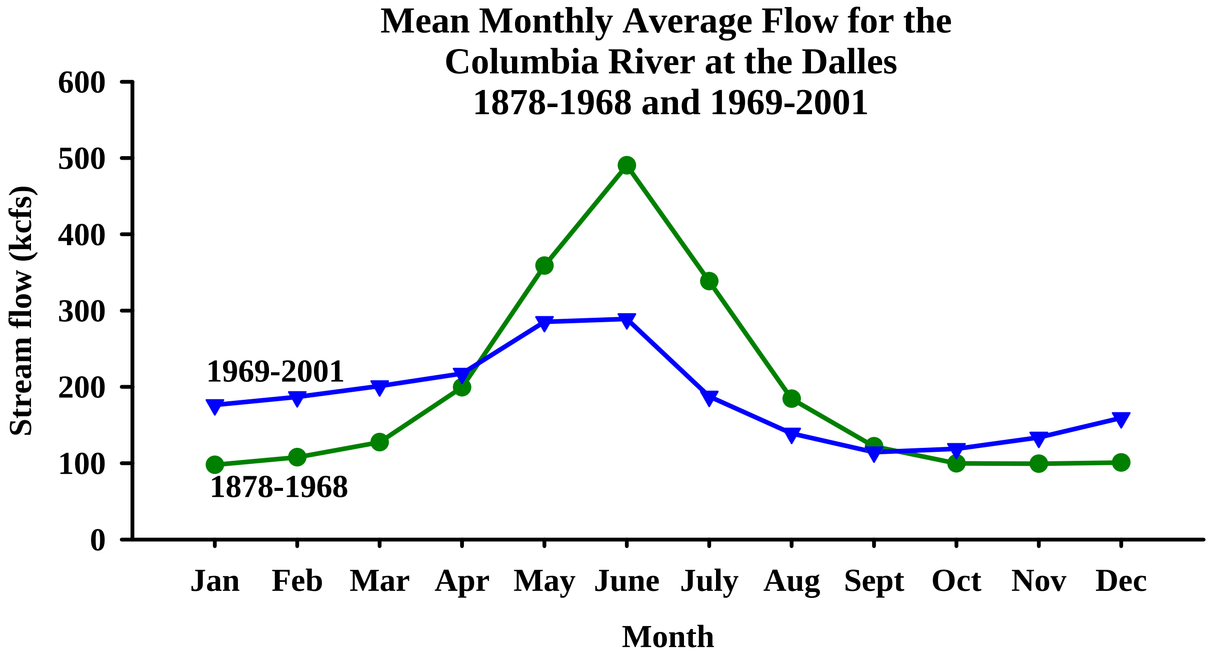


Figure 2-13. Mean monthly average flow at the Dalles. Construction of flow regulating dams has resulted in modification of the annual hydrograph of the Columbia River.

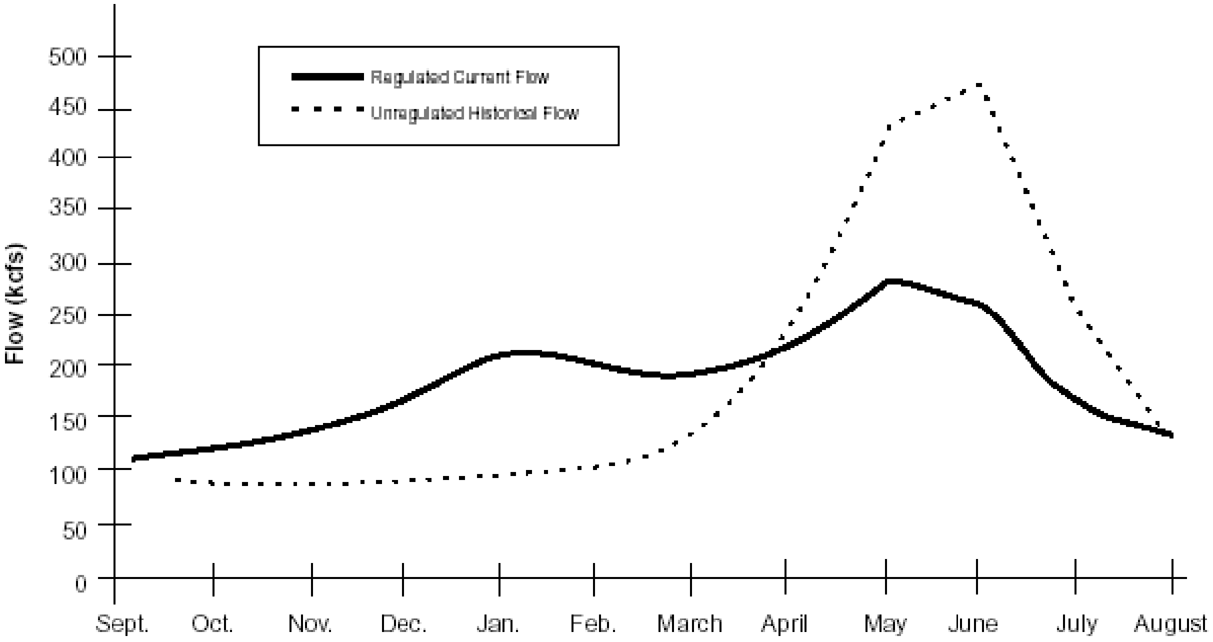


Figure 2-14. Current regulated mean monthly flow compared to historical unregulated mean monthly flow at Bonneville Dam (USACE 2001).

In addition to magnitude, the timing of maximum spring freshet flow has also changed as a result of hydropower operations and irrigation withdrawals. The mean predevelopment maximum spring freshet flow date was June 12 compared to the present mean date of May 29, an approximate 2 week shift in maximum spring freshet flow (Bottom et al. 2001, Jay and Naik 2002).

Finally, freshet styles have been affected by climate and human actions. There are three primary types of spring freshets based on the source of flow: large winter snowpack without considerable spring rain, normal winter snowpack with considerable spring rains, and large winter snowpack with considerable spring rains. The largest freshet flows on record have been associated with rain-on-snow events. Flow regulation is relatively effective in dampening freshets associated solely with snowpack; winter reservoir drawdown provides storage capacity for the steadily melting snowpack. However, heavy spring rains are more difficult to predict and flows are difficult to control because snowmelt rate is substantially higher. Although, the gradual warming of the region has made accumulation of low elevation spring snowpack less likely, decreasing the probability of spring freshets resulting from rain-on-snow events (Bottom et al. 2001, Jay and Naik 2002).

Total mainstem freshwater input at the head of the Columbia River estuary is best measured at Beaver, Oregon; flows at Beaver are the sum of flows for the interior and western Columbia River subbasins. The gauge there includes inputs from some substantial basins downstream of the Dalles (Willamette, White Salmon, Sandy, Lewis, etc.). Because dams from Bonneville upstream capture spring runoff in impoundments, flows from lower Columbia tributaries below Bonneville have become more important contributors to estuary flow during spring and winter runoff periods (Bottom et al. 2001). Average flow at Beaver is now substantially lower than pre-dam flows (Bottom et al. 2001; Figure 2-15).

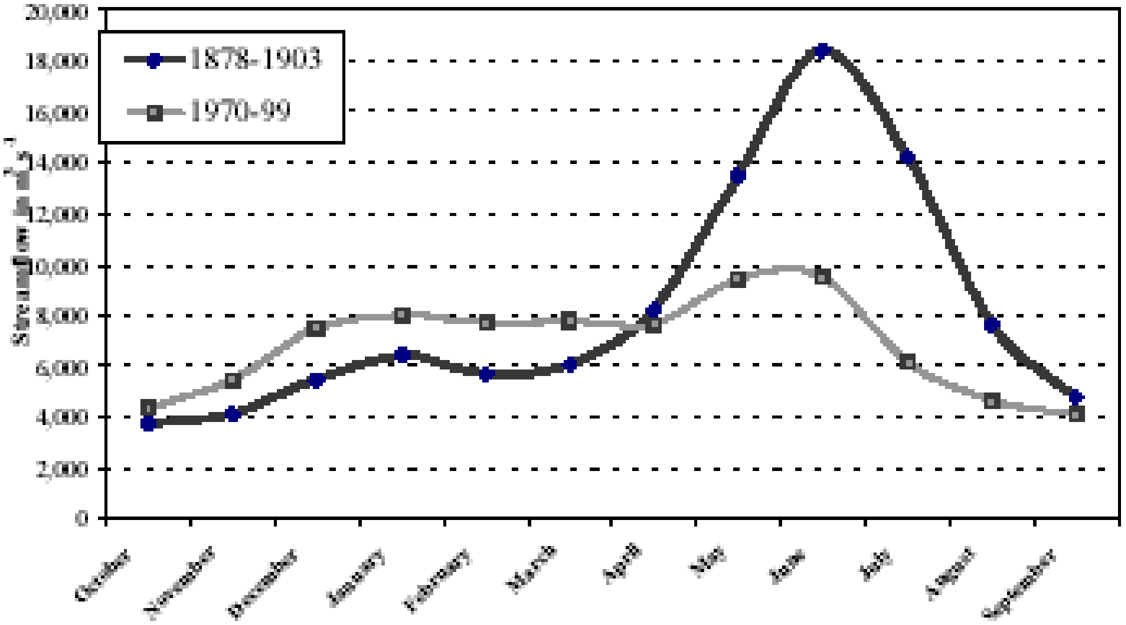


Figure 2-15. Comparison of historical (1878-1903 [data missing]) and recent (1970-1999) Columbia River annual flow cycle measured at Beaver, OR (Bottom et al. 2001).

Reduction of maximum flow levels, dredged material deposition, and diking measures have all but eliminated overbank flows in the Columbia River (Bottom et al. 2001). Overbank flows were historically a vital source of new habitats. Moreover, springtime overbank flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands. Historical bankfull flow level for the mainstem Columbia River below Vancouver was approximately 18,000 cubic meters per second (cms); current bankfull level is determined by the hydropower project flood level of about 24,000 cms. Historical bankfull flow levels were common prior to 1975 but are rare today; current bankfull flows have only been exceeded four times since 1948 (Figure 2-16). Further, the season when overbank flow is most likely to occur today has shifted from spring to winter, as western subbasin winter floods (not interior subbasin spring freshets) are now the major source of peak flows (Bottom et al. 2001, Jay and Naik 2002).

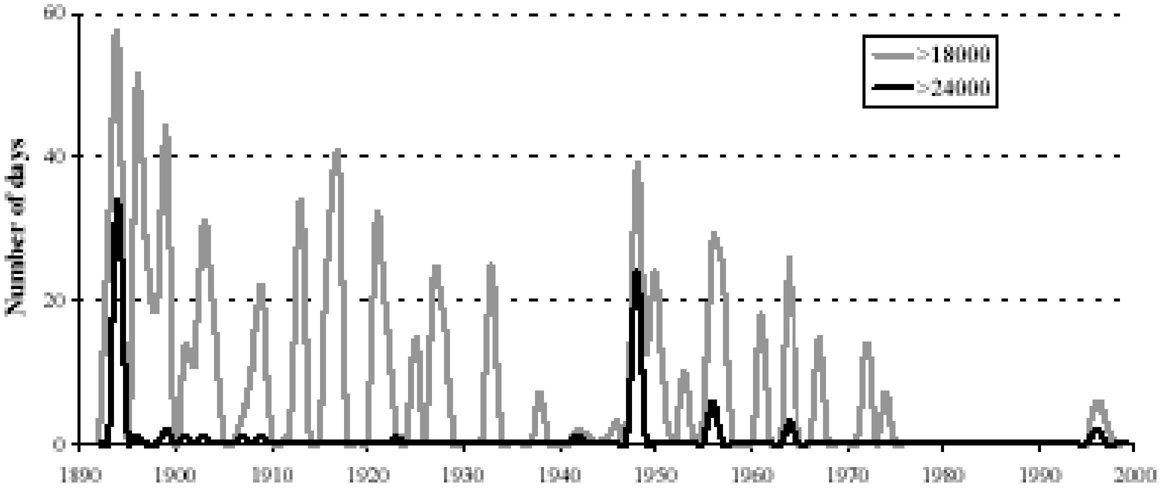


Figure 2-16. Frequency of mainstem Columbia River flow above historical bankfull (18,000 cms) and current bankfull (24,000 cms) flow levels.

2.3.1.2 Sediment Transport

Sediments in the estuary may be marine or freshwater derived; throughout the entire estuary, sediments comprise gravel (1%), sand (84%), silt (13%), and clay (2%) (Hubbell and Glenn 1973, Roy 1982 as cited in Moritz et al. 1999). Sediment transport in the lower mainstem and estuary is largely driven by the Columbia River's hydrologic cycle; most sediment transport coincides with the spring freshet, although high sediment concentrations can also be transported during infrequent winter floods (USACE 2002). Sediments are transported via sediment suspended in the water column or bed load movement. These mechanisms of sediment transport determine the sediment supply to the estuary, which determines the bathymetry of the estuary through the processes of erosion and accretion. Estuary bathymetry is one of the primary factors determing the types of habitat present in the estuary (USACE 2001; Figure 2-12). The following discussion is a brief synopsis of sediment transport mechanisms in the lower Columbia River and estuary; more detailed descriptions of sediment transport processes and estimates of lower Columbia River and estuary sediment budgets can be found in Whetten et al. (1969), Sherwood et al. (1984), Sherwood et al. (1990), Gelfenbaum et al. (1999), Moritz et al. (1999), USACE (1999), Buijsman (2000), Bottom et al. (2001), Kaminsky et al. (2002b), and USACE (2002), to name a few.

The entire Columbia River basin has two principal sediment sources: the upper watershed above the Snake River confluence that produces fine sediments from surficial deposits and the Cascades that supply coarse sediments (sand) resulting from erosion of volcanic material (Whetten et al. 1969 as cited in USACE 2002). Under average flow conditions, each sediment source was independently transported and deposited, with the upper basin sediments transported primarily as suspended sediment and the Cascade sediments transported primarily as bedload (Whetten et al. 1969 as cited in USACE 2002). Thus, sediment from either source may be present in the lower Columbia River and estuary.

Suspended sediment is supported by buoyancy and turbulence within the water column; because particles travel about the same speed as river velocity, they generally move substantial distances before depositing (USACE 2002). There are two main categories of suspended sediments: wash load and bed sediment load (USACE 2002). Wash load comprises silt and clay particles and is often generated from outside sources such as tributaries and local runoff (USACE 2002). Bed sediment load is composed of larger particles such as sand and is governed by the combination of the river's transport potential, the available particle (sand) supply, and the settling properties of the particles (USACE 2002). Sand constitutes about 95% of the total bed material found in the estuary and lower Columbia River mainstem (USACE 2002). However, sand typically constitutes less than 15% of the suspended sediment load, which is generally comprised of about 70-90% fine materials such as silt and clay (USACE 2002). The sand component of the suspended sediment may increase to over 30% when discharge exceeds 400,000 cfs (USACE 2002); however, flows of this magnitude are rare in the present era of water management.

Bed load movement describes the process of larger particles, such as sand or gravel, rolling or bouncing along the riverbed (USACE 2002). Because water velocity at the surface of the riverbed is slower than in the water column, bed load particles move slower than suspended sediments (USACE 2002). Further, bed load particles typically move intermittently and cover short distances during each movement (USACE 2002). Bed load movement typically occurs in a layer only a few sand grains thick (USACE 2002). Bed load movement shapes the riverbed into a series of sand waves; these waves continually move downstream as sand particles are eroded from the upstream face and deposited in the downstream trough (USACE 2002). Therefore, through this continually downstream movement, all the sand particles in a sand wave are eroded, transported, deposited, buried, and eventually eroded again (USACE 2002).

Currently, the most important sediment deposition conditions present in the estuary include shoaling in the navigation channel and deposition/accumulation of sand in low energy areas in the estuary and along the coast (USACE 2002). Shoaling in the navigation channel is a redistribution of bed sediments, rather than an accumulation of sediments, because it does not change the volume of bed material within a given reach (USACE 2002). Sediments generally accumulate in bays and shallow areas throughout the estuary (USACE 2002). Hubbell and Glenn (1973, as cited in USACE 2002) indicated that over 80% of the accumulated sediments was comprised of sand; although the percentage of accumulated silt increases in estuary bays relative to other shallow areas, sand was still the dominant material deposited.

Because sand sediments are vital to natural habitat formation and maintenance in the estuary, dredging and disposal of sand and gravel have been one of the major causes of estuarine habitat loss over the last century (Bottom et al. 2001); estimates of dredging volumes over time are depicted for different reaches in the lower Columbia River (Figure 2-17 and Figure 2-18). From 1958-1997, supply of sand to the estuary from upriver sources was estimated at 1.4 million cubic meters per year (Mm^3/yr; Gelfenbaum et al. 1999). Meanwhile, from 1956 to 1983, the US Army Corps of Engineers (USACE) removed an average of 0.9 Mm^3/yr from the Columbia River entrance and, from 1984 to 1998, the USACE removed an average of 2.5 Mm^3/yr (Kaminsky et al. 2000). Therefore, it is possible that much of the sand entering the estuary from upriver sources does not remain in the estuary and is disposed of in deep-water ocean sites or upland site outside the of the Columbia River littoral cell (Kaminsky et al. 2000, 2002b, Kaminsky 2002a). Further, because of flow regulation and river dredging operations, the sand removed from the lower river cannot be replenished in the absence of an unmitigated, catastrophic event, such as an extreme flood or volcanic eruption (Kaminsky 2002a). Present conditions of sand transport are one of net sand extraction from the river system, because the net supply of river sand has decreased by a factor of 3 over the historical period while the removal of sand has increased by a factor of 2.5 (Kaminsky 2002a). Future conditions of sand transport are not likely to improve in the next 20 years, based on the proposed dredging activities of the USACE; continued losses of Columbia River sand transport may exacerbate the present erosion trends in the coast and nearshore zone of the Columbia River littoral cell (Kaminsky 2002a).

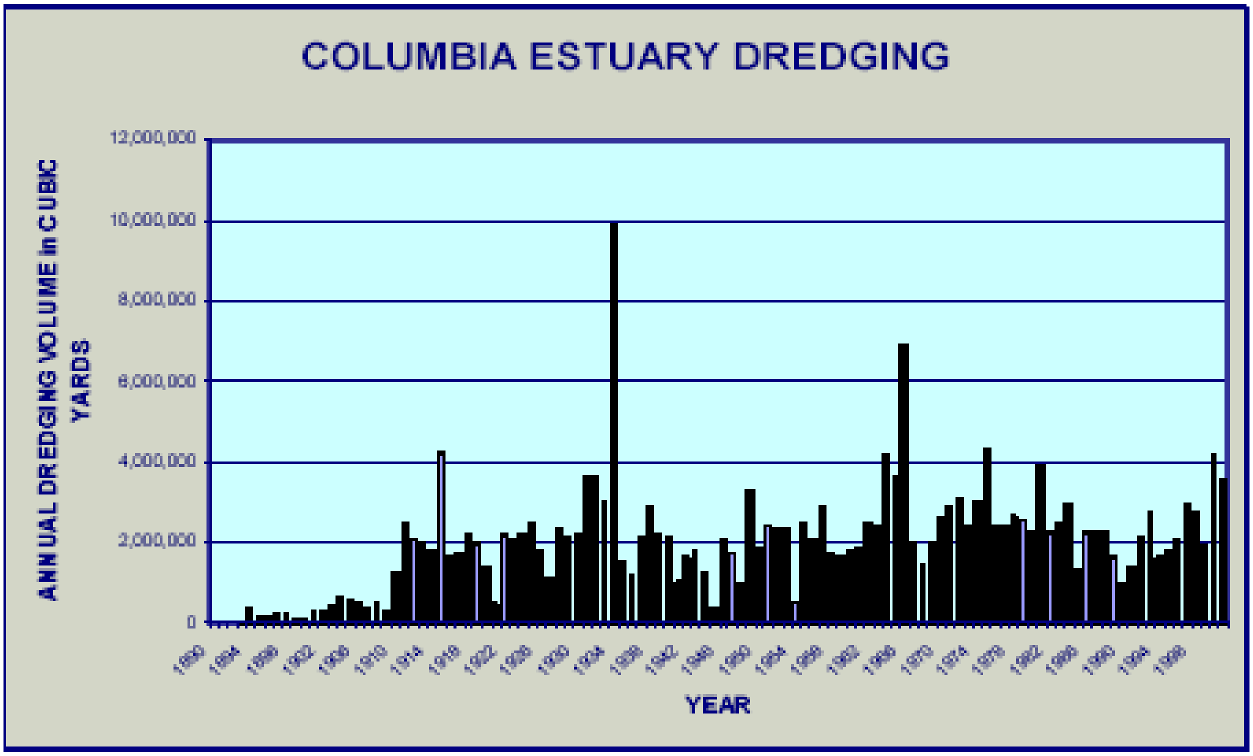


Figure 2-17. Volume of material dredged over time from the Columbia River between rm 3 and 40 (USACE 2002).

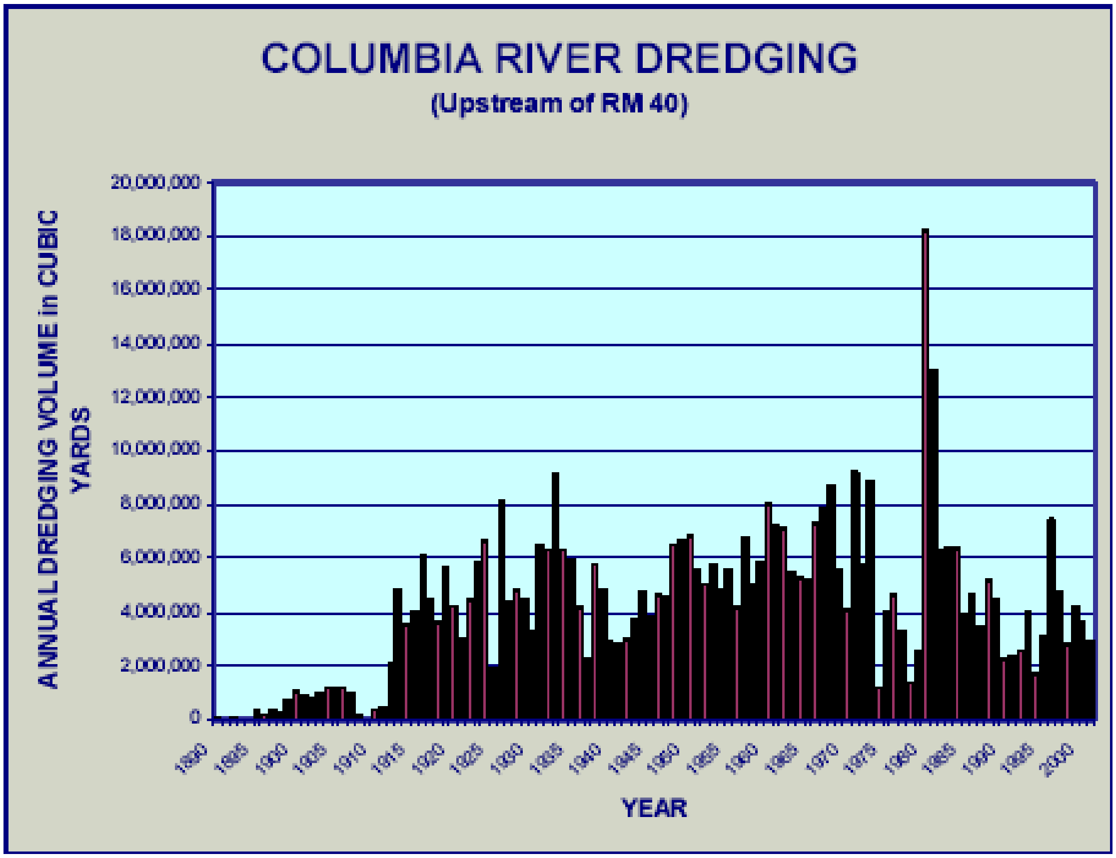


Figure 2-18. Volume of material dredged over time from the Columbia River between rm 40 and 106 (USACE 2002).

Dredging operations at the mouth of the Columbia River have become a topic of considerable debate because of the potential to affect shoreline erosion; consensus regarding the potential erosion effects of this dredging has not been reached (Kaminsky 2002a, 2002b, Kaminsky et al. 2002a, 2002b, Moritz 2002). One hypothesis is that current shoreline erosion cannot be attributed to dredging and disposal practices at the mouth of the Columbia River, as supported by records of dredging and disposal actions (Moritz 2002). For example, from 1905 to 1950, the mouth of the Columbia River navigation channel was maintained at a shallower depth than today and dredging at the mouth was sporadic (Figure 2-19; Moritz 2002). Further, all dredged sand from this time period was deposited either in high flow areas of the estuary or on the ebb-tidal shoal (Moritz 2002). Meanwhile, from 1950 to the present, about 4 million cubic yards are removed from the navigation channel at the mouth of the river; two thirds of all dredged sediment was placed within active sediment transport zones in the river mouth or in adjacent nearshore areas with a depth less than 18m (Moritz 2002). Moritz (2002) estimated that nearly 90% of all sediment dredged from the navigation channel at the mouth of the Columbia River has been deposited in a location where the sediment benefits littoral areas of the Columbia River littoral cell. In the most recent years (i.e. 1997 to present), 90% of the sand dredged from the navigation channel at the mouth of the Columbia River has been placed in two dispersive nearshore sites on the ebb-tidal shoal (Moritz 2002). To date, 80% of the dredge material deposited at these sites has been dispersed, of which less than 10% has been transported back to the navigation channel. Based on this history of dredge and disposal actions at the mouth of the Columbia River, Moritz (2002) suggested that dredging and disposal activities have helped maintain the ebb-tidal shoal and minimize shoreline erosion, rather than contribute to current erosion occurring in the Columbia River littoral cell.

The alternate hypothesis is that dredging and disposal practices at the mouth of the Columbia River have contributed to shoreline erosion within the Columbia River littoral cell (Kaminsky 2002a, 2002b, Kaminsky et al. 2002a, 2002b). Estimates of projected dredging operations indicate that about 6.7 million cubic yards of sand will be removed annually from the lower river, while the sand supply from upland sources is estimated at 1.95 million cubic yards annually, resulting in an annual net removal of about 4.75 million cubic yards of sand (Kaminsky 2002a). Sand transported via the Columbia River has previously served as a source for accreting sediments along Long Beach (Gelfenbaum et al. 1999); as the historical Columbia River sand supply decreases, the southern portion of the Long Beach peninsula is predicted to undergo net erosion (Kaminsky 2002a). Since 1997, the Southwest Washington Coastal Erosion Study’s morphology beach monitoring program has documented net recession along the southern portion of the Long Beach peninsula (Kaminsky 2002a). Preliminary shoreline change modeling results indicate that current shoreline configuration is changing in response to reduced sediment supply, primarily from the ebb-tidal deltas at the mouths of the Columbia River and Grays Harbor (Kaminsky et al. 2002a, 2002b). Additionally, future shoreline position will likely be a function of sediment supply from the Columbia River, ebb-tidal deltas, and the nearshore ocean lower shoreface (Kaminsky et al. 2002b). Based on proposed future dredge operations and disposal sites, use of upland or deepwater ocean sites for dredge disposal may become more prevalent, which will contribute to the decrease in sediment supply from the Columbia River (Kaminsky et al. 2002b). Strategic utilization of dredged sand from navigation projects in the Columbia River, Willapa Bay, and Grays Harbor may be one of the only viable options for maintaining sediment budgets and natural sediment dispersal pathways to reduce erosion in the Columbia River littoral cell (Kaminsky 2002b).

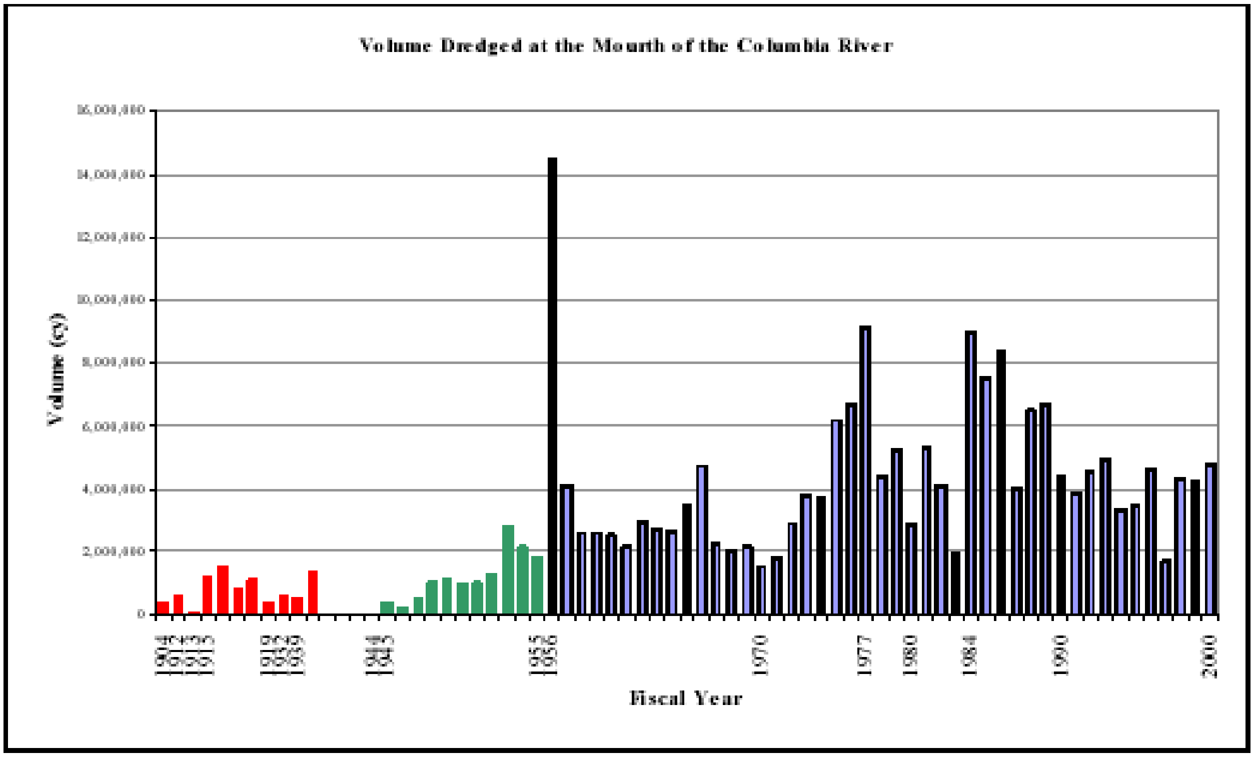


Figure 2-19. Volume of material dredged from the mouth of the Columbia River over time (USACE 2002).

The volume and type of sediment transported by the mainstem Columbia River has profound impacts on the estuary food web and species interactions within the estuary. For example, organic matter associated with the fine sediment supply maintains the majority of estuarine secondary productivity in the food web (Simenstad et al. 1990, 1995 as cited in Bottom et al. 2001). Also, turbidity (as determined by suspended sediments) affects estuary habitat formation, regulates primary production via affects on light penetration, and decreases predation on juvenile salmonids via decreased predator efficiency.

Sediment transport is non-linearly related to flow; thus, it is difficult to accurately apportion causes of sediment transport reductions into climate change, water withdrawal, or flow regulation (Jay and Naik 2002). However, the largest single factor in reduced sediment transport appears to be the reduction of spring freshet flow as a result of water regulation and irrigation withdrawal. Jay and Naik (2002) compared sediment transport data from the Columbia River at Beaver, Oregon, for the pre-1970 and post-1990 periods; they concluded that sand supply in the Columbia River remains available and has not reduced Columbia River sand transport. Findings of the USACE (1999, 2001, 2002) are consistent with this conclusion; they determined that there has been no substantial change in the river's sand supply. Further, the USACE (2002) suggested that sand supply in the Columbia River will unlikely become limiting to sediment transport because the riverbed is underlain by alluvial sand deposits that range in thickness from 100 ft. near Vancouver to 400 ft. in the estuary (Gates 1994 as cited in USACE 2002). Figure 2-20 depicts the estimated volume of sand transported in the Columbia River at Vancouver, Washington; years of high sand transport volume correspond with high flow years and recent era sand transport volumes are generally lower than historical sand transport volumes as a result of water regulation.

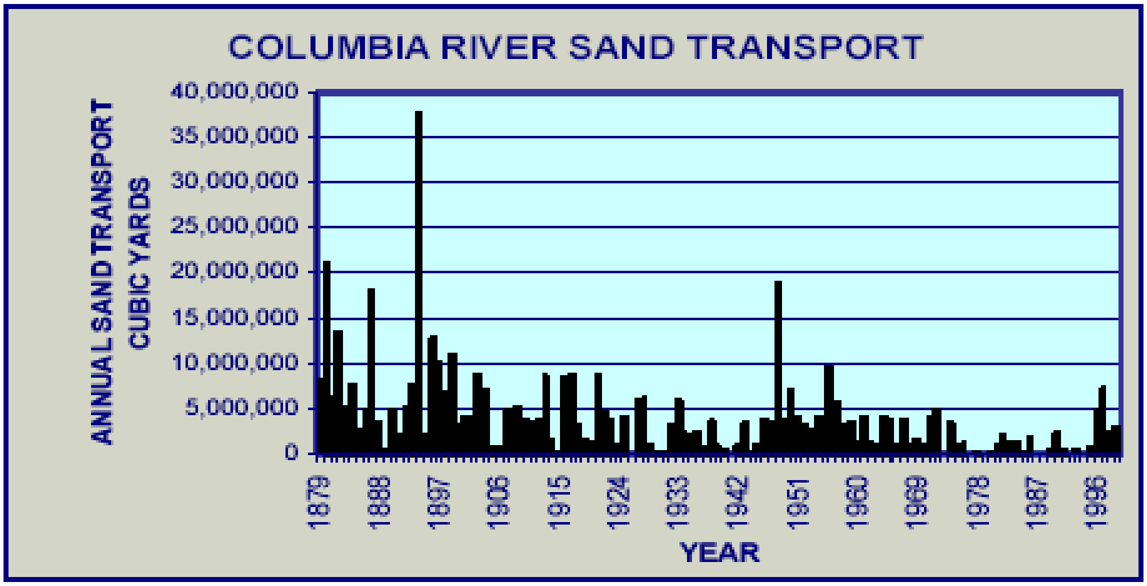


Figure 2-20. Total volume of sand transported annually in the Columbia River at Vancouver, Washington (Cited in USACE 2002; derived from Sherwood et al. 1990 and Bottom et al. 2001).

Recent analyses indicate a two-thirds reduction in sediment-transport capacity of the Columbia River relative to the pre-dam period (Sherwood et al. 1990, Gelfenbaum et al. 1999). Flow reductions affect estuary habitat formation and maintenance by reducing sediment transport (Bottom et al. 2001, USACE 2001). Moreover, the nature of sediments reaching the estuary has been altered. Research indicates that fine materials may be supply limited (which is rare in light of urban development, timber harvest, and agriculture), while sand transport is limited by discharge (Sherwood and Creager 1990). Regulated flows are usually sufficient to transport fine materials (silt, clay, fine sand), but not enough to transport sand and gravels. Thus, under regulated flow conditions, the reduction in sand transported to the estuary is disproportionately greater than reductions in flow and total sediment load (Bottom et al. 2001, Jay and Naik 2002); for example, the reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001). Sand and gravel substrates are important components of preferred salmonid habitat in the estuary while organic matter associated with fine sediments is an important component of the food web.

Because of water velocity reductions, sediments and nutrients that would otherwise have been transported downstream accumulate in reservoirs (Robeck et al. 1954 and Puig et al. 1987 as cited in Weitkamp 1994). Thus, Columbia River reservoir construction has trapped much of the yearly upstream sediment load behind dams. Reservoirs also restrict bedload transport (i.e. movement of sediment along the riverbed when flow is sufficient). Historically, the amount of sediment supplied to the estuary was a function of the type of sediments available and river discharge. Changes in the sources of sedimentation and the regulation of upriver flows, coupled with entrapment of sediment behind dams, have changed sediment supply to the estuary. The idea of mainstem Columbia River reservoirs acting as sediment sinks is contrary to the findings of Whetten et al. (1969, as cited in USACE 2002); they found that sediment generally was not accumulating in mainstem reservoirs as a result of scour by high discharge.

Construction of the north and south jetties significantly increased sediment accretion in marine littoral areas near the mouth of the Columbia River and have decreased the inflow of marine sediments into the estuary. Ocean currents that formerly transported marine sediments into the estuary and Columbia River sediments along the marine littoral areas were disrupted as a result of jetty construction. Accretion, particularly in areas adjacent to the river mouth (i.e. Long Beach, Clatsop Spit), increased significantly in the late 1800s and early 1900s. Sediment accumulation rates have slowed since 1950, potentially as a result of reduced sediment supply from adjacent deltas or the Columbia River (Kaminsky et al. 1999). Because of the decreased sediment supply from the Columbia River and ebb-tidal deltas, recent modeling results indicate that the shorelines immediately north of the historical sediment source areas at the entrance to the Columbia River are susceptible to erosion in the future; accurate estimates of the Columbia River sediment supply are vital to realistic model predictions (Kaminsky et al. 2000). Conversely, Moritz (2002) suggested that the apparent widespread erosion within the Columbia River littoral cell is actually a localized re-distribution of sands resulting from the Columbia River ebb-tidal shoal that was initially pushed offshore after jetty construction and is now being forced toward an equilibrium through present day ocean currents/waves.

2.3.1.3 Salinity and Nutrients

River discharge (estuary outward flow), tidal processes (estuary inward flow), and channel depth determine the salinity gradient and the type and location of available nutrients (Figure 2-12). Columbia River flow may seasonally vary by an order of magnitude, which can significantly influence salinity intrusion and salinity stratification; salinity intrusion decreases while salinity stratification increases with higher river flows. Tides have complex effects on salinity; tide-induced turbulent vertical mixing inhibits salinity intrusion, while horizontal transport by tides is the primary salt transport mechanism during strong tides or low river discharge. The dependence of salinity intrusion on channel depth is strong; the controlling channel depth has doubled over the last 120 years. Bathymetric changes have likely caused the greatest changes in salinity intrusion and stratification, but reduced spring freshet flows have also substantially altered salinity intrusion length (Figure 2-21; Bottom et al. 2001).

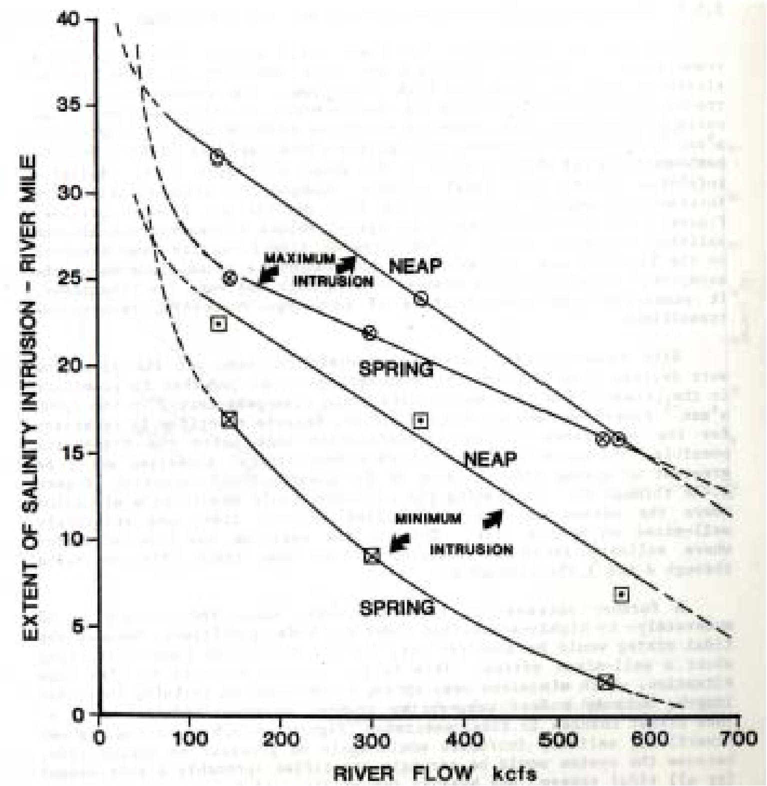


Figure 2-21. Maximum and minimum salinity intrusion distance in the Columbia River estuary, based on 1980 bathymetric conditions (Jay 1984 as cited in Bottom et al. 2001).

Operation of the Columbia River hydrosystem controls river flows and Columbia River flow affects salinity gradients. Increased river flow decreases the extent and duration of intrusion of salt water into the estuary, while decreased river flow does the opposite. Altered estuary bathymetry and flow have affected the extent and pattern of salinity intrusions into the Columbia River; stratification has increased and mixing has decreased (Sherwood et al. 1990 as cited in Williams et al. 2000).

The estuary turbidity maximum (ETM) is an area of elevated levels of suspended particulate material, in particular, river bed sediments, other particulate material, and associated bacteria. Suspension of material in the ETM is a result of turbulence caused by tidal forces pushing saline water upriver below the outflowing river water (Figure 2-22). The ETM is an critical zone of organic matter accumulation and cycling (Figure 2-23), especially in the current imported microdetritus-based food web as discussed in subsequent sections. In the Columbia River, the ETM appears to move upstream with the leading edge of the salt wedge during flood tides, then retreats with the salt wedge during ebb tides. The combination of tidal energy and river discharge determine the location, size, shape, and salinity gradients of the Columbia River ETM (Figure 2-24). As depicted in this figure, low river flow allows the ETM to migrate further upstream; this is particularly true during neap (flood) tides (Figure 2-24; Scenario 1 and 2). During high flows, river discharge maintains the ETM location closer to the river mouth (Figure 2-24; Scenario 3). The length of the ETM ranges from 0.5 to 3 miles and the location fluctuates up to 9 miles daily, based on river discharge and tide cycle. On the south bank, the ETM generally migrates between Youngs Bay and Tongue Point, while on the north bank, the ETM is usually on either side of Point Ellice (USACE 2001).

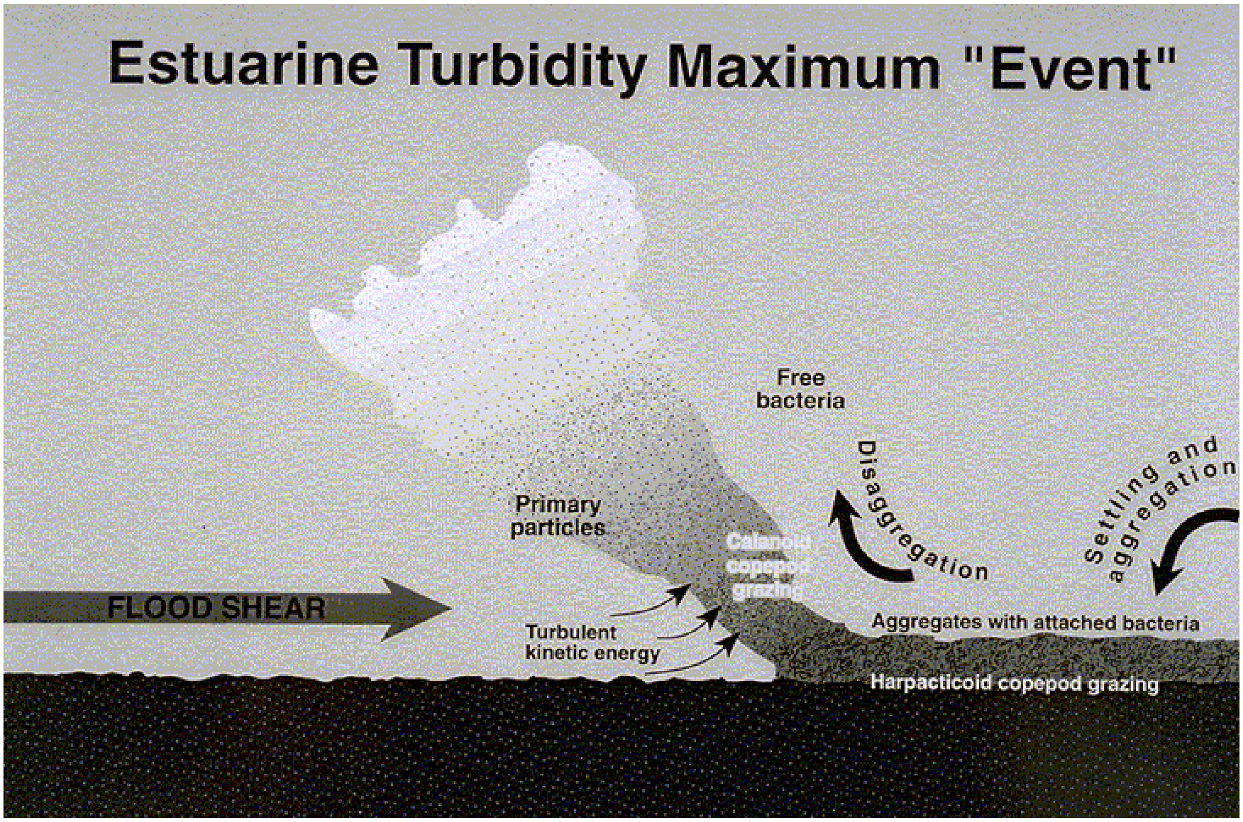


Figure 2-22. Diagram of an ETM "event" as tidal forces push salinity upriver beneath the outflowing river water (NSF 2003).

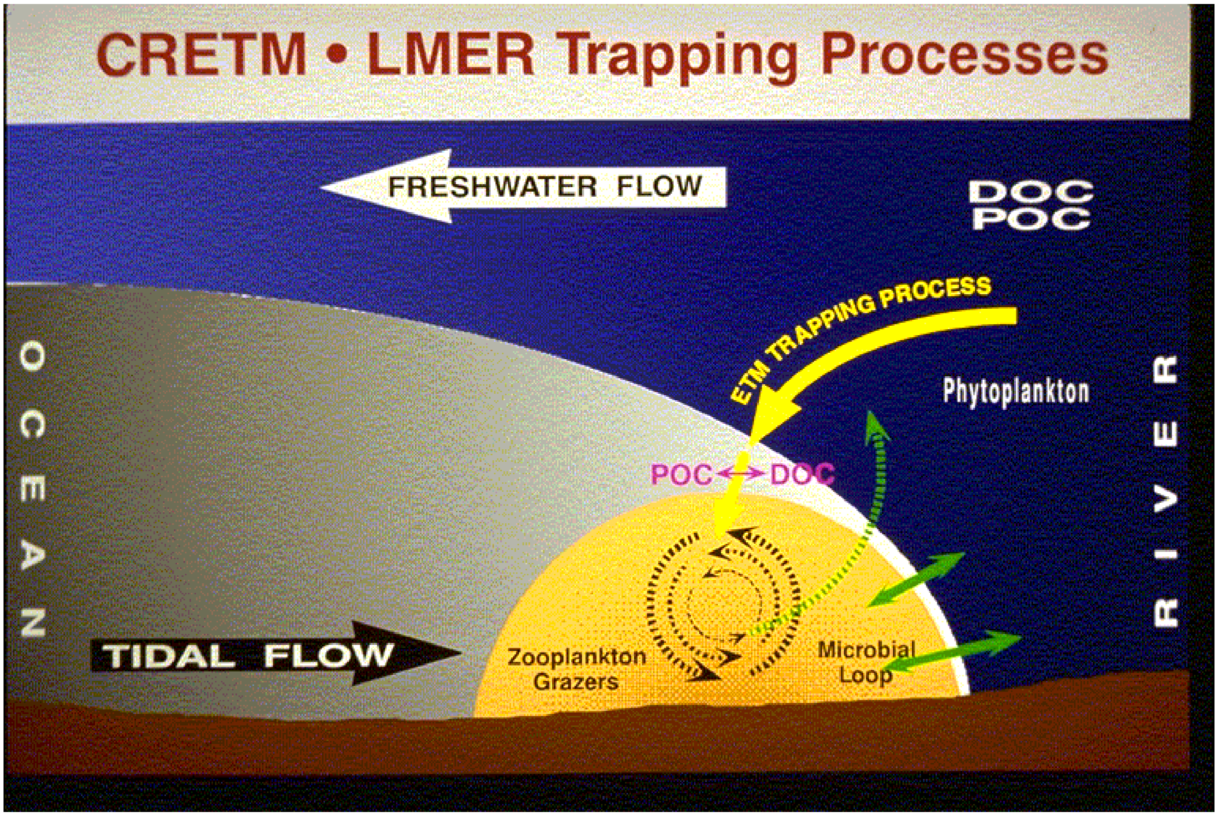
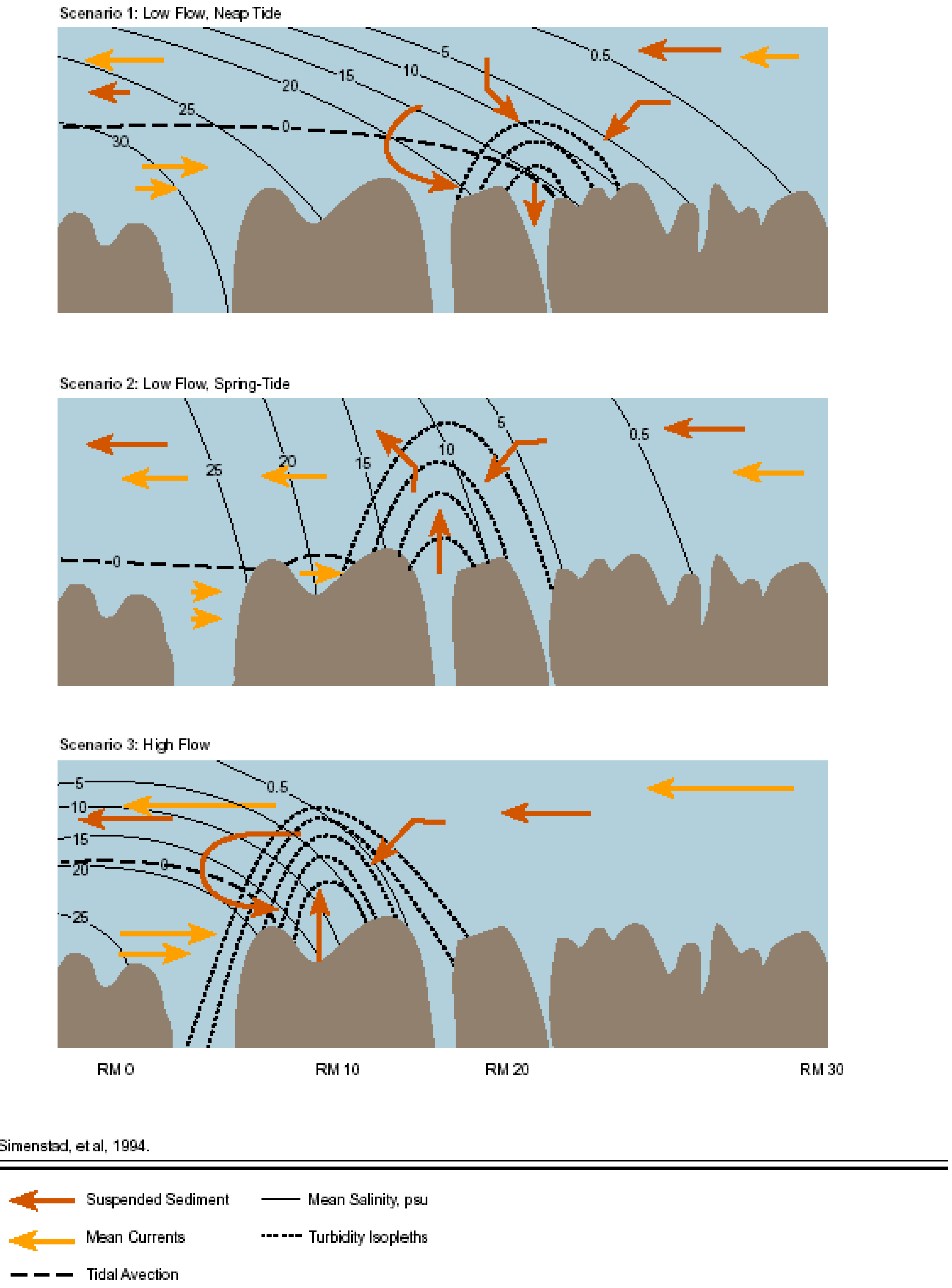


Figure 2-23. Diagram of biological activity within the ETM, illustrating the productivity of this area (NSF 2003).



Source: Simenstad, et al, 1994.

Figure 2-24. Variations in the estuary turbidity maximum (ETM) under different river flow and tide cycle conditions (USACE 2001).

Hydropower generation in the Columbia River has altered the amount and timing of water delivered to the Columbia River plume; the biological effects to juvenile salmonids of this altered flow pattern on the plume environment are largely under-studied (Bisbal and McConnaha 1998; Williams et al. 2000). Prior to hydrosystem operations, the coastal plume had well-defined seasonal directions: in winter, the plume extended toward the north while in the summer, the plume reversed and net transport was in a southwesterly direction, up to 400 km (Ebbesmeyer and Tangborn 1992 as cited in Bisbal and McConnaha 1998). Further, evidence suggests that the shift of freshet flows from the spring to the winter has altered sea surface salinities along a substantial part of the west coast of North America (Ebbesmeyer and Tangborn 1992 as cited in Williams et al. 2000). The nearshore environment, particularly that associated with the Columbia River plume, is important habitat to outmigrating juvenile salmonids (NMFS et al. 1998, Pearcy 1992 as cited in NMFS 2000c). Hydrologic conditions associated with the Columbia River plume creates a highly productive, low salinity zone compared to the surrounding ocean environment. Recent data suggests that juvenile salmonids are concentrated along this productive zone of the Columbia River plume during their early ocean existence (NMFS et al. 1998). Inter-annual variation in ocean recruitment of salmon is high and believed to be associated with annual variation in nearshore ocean physical and biological conditions (NMFS et al. 1998). Anthropogenic factors that may alter this productive plume environment, as well as management actions such as large releases of hatchery salmonids that may create competition for resources, can decrease survival during plume residence (Bisbal and McConnaha 1998).

Decreased spring flows and sediment discharges have reduced the extent, speed of movement, thickness, and turbidity of the Columbia River plume that previously extended far out and south of the river mouth during spring and summer (Ebbesmeyer and Tangborn as cited in Bisbal and McConnaha 1998; Barnes et al. 1972, Cudaback and Jay 1996, Hickey et al. 1998 as cited in NMFS 2000c). Although additional nutrients are available from upwelling during low river flows, low river discharge is unfavorable for juvenile salmonid survival because of reduced turbidity in the Columbia River plume (Pearcy 1992 as cited in NMFS 2000c). Decreased plume turbidity results in increased foraging efficiency of birds and fish predators, increased residence time of fish in the estuary and nearshore ocean environment where predation is high, decreased incidence of fronts with concentrated food resources for juvenile salmonids, and reduced overall total secondary productivity based on upwelled and fluvial nutrients (Pearcy 1992 as cited in NMFS 2000c). Further, decreased estuarine turbidity has allowed for increased predation on juvenile salmonids throughout the estuary (Junge and Oakley 1966, Bottom and Jones 1990 as cited in Nez Perce et al. 1995).

2.3.2 Habitat Change

Historically, environmental conditions in the Columbia River mainstem and estuary were controlled by ocean processes, Columbia River Basin landscape conditions, and riverine processes, which were influenced by climate and a host of natural processes and disturbance. The historical mainstem and estuary conditions were highly variable and the magnitude of environmental changes suggest major shifts in estuarine and riverine habitat conditions. Alterations to ocean and riverine processes have changed the amount and types of habitat in the lower Columbia River mainstem and estuary.

2.3.2.1 Climate

Variations in Columbia River discharge as a result of climate effects occur in time scales from years to centuries (Chatters and Hoover 1986, 1992 as cited in Bottom et al. 2001);

research on climate cycles as they affect ocean productivity and salmonid survival has focused on the Pacific Decadal Oscillation (PDO; typically 40-50 year cycle) and the El Niño-Southern Oscillation (ENSO; typically 3-7 year cycle; Mantua et al. 1997 as cited in Bottom et al. 2001). The Columbia Basin's climate response to these cycles is governed by the basin's latitudinal position; climate in the region displays a strong response to both the PDO and ENSO cycles (Mantua et al. 1997 as cited in Bottom et al. 2001, Mote et al. 2003). Warm phases of ENSO (i.e. El Niño) and PDO cycles correspond with winter and spring weather that is warmer and drier than average; cool phases of ENSO (i.e. La Niña) and PDO typify cooler, wetter weather (Mote et al. 2003). Climate effects of short-term El Niño cycles are strengthened during warm phases of the PDO, while La Niña effects are intensified during a cold PDO phase (Gershunov et al. 1999, Mote et al. 2003). Strong El Niño winters result in Columbia and Willamette River flows that are 91 and 92% of the long-term annual average, respectively; conversely, strong La Niña winters result in Columbia and Willamette River flows that are 110 and 111% of the long-term annual average, respectively (Bottom et al. 2001). When the ENSO and PDO cycle phases are out of sync (i.e. cool ENSO/warm PDO or warm ENSO/cool PDO), streamflow tends to be near the long-term average (Mote et al. 2003).

In addition to the substantial direct affects climate has on river flow, climate indirect effects on other factors are often striking as a result of the relationship between river flow and other factors. For example, sediment discharge increases more than linearly with flow; thus, as climate affects flow, the effects on sediment discharge are amplified (Bottom et al. 2001). Another possible magnification of climate effects is the organic matter supplied during high river discharge; the extent to which this organic matter supports estuarine secondary production depends largely on whether the material is trapped in circulation processes associated with the estuary turbidity maximum (Bottom et al. 2001). Despite our ability to measure changes in climate, Bottom et al. (2001) discussed the difficulty in separating climate versus anthropogenic effects on river discharge and sediment/nutrient discharge.

Current climate projections predict gradual warming of the region, potentially with higher precipitation, particularly in winter (Hamlet and Lettenmaier 1999, Mote et al. 2003); the predicted precipitation changes are well within the 20th century annual variability range. Mote et al. (2003) indicated that, of the predicted precipitation and temperature changes, temperature changes are likely more important because they shift river flow from summer to winter. The Columbia River, being a large, snowmelt-dominated watershed (Neal 1972), is not expected to be susceptible to increased risk of spring flooding, rather, will be strongly influenced by changes in low flow because of limited reservoir storage and anthropogenic demands on water (Callahan et al. 1999 and Miles et al. 2000 as cited in Mote et al. 2003). The predicted future climate conditions will possibly reduce the likelihood of spring freshets caused by heavy spring rain on late snowpack because warmer temperatures will not allow the accumulation of snow late into the spring. This freshet style (rain on snow) has historically produced the most substantial increases in river discharge (Bottom et al. 2001). A potential consequence of this climate change is heightened conflicts over water supply during the critical spring season as a result of increased water demand and decreased natural flows (Hamlet and Lettenmaier 1999, Mote et al. 2003).

Climate has substantial effects on nearshore and ocean productivity; variability in productivity as a result of climate has important implications for many focal species in the subbasin, particularly those that make extensive use of the lower estuary, nearshore ocean, or open ocean environments. For example, the timing of spring upwelling and spring phytoplankton blooms are largely determined by the character of upwelling winds (i.e. variable winds produce more upwelling) and the circulation and stratification of the upper ocean, which is significantly influenced by winter climate (Logerwell et al. 2003 as cited in Mote et al. 2003). Additionally, the PDO cycle has profound effects on ocean nutrient levels. The warm PDO phase results in warmer and more thermally stratified coastal waters off Washington and Oregon, causing poor nutrient conditions; the opposite is true for the cold PDO phase (Mote et al. 2003). It has been suggested that potential oceanic warming that results from the predicted climate change may push the range of some salmon north out of the Pacific Ocean entirely (Welch et al. 1998 as cited in Mote et al. 2003), however, the notion that ocean thermal limits alone determine salmon distribution is likely too simplistic (Walker et al. 2000 as cited in Mote et al. 2003). Thus, minor oceanic warming may not lead to drastic changes in salmonid distribution unless accompanied by substantial changes in the oceanic food web, such as prey distribution (Mote et al. 2003).

2.3.2.2 River Flow

The Columbia River has the largest annual flow of any river on the Pacific coast of North America. Historically, unregulated flows at the mouth ranged from 79,000 cfs to over 1 million cfs, with average flows about 273,000 cfs (Marriot et al. 2002). Currently, discharge at the mouth of the river ranges from 100,000 to 500,000 cfs, with an average of about 260,000 cfs (Marriot et al. 2002). Highest flows are experienced during and just after winter storms, generally from December through March. Flows and sediment load have been altered by construction of 31 irrigation and hydropower dams in the basin since 1890. Prior to human influence, the Columbia River estuary had extensive sand beds and variable river flows. However, the construction of upriver hydroelectric dams has dramatically changed the nature of the estuary, as these dams have translated into different flow rates and sediment discharges (Figure 2-13, Figure 2-14, Figure 2-15, and Figure 2-16). Moreover, channel deepening, use of jetties and dredging to stabilize channels, development of perennial wetland areas, and isolation of remaining wetlands from the mainstem river have altered the physical character of the Columbia River estuary and these changes have affected the biological systems that the estuary supports. Introduction of non-native species and degradation of water quality have also impacted the estuarine biota. All of these influences interact in complex ways. The quantitative estimates of habitat loss, however, do not reflect the qualitative losses that have also occurred, and which may have important effects on the salmon rearing capacity of the estuary.

Because of changes to flow and sediment transport and the various habitat alterations that have occurred in the estuary, the availability of shallow (10cm-2m depth), low velocity (<30 cm/s) habitats appears to decrease at a steeper rate with increasing flow compared to historical conditions (see also the physical process description of sediment transport in section 2.3.1.2). Further, the resilience of the estuary to increasing water depth with increasing flow appears to have decreased, likely as a result of disconnectedness with the historical floodplain. These conditions have decreased the shallow water refugia for juvenile salmonids and likely contribute to decreased survival during high flow conditions (NMFS 2000c).

2.3.2.3 Water Temperature

Many factors can cause high stream temperatures, but they are generally related to land-use practices rather than point source discharges. For example, some actions that result in high stream temperatures are the removal of riparian vegetation that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have decreased stream base flows, which contribute to increases in temperature. Other land uses that create shallower streams can also cause temperature increases. These land uses have occurred in some combination throughout the lower mainstem and estuary; however, the degree of water temperature increase within the lower mainstem and estuary as a result of these land uses is not completely understood. Water temperature alterations affect salmonid metabolism, growth rate, disease resistance, and the timing of adult migrations, fry emergence, and smoltification (NMFS 2000c).

2.3.2.4 Channel Confinement

The most significant habitat changes from historical to current conditions have been the loss of tidal marsh and tidal swamp habitat that are critical to juvenile salmonids, particularly small or ocean-type salmonids (Thomas 1983, USACE 2001, Johnson et al. 2003b). Thomas (1983) noted that diking has caused more of the estuary habitat changes documented in the historical/current habitat comparison than any other factor, anthropogenic or natural. This conclusion is consisted with the findings of Kukulka and Jay (2003) who indicated that dike removal alone would restore considerable amounts of shallow water estuary habitats. Further, diking entirely removes habitat from the estuarine system, while other anthropogenic factors change estuary habitats from one type to another (Thomas 1983). The degree to which estuary habitat types have been effected by diking is directly proportional to elevation; thus, the highest elevation habitat type (i.e. tidal swamp) has been impacted by diking the most (Thomas 1983).

Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon access to a wide expanse of low-velocity marshland and tidal channel habitats (Bottom et al. 2001). Flooding occurred frequently and was important to habitat diversity and complexity. Historical flooding also allowed more flow to off channel habitats (i.e. side channels and bays) and deposited more large woody debris into the ecosystem. Historically, seasonal flooding increased the potential for salmonid feeding and resting areas in the estuary during the spring/summer freshet season by creating significant tidal marsh vegetation and wetland areas throughout the floodplain (Bottom et al. 2001). In general, the river banks were gently sloping, with riparian and wetland vegetation at the higher elevations of the river floodplain becoming salmonid habitat during flooding river flows or flood tides. It is estimated that the historical estuary had 75 percent more tidal swamps than the current estuary because tidal and flood waters could reach floodplain areas that are now diked or otherwise disconnected from the main channel (USACE 2001, Johnson et al. 2003b).

Mainstem habitat in the Columbia and Willamette Rivers have for the most part been reduced to a single channel where floodplains have been reduced in size, off-channel habitat has been lost or disconnected from the main channel, and the amount of large woody debris has been reduced (NMFS 2000c). Most of the remaining mainstem habitats are affected by flow fluctuations associated with reservoir management (NMFS 2000c). Dikes prevent over-bank flow and affect the connectivity of the river and floodplain (Tetra Tech 1996); thus, the diked floodplain is higher than the historical floodplain and inundation of floodplain habitats only occurs during times of extremely high river discharge (Kukulka and Jay 2003). There is a critical level (i.e. the elevation of the diked floodplain) where water level must reach before substantial floodplain habitat are inundated; this threshold level varies between reaches (Kukulka and Jay 2003). Above this critical water level, large amounts of shallow water floodplain habitats become available with small increases in water level up to an optimum threshold (Kukulka and Jay 2003). With continued floodplain inundation above this threshold, availability of shallow water habitats decrease (Kukulka and Jay 2003), presumably because the shallow water habitats initially created at the critical water level no longer satisfy the depth criteria of shallow water habitat (0.1 to 2.0 m in this case). Under a modern bathymetry and flow regime scenario, the critical river discharge level in which significant shallow water habitats become available through floodplain inundation is relatively high and the frequency of occurrence of this river discharge is rare; thus, floodplain inudation is uncommon and availability of shallow water habitats is limited (Kukulka and Jay 2003). As is the case in the estuary (Bottom et al. 2001), loss of these vital mainstem floodplain habitats has likely reduced the productive capacity of the lower Columbia River for juvenile salmonids (particularly fry and subyearling smolts).

2.3.2.5 Channel Modifications

Development of a shipping channel has greatly affected the morphology of the estuary. The extensive use of jetties and diking to maintain the shipping channel has impacted natural flow patterns and large volumes of sediments are dredged annually. Dredged materials are disposed of in-water (in the ocean or in the flow adjacent to the shipping channel), along shorelines, or on upland sites. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year in the estuary. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays. Saltwater intrusion patterns have been reduced, and habitat types have been altered. Disposal of dredge materials has created barren land or islands that have indirectly increased avian predation on salmonids.

2.3.2.6 Contaminants

Industrial and urban development and agricultural practices in the lower Columbia River has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on juvenile salmonids is not clear. In general, contaminants affect survival by increasing stress, predisposing fish to disease, and interrupting physiological processes. Tributary water quality problems contribute to poor water quality where sediment and contaminants from the tributaries settle in mainstem and estuary habitats (NMFS 2000c). Further, the dampening of peak and sustained flood flows by hydrosystem operations has increased the accretion of sediments facilitating the accumulation of pollutants from the entire Columbia River basin in estuarine sediments (Sherwood et al. 1990 as cited in Nez Perce et al. 1996). Less water volume translates to less dilution and higher concentrations of pollutants; any stresses imposed on juvenile fish will be exacerbated by the presence of contaminants (Nez Perce et al. 1995).

The most recent data regarding contaminant effects on juvenile salmonids have been generated through assessment work for the USACE proposed channel deepening project (USFWS 1999a, NWFSC 2001, USACE 2001, NMFS 2002, USFWS 2002). Recent sampling of hatchery and wild juvenile salmon near Sand Island at the mouth of the Columbia River indicated the presence of contaminants in the food chain of juvenile salmonids (NMFS 2002). Elevated concentrations of DDT and PCBs were detected in both whole body and stomach content samples (NMFS 2002). The whole body concentrations of DDT and PCBs were among the highest concentrations measured at estuarine sites in Washington and Oregon; the whole body DDT levels were greater than and the whole body PCB levels were similar to concentrations detected in juvenile chinook salmon in the Duwamish estuary, which is a heavily contaminated industrial estuary near Seattle (NMFS 2002). Further, the presence of elevated concentrations of DDT and PCBs in stomach content samples is clear evidence that exposure to these contaminants is occurring in the estuary (NMFS 2002).

Studies of sub-lethal exposure of juvenile salmon to contaminants in urban estuaries suggest that these contaminants could affect the survival, growth, and fitness of salmon (Casillas et al. 1996). A series of experiments with natural and laboratory exposure of fall chinook salmon to hydrocarbon pollutants in Puget Sound estuaries demonstrated impaired growth, reduced immune defenses, and increased susceptibility to disease (Stein et al. 1995, Arkoosh et al. 1998a, Arkoosh et al. 1998b, Stehr et al. 2000). Water quality issues could reduce productivity for species that make extensive use of estuarine habitats for rearing, such as subyearling chinook, and chum salmon.

In the case of bald eagles, concentrations of PCBs, pesticides, and dioxins were found in bald eagle eggs collected along the lower Columbia River at concentrations associated with reduced breeding success based on eagles studied elsewhere (Anthony et al. 1993, USFWS 1999b). Reproductive problems for lower Columbia River bald eagles include eggshell thinning and a low number of young produced per occupied nest, which is considered a result of embryo dessication and mortality caused by bioaccumulative organochlorine contaminants such as DDE and PCBs (Anthony et al. 1993, USFWS 1999b). Eggshell thinning, generally attributed to DDE (a DDT derivative), was prevalent in eagle eggs and shell fragments collected along the river (Anthony et al. 1993, USFWS 1999b). Anthony et al. (1993) reported a significant relationship between eggshell thickness and breeding success among lower Columbia breeding pairs, but follow up studies in 1994 and 1995 did not show a significant relationship (USFWS 1999b). The latter studies also showed that the contaminants DDE and total PCBs declined in eggs sampled in 1994 and 1995 compared to eggs sample 10 years earlier. Even though egg concentrations have declined, values still exceeded no-effect levels estimated for the species. Recent increases in productivity and breeding success have been observed in lower Columbia River bald eagles and is likely a result of recruitment of eagles from outside regions and possibly improving contaminant conditions (USFWS 1999b, Isaacs and Anthony 2003). However, lower Columbia River eagles nesting below rm 60 continue to experience poor reproduction compared to bald eagles nesting elsewhere in Oregon and Washington. Productivity is lowest for bald eagles nesting between rm 13 and 31 (USFWS 1999b, Isaacs and Anthony 2003).

Osprey eggs collected in 1997 and 1998 along the lower 410 km of the Columbia River exhibited the highest DDE values reported for osprey in North America during the late 1980s and 1990s; additionally, DDE concentrations in eggs collected along the Columbia River were twice the concentration of eggs collected along the Willamette River in 1993 (Henny et al. 2003a, 2003b). Osprey eggshell thickness followed the classic semi-logarithmic response to DDE, as eggshell thickness decreased with increasing DDE concentration. Reproductive success was higher for nests that contained eggs with DDE concentration below 4,200 µg/kg; at this concentration, DDE results in 15% eggshell thinning (Wiemeyer et al. 1988 as cited in Henny et al. 2003a). Additionally, Henny et al. (2003a) noted that DDE concentrations in largescale suckers (a primary food item of osprey) in the Columbia River was double the levels detected in the Willamette River. Despite contaminant levels in osprey known to cause eggshell thinning, the lower Columbia River osprey population was increasing (Henny et al 2003a), but not as fast as the population nesting along the Willamette River (Henny et al. 2003b). The other contaminants found in osprey eggs (e.g., PCBs, dioxins, furans, mercury and other organochlorine pesticides), except for one egg with a high total dioxin-like activity calculated from PCBs and dioxins, appeared to be below any known effect levels for ospreys. During 1997 and 1998, osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population (Henny et al. 2003a).

Contaminant concentrations above available reference levels have been observed in river otter tissue samples; however, detrimental physiological effects have not been clearly established. For example, concentrations of organochlorines (i.e. PCBs, pesticides, dioxins, and furans) were higher in lower Columbia River otter samples compared to reference sites outside the lower Columbia River basin (Tetra Tech 1996). In general, observed contaminant concentrations in river otters increased with age; also, for age 2+ river otters, tissue contaminant levels decreased from rm 119.5 (near Vancouver/Portland) to rm 11.0 (Tetra Tech 1996). A number of physiological concerns were documented in river otters compared to otters from the reference sites: abnormal liver function, lower baculum weight and length, and lower mean testes weight (Tetra Tech 1996). However, when compared to previous tissue contaminant concentration data (Henny et al. 1981 as cited in Tetra Tech 1996), contaminant levels in river otter tissue in the 1990s indicate a major decline in PCB concentrations (Tetra Tech 1996). Further, data suggests that certain physiological problems may be temporary because organs of older males did not show significant size differences compared to reference animals (Tetra Tech 1996).

In the lower 150 miles of the mainstem Columbia River, the states of Oregon and Washington have found the following contaminants above guidance levels for fish tissue and sediment: organochlorines (including DDT, DDD, DDE, PCB, aldrin, dieldrin, trichlorobenzene, pyrene, and PAHs), and toxic metals (including mercury, cyanide, arsenic, chromium, iron, nickel, silver, zinc, cadmium, and copper; Tetra Tech 1993 as cited in Nez Perce et al. 1995). The U.S. Environmental Protection Agency has identified numerous water quality concerns for the Columbia River mainstem, including temperature, PCBs, dioxins, furans, pesticides, metals, and bacteria in the Columbia River estuary and temperature, PCBs, dioxins, furans, pesticides, metals, bacteria, dissolved oxygen, and total suspended solids in the Columbia River mainstem below Bonneville Dam (Nez Perce et al. 1995). However, two of the more widely known contaminants, DDT and PCBs, were much more prevalent in the lower Columbia River in the 1960s and early 1970s than they are today; their concentrations have continued to decline since 1972, when the use of DDT was banned (USACE 2001).

Data collected in the early to mid 1990s suggest that contaminant concentrations in water, sediment, or biota result in localized impairment throughout the lower Columbia River (i.e. Bonneville Dam to the mouth; Tetra Tech 1996). Metals concentration exceedance of sediment reference levels indicate possible localized effects to benthic organisms; further, some organic compounds (i.e. PCBs, DDT and derivatives, dioxins, and furans) detected in sediment and fish tissue are high enough to biomagnify through the food chain and cause adverse effects to piscivorous organisms (Tetra Tech 1996). In general, contaminant concentrations are higher in resident benthic-dwelling fish (such as largescale sucker) compared to migratory salmonids; thus, potential adverse physiological effects to biota, biomagnification to upper trophic level organisms, and human health risks associated with fish consumption are higher in benthic fish than salmonids (Tetra Tech 1996, USFWS 2003).

For years, the unmitigated flow of deicing agents from the Portland International Airport (PDX) directly into Columbia Slough has been a concern. Although PDX uses deicing agents in limited quantities, untreated flow of deicing agents can cause significant water quality problems. Deicing agents (typically a glycol mixture) are highly biodegradable and exert substantial biological oxygen demand when released to surface water. Biological oxygen demand decreases the dissolved oxygen level in the receiving surface water; decreased dissolved oxygen can stress organisms, making them less competitive and decreasing survival through a host of confounding factors. In 2003, PDX activated a glycol recovery system; the system combines underground monitoring, metering, storage, and aeration, as well as treatment by the City of Portland’s wastewater treatment plant. The glycol recovery system is intended to decrease glycol discharge levels to comply with the Oregon Department of Environmental Quality's total maximum daily load requirements for the Columbia Slough.

2.3.2.7 Restoration

Habitat actions proposed in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (BiOp; NMFS 2000c) are intended to accelerate efforts to improve survival in priority areas while laying the foundation for long-term habitat strategies. The overarching objectives of the habitat strategy are: protect existing high quality habitat, restore degraded habitats and connect them to functioning habitats, and prevent further degradation of habitat and water quality. Specifically, Reasonable and Prudent Alternative (RPA) Actions 158 through 163 of the BiOp detail specific actions related to estuarine habitat while RPA Actions 156 and 157 address habitat issues within the lower mainstem (NMFS 2000c). An "Action Plan" has recently been published that outlines a plan for implementing the above RPA actions related to estuary and mainstem habitat restoration, as well as RPA actions that address planning, modeling, and research, monitoring, and evaluation needs described in the BiOp (BPA and USACE 2003).

Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. RPA Action 160 in the BiOp called for an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, with the intention of rebuilding productivity for ESA-listed salmon population in the lower 46 miles of the Columbia River. There is considerable uncertainty whether the 10,000 acres is the precise amount needed to produce desired increases in salmonid productivity or if the 10-year schedule is an appropriate time scale for recovery efforts. NMFS (2000c) identified the importance of continued monitoring and evaluation of the estuary restoration program and the 10,000-acre goal to ensure that habitats being restored are important for salmon survival and recovery. NMFS (2000c) also suggested examples of acceptable habitat improvement efforts, including but not limited to: acquiring diked lands, breaching levees, improving plant communities, reestablishing flow patterns, or enhancing connections between lakes, sloughs, side channels, and the main channel.

Dike removal could provide a sizable increase in shallow water habitat, even without restoration of historical flow regimes (Kukulka and Jay 2003). Dike removal alone provided more of an increase in shallow water habitat than flow restoration without dike removal. Restoration of natural flows increases the duration of shallow water habitat inundation in high-flow years, but individually does not restore the large size of the area historically inundated.

Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids (Bisbal and McConnaha 1998). For example, changes in hydrosystem water management should attempt to provide benefits for the full range of salmonid life history patterns and not just the current majority. Restoration efforts need to move from the practice of management for average biological conditions to management for the full spectrum of possible biological variation (Williams et al. 1996 as cited in Bisbal and McConnaha 1998).

2.3.3 Historical vs. Current Habitat Condition

Current ecological conditions in the Columbia River estuary reflect years of anthropogenic impacts that have altered natural ecosystem inputs and processes and affected habitat conditions for all species that utilize the estuary. The extent of change of estuary habitat is highly dependent on location in the estuary and the type of habitat.

Significant effort has focused on quantifying the loss or change of habitats within the estuary and lower Columbia mainstem over time. The two methods employed to quantify habitat change include bathymetry and satellite imagery. Although there is some difficulty in comparing results of the two different methods, the underlying conclusion from both methods is that estuary and mainstem habitats have changed significantly as a result of human influence. Bathymetry is a low resolution method that provides coarse delineations of habitat types; further, bathymetry provides a means to segregate aquatic habitat based on depth criteria. Satellite imagery provides a high resolution habitat mapping method that principally uses vegetative communities to describe habitat types. Because of the use of vegetation, satellite imagery is generally not capable of distinguishing different types of aquatic habitats. Different satellite imagery technology are available that provide different levels of resolution; two of these technologies are compared in Garono et al. (2003b).

Using bathymetric survey maps of the U.S. Coast Survey (now U.S. Geodetic Survey), five major types of estuary (i.e. rm 0-46.5) habitat were defined by the Columbia River Estuary Data Development Program (Thomas 1983) according to elevation and the dominant vegetation: tidal swamps, tidal marshes, shallows/flats, medium depth water, and deep water. Change in acreage from 1870 to 1983 was estimated (Table 2-5). Additionally, Thomas (1983) investigated five categories of non-estuarine habitat (i.e. developed floodplain, natural and filled uplands, non-tidal swamps, non-tidal marshes, and non-tidal water) to identify the fate of floodplain areas that were removed from the estuarine system. Some estuary habitat has been lost and converted to non-estuarine habitat, while other habitats have been lost as result of succession to another estuarine habitat type (Thomas 1983). As a result, the relative proportions of the five estuary habitat types has changed considerably from 1870 to 1983. Also, the significance of loss of certain habitat types has been partially masked by the formation of these habitats elsewhere. Further, the geographic movement of estuary habitats is not clear from the quantification of total acreage change. For example, the total acreage of a certain habitat type within a particular estuary area may not have changed considerably from historical to current conditions, however, the location of this habitat type within the estuary area may be completely different. The habitat change within each estuary region and from one type to the next is discussed in the following subsections.

The Lower Columbia River Estuary Partnership (LCREP) was interested in describing the location and distribution of estuarine and tidal freshwater habitat cover types along the Columbia River from the mouth to Bonneville Dam using a consistent method and data source (Garono et al 2003c) as well as understanding recent habitat change in the estuary and lower Columbia River mainstem (Garono et al 2003a). The habitat mapping focused on estuarine and tidal freshwater habitats; areas not located along the river and >175 ft elevation (for the eastern dataset) or >100 ft elevation (for the western dataset) were deleted from the habitat classification (Garono et al 2003c). Although habitat change expressed as the percent of the 1992 area indicates considerable change from 1992 to 2000, the percent of total habitat comprised by each land cover class is similar in both 1992 and 2000. Further, it is important to note the losses and gains of each habitat type, as well as the transition among habitat types. For example, most of the loss of shrub-scrub wetland habitat was to either herbaceous or forested wetlands; the absolute loss of the shrub-scrub wetland habitat was offset by substantial transition of herbaceous wetlands to shrub-scrub wetlands. Much of the increase in deciduous forest upland habitat coverage was a result of transition of shrub-scrub upland, coniferous forest upland, or mixed forest upland habitats; this may be indicative of normal successional transitions. A considerable amount of the change in area of habitat cover was potentially explained by either natural habitat succession or error associated with differences in accuracy of the two data sets. In general, if a specific habitat type changed from 1992 to 2000, it remained within the larger designation of wetland or upland, that is, wetlands transitioned to other wetlands while uplands transitioned to other uplands.

Johnson and O'Neil (2001) developed a habitat classification system to describe wildlife habitats present in Washington and Oregon. The habitats described by Johnson and O'Neil (2001) have been used in the NPCC subbasin planning process throughout the Columbia Basin. Maps of many NPCC subbasins depicting the habitat coverage in 1850 and 1999 are currently available through the Interactive Biodiversity Information System (IBIS) website (http://ibis.nwhi.org).

Comparison of estuary and lower mainstem habitats describe by the three primary classification systems and mapping efforts (Thomas 1983, Johnson and O'Neil (2001)/IBIS (2003), Garono et al. 2003c) is difficult because of the different purposes of each effort. Further, each effort covered a different geographic area, encompassed different time periods, and utilized a different method or resolution. These differences may contribute to different results obtained during each effort. Nevertheless, we attempt to describe the changes in habitat in the Columbia River estuary and lower mainstem based on the findings of these habitat mapping projects. Regardless of the differences, each mapping project reached the conclusion that estuary and mainstem habitats have changed significantly as a result of human influence.

Other habitat inventory efforts include that of Christy and Putera (1992) and Graves et al. (1995) who extended the work of Thomas (1983); these mapping efforts used Geographic Information Systems methods (GIS) to delineated Thomas' (1983) estuary habitat types from rm 46.5 to rm 105. Finally, Johnson et al. (2003b) summarized many of the habitat inventory efforts to date (Thomas 1983, Graves et al. 1995, USACE 1996, Garono et al. 2002) to describe habitat changes in the Columbia River estuary and lower mainstem up to Bonneville Dam. A qualitative change in habitat characteristics by estuary area is included in Table 2-6. These studies are identified here primarily to inform the reader that other habitat mapping projects exists for the Columbia River estuary and lower mainstem.

Table 2-5. Estimated change in estuary habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983).

HABITAT TYPE **Estuary Region**	**1870 Acreage**	**1983 Acreage**	**Change**
DEEP WATER			
Entrance	8,900	10,580	+1,680 (19%)
Mixing Zone	8,450	8,360	-90 (1%)
Youngs Bay	810	850	+40 (5%)
Baker Bay	1,800	450	-1,350 (75%)
Grays Bay	2,270	1,690	-580 (26%)
Cathlamet Bay	6,390	5,590	-800 (13%)
Upper Estuary	6,520	5,060	-1,460 (22%)
TOTAL	**35,140**	**32,580**	**-2,560 (7%)**
MEDIUM DEPTH WATER			
Entrance	4,480	2,640	-1,840 (41%)
Mixing Zone	10,780	10,330	-450 (4%)
Youngs Bay	1,120	870	-250 (22%)
Baker Bay	4,700	1,350	-3,350 (71%)
Grays Bay	2,230	2,040	-190 (9%)
Cathlamet Bay	8,190	5,700	-2,490 (30%)
Upper Estuary	2,710	2,790	+80 (3%)
TOTAL	**34,210**	**25,720**	**-8,490 (25%)**
SHALLOW/TIDAL FLATS			
Entrance	2,980	1,680	-1,300 (44%)
Mixing Zone	9,540	9,490	-50 (1%)
Youngs Bay	4,400	3,860	-540 (12%)
Baker Bay	4,830	8,450	+3,620 (75%)
Grays Bay	3,790	4,330	+540 (14%)
Cathlamet Bay	13,330	14,250	+920 (7%)
Upper Estuary	1,770	2,710	+940 (53%)
TOTAL	**40,640**	**44,770**	**+4,130 (10%)**
TIDAL MARSH			
Entrance	0	250	+250
Mixing Zone	10	10	0
Youngs Bay	7,210	980	-6,230 (86%)
Baker Bay	1,640	730	-910 (56%)
Grays Bay	310	760	+450 (145%)
Cathlamet Bay	5,580	5,960	+380 (7%)
Upper Estuary	1,430	510	-920 (64%)
TOTAL	**16,180**	**9,200**	**-6,980 (43%)**
TIDAL SWAMP			
Entrance	0	0	0
Mixing Zone	0	0	0
Youngs Bay	3,000	130	-2,870 (96%)
Baker Bay	3,480	0	-3,480 (100%)
Grays Bay	4,410	510	-3,900 (88%)
Cathlamet Bay	7,950	4,060	-3,890 (49%)
Upper Estuary	11,180	2,250	-8,930 (80%)
TOTAL	**30,020**	**6,950**	**-23,070 (77%)**
TOTAL ESTUARY	**156,190**	**119,220**	**-36,970 (24%)**

Table 2-6. Qualitative description of the change in habitat characteristics from historical to current conditions by area, including a judgment of relative importance (adapted from Johnson et al. 2003b; L, M, and H refer to Low, Medium, and High).

Area	Tidal Exchange	Bathymetry	Salinity
Entrance	***L***-only a small area of historical marshes and swamps	***H***-very large increases in deep water area, and loss of medium and shallow depth areas	***L***-probably somewhat less dynamic, but still ocean-dominated
Mixing Zone	***L***-only a small area of historical marshes and swamps	***L***-little change in area, although high degree of shifting of locations	***M***-very dynamic salinity zone, probably altered by flow regulation
Youngs Bay	***H***-substantial loss of tidal marsh and swamp	***M***-loss of medium and shallow depth areas	***M***-very dynamic salinity zone, probably altered by flow regulation
Baker Bay	***H***-substantial loss of tidal marsh and swamp	***H***-substantial loss of deep and medium deep areas, and increase in shallow areas	***M***-very dynamic salinity zone, probably altered by flow regulation
Grays Bay	***H***-substantial loss of tidal swamp	***M***-shift from deepwater area to shallow flats	***L***-a small change in dilute salinity dynamics
Cathlamet Bay	***M***-loss of tidal swamps, but gain in tidal marsh	***M***-loss of deep and medium deep areas	***L***-a small change in dilute salinity dynamics
Upper Estuary	***H***-substantial loss of tidal swamp and marsh	***H***-loss of deep and gain in medium deep area, and substantial increase in shallow areas	***L***-a small change in dilute salinity dynamics
Tidal Freshwater Middle Reach (RM46-102)	***H***-substantial loss of tidal swamp and marsh, and non-tidal wetland	***H***-loss of shallow area, and gain in deep area	***L***-salinity not a factor
Tidal Freshwater Upper Reach (RM 102-146)	***H***-substantial loss of tidal swamp and marsh suspected, and gain in non-tidal wetland	***H***-loss of shallow area, and gain in deep area	***L***-salinity not a factor

2.3.3.1 Deep Water Habitat

Thomas (1983) documented a total loss of 2,560 acres of deep water habitat from 1870 to 1983; this represents a 7% loss of the 1870 acreage (Table 2-5). The most substantial losses of deep water habitat include 1,350 acres in the Baker Bay and 1,450 acres in the Upper Estuary. Loss of deep water habitat in Baker Bay represents the migration of Sand Island from the Entrance area to Baker Bay, which had occurred naturally by 1885. Jetty construction moderated the variability in water movement within the Entrance area, causing the retention of Sand Island in its present location (Thomas 1983). Further, maintenance dredging activities of the river bar and navigation channel in the Entrance area have contributed to increases of deep water habitat in this area (Thomas 1983). Although little change of deep water habitat acreage was observed in the Mixing Zone and Youngs Bay areas, location of deep water habitats in these areas has shifted as a result of migration of the channel (Thomas 1983). Loss of deepwater habitats in the subareas furthest upstream (Grays Bay, Cathlamet Bay, and Upper Estuary) was primarily a result of accretion that converted these habitats to medium depth or shallow/flats habitat. Deep water habitat losses were complemented by a 1,680 acre gain in the Entrance area; this increase in deep water habitat was also related to the migration of Sand Island.

In the Columbia Estuary Subbasin, there has been close to a complete loss of open water habitat from 1850 to 1999; as of 1999, only 878 acres of this habitat type remained in the subbasin (Table 2-7 and Figure 2-25). The open water habitat type does not have a water depth designation, thus, it is not clear which open water habitats comprise deep, medium, or shallow depths. Much of the historical open water habitat type was converted to the bays and estuaries habitat type (Table 2-7 and Figure 2-25). In the Columbia Lower Subbasin, a similar loss of open water habitat and conversion to bays and estuaries habitat occurred from the historical to current conditions (Table 2-8 and Figure 2-26). The apparent conversion of open water habitat to bays/estuaries habitat in these subbasins is a function of the different mapping data and methods used for the current and historical maps rather than an actual habitat conversion (Thomas O'Neil, Northwest Habitat Institute, personal communication). In the historical era mapping effort, the focus was on terrestrial habitats and the bays/estuaries habitat type was not even included in the habitat classification. Thus, although bays/estuaries habitat may have been present historically, location this habitat type was not mapped and much of the Columbia River corridor was classified as open water habitat. During the current era mapping effort, bays/estuaries habitat was classified and included in the terrestrial layer of the map while open water was included in the aquatic map layer. Because the terrestrial layer was overlayed on the aquatic layer, any bays/estuaries habitat in the same location as open water habitat would override the open water habitat type. Thus, on the current era map, bays/estuaries habitat may be overestimated and open water habitat may be underestimated.

In an analysis of recent habitat change, Garono et al (2003a) observed very little change in water habitat from 1992 to 2000 (Table 2-9). Again, there is no water depth designation to this water habitat type, so it is not clear which water habitats comprise deep, medium, or shallow depths.

2.3.3.2 Medium Depth Habitat

Except for the Upper Estuary area, Thomas (1983) documented a loss of medium depth water habitat in all areas of the estuary from 1870 to 1983 (Table 2-5). The collective loss of medium depth water habitat in the estuary was 8,490 acres, which represents about 25% of the 1870 acreage (Table 2-5). Substantial acreages of medium depth water were converted to deep water in the Entrance Subarea and to tidal flats in the Baker Bay Subarea; this is consistent with the migration of Sand Island and the maintenance of the navigation channel as described above. In Cathlamet Bay, considerable acreage of medium depth habitats was converted to shallows/flats through the process of accretion.

2.3.3.3 Shallow Water/Flats Habitat

The shallow water/flats habitat type is the only habitat where an estuary-wide increase in acreage occurred from 1870 to 1983 (Table 2-5). There are two basic processes by which shallow water/flats habitat can be created: accretion in deep/medium depth water habitats or erosion of tidal marsh or tidal swamp habitat (Thomas 1983). Formation of shallow water/flats habitat in the estuary from 1870 to 1983 have primarily been a result of the former process (Thomas 1983). The Entrance area showed the only substantial loss of shallow water/flats habitat while a large increase of this habitat type was observed in Baker Bay; these changes are consistent with the natural migration of Sand Island (Thomas 1983). Further, construction of the South Jetty resulted in considerable accretion of sand in the Entrance area; as a result, sand dunes have formed in areas that were formerly shallow water/flats habitat (Thomas 1983). In the more upstream areas (Grays Bay, Cathlamet Bay, and the Upper Estuary), losses of former medium and deep water habitats resulting from accretion have contributed to the increases in shallow water/flats habitat (Thomas 1983).

The shallow water/flats habitat defined by Thomas (1983) may have been mapped as open water, or bays/estuaries by Johnson and O'Neil (2001) and IBIS (2003) or as water by Garono et al. (2003c). As previously discussed, there is no depth designation to the general water habitat types of Johnson and O'Neil (2001) and Garono et al. (2003c); thus, comparison to the specific depth water habitats of Thomas (1983) is not appropriate. The bays and estuaries habitat type (Johnson and O'Neil 2001) was previously discussed in section 2.3.3.1; this habitat type appeared to replace much of the open water habitat in the estuary and lower mainstem (Figure 2-25 and Figure 2-26; IBIS 2003).

2.3.3.4 Tidal Marsh Habitat

Approximately 10,500 acres of 1870 tidal marsh acreage have been lost, however, the formation of about 3,500 acres of new tidal marsh resulted in the net loss of about 7,000 acres (Table 2-5). The 1870 estimate of tidal marsh acreage was difficult to determine because tidal marsh often occurred in a mosaic with tidal swamp habitat (Thomas 1983). In general, tidal marsh habitat loss is a result of extensive diking; high elevation tidal marshes have been diked more than lower elevation marshes (Thomas 1983). New tidal marsh formation has resulted primarily from vegetative colonization of disposed dredge material, but colonization has also occurred along natural shorelines and in shallow water/flats habitat (Thomas 1983). The location of tidal marsh habitat within each estuary area has changed as a result of modified flow regime, modified tidal action, and/or shipping channel development and maintenance.

In the Entrance area, the small gain of tidal marsh habitat has resulted from changes to wave action as a result of jetty construction (Thomas 1983). Formerly, wave action in the Entrance area prevented vegetative colonization (Thomas 1983). The jetties have resulted in decreased wave action, allowing the formation of tidal marsh habitat in the now sheltered area of Trestle Bay (Thomas 1983). In Baker Bay, the historical tidal marsh habitats have all been diked and therefore considered as lost (Thomas 1983). The 730 acres of tidal marsh habitat in Baker Bay in 1983 was all recently formed along shorelines in areas that were formerly exposed to wave action where vegetation could not colonize (Thomas 1983). A similar situation has occurred in Youngs Bay, where much of the historical tidal marsh habitat has been lost to diking and close to half of the 1983 tidal marsh habitat was recently formed (Thomas 1983). In Grays Bay, diking has not affected tidal marsh acreage because most diked areas were formerly tidal swamp; the gain of tidal marsh habitat in the Grays Bay area resulted from accretion in tide flats followed by bulrush colonization (Thomas 1983). A similar situation has occurred in Cathlamet Bay, however, the formation of tidal marsh habitats has occurred primarily in areas of dredge spoils deposition (Thomas 1983). In the Upper Estuary area, the net loss of tidal marsh habitat was the product of substantial losses of tidal marsh habitat on Tenasillahe Island as a result of diking that were offset by tidal marsh formation in areas of dredge spoils deposition (Thomas 1983).

The tidal marsh habitat defined by Thomas (1983) may have been mapped as herbaceous wetlands by Johnson and O'Neil (2001) and IBIS (2003; Table 2-3). In the Columbia Estuary Subbasin, almost 31,000 acres of herbaceous wetlands have been lost from 1850 to 1999; this represents a 67% loss of the 1850 acreage of herbaceous wetlands (Table 2-7 and Figure 2-25).

In the Columbia Lower Subbasin, approximately 140,000 acres of herbaceous wetlands have been lost from 1850 to 1999; this represents a 94% loss of the 1850 acreage of herbaceous wetlands (Table 2-8 and Figure 2-26). The percentage and absolute acreage loss of herbaceous wetlands determined by IBIS (2003) are considerably higher than the results of Thomas (1983); regardless, both mapping efforts document a substantial loss of the tidal marsh or herbaceous wetland habitat type.

The tidal marsh habitat defined by Thomas (1983) may have been mapped as herbaceous wetlands or scrub-shrub wetlands by Garono et al. (2003a;Table 2-3). The recent habitat change analysis by Garono et al. (2003a) documented an increase of 8,495 acres of herbaceous wetland habitat from 1992 to 2000; this increase represents 17% of the 1992 acreage (Table 2-9). Most of the herbaceous wetland habitat in 2000 was formerly scrub-shrub wetland (44%), forested wetland (31%), or urban areas (24%). Garono et al. (2003a) felt it was unlikely that urban habitats had converted to herbaceous wetlands from 1992 to 2000; rather, this result may be a function of the ability of the 2000 data set to better discriminate between actual urban areas and vegetated areas within and around urban areas. Conversely, Garono et al. (2003a) observed a loss of about 9,000 acres of scrub-shrub wetlands, which represent about 36% of the 1992 habitat acreage (Table 2-9). Most of the habitat loss of scrub-shrub wetlands was a result of conversion to herbaceous wetlands (44%) or forested wetlands (21%) (Garono et al. 2003a).

2.3.3.5 Tidal Swamp Habitat

Tidal swamp habitat was by far the most impacted estuarine habitat type; almost all of the 1870 tidal swamp habitat has been converted to one of the diked floodplain/non-tidal habitats described below (Thomas 1983). Loss of tidal swamp habitat alone was responsible for 62% of the total estuary habitat loss (Thomas 1983). Thomas (1983) reasoned that, because of their elevation and/or irregular tidal influence, tidal swamp habitat is the estuarine habitat most susceptible to diking. Historically, few tidal swamps were present in the Entrance and Mixing Zone areas, thus little change has been observed in these areas (Thomas 1983). There has been almost complete loss of all 1870 tidal swamp habitat from the Youngs Bay and Baker Bay areas; as a result, brackish water tidal swamps have been essentially eliminated from the estuary (Thomas 1983). In the areas furthest upstream, tidal swamp acreage losses have been extensive, however, a substantial amount of tidal swamp acreage is still present, particularly in the Cathlamet Bay area (Thomas 1983).

The tidal swamp habitat defined by Thomas (1983) may have been mapped as Westside riparian-wetlands by Johnson and O’Neil (2001) and IBIS (2003;Table 2-3). However, the Westside riparian-wetland habitat type typically occupies patches or linear strips within a forest matrix; other characteristics of this habitat type (Johnson and O’Neil 2001) indicate that it may differ substantially from the tidal swamp described by Thomas (1983). Nevertheless, Westside riparian-wetland appears to be the most closely related habitat type to tidal swamp. In the Columbia Estuary Subbasin, an increase of about 6,000 acres (i.e. 41% of 1850 acreage) of Westside riparian-wetlands occurred from 1850 to 1999 (Table 2-7 and Figure 2-25). Similarly in the Columbia Lower Subbasin, Westside riparian-wetland habitat acreage increased by about 3,000 acres (i.e. 24% of 1850 acreage) from 1850 to 1999 (Table 2-8 and Figure 2-26). This result was completely opposite that observed by Thomas (1983) for tidal swamp habitat. The increased acreage of Westside riparian-wetland from 1850 to 1999 is most likely a result of different resolutions between the mapping data rather than an actual increase in this wetland habitat type; the habitat change result for this habitat type would likely be much different if the resolution in the 1850 and 1999 data were similar (Thomas O’Neil, personal communication).

The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements. Further, tidal marsh and swamp habitat acreage constituted 30% of the total 1870 acreage while these habitats comprise only 14% of the total 1983 estuarine habitat acreage.

The tidal swamp habitat defined by Thomas (1983) may have been mapped as forested wetlands by Garono et al. (2003a; Table 2-3). The recent habitat change analysis by Garono et al. (2003a) documented an increase of about 5,500 acres of forested wetland habitat from 1992 to 2000; this increase represents 49% of the 1992 acreage (Table 2-9). Most of the forested wetland habitat in 2000 was formerly scrub-shrub wetland (21%) or herbaceous wetland (9%); thus, the increase in forested wetland habitat appears to be partially explained by succession of other wetland habitats. The increase of forested wetland habitat is completely opposite that observed by Thomas (1983) for tidal swamp habitat; this difference is likely a result of the different time period, geographic area, and method used in each study.

2.3.3.6 Non-Estuarine Wetlands

Thomas (1983) estimated that about 7,000 acres of non-estuarine wetlands habitat (i.e. non-estuarine swamps, marsh, and water) were created in the estuary from 1870 to 1983; most of this area was formerly tidal swamps and, to a lesser extent, tidal marsh. Non-estuarine wetlands habitat was created in all estuary areas except the Mixing Zone (Table 2-10).

Similar habitat types defined by Johnson and O'Neil (2001) (i.e. Westside riparian-wetlands, herbaceous wetlands) or by Garono et al. (2003a) (i.e. forested wetlands, herbaceous wetlands) (Table 2-3) have already been discussed.

2.3.3.7 Forested Uplands

Forest upland habitats in the Columbia River estuary and lower mainstem characterized by Johnson and O'Neil (2001) include Westside (mesic) lowlands conifer-hardwood forest, Westside oak and dry Douglas fir forest, and montane mixed conifer forest. In the Columbia Estuary Subbasin and the Columbia Lower Subbasin, Westside lowlands conifer-hardwood forest increased by about 17,500 and 33,000 acres, respectively, from 1850 to 1999 (Table 2-7, Table 2-8, Figure 2-25, and Figure 2-26). In the analysis of more recent habitat change, Garono et al (2003a) documented an increase of about 4,500 acres of coniferous forest upland from 1992 to 2000 (Table 2-9). About half of the coniferous forest upland habitat in 1992 remained as such in 2000; much of the remaining coniferous forest upland habitat in 2000 was a result of conversion of mixed forest upland (26%), deciduous forest upland (18%), and scrub-shrub upland (18%).

In the Columbia Estuary Subbasin and the Columbia Lower Subbasin, montane mixed conifer forest decreased by about 4,500 and 2,500 acres, respectively, from 1850 to 1999 (Table 2-7, Table 2-8, Figure 2-25, and Figure 2-26). Most of the historical montane mixed conifer forest was recently classified as Westside lowlands conifer-hardwood forest in both subbasins; this may be an artifact of the different resolution of mapping data from 1850 to 1999. For the mixed forest upland habitat type, Garono et al (2003a) observed a loss of about 6,000 acres from 1992 to 2000 (Table 2-9); most of the lost mixed forest upland habitat was explained by the conversion to deciduous forest upland (26%) and coniferous forest upland (26%).

In the Columbia Lower Subbasin, Westside oak and dry Douglas fir forest habitat decreased by about 86,000 acres from 1850 to 1999 (Table 2-8 and Figure 2-26); this represents a 93% loss of this habitat type. Most of the Westside oak and dry Douglas fir forest habitat appears to have been converted to the agriculture, pastures, and mixed environs or the urban and mixed environs habitat types (Figure 2-26). Conversely, Garono et al. (2003a) documented a substantial increase in deciduous forest upland from 1992 to 2000; the increase of over 11,000 acres of this habitat represents a 429% change over the 1992 acreage (Table 2-9). The increase in deciduous forest upland habitat acreage in 2000 was a result of conversion of scrub-shrub upland, mixed forest upland, and coniferous forest upland.

2.3.3.8 Developed Floodplain

Thomas (1983) estimated that about 24,000 acres of developed floodplain habitat were created in the estuary from 1870 to 1983; most of this area was formerly tidal swamps and, to a lesser extent, tidal marsh. Developed floodplain habitat was not created in the Entrance or Mixing Zone areas; developed floodplain habitat was somewhat evenly distributed among the other five estuary areas (Table 2-10).

The developed floodplain habitat of Thomas (1983) is most closely related to the agriculture, pastures, and mixed environs and the urban and mixed environs habitat types of Johnson and O’Neil (2001). In the Columbia Estuary Subbasin, 16,887 acres of the agriculture, pastures, and mixed environs habitat type and 6,344 acres of the urban and mixed environs habitat type were created between 1850 and 1999 (Table 2-7 and Figure 2-25). Thus, the combined creation of these two habitat types from 1850 to 1999 (i.e. 23,231 acres) is extremely similar to the creation of developed floodplain habitat from 1870 to 1983 documented by Thomas (1983). In the Columbia Lower Subbasin, a considerable amount of the agriculture, pastures, and mixed environs habitat type (i.e. 110,041) and the urban and mixed environs habitat type (i.e. 89,900) were created between 1850 and 1999 (Table 2-8 and Figure 2-26).

In the analysis of more recent habitat change, Garono et al. (2003a) observed a decrease of about 2,000 acres of the urban habitat type from 1992 to 2000, which represents a decrease of about 14% of the 1992 acreage. As previously mentioned, Garono et al. (2003a) felt it was unlikely that urban habitat coverage had decreased from 1992 to 2000; rather, this result may be a function of the ability of the 2000 data set to better discriminate between actual urban areas and vegetated areas within and around urban areas.

The results presented by Thomas (1983) and IBIS (2003) are consistent with the habitat mapping data summarized by Johnson et al. (2003b). In the tidal freshwater portion of the lower mainstem from rm 46-102, there was a general increase in upland habitat complemented by a substantial loss of non-tidal water/wetland, tidal flats, and tidal marsh habitat types; similarly, from rm 105-146, there was an increase of non-tidal water/wetland and upland habitat balanced with a substantial loss of tidal flats and tidal marsh habitat types (Johnson et al. 2003b). In both reaches of the tidal freshwater portion of the lower mainstem, there was no available comparison category for tidal swamp habitat (Johnson et al 2003b).

2.3.3.9 Natural and Filled Uplands

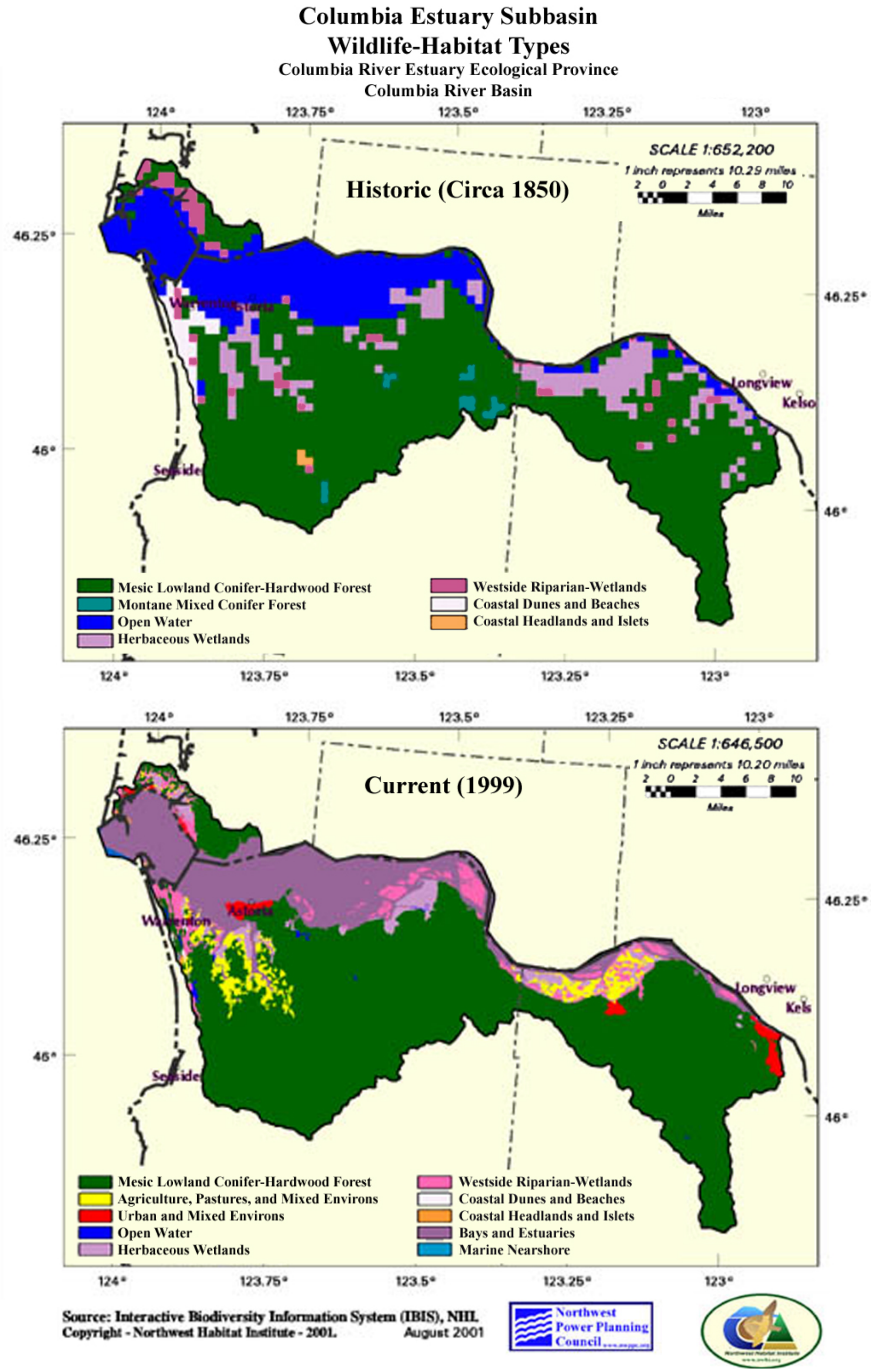
The 1,900 acres of historical natural and filled upland habitat identified by Thomas (1983) was comprised mostly of sand dunes throughout the Entrance, Youngs Bay, and Baker Bay areas (Table 2-10). A considerable amount of natural and filled upland habitat was created from 1870 to 1983; some of this habitat was created as a result of accretion of sand in Baker Bay and along Clatsop Spit, however, most of this created habitat resulted from the disposal of dredge spoils (Thomas 1983).

The natural and filled upland habitat defined by Thomas (1983) may have been mapped as coastal dunes and beaches habitat by Johnson and O’Neil (2001) and IBIS (2003; Table 2-3). In the Columbia Estuary Subbasin, almost all of the historical coastal dunes and beaches habitat were lost by 1999 (Table 2-7 and Figure 2-25), which is contrary to the results of Thomas (1983). Numerous factors may explain this difference, including dissimilar habitat types and different time periods, geographic area, or methods used in each study.

The natural and filled upland habitat defined by Thomas (1983) may have been mapped as unconsolidated shore habitat by Garono et al. (2003a; Table 2-3). From 1992 to 2000, there was a loss of about 4,500 acres of unconsolidated shore habitat, which represents about 20% of the 1992 habitat acreage (Table 2-9). This result is also conflicts with the results of Thomas (1983) but is consistent with IBIS (2003).

Table 2-7. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the Columbia Estuary Subbasin (IBIS 2003).

	Acreage		
Habitat Name	**Historical (circa 1850)**	**Current (1999)**	**Change**
Westside (mesic) Lowlands Conifer-Hardwood Forest	303,217	320,712	+17,495 (6%)
Montane Mixed Conifer Forest	4,466	0	-4,466 (100%)
Agriculture, Pastures, and Mixed Environs	0	16,887	+16,887
Urban and Mixed Environs	0	6,344	+6,344
Open Water - Lakes, Rivers, and Streams	105,277	878	-104,399 (99%)
Herbaceous Wetlands	45,720	14,887	-30,833 (67%)
Westside Riparian-Wetlands	14,186	20,064	+5,878 (41%)
Coastal Dunes and Beaches	8,634	375	-8,259 (96%)
Coastal Headlands and Islets	741	510	-231 (31%)
Bays and Estuaries		101,022	+101,022
Marine Nearshore		562	+562
Total Acres:	**482,238**	**482,235**	



Source: Interactive Biodiversity Information System (IBIS), NHI.
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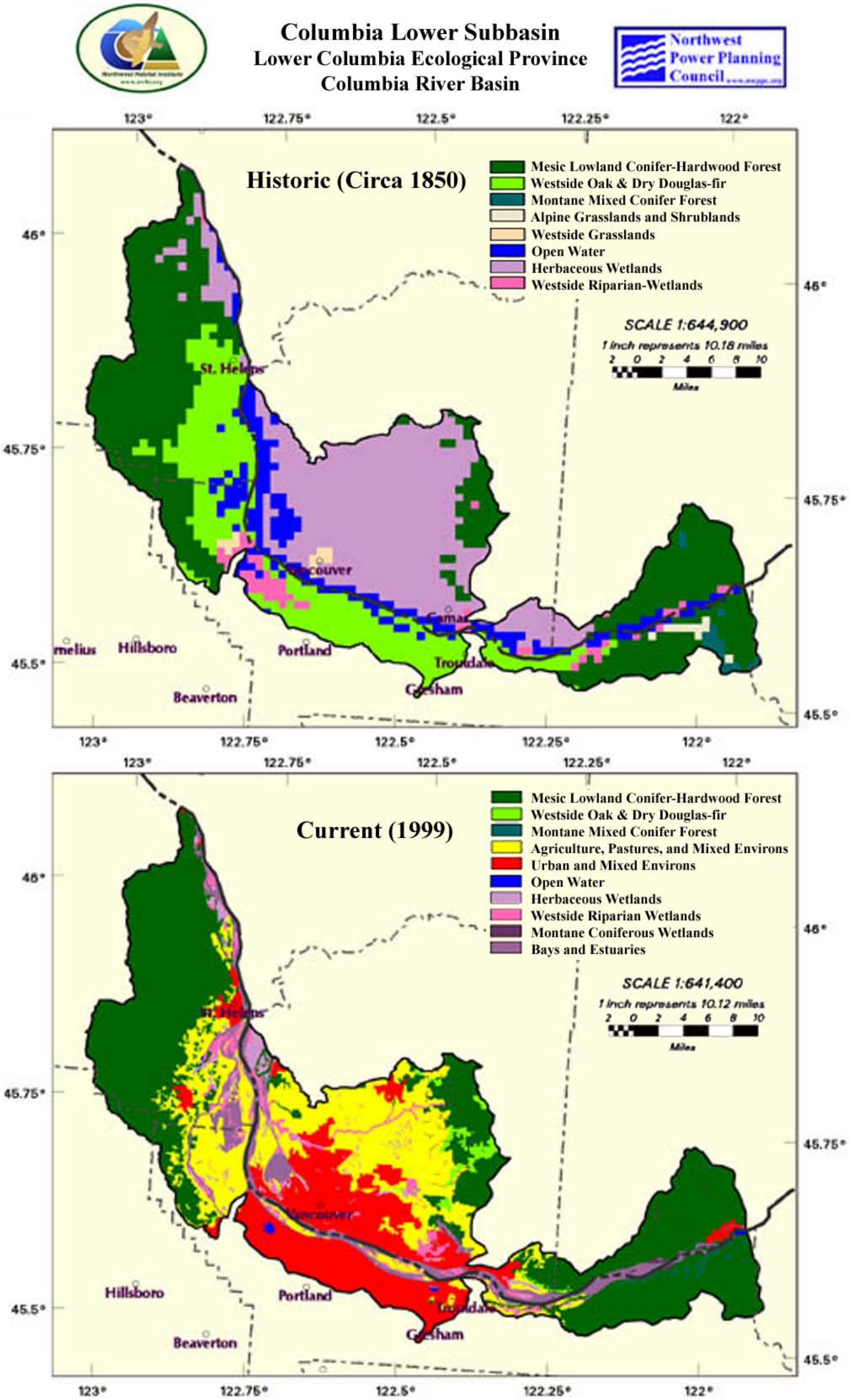
Figure 2-25. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Estuary Subbasin (IBIS 2003).

Table 2-8. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the lower Columbia Lower Subbasin (IBIS 2003).

	Acreage		
Habitat Name	**Historical (circa 1850)**	**Current (1999)**	**Change**
Westside (mesic) Lowlands Conifer-Hardwood Forest	185,062	218,043	+32,981 (18%)
Westside Oak and Dry Douglas-fir Forest and Woodlands	92,444	6,206	-86,238 (93%)
Montane Mixed Conifer Forest	4,161	1,772	-2,389 (57%)
Alpine Grasslands and Shrublands	2,471	0	-2,471 (100%)
Westside Grasslands	2,965	0	-2,965 (100%)
Agriculture, Pastures, and Mixed Environs	0	110,041	+110,041
Urban and Mixed Environs	0	89,900	+89,900
Open Water - Lakes, Rivers, and Streams	44,350	841	-43,509 (98%)
Herbaceous Wetlands	149,521	9,413	-140,108 (94%)
Westside Riparian-Wetlands	12,982	16,086	+3,104 (24%)
Montane Coniferous Wetlands	0	1,912	+1,912
Bays and Estuaries	0	39,742	+39,742
Total Acres	**493,953**	**493,950**	



Source: Interactive Biodiversity Information System (IBIS), NHI.
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Figure 2-26. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Lower Subbasin (IBIS 2003).

Table 2-9. Estimated change in Columbia River estuary habitat cover types from 1992 to 2000 (Garono et al. 2003a).

	1992		2000		Change	
Land Cover Class	**Area (acres)**	**% of Total**	**Area (acres)**	**% of Total**	**Area (acres)**	**% of 1992 Total**
Herbaceous Wetland	50,106.0	18.1	58,601.0	21.1	8,495.0	17
Shrub-Scrub Wetland	24,781.7	8.9	15,810.5	5.7	-8,971.1	-36
Forested Wetland	11,101.9	4.0	16,580.7	6.0	5,478.8	49
Herbaceous Upland	6,568.5	2.4	11,415.3	4.1	4,846.7	74
Shrub-Scrub Upland	21,659.7	7.8	6,993.6	2.5	-14,666.2	-68
Deciduous Forest Upland	2,627.2	1.0	13,886.8	5.0	11,259.6	429
Coniferous Forest Upland	9,354.7	3.4	13,985.6	5.0	4,631.0	50
Mixed Forest Upland	11,403.4	4.1	5,274.2	1.9	-6,129.2	-54
Unconsolidated Shore	22,709.2	8.2	18,123.4	6.5	-4,585.8	-20
Urban	14,433.7	5.2	12,482.0	4.5	-1,951.6	-14
Water	102,758.9	37.0	102,871.0	37.0	112.2	0.1
Other			1,480.2	0.5	1,480.2	-

Table 2-10. Estimated change in non-estuarine habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983).

HABITAT TYPE Estuary Region	1870 Acreage	1983 Acreage	Change
DEVELOPED FLOODPLAIN			
Entrance	0	0	0
Mixing Zone	0	0	0
Youngs Bay	0	6,670	+6,670
Baker Bay	0	3,420	+3,420
Grays Bay	0	3,270	+3,270
Cathlamet Bay	0	4,150	+4,150
Upper Estuary	0	6,440	+6,440
TOTAL	**0**	**23,950**	**+23,950**
UPLANDS – NATURAL AND FILLED			
Entrance	530	1,300	+770 (145%)
Mixing Zone	0	590	+590
Youngs Bay	350	1,070	+720 (206%)
Baker Bay	1,050	1,600	+550 (52%)
Grays Bay	0	120	+120
Cathlamet Bay	0	920	+920
Upper Estuary	0	1,990	+1,990
TOTAL	**1,930**	**7,590**	**+5,660 (293%)**
NON-ESTUARINE SWAMP			
Entrance	0	130	+130
Mixing Zone	0	0	0
Youngs Bay		1,370	+1,370
Baker Bay	0	1,260	+1,260
Grays Bay	0	200	+200
Cathlamet Bay	0	110	+110
Upper Estuary	0	250	+250
TOTAL	**0**	**3,320**	**+3,320**
NON-ESTUARINE MARSH			
Entrance	0	360	+360
Mixing Zone	0	0	0
Youngs Bay	0	930	+930
Baker Bay	0	170	+170
Grays Bay	0	40	+40
Cathlamet Bay	0	430	+430
Upper Estuary	0	1,200	+1,200
TOTAL	**0**	**3,130**	**+3,130**
NON-ESTUARINE WATER			
Entrance	50	0	-50 (100%)
Mixing Zone	0	0	0
Youngs Bay	0	160	+160
Baker Bay	0	70	+70
Grays Bay	0	50	+50
Cathlamet Bay	0	270	+270
Upper Estuary	0	410	+410
TOTAL	**50**	**960**	**+910 (1,820%)**
TOTAL	**1,980**	**38,950**	**+36,970 (1,867%)**

2.4 Species/Habitat Interactions

Discussions of interactions between species and habitats are divided into multiple sections. Section 2.4.1 Focal Species Habitat Associations presents the general estuary and lower mainstem habitats associated with each focal species. Section 2.4.2 Salmonids provides a more detailed discussion of the known and suspected biological relationships between salmonids and the estuary and lower mainstem ecosystem. Sections 2.4.3 through 2.4.13 discuss the relationships between other focal species and the estuary and lower mainstem ecosystem.

2.4.1 Focal Species Habitat Associations

A species/habitat matrix was developed for the estuary focal species (Table 2-11); the matrix summarizes a qualitative assessment of potential species utilization within coarse estuary and mainstem habitats. Habitats were chosen for two reasons: 1) habitats were included in a current versus historical acreage comparison in the Columbia River estuary (Thomas 1983, Johnson et al. 2003b), or 2) habitats were considered important based on WDFW input. The utilization levels are based on professional interpretation of the reviewed literature and life history descriptions in the Technical Foundation; the utilization levels are an arbitrary qualitative scale that includes the following levels of habitat use: none, low, medium, high, and critical. The first four categories are self-explanatory; the critical designation indicates that the habitat type is critical to the survival of the particular life stage of the focal species. There are numerous habitat classification system available for fish and wildlife research (i.e. Rosgen stream channel typing, Cowardin wetland and deepwater habitat classification (Cowardin et al. 1979), wildlife habitat classification (Johnson and O'Neil 2001)); choice of the appropriate systems depends on the purpose of the project as described further in section 2.1.5. For this analysis, the coarse habitat types described in the current versus historical acreage comparison (i.e. Thomas 1983) provide a context to discuss potential effects of estuary habitat change over time on focal species. These estuary habitats have previously been defined in section 2.1.5.

Utilization levels of each habitat type by focal species is *not* intended to serve as the ultimate authority in determining importance of that habitat type. For example, the fish focal species do not utilize old growth/mature forests; however, the importance of this habitat type should not be ignored. More complete habitat associations specifically for wildlife species have been developed by Johnson and O'Neil (2001) and continue to be updated on the Northwest Habitat Institute's (NHI) webpage (www.nwhi.org; Table 2-12). This table presents the known wildlife focal species habitat associations within the Columbia Estuary and Columbia Lower Subbasins; thus, focal fish species are not included. The wildlife-habitat type column follows the classification of Johnson and O'Neil (2001) and is consistent with the habitats presented in Table 2-7 and Table 2-8. The association type column provides a qualitative description of the level of association between the species and the habitat. The activity type column describes the behavior that occurs within the habitat type. Finally, the confidence level indicates the level of certainty of the relationship between the species and the habitat type. NHI has also determined if a relationship exists among wildlife species and the various life stages of salmonids; those wildlife focal species that interact with salmonids are presented in Table 2-13. The relationship type column indicates the degree and repeatability of the relationship between the focal species and salmonids. The salmonid stage column describes the salmonid life stage affected by the relationship with the wildlife focal species.

Table 2-11. Likelihood of focal species utilization within various lower Columbia River mainstem and estuary habitat types.

				Riverine/Estuarine Habitat			Transition Habitat			Upland Habitat		
				Estuary Habitat Classification (Thomas 1983, Johnson et al. 2003b)					WDFW Priority Habitat Classification			
				Deep Water	Medium Depth Water	Tidal Flats	Tidal Marsh	Tidal Swamp	Riparian	Old Growth/ Mature Forest (see Note below)	Freshwater Wetland (i.e. isolated from river corridor)	Rural Natural Open Space
				Percent Habitat Change from 1870 to 1983 (Thomas 1983, Johnson et al. 2003b)								
Species	Primary Life Stage	Level of Use	Primary Season of Use	-13	-19	+10	-49	-74	-	-	-	-
Ocean-type salmonid[a]	Subyearling Juveniles	Migratory	Spring-Fall	◓	◕	◕	●	●	●	○	○	○
Stream-type salmonid[a]	Yearling Smolt	Migratory	Summer	◕	◕	◕	◕	◕	◕	○	○	○
Pacific Lamprey[b]	Ammocoetes or Macrothalmia	Migratory or Resident	Potentially Year-round	◕	◕	◔	◕	◕	◕	○	○	○
White Sturgeon[c]	Juveniles and Adults	Migratory or Resident	Year-round	●	◓	◓	◔	◔	◔	○	○	○
Northern Pikeminnow[d]	Juveniles and Adults	Migratory or Resident	Year-round	◓	◕	◓	◕	◕	◕	○	○	○
River Otter[e]	Juveniles and Adults	Resident	Year-round	◓	◓	◓	◕	◕	◕	◔	◕	◓
Caspian Tern[f]	Juveniles and Adults	Resident	Spring to Fall	◕	◕	◕	◔	◔	◔	○	○	◓
Bald Eagle/ Osprey[g]	Juveniles and Adults	Resident	Spring to Fall	◓	◓	◓	◔	◕	◕	◕	◓	◔
Yellow Warbler[h]	Juveniles and Adults	Resident	Spring to Fall	○	○	○	◔	●	●	◔	◕	◔
Red-eyed Vireo[i]	Juveniles and Adults	Resident	Spring to Fall	○	○	○	◔	●	●	◓	◕	◔
Sandhill Crane[j]	Juveniles and Adults	Resident	Winter	○	○	◓	◕	○	◕	○	◕	◕
Columbian White-tailed Deer[k]	Juveniles and Adults	Resident	Year-round	○	○	○	◓	◕	◕	◕	◓	◕

Note: Use of multiple habitat classification systems is problematic; considerable overlap occurs between habitat designations in different classifications. The habitat types used in the comparison of current and historical habitat conditions (Johnson et al. 2003b) are very general and are not intended to fully describe the vegetation components of the habitat. The WDFW Priority Habitats may be general or specific, depending on the category. For example, old growth/mature forests are described by specific tree diversity, density, and canopy layers but have no elevation specifications. Therefore, old growth forests could be a subset of tidal swamps or part of the upland region. In fact, the 74% loss of tidal swamp habitat may have consisted primarily of old growth tidal swamps and the importance of old growth habitats in the lower mainstem and estuary should not be underestimated. On the other hand, the WDFW riparian habitat category is very general and may encompass habitats categorized as tidal marsh or tidal swamp. Finally, use of the word "tidal" implies some influence of inflowing saltwater on the lower Columbia River mainstem and estuary habitats. In the Columbia River, the influence is generally realized as fluctuating water levels and not as substantial changes in salinity levels over the tidal cycle; many tidal areas in the lower Columbia River remain dominated by freshwater. In general, salinity can have an over-riding influence on estuary and mainstem habitats as it controls plant and animal species assemblages that occur in specific areas because most species have very specific salinity tolerance.

Qualitative Scale of Habitat Use:

● Critical
◕ High
◓ Medium
◔ Low
○ None

[a] Estuary habitats are utilized primarily by outmigrating juvenile salmonids, except for cutthroat trout that have been observed to occupy estuarine and tidewater habitats for the entire ocean residence period. The importance of the estuary and mainstem littoral habitats varies and is roughly equivalent to the amount of time each species utilizes the estuary and lower mainstem. Generally, salmonids that emigrate as fry or sub-yearlings (i.e. ocean-type chinook and chum salmon) use the estuary extensively for rearing, while salmonids that emigrate as yearlings spend less time in the estuary.

[b] Pacific lamprey do not feed during the transformation from ammocoetes to macrothalmia, which occurs around the time of migration from freshwater to saltwater. Although little is known about Pacific lamprey utilization of estuary or lower mainstem habitats, lampreys are not expected to spend much time in the lower mainstem or estuary.

[c] White sturgeon have been observed congregating in the Columbia River estuary during summer, presumably in relation to food availability. However, white sturgeon are likely present in the lower mainstem and estuary throughout much of the year. Estuary and lower mainstem habitat usage likely varies by age, with younger fish using nearshore or medium depth habitats and adults using deepwater habitats.

[d] Northern pikeminnow are freshwater species and are not known to use estuarine habitats. Northern pikeminnow are warm water species that inhabit the medium and deep water habitats of the Columbia River mainstem.

[e] River otter juveniles and adults are closely associated with aquatic habitats; pups are usually born in a subterranean burrow and begin to swim at about 2 months. River otters feed in water and on land; otters have been observed traveling long distances over land.

[f] Caspian terns can nest in a variety of substrates among an assortment of vegetation types; nests are commonly on sandy substrates in close proximity to abundant fish resources. Breeding Caspian terns almost exclusively eat fish; feeding occurs in near-shore and mid-channel habitats.

[g] Osprey may be found in various estuary and lower mainstem habitats. Presence is most likely in tidal swamps or riparian areas where adequate nest sites exist in proximity to aquatic habitats where fish/birds are abundant and available for consumption.

[h] Possible breeding evidence of yellow warblers has been documented in the Columbia River estuary and along the lower mainstem. If present, yellow warblers would most likely be found in tidal swamp, riparian, or freshwater wetland habitats because they are a riparian obligate species most strongly associated with wetlands that contain Douglas spirea and deciduous tree cover.

[i] Red-eyed vireos are relatively abundant in the Puget Sound and northeast Washington; there has been no confirmed breeding in the Columbia River estuary while possible breeding evidence has been documented along the mainstem near Bonneville. If present, red-eyed vireos would most likely be found in tidal swamp, riparian, or freshwater wetland habitats where woody species satisfy the canopy height and density requirements.

[j] The Columbia River estuary and lower mainstem is generally a migratory stop for sandhill cranes that breed in the Central Valley of California; up to 1,000 sandhill cranes have wintered on lower Columbia River bottomlands in recent years.

[k] Columbian white-tailed deer are generally associated with riparian and wetland habitats; their strongest habitat association is with oak and Douglas fir forest in close proximity to a stream or river.

Table 2-12. Wildlife focal species habitat associations in the Columbia Estuary and Columbia Lower Subbasins (IBIS 2003).

Focal Species	Wildlife-Habitat Type	Association Type	Activity Type	Confidence Level	Comments
Columbian White-tailed Deer	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Feeds and Breeds	High	none
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Closely Associated	Feeds and Breeds	High	Strong association with oak within 200 meters of a stream or river.
	Agriculture, Pastures, and Mixed Environs	Generally Associated	Feeds and Breeds	High	none
	Urban and Mixed Environs	Generally Associated	Feeds and Breeds	High	none
	Herbaceous Wetlands	Generally Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none
Caspian Tern	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds and Breeds	High	Nests on sandbars and dredge spoil islands within rivers.
	Herbaceous Wetlands	Closely Associated	Feeds	High	none
	Coastal Dunes and Beaches	Closely Associated	Other (see comments)	High	O = roosting/resting.
	Coastal Headlands and Islets	Generally Associated	Other (see comments)	High	O = roosting/resting.
	Bays and Estuaries	Closely Associated	Feeds	High	none
	Marine Nearshore	Closely Associated	Feeds	High	none
Bald Eagle	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Montane Mixed Conifer Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Agriculture, Pastures, and Mixed Environs	Generally Associated	Feeds	High	none

	Urban and Mixed Environs	Generally Associated	Feeds and Breeds	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds	High	none
	Herbaceous Wetlands	Generally Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none
	Coastal Dunes and Beaches	Present	Feeds	High	none
	Coastal Headlands and Islets	Generally Associated	Feeds and Breeds	High	none
	Bays and Estuaries	Generally Associated	Feeds and Breeds	High	Requires some sort of structure to place nest on, such as old pilings, if breeding is to occur in this habitat.
	Marine Nearshore	Generally Associated	Feeds	High	none
Osprey	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Montane Mixed Conifer Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Agriculture, Pastures, and Mixed Environs	Present	Reproduces	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Urban and Mixed Environs	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none
	Coastal Headlands and Islets	Generally Associated	Reproduces	Moderate	none
	Bays and Estuaries	Generally Associated	Feeds and Breeds	Moderate	Requires some sort of structure to place nest on, such as old pilings, if breeding is to occur in this habitat.
	Marine Nearshore	Generally Associated	Feeds	Moderate	none

River Otter	Urban and Mixed Environs	Present	Feeds	High	Might be found in marinas.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds and Breeds	High	Dens placed in banks.
	Herbaceous Wetlands	Closely Associated	Feeds and Breeds	High	none
	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none
	Coastal Dunes and Beaches	Generally Associated	Feeds and Breeds	Moderate	Uses this habitat in the Puget Sound, Hood Canal, etc., but not likely to use outer coast beaches.
	Coastal Headlands and Islets	Present	Feeds and Breeds	High	Only where this habitat is near estuaries, coastal bogs, or along the Puget Sound and Strait of Juan de Fuca. Not likely on the outer coast.
	Bays and Estuaries	Closely Associated	Feeds and Breeds	High	none
	Marine Nearshore	Generally Associated	Feeds	High	Puget Sound, Hood Canal etc. only, not outer coast.
Sandhill Crane	Agriculture, Pastures, and Mixed Environs	Closely Associated	Feeds and Breeds	High	Also includes staging areas; must have roosting areas within the range.
	Herbaceous Wetlands	Closely Associated	Feeds and Breeds	High	none
Yellow Warbler	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none
Red-eyed Vireo	Mesic Lowlands Conifer-Hardwood Forest	Present	Feeds and Breeds	Moderate	Requires a hardwood component.
	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	Moderate	Range of red-eyed vireo overlaps that of large black cottonwood groves.

Table 2-13. Focal species relationship to salmonids (IBIS 2003).

Common Name	Relationship Type	Salmonid Stage	Comments
Caspian Tern	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
Bald Eagle	Indirect	Incubation - eggs and alevin	Feed on birds that feed on salmon.
	Indirect	Freshwater rearing - fry, fingerling, and parr	Feed on birds that feed on salmon.
	Strong, consistent	Carcasses	none
	Indirect	Saltwater - smolts, immature adults, and adults	Feed on birds that feed on salmon.
	Strong, consistent	Spawning - freshwater	none
	Indirect	Carcasses	Feed on birds that feed on salmon.
	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
Osprey	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
	Strong, consistent	Spawning - freshwater	none
	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
River Otter	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
	Strong, consistent	Spawning - freshwater	none
	Strong, consistent	Carcasses	none

2.4.2 Salmonids

Estuaries are important for many species, particularly anadromous salmonids. For example, anadromous salmonids that survive to reproduce migrate through the estuary at least twice during their life cycle; the estuary serves as a vital transition zone during the physiological acclimation from freshwater to saltwater (Simenstad et al. 1994b, Thorpe 1994 as cited in Bottom et al. 2001). Further, estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995); estuarine habitats serve as a productive feeding area, free of marine predators.

Many studies indicate that estuarine conditions are important in salmonid survival rates; however, to date researchers have not been able to specifically agree on what attributes of the estuary confer enhanced survival to salmon. Certain general physical and biological functions performed by estuaries, however, can be assumed to have direct impacts on salmon as they transition from their natal river basins to seawater.

2.4.2.1 Conceptual Models

The natural forces of ocean tides and river flows have been influenced by anthropogenic factors. The basic habitat-forming processes (i.e. physical forces of the ocean and river) create the conditions that define the estuarine and mainstem freshwater habitats. The created habitat types provide an opportunity for the primary plant production that serves as the base of complex food webs. All of these pathways combine to influence the growth, survival, and, eventually, the production of juvenile salmonids moving through the lower Columbia River (USACE 2001). These processes and pathways are generally described in the juvenile salmonid production conceptual model as illustrated below (Figure 2-27 and Table 2-14). The conceptual model was developed to describe juvenile salmonid production in the Columbia River estuary; it does not address the premise that population structure and life history diversity may be equally as important in determining salmonid survival. Further, although the conceptual model was developed with an ecosystem focus, it needs to be scrutinized to determine applicability to other tidal freshwater and estuary species. The foundational basis for a wildlife species conceptual model has been developed by Johnson and O’Neil (2001).

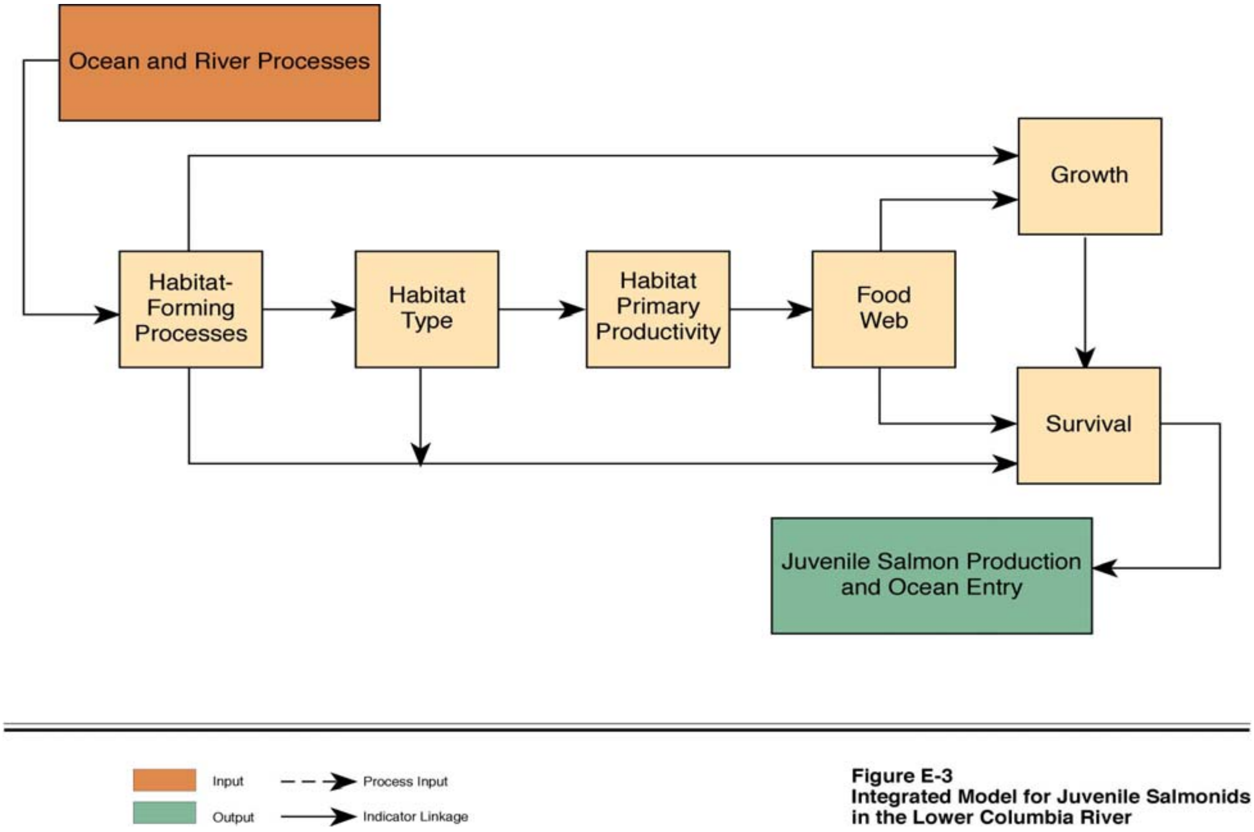

Figure 2-27. Conceptual model of the major components affecting juvenile salmonid production in the Columbia River estuary (USACE 2001).

Table 2-14. Conceptual model pathways and components for juvenile salmonid production in the Columbia River estuary (USACE 2001).

Model Pathways	Pathway Description	Model Components	Component Description
Habitat-Forming Processes	Physical processes that define the living conditions and provide the requirements fish naturally need within the river system are included in the Habitat-Forming Processes Pathway.	Suspended Sediment	Sand, silt, and clay transported in the water column
		Bedload	Sand grains rolling along the surface of the riverbed
		Woody Debris	Downed trees, logs, root wads, limbs
		Turbidity	Quality of opacity in water, influenced by suspended solids and phytoplankton
		Salinity	Saltwater introduced into freshwater areas through tidal ocean process
		Accretion/ Erosion	Deposited/carved sediments
		Bathymetry	Topographic configuration of the riverbed
Habitat Types	This pathway describes definable areas that provide the living requirements for fish in the Lower Columbia River.	Tidal Marsh and Swamp	Areas between mean lower low water (MLLW) and mean higher high water (MHHW) dominated by emergent vegetation (marsh) and low shrubs (swamp) in estuarine and riverine areas.
		Shallow Water and Flats	Areas between 6-foot bathymetric line (depth) and MLLW
		Water Column	Areas in the river where depth is greater than 6feet
Habitat Primary Productivity	This pathway describes the biological mass of plant materials that provides the fundamental nutritional base for animals in the river system.	Light	Sunlight necessary for plant growth
		Nutrients	Inorganic source materials necessary for plant growth
		Imported Phytoplankton Production	Material from single-celled plants produced upstream above the dams and carried into lower reaches of the river
		Resident Phytoplankton Production	Material from single-celled plants produced in the lower reaches of the river
		Benthic Algae Production	Material from simple plant species that inhabit the river bottom
		Tidal Marsh and Swamp Production	Material from complex wetland plants (hydrophytes) present in tidal marshes and swamps

Food Web	The Food Web pathway shows the aquatic organisms and related links in a food web that supports growth and survival of salmonids.	Deposit Feeders	Benthic organisms such as annelid worms that feed on sediments, specifically organic material and detritus
		Mobile Macroinvertebrates	Large epibenthic organisms such as sand shrimp, crayfish, and crabs that reside and feed on sediments at the bottom of the river
		Insects	Organisms such as aphids and flies that feed on vegetation in freshwater wetlands, tidal marshes, and swamps
		Suspension/Deposit Feeders	Benthic and epibenthic organisms such as bivalves and some amphipods that feed on or at the interface between sediment and the water column
		Suspension Feeders	Organisms that feed from the water column itself, including zooplankton
		Tidal Marsh Macrodetritus	Dead and decaying remains of tidal marsh and tidal swamp areas that are an important food source for benthic communities
		Resident Microdetritus	Dead and decaying remains of resident phytoplankton and benthic algae, an important food source for zooplankton
		Imported Microdetritus	Dead remains of phytoplankton from upstream that serve as a food source for suspension and deposit feeders
Growth	The Growth Pathway highlights the factors involved in producing both the amount of food and access by fish to productive feeding areas.	Habitat Complexity, Connectivity, and Conveyance	Configuration of habitat mosaics that allow for movement of salmonids between those habitats
		Velocity Field	Areas of similar flow velocity within the river
		Bathymetry and Turbidity	River bottom and water clarity conditions that influence the ability of salmonids to locate their prey
		Feeding Habitat Opportunity	Physical characteristics that affect access to locations that are important for fish feeding
		Refugia	Shallow water and other low energy habitat areas used for resting and cover
		Habitat-Specific Food Availability	Ability of complex habitats to provide feeding opportunities when fish are present

Survival	The Survival Pathway is a summary of key factors controlling or affecting growth and migration.	Contaminants	Compounds that are environmentally persistent and bioaccumulative in fish and invertebrates
		Disease	Pathogens (viruses, bacteria, and parasites) that pose survival risks for salmon
		Suspended Solids	Sand, silt, clay, and organics transported within the water column
		Stranding	Trapping of young salmonids in areas with no connectivity to water column habitat
		Temperature and Salinity Extremes	Temperature or salinity conditions that are problematic to salmonid survival
		Turbidity	Water clarity as it pertains to potential for juvenile salmonids to be seen by predators
		Predation	Potential for piscivorous mammals, birds, and fish to prey on salmonids
		Entrainment	Trapping of fish or invertebrates into hopper or pipeline dredges

The general conceptual model has been separated into component parts. The first figure in the series (Figure 2-28) is the juvenile salmon growth and survival conceptual model developed by Bottom et al. (2001); this conceptual model incorporates the premise that salmonid population structure and life history diversity plays an important role in salmonid survival. The next series of diagrams (Figure 2-29, Figure 2-30, and Figure 2-31) describe a conceptual model for juvenile salmonid production in the lower Columbia River and estuary detailed in USACE (2001); the conceptual model represents a 6 month collaborative effort by the USACE, Battelle Marine Science Laboratories, Parametrix, Inc., the Port of Portland, NMFS, USFWS, Limno-Tech, Inc., University of Washington, and the Sustainable Ecosystems Institute Science Panel. This conceptual model presents some of the same concepts as the Bottom et al. (2001) model. As previously mentioned, the conceptual model presented here was developed specifically for juvenile salmon production; the model needs to be scrutinized for applicability to other focal species. In regards to wildlife focal species, Johnson and O'Neil (2001) have explored possible components that would serve as a foundation for wildlife conceptual models, although such models have not been iteratively developed.

As described in the overall conceptual model for juvenile salmon production in the estuary (Figure 2-27), the type of available habitat determines the food web, which then drives salmon growth, survival, and ultimate production from the estuary. Within the food web, the available habitat determines the amount and type of primary productivity and hence, the base of the food web (Figure 2-29). In turn, the food web base determines the amount and type of prey species available to juvenile salmonids and therefore influences growth and survival (Figure 2-29). Salmonid growth is also influenced by habitat-forming processes and the types of habitat available as these provide refuge and affect each individuals energy costs (Figure 2-30). Growth is also affected by temperature and other compounding factors such as hatchery practices that may result in density-dependent competition as a result of large releases of hatchery fish (Figure 2-28). Finally, all of the base components of the conceptual model (i.e. habitat-forming processes, habitat type, food web, and growth) in conjunction with the physiological condition and adaptive behaviors of juvenile salmonids determines the ultimate production from the estuary (Figure 2-31).

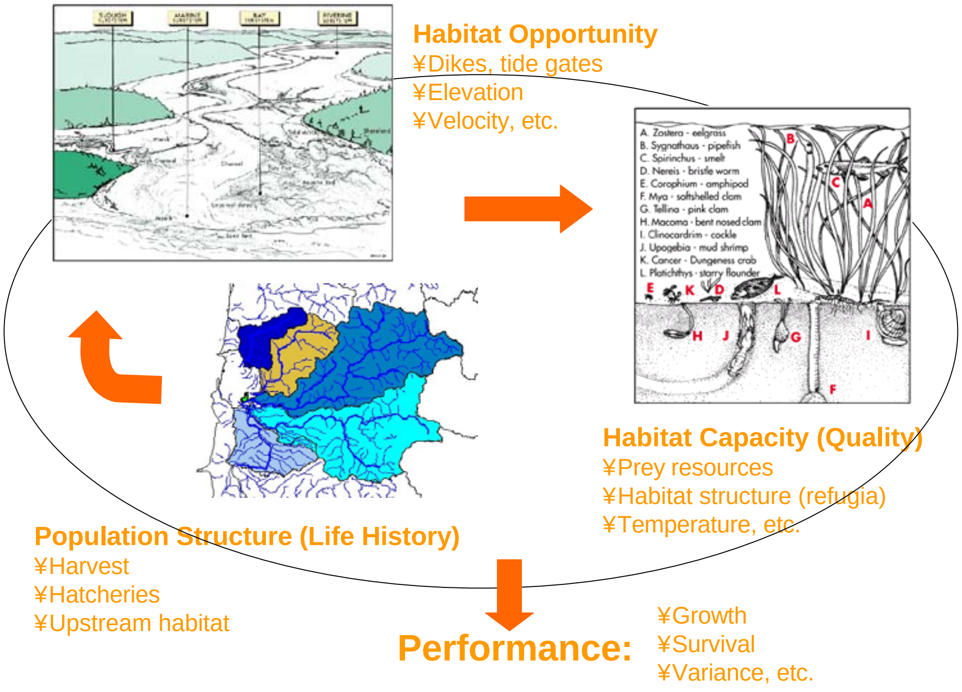

Figure 2-28. Conceptual model for juvenile salmon growth and survival in the Columbia River estuary (from Bottom et al. 2001).

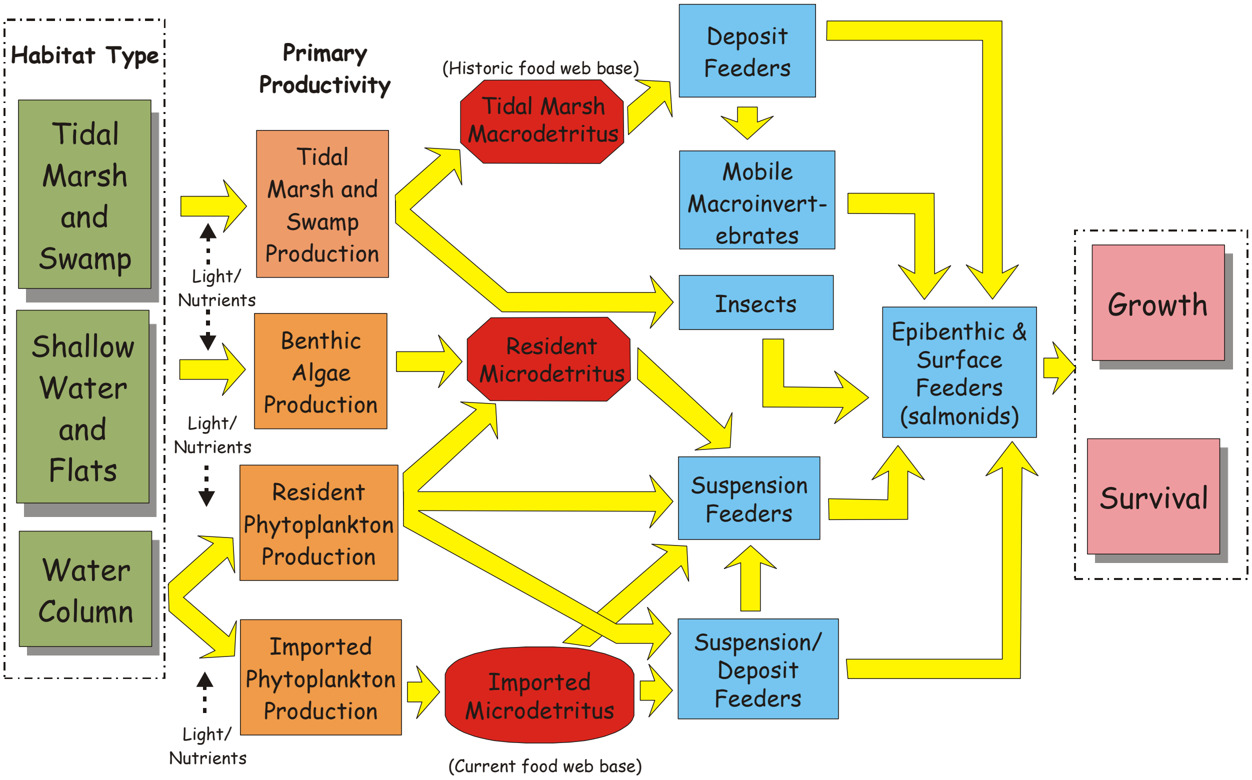

Figure 2-29. Conceptual model of the Columbia River estuary food web (adapted from USACE 2001).

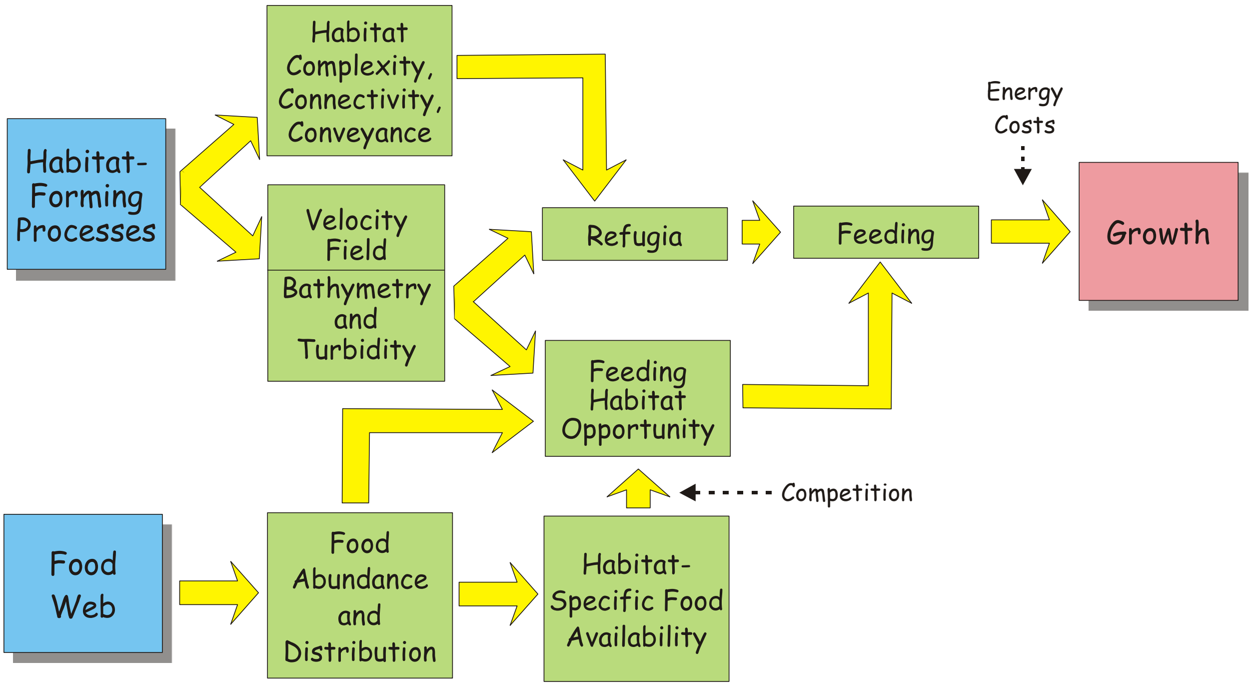

Figure 2-30. Conceptual model of juvenile salmonid growth in the Columbia River estuary (adapted from USACE 2001).

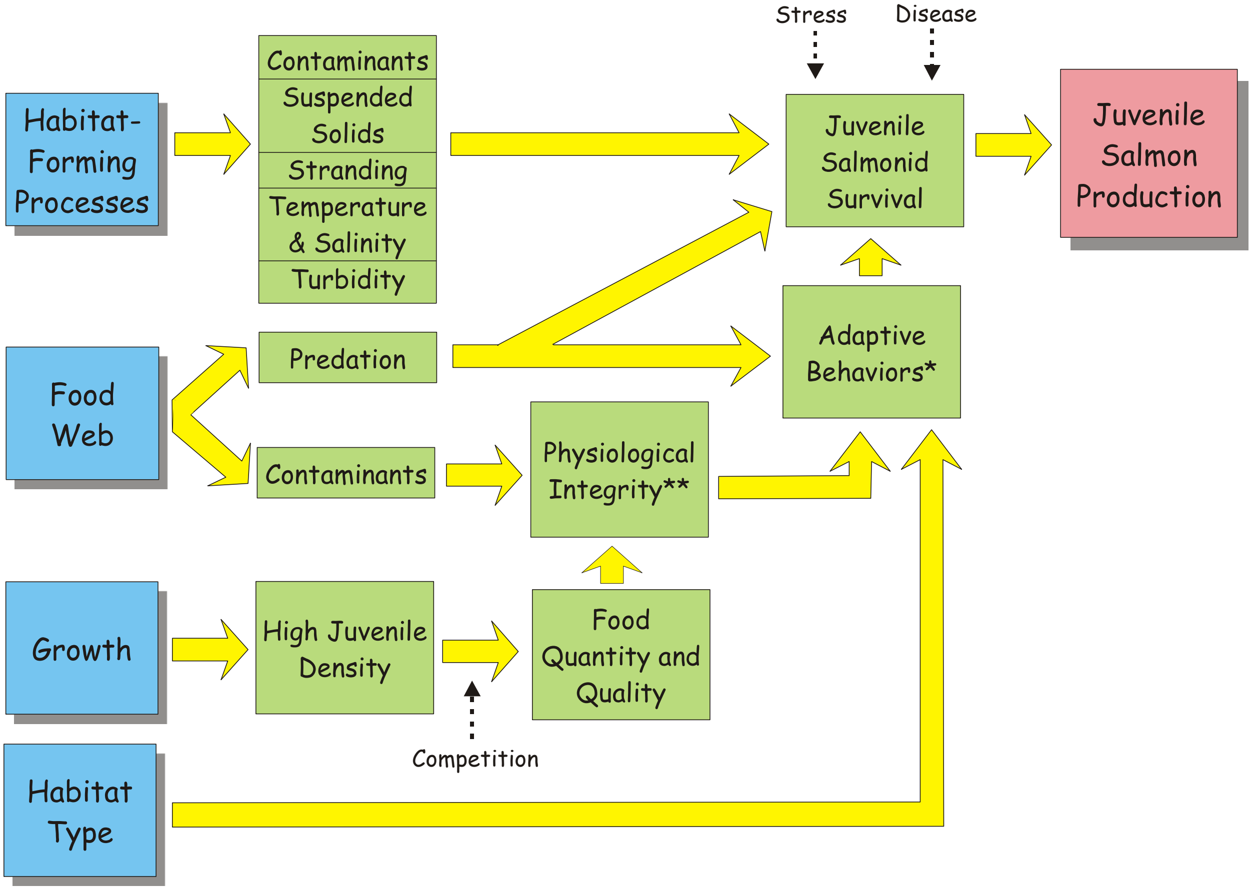

Figure 2-31. Conceptual model of juvenile salmonid production from the Columbia River estuary (adapted from USACE 2001).

2.4.2.2 Habitat Requirements

The freshwater habitat requirements for juvenile salmonids are well studied and understood; however, the estuarine habitat requirements of juvenile salmonids are just now coming into focus. In describing estuarine habitat requirements, juvenile salmonids are divided into two primary life-history types: ocean- and stream-type. Johnson et al. (2003b) recently presented the current understanding of the estuarine physical habitat requirements and threshold levels of juvenile salmon (Table 2-15). Note that the studies related to salinity, water temperature, and turbidity addressed threshold levels of exposure in which salmonids could survive. Although threshold levels may be similar among ocean- and stream-type salmonids, there is not complete agreement among researchers on the preferred ranges of these parameters for different salmonids.

Table 2-15. Physical habitat requirements and threshold levels of juvenile salmonids in relation to various habitat parameters (adapted from Weitkamp et al. 2001, as cited in Johnson et al. 2003b).

Parameter	Ocean-Type	Stream-Type
Water Depth	Surface waters	Surface to 6 m
Currents	Less than ~9 cm/second Less than 30 cm/second for current threshold modeling (1)	Found throughout a wide range of current velocities and tend to avoid low-velocity areas
Substrate	Varies (mostly sand/silt)	Varies, but tends to be associated with the water column to a greater extent than with substrate type
Salinity	Upon hatching 15-20 ppt (2) Juveniles 30 ppt seawater (3) Chinook fry of 1.5 gram could survive and grow in seawater (4)	Generally same as ocean-type
Water Temperature	Can tolerate brief periods of 15-20˚C; Lethal at approximately 22˚C (5) Sub-lethal effects can occur below lethal threshold, but vary.	Coho preferred range of 12-14˚C; Upper lethal temperature was 25˚C (6)
Turbidity	LC_{50} for coho (summer conditions) 1.2 g/l (7) LC_{50} for chum (summer conditions) 2.5 g/l (8)	Generally same as ocean-type

(1) Bottom et al. 2001, (2) Wagner et al. 1969, (3) Tiffan et al. 2000, (4) Clark and Shelbourn 1985, (5) Brett 1971, Lee and Rinne 1980, (6) Brett 1952, (7) Noggle 1978, (8) Smith 1978.

2.4.2.3 Habitat Utilization

Juvenile salmon may be found in the Columbia River estuary at all times of the year, as different species, life history strategies and size classes continually move into tidal waters; Wissmar and Simenstad (1998) estimated that there may be as many as 35 potential life history strategies for ocean-type chinook. Peak estuary entrance varies among and within species. Rich (1920) reported that juvenile migration span of any given chinook brood in the Columbia River basin is around 18 months – from fry that emigrate to the estuary soon after emerging in December to yearlings that do not leave until late their second spring. Myers and Horton (1982) have suggested that differentiation of life history forms may be a mechanism for partitioning limited estuarine habitats. Duration of estuarine residence varies from species to species. Coho, stream-type chinook salmon, steelhead, and anadromous cutthroat trout typically rear in fresh water for a year or more, and move rapidly through the estuary on their way seaward (<6 weeks). Chum and ocean-type chinook salmon make greater use of the estuary. Chum salmon typically live in the estuary for several weeks, and ocean type chinook that migrate to the estuary as fry can reside in estuaries for up to 2 months or more (Healey 1982).

Estuaries have important impacts on juvenile salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995). Estuarine habitats provide young salmonids with a productive feeding area, free of marine predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment. Studies conducted by Emmett and Schiewe (1997) in the early 1980s have shown that favorable estuarine conditions translate into higher salmonid survival. During this research, juvenile coho and chinook smolts were collected and released in the river, in the estuary, in the transition zone outside the estuary, and in the ocean; efforts were replicated over multiple years. In both coho and chinook, smolts released in the estuaries consistently contributed in higher rates to commercial fisheries or returned at higher rates than smolts released outside the estuaries.

Studies show that habitat use of juvenile salmon within the estuary environment is size related. Fry less than 60 mm usually occupy shallow, protected habitats such as salt marshes, tidal creeks and intertidal flats (Levy and Northcote 1982, Myers and Horton 1982, Simenstad et al. 1982, Levings et al. 1986 as cited in Bottom et al. 2001). Fish 60-100 mm move to slightly deeper shoals and channels further from the shoreline (Healey 1982, 1991, Myers and Horton 1982, as cited in Bottom et al. 2001). Fish greater than 100 mm can be found in both deep and shallow water habitats. (Levy and Northcote 1982, Myers and Horton 1982, Simenstad et al. 1982, Bottom et al. 1984). These generalizations hold true more during the day than at night, when schooling fry or fingerlings may be seen venturing into deeper waters (Schreiner 1977, Kjelson 1982, Bax 1983, Healey 1991, Salo 1991, as cited in Bottom et al. 2001). Moreover, salmonids must continually adjust their habitat distribution in relation to twice-daily tidal fluctuations and seasonal and anthropogenic variations in river flow. Juveniles have been observed to move from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again (Healey 1982). These patterns of movement suggest that access to suitable low-tide refuge near marsh habitat may be an important factor in production and survival of salmonid juveniles in the Columbia River estuary.

2.4.2.4 Habitat Availability

Using a model that incorporated predevelopment and current river flows and estuarine bathymetry, the habitat availability for juvenile salmonids in the historical and present estuary were simulated and compared. Based on the velocity criteria ($< 0.3\text{m s}^{-1}$), habitat opportunity has declined in the upriver tidal freshwater mainstem and the upper estuary peripheral bays (Cathlamet and Grays) while it has not changed substantially in the lower regions of the estuary (lower estuary mainstem and lower estuary peripheral bays [Youngs and Baker]). Based on the depth criteria (0.1 to 2 m), habitat opportunity has increased in all regions compared to historical conditions, except in the upriver tidal freshwater mainstem. However, limitations in the representation of historical and modern bathymetry in the model limit confidence in the depth criteria results and prevent comparison of historical and current habitat opportunity based on the combined depth and velocity criteria. Despite model limitations, results indicate that the availability of suitable juvenile salmonid estuary habitat varies in response primarily to bathymetry, but also to river discharges and tides. Also, seasonal and inter-annual variability is important particularly in upper regions of the estuary where habitat opportunity is reduced during freshet flows (Bottom et al. 2001).

Small changes in salinity distribution may have significant effects on the ecology of fishes in the estuary, including salmonids. Salinity distribution, as affected by tidal flow and river discharge, determines the location of the ETM; salinity and the ETM are primary factors explaining seasonal species distributions and the structure of entire fish, epibenthic, and benthic invertebrate prey species assemblages throughout the Columbia River estuary (Haertel et al. 1969, Bottom and Jones 1990, Jones et al. 1990 as cited in NMFS 2000c and Simenstad et al. 1994b as cited in USACE 2001). By altering the distribution of preferred habitats within specific salinity ranges and the particular array of species that salmon encounter at different locations during their estuarine residence, small changes in salinity structure may have significant effects on the estuarine food web and fish production in the estuary. In particular, small changes in the distribution and gradient of oligohaline salinities may change the type of habitats available when juvenile salmon make the critical physiological transition from fresh to brackish water (NMFS 2000c).

2.4.2.5 Habitat Connectivity

Within the estuary, rapid changes in salinity gradients, water depths, and habitat accessibility impose important energetic and ecological constraints that salmonids do not encounter in freshwater (Bottom et al. 2001). Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids (Simenstad et al. *in press* as cited in Bottom et al. 2001). As subyearlings grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum and ocean type chinook salmon that rear in the estuary for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. If juvenile salmonid life cycles require specific spatial and temporal sequences, then areas suitable for supporting salmonids may remain unused if their connectivity with other habitats is lost (Bottom et al. 1998). That is, the connectedness of these habitats likely determines whether juvenile salmonids are able to access the full spectrum of habitats they require.

Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for high salmonid production in the estuary. In particular, tidal marsh habitats, tidal creeks and associated complex dendritic channel networks may be especially important to subyearlings as areas of both high insect prey density, and as potential refuge from predators afforded by sinuous channels, overhanging vegetation and undercut banks (McIvor and Odum 1988). Salmonid production in estuaries is supported by detrital food chains (Healey 1979, 1982). Therefore habitats that produce and/or retain detritus, such as tidal wetlands emergent vegetation, eelgrass beds, macro algae beds and epibenthic algae beds, are particularly important (Sherwood et al. 1990). Historically, before the Columbia River was isolated from its floodplain, influx of organic matter occurred regularly during spring freshets.

The importance of proximate availability of feeding and refuge areas may hold true even for species that move more quickly through the estuary. For example, radio tagged coho in Grays Harbor estuary moved alternatively from low velocity holding habitats to strong current passive downstream movement areas (Moser et al. 1991). Consistent with these observations, Dittman et al. (1996) suggest that habitat sequences at the landscape level may be important even for species and life history types that move quickly through the estuary during the important smoltification process, as salmon gather the olfactory cues needed for successful homing and these cues may depend on the environmental gradients experienced during migrations.

2.4.2.6 Habitat Capacity

Diking and filling activities in the estuary have likely reduced the rearing capacity for fry and sub-yearling life stages by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore (Bottom et al. 2001, NMFS 2000c). Dikes throughout the lower Columbia River and estuary have disconnected the main channel from a significant portion of the wetland and floodplain habitats. Further, filling activities (i.e. for agriculture, development, or dredge material disposal) have eliminated many wetland and floodplain habitats. Because fry and subyearling smolts rely heavily on emergent and forested wetlands and floodplain habitats for food and refugia, reduction of these habitats have reduced the capacity for these salmonid life stages.

Both large woody debris and sand/gravel substrates are important factors defining the quantity and quality of estuarine habitat for salmonids; changes in flow cycles, flow magnitude, and habitat isolation has decreased the availability of these estuarine habitat components to juvenile salmonids (Sherwood et al. 1990 as cited in Nez Perce et al. 1995, NMFS 2000c, Bottom et al. 2001, USACE 2001). *Anecdotal* observations indicate that salmonids congregate near large woody debris; feeding may be enhanced because of the deposition of organic matter and the production of small benthic prey species. Much of the habitat that served as the large woody debris source (i.e. tidal swamps/wetlands, freshwater riparian forests and forested wetlands) has been disconnected from the lower river and estuary via diking and subsequent development. Decreases in flow decreases bedload transport of sand and large woody debris movement; recruitment of these important habitat features to estuary habitats has decreased. Restoration of lost estuary wetland habitat and historical flow patterns may benefit recovery of depressed salmonid stocks (ISAB 2000, NMFS et al. 2000).

2.4.2.7 Migration and Spawning

Hydrologic effects of the Columbia River hydrosystem include water level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. Altered flow regimes can affect the migratory behavior of juvenile salmonids. For example, water level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and strand juveniles during the downstream migration. Reservoir drawdowns reduce available habitat which concentrates organisms, potentially increasing predation and disease transmission (Spence et al. 1996 as cited in NMFS 2000c).

Altered flow regimes can affect the spawning success of mainstem Columbia River spawners. For example, reservoir drawdowns in the fall for flood control produces high flow for fall spawners; fish may spawn in areas that are dewatered during the winter or spring, potentially resulting in complete egg mortality (NMFS 2000c).

2.4.2.8 Food Web Structure

There is a general inference today that the capacity of the Columbia River estuary to produce salmonids has decreased from historical levels. Losses of emergent marsh and forested wetland habitats have been substantial, and may be a major factor affecting the capacity of the estuary to support juvenile salmon. Studies show that small subyearling ocean-type chinook salmon occupy shallow habitats and feed extensively on emergent insects. The diet composition and distribution of small juveniles far into shallow tidal channels and sloughs at high tide suggest that these fish are rearing in direct association with vegetated edges of estuarine wetlands (Simenstad et al. 2000). However, habitat alterations such as artificial river confinement and water regulation through hydrosystem operations have restricted access to some productive Columbia River estuary floodplain habitats. The current estuary food web does not support the same diversity of salmon life-history types that occurred historically (Bottom et al. 2001).

Juvenile salmonids are part of a complex food web in the lower Columbia River mainstem and estuary (Figure 2-29; USACE 2001). Plant primary productivity is the base of the food web; plant material can be incorporated into the food web via direct consumption or through decaying material and consumption by detritivores (Jones et al. 1990 as cited in USACE 2001). Salmonids consume prey species supported by resident plant material and resident and imported plankton and detritus. The relative amount of available prey species depends on the abundance of estuary habitat types as well as the input of imported detrital material from upstream sources. The contribution of imported detritus is controlled primarily by reservoir production and flow rates from Bonneville Dam. Subyearling salmonids feed primarily on benthic prey items available in near-shore habitats while yearling salmonids feed primarily on zooplankton available in the water column; larvae and adult floating insects appear to be important prey items for most salmonids. Prey availability and consumption varies with tide stage; prey items inhabiting shallow habitats become more available during high tides while planktonic prey items appear to be equally available at different tide levels. Further, food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000).

Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995). Juvenile chinook salmon growth in estuaries is often superior to river-based growth (Rich 1920a, Reimers 1971, Schluchter and Lichatowich 1977). Ability of the Columbia River estuary to support juvenile salmonid growth and maximize survival to the time of ocean entry depends on habitat productivity and access to productive habitats (Figure 2-30 and Figure 2-28; Brodeur et al. 2000, Bottom et al. 2001). The estuarine food web was historically macrodetritus-based because of the abundance of emergent, forested, and other wetland rearing areas throughout the estuary (Figure 2-29; Bottom et al. 2001, USACE 2001, Johnson et al. 2003b); these areas have been largely been lost or disconnected from the river via dike construction and subsequent development. Emergent plant production in the estuary has decreased by 82% and benthic macroalgae production by 15% (Sherwood et al. 1990 as cited in Nez Perce et al. 1995). The loss of wetland habitats combined with the development of reservoirs throughout the Columbia River has shifted the food web to a microdetritus base, primarily in the form of imported phytoplankton production from upriver reservoirs that dies upon exposure to salinity in the estuary (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). Imported phytoplankton are found within the water column and support a pelagic food web that is less accessible to small juvenile salmonids that inhabit the edge habitat throughout the lower Columbia River and estuary (Sherwood et al. 1990 as cited in USACE 2001, USACE 2001).

While the macrodetritus-based food web was historically distributed throughout the lower river and estuary, the modern microdetritus-based food web is focused on the spatially confined turbidity maximum region of the estuary (Bottom et al. 2001). This modified food web benefits exotic species (American shad) and lower estuary forage fish (northern anchovy, Pacific herring, longfin smelt) and is a disadvantage to anadromous salmonids (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). Although these forage fish are found in the diet of larger juvenile salmonids in the lower estuary and nearshore ocean, the presence of these forage fish unlikely satisfies smaller ocean-type salmonid feeding requirements in the estuary (Bottom and Jones 1990 as cited in USACE 2001). Survival tradeoffs between juvenile salmon estuary feeding requirements and estuary food web support of feeding requirements in the lower estuary and nearshore ocean are unknown.

Habitat alterations such as artificial river confinement have restricted access to some productive Columbia River estuary floodplain habitats. Further, water regulation through the hydrosystem operation has decreased seasonal freshet flows. Flow volumes that create over bank flows are rare, which further restricts access to any existing riparian wetland or forest habitat. Thus, because of the alteration of the estuary food web and the restricted habitat access, productive capacity of the estuary has decreased from historical levels (Bottom et al. 2001, NMFS 2000c, USACE 2001, Johnson et al. 2003b).

The role and importance of microbial communities in the modern day estuary food web has recently been the focus of a considerable amount of research. As discussed previously in section 2.3.1.3, the ETM traps particulate material of river and ocean origin. The residence time of these particles within in the ETM is believed to be 2-4 weeks, compared to the 1-2 day residence time of water (Neal 1972 as cited in Crump et al. 1999) or associated free-living bacteria outside the ETM (Crump et al. 1999). The circulation and trapping processes in the ETM facilitates attachment among particles, forming rapidly settling macroaggregates. In the Columbia River estuary, bacteria associated with these particles are believed to be a primary food source within the food web (Baross et al. 1994, Crump et al. 1998 as cited in Crump et al. 1999). For example, particle-attached bacteria accounted for about 90% of the heterotrophic bacterial activity in the Columbia River estuary water column; these bacteria were 10-100 times more active than free-living bacteria outside the ETM (Crump and Baross 1996, Crump et al. 1998 as cited in Crump et al. 1999). Crump et al. (1999) noted that a large part of the particle-attached bacteria in the ETM were unrelated to river or coastal ocean bacteria, suggesting these ETM bacteria developed in the estuary. Further, these bacteria attached to ETM particles are extremely important degraders of particulate organic matter in the system and serve as the food base for detritivorous copepods (the dominant grazer; Simenstad et al. 1994a) as well as rotifers and protozoa (Crump and Baross 1996). These organisms are often important in the diet of salmonids.

The estuarine food web can be highly variable because of differential pulses of organic matter and the varied distributions of food sources across estuarine habitats (Wissmar and Simenstad 1998 as cited in USACE 2001). Because of seasonal changes in habitats and prey resources caused by changes in habitat-forming processes, salmonids encounter a seasonally varying array of habitat conditions and prey resources. Consequently, the contribution of the estuary for juvenile salmonid survival, growth, passage, and smolting varies seasonally, especially when salmonids localize their rearing and movements in a specific estuarine region or habitat (USACE 2001).

The marine fish community off the mouth of the Columbia River has changed since the 1980s and is structured by physical oceanographic characteristics (such as salinity, temperature, and chlorophyll). The distribution and abundance of the nearshore marine predator and forage fish community affects the amount of predation on juvenile salmonids; that is, high prey densities increases the probability of predation on juvenile salmonids while high forage fish density decreases the probability of predation on juvenile salmonids (NMFS 1998, NMFS et al. 1998).

2.4.2.9 Changes in Salmonid Life History and Estuarine Residence Time

The physical habitat requirements of juvenile salmonids are related to their life history pattern (i.e. stream-type vs. ocean-type). The primary factors that describe physical habitats are water depth, water velocity, and substrate type, while secondary physical factors are water temperature, salinity, and turbidity (USACE 2001). Salmonids adapt to relatively wide ranges within the secondary physical factors. Anthropogenic factors may create artificial selection (Sheridan 1995 as cited in Bisbal and McConnaha 1998), add challenges for salmonids to maintain their biological diversity and ability to withstand environmental variation, and thus, can alter the biological structure of salmonid populations and reduce the variation in life history patterns (Bisbal and McConnaha 1998). Most mitigation efforts are optimized based on juvenile fish adundance, rather than life history diversity, such as the process of transporting emigrating juvenile salmonids past Columbia River dams (Bisbal and McConnaha 1998).

Rich (1920) investigated juvenile chinook life history and migration in the estuary from 1914-1916. He collected 1365 fish and discussed scale patterns of fish captured at different locations or known to be of a specific origin (such as a specific tributary or hatchery). From this scale pattern analysis, Bottom et al. (2001) classified the life history patterns described below (Table 2-16). Rich’s 1916 data show that chinook fry were present in the estuary from late March through September and chinook fingerlings were present from April to December (Bottom et al. 2001). Based on a comparison of average fork lengths of different sample groups, Rich (1920) indicated that growth in the estuary was particularly rapid in June, July, and August; however, Rich (1920) cautioned that average fork length comparisons may not represent actual growth rates because sampling in successive months likely measured entirely different groups of fish.

Table 2-16. Chinook life history types from scale analysis of fish captured in the Columbia River estuary (from Bottom et al. 2001 based on Rich 1920).

Life-history Type Collected	Rearing Behavior	% of Total
Fry	Fish that moved into the estuary as fry shortly after emergence	33%
Fingerling		
Smolts and recent arrivals	Fish too recently arrived at the estuary to have evidence of estuarine rearing on their scales. Includes both smolts and fingerlings bound for estuarine rearing habitats	28%
Fluvial-rearing	Fluvial rearing as fry and as fingerling. Includes fish that reared near their natal areas, and also fish that migrated into larger rivers downstream from their natal sites to rear, but which did not rear in the estuary	6%
Estuarine-rearing	Fish that reared for a short time in their natal stream then migrated to the estuary to rear	25%
Fluvial and estuarine-rearing	Fish with evidence of either adfluvial or estuarine rearing, but with scale patterns that did not lend themselves to identifying a fish in either category with certainty.	8%

Bottom et al. (2001) used historical and contemporary fish surveys to assess changes in use of estuarine environments by juvenile salmon. They conclude that population structure and life history diversity of subyearling ocean-type chinook salmon has simplified significantly since the early part of last century. Historically, chinook salmon in the Columbia River exhibited a wide diversity of life history types, using streams, rivers, the estuary, and perhaps the Columbia River plume as potential rearing areas. For ocean-type chinook salmon, there may be as many as 35 potential life history strategies (Wissmar and Simenstad 1998 as cited in USACE 2001, Bottom et al. 2001). Bottom et al. (2001) suggest that human affects on the environment have caused chinook life history patterns to be more constrained and homogenized than historical data show. Data collected by Rich (1920) show several forms of ocean-type chinook life histories, based on scale patterns, length, and time of capture. Groups of fish migrated to the estuary as either fry or fingerlings, in the spring or fall. Individual fingerlings arrived in the estuary throughout the year. Some fish remained in the estuary for extended periods of time while others migrated seaward rapidly. Fish from a brood represented a continuum of rearing and migrant behaviors spanning an 18-month period. However, even the work of Rich (1920) may have underestimated the historical diversity of estuarine rearing behaviors because many changes in the basin had already occurred. Migration timing and size of juvenile salmonids entering the estuary are important factors affecting stock life histories, maturation, and ultimate survival (Reimers 1973, Schluchter and Lichatowich 1977, Groot and Margolis 1991 as cited in Nez Perce et al. 1995).

By contrast, today ocean-type chinook with estuarine rearing life histories are not a primary life history form observed by managers and resource users. Most modern day ocean-type chinook fit into one of three groups: subyearling migrants that rear in natal streams, subyearling migrants that rear in larger rivers and/or the estuary, yearling migrants. Today, fish enter the estuary later (by at least two weeks) in pulses that coincide with hatchery releases. Subyearling chinook abundance in the estuary is limited; most chinook are yearlings with a homogeneous size distribution. Abundance patterns of juvenile chinook in the estuary now reflect hatchery management practices more than historical migration behavior. Although, current life history diversity may be underestimated because most research has focused on the migration and survival of hatchery yearlings and large natural subyearlings, not smaller subyearlings. Nevertheless, the uniform sizes and rapid estuary migrations of chinook salmon compared to historical observations suggests a loss of diversity and type of life history responses (Bottom et al. 2001). Hatchery practices have promoted a decrease in life history diversity; restoration efforts need to consider habitats/life histories that may be limited or non-existent today (Bottom et al. 2001).

Also, the size range of fish sampled today is smaller than the historical ranges. Size distributions indicate that historical juvenile entry continued from spring through fall, with some extended estuarine residence. The flux of chinook entering the estuary included fry that migrated to the estuary in the fall and may have overwintered in the lower reaches (Bottom et al. 2001). Smaller fish historically present in the fall are poorly represented in modern sampling studies. Today’s chinook are composed of relatively few fry, and many larger subyearlings that likely do not reside in the estuary for extended periods. Bottom et al. (2001) suggest that the data indicate that ocean-type chinook with estuarine rearing life histories are now substantially reduced in proportion relative to their historical levels. The authors caution, however, that present day diversity may be underestimated by inclusion of data from modern monitoring programs that emphasize migration and survival of hatchery yearlings and subyearlings, but did not sample in many shallow-water habitats where smaller size ranges of juveniles would be more likely to be found.

2.4.3 Pacific Lamprey

Juvenile lamprey depend on sand and silt substrates, thus, habitat forming processes and conditions that create this habitat characteristic are likely beneficial to juvenile lamprey survival. Anthropogenic factors that introduce more sand and silt to a river’s substrate (i.e. riparian zone development, logging, road building either within the subbasin or in upriver locations) may contribute to the development of habitat preferred by juvenile lamprey. Further, the altered Columbia River flow regime resulting from water regulation has decreased the flow volumes capable of transporting large volumes of sand/silt to the estuary/ocean; thus, sand and silt substrates are more likely to remain in the mainstem compared to historical conditions.

2.4.4 Sturgeon

Hard-bottom, high-velocity, structured habitats with adequate interstitial space are critical as spawning and incubation substrate as well as juvenile predation refuge and feeding areas for white sturgeon (Parsley et al. 1993; Perrin et al. 1999; Parsley et al. 2002; Secor et al. 2002). White sturgeon juveniles that burrow into fine sediments commonly die as a result of suffocation. Maintenance of these preferred white sturgeon habitats are important to the species continued productivity in the lower Columbia River and estuary. Anthropogenic factors that continue to introduce more sand and silt to the river’s substrate (i.e. riparian zone development, logging, road building) likely decreases the availability of preferred white sturgeon habitat. Further, the decreased the flow volumes resulting from Columbia River water regulation has decreased sand/silt transport to the estuary/ocean; thus, sand and silt substrates are more likely to remain in the mainstem, adversely affecting white sturgeon. These habitat changes have likely occurred in mainstem and distributary channel habitats.

Altered daily and seasonal river discharge and thermal regimes resulting from impoundment and dam operations also may alter migration, limit habitat availability, and affect timing, location and success of reproduction (Paragamian and Kruse 2001; Paragamian *et al.* 2001; Anders *et al.* 2002; Cooke *et al.* 2002; Jager *et al.* 2002; Secor *et al.* 2002). Parsley *et al.* (2001) simulated drawdown of a Columbia River reservoir and concluded that the quality and quantity of white sturgeon spawning habitat would increase as reservoir levels were lowered. However, these authors suggested this outcome was due to increased availability of suitable velocities for spawning (Parsley *et al.* 1993) despite a decrease in total area of the river (Parsley *et al.* 2001).

Important empirical correlations between water year; discharge characteristics during June, July and August; and recruitment measured during September in the lower Columbia River impoundments attest to the importance of flow alterations on white sturgeon recruitment (Counihan *et al.* in press). An understanding of a positive relationship between discharge (water years) and natural production of Columbia River white sturgeon has existed since the late 1980s (Beamesderfer et al. 1995). Furthermore, consistent annual recruitment in the lower Columbia River, in the Bonneville Dam tailrace, and downriver areas were associated with conditions representing good water years due to the artificial constriction of the Columbia River through Bonneville Dam; as such hydro development has artificially created what functionally amounts to white sturgeon spawning channels downstream from Bonneville Dam, resulting in reliable annual recruitment (L. Beckman USGS (retired), G. McCabe Jr. NMFS (retired), M. Parsley, USGS, Cook Washington. personal communication).

Flow alterations can also affect white sturgeon spawning and embryo hatching success, to the extent that flow they alter downstream thermographs. In the lower Columbia River, annual white sturgeon spawning appears to be triggered consistently when water temperature reaches 50°F (10°C) (M. Parsley, US Geological Survey, G. McCabe, NMFS (retired), personal communication). Spawning in the four impoundments farthest downstream occurs exclusively in tailrace areas immediately downstream from hydropower dams when water temperatures reach 54°F (12°C) (Parsley *et al.* 1993). Because water temperatures generally reach spawning temperatures first in downstream areas of the Columbia Basin, annual spawning is usually initiated downstream from Bonneville Dam when water temperatures reach 50°F (10°C), followed by spawning activity in each adjacent upstream tailrace when lower impoundment water temperatures reach and exceed 54°F (12°C). Most spawning occurs in the four farthest downriver Columbia River impounded areas at 57°F (14°C) (Parsley *et al.* 1993; Anders and Beckman 1995) with an optimum range generally cited as 54-57°F (12-14°C) for those areas.

Sturgeon are particularly abundant in deep-water habitats of the Columbia River subject to channel maintenance and dredging activities. Suction dredging in deep areas (66-85 ft [20-26 m]) in the lower Columbia River is known to seriously injure and kill juvenile white sturgeon (Buell 1992) but the magnitude of the population impact is unclear. Channel deepening also may affect sturgeon directly via entrainment or indirectly via habitat or food interactions, but the net effect is unclear and speculation continues.

Very little is known regarding the effects of food source abundance for white sturgeon in marine and estuarine environments, but, based on empirical growth studies of white sturgeon in the four Columbia River impoundments farthest downstream and in the lower Columbia River, annual juvenile growth rates in the impounded areas generally surpassed those in the lower Columbia River until approximately age 7 or 8. Following this age, mean annual growth rate in the lower Columbia River, possibly including the estuary, generally exceeded rates in the impoundments (M. Parsley, USGS, personal communication). This increase in relative growth rate for juvenile white sturgeon downstream from Bonneville Dam was thought to result from access to food items unavailable in the impoundments (e.g. Eulachon) (DeVore et al. 1995; M. Parsley, J. Devore, personal communication).

2.4.5 Northern Pikeminnow

Northern pikeminnow abundance in the mainstem Columbia River below the Snake River confluence is greatest in the lower mainstem from the estuary to the Dalles Dam (Beamesderfer et al. 1996). Although Northern pikeminnow have relatively broad spawning and rearing requirements, they seem to prefer low velocity water with clean rocky substrate. Anthropogenic factors that contribute to sedimentation and the altered flow regime of the Columbia River likely have decreased the availability of these preferred pikeminnow habitats. However, Northern pikeminnow have successfully adapted to the changing habitat conditions in the lower Columbia River mainstem as evidenced by their current abundance; it is anticipated that Northern pikeminnow will continue to thrive under the current trend of habitat alterations.

2.4.6 Eulachon

Hydropower development on the Columbia River has decreased the available spawning habitat for eulachon. Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon (Smith and Saalfeld 1955). Similar developments on tributary rivers, like the Cowlitz, also may have decreased spawning habitat.

Eulachon freshwater spawning habitat can be affected by in-channel conditions. Eulachon are broadcast spawners with highly adhesive eggs that attach to coarse sandy substrates. Dredging has the potential to impact adult and juvenile eulachon (Larson and Moehl 1990). In a 2001 study, researchers found that the sand wave movements in near-shore areas of dredging operations in the lower Columbia River made the substrate too unstable for the incubation of eulachon eggs. Recommendations of the study suggested that channel-deepening operations be scheduled to avoid eulachon spawning areas during peak spawning times (Romano et al. 2002). The same recommendations have been echoed in the Washington and Oregon Eulachon Management Plan concerning dredging activities in tributaries to the Columbia River.

2.4.7 River Otter

In the estuary, river otters are concentrated in shallow water tidal sloughs and creeks associated with willow-dogwood and Sitka spruce habitats located primarily in the Cathlamet Bay area and along the Oregon riverbank (Howerton et al. 1984); otters likely inhabit similar areas throughout the tidal freshwater area of the lower Columbia. Dikes throughout the estuary have disconnected substantial amounts of side channel and floodplain habitats from the mainstem. However, the Cathlamet Bay area remains as one of the most intact and productive tidal marsh and swamp habitat throughout the entire estuary. Because river otters are capable of traveling over land, it is not understood how the loss of habitat connectivity of side channel and floodplain habitat has affected species' behaviors such as foraging, resting, mating, and rearing.

2.4.8 Columbian White-tailed Deer

Columbian white-tailed deer are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; however, they can be found breeding or feeding in any number of habitats (lowland forest, grasslands, riparian wetlands, agriculture/pastures/mixed environments, urban/mixed environments; Johnson and O'Neil 2001). Agriculture and urban development throughout the lower Columbia River and estuary decreased the acreage of some of these habitats while increasing the acreage of others; thus, the net effect on Columbian white-tailed deer is difficult to quantify but appears to have negatively affected population abundance. Establishment of the Columbian White-Tailed Deer National Wildlife Refuge and other recovery efforts have focused on providing deer with appropriate contiguous habitat.

2.4.9 Caspian Tern

Caspian terns were not historically present in the Columbia River estuary. Management actions (i.e. periodic deposition of dredge spoils forming flat, sandy, unvegetated, mid-channel habitats) have created preferred habitat, encouraging colonization by Caspian terns. The altered Columbia River flow regime as a result of water regulation will likely produce variable effects on the presence of preferred Caspian tern habitat. For example, reduced peak flows are less likely to erode or inundate newly created dredge spoils islands; thus, sand substrates may remain stationary for long periods of time, but, without periodic inundation, vegetational succession begins and Caspian terns do not adapt well to the presence of vegetation in the breeding area. Further, decreased peak river flows and decreased wave action as a result of jetty construction have generally increased the amount of accretion throughout the estuary, which has increased the presence of the preferred newly formed, flat, sandy habitats of Caspian terns.

2.4.10 Bald Eagle

In western Washington, nest trees are most often old-growth Douglas-fir (Pseudotsuga menziesii) and Sitka spruce (Picea sitchensis) near the coast (Grubb 1976 as cited in Stinson et al. 2001), with a higher component of mature grand fir (Abies grandis) and black cottonwood (Populus balsamifera) around Puget Sound (Watson and Pierce 1998 as cited in Stinson et al. 2001). Assuming the presence of an adequate food supply, the single most critical habitat factor associated with bald eagle nest locations and success is the presence of large trees (Watson and Pierce 1998 as cited in Stinson et al. 2001). Thus, loss or alteration of nesting habitat as a result of natural events (e.g., fire, windstorms, etc.) or human-caused alterations (e.g., timber harvest, development) that results in permanent loss of nest trees or potential nesting habitat or prevents trees from attaining the size capable of supporting a nest, has the potential to reduce the number of nesting territories in Washington. Further, roost sites and perch sites also are often associated with large trees, so availability of this mature forest habitat determines potential bald eagle territories.

Declines in salmonid abundance has likely negatively affected bald eagles. Because the time of spawning for most Columbia River salmon runs is from August to January, declines in salmon runs have probably primarily affected the distribution and abundance of post-breeding and wintering bald eagles. Supplementation of salmon runs through hatchery fish generally does not replace the carcasses that historically provided food for bald eagles. Likewise, abundance of many seabirds and waterfowl have declined in recent years; loss of this prey base has also likely negatively affected eagles (Stinson et al. 2001).

Contaminant-free prey is necessary to maintain the reproductive health and survival of bald eagles. Organochlorine compounds and derivatives are still present in the Columbia River estuary and lower mainstem as result of industrialization within the subbasins. Often, contaminants are re-released in the ecosystem during river dredging. Bald eagles in the Columbia River estuary have exhibited chronic low nest productivity, apparently because of a variety of contaminants, including DDE, PCB’s, and dioxins (Anthony et al. 1993 as cited in Stinson et al. 2001). Residual DDT and PCBs continue to accumulate and concentrate as individuals consume contaminated prey. Some eagles may contain elevated levels of DDE in their tissues that prevents successful reproduction, or their territory may contain contaminated prey that continues to affect the resident eagles (Jenkins and Risebrough 1995 as cited in Stinson et al. 2001).

2.4.11 Osprey

Breeding osprey are concentrated in forested riparian areas, generally nesting atop trees or rock pinnacles. Osprey have adapted with human development and have been observed nesting on artificial structures such as channel markers or utility/light poles; recent data (late 1990s) suggests that the osprey population along the lower Columbia River mainstem may be increasing. Although habitat alterations do not appear to be having significant detrimental effects on osprey along the lower Columbia River, Columbia River osprey eggs contained the highest concentration of DDE (derivative of formerly banned pesticide DDT) reported in North America in the late 1980s and 1990s (Henny et al. 2003); DDE adversely affects eggshell thickness and decreases breeding success.

2.4.12 Sandhill Crane

The lower Columbia River mainstem and estuary is not a historical breeding or overwintering area for sandhill cranes. Agricultural development throughout the lower Columbia River floodplain has likely attracted overwintering sandhill cranes; for the last seven or eight years, an average of a few hundred, but up to 1,000 cranes have overwintered in the lower Columbia River floodplain. Reclamation of agricultural land for habitat restoration projects may discourage overwintering by sandhill cranes, although future development of herbaceous wetlands may provide adequate winter habitat for sandhill cranes currently using the region.

2.4.13 Yellow Warbler and Red-eyed Vireo

The yellow warbler and red-eyed vireo are both riparian obligate species; warblers prefer shrub-dominated habitats and vireos prefer dense, closed canopy forests. Habitat alterations along the lower Columbia River corridor have likely been more damaging to the possible presence of red-eyed vireos as opposed to yellow warblers. Dense riparian forests along the lower Columbia River are likely less abundant than shrub-dominated wetland habitat. Neither species is likely greatly affected by the disconnectedness of floodplain habitat from the mainstem.

2.5 Ecological Relationships

Ecological relationships describe species-species relationships and species-environment relationships; paramount to these relationships are the effects to the specific life stage of focal species, if known. Two general categories of interspecies relationships exist: native-native interactions (Section 2.5.1) and native-exotic interactions (Section 2.5.2). Each of these categories are addressed separately below; each section addresses predation and competition aspects of species interactions. Additionally, the discussion of exotic species addresses full scale ecosystem alterations.

2.5.1 Native Species Interactions

2.5.1.1 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. Piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of outmigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary. Native fishes, particularly northern pikeminnow, prey on juvenile salmonids. Marine mammals prey on adult salmon, but the significance is unclear.

Caspian terns are native to the region but were not historically present in the lower Columbia River mainstem and estuary; they have recently made extensive use of dredge spoil habitat and are a major predator of juvenile salmonids in the estuary. The terns are a migratory species whose nesting season coincides with salmonid outmigration timing. Since 1900, the tern population has shifted from small colonies nesting in interior California and southern Oregon to large colonies nesting on dredge spoil islands in the Columbia River and elsewhere (NMFS 2000c). Many of these Columbia River dredge spoils islands were created as a result of dredging the navigational channel after the eruption of Mt. St. Helens in 1980; however, Rice Island was initially constructed from dredge spoils around 1962 (Geoffrey Dorsey, USACE, personal communication). Caspian terns did not nest the estuary until 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds (and others) moved to Rice Island in 1987 and the colony expanded to 10,000 pairs. Diet analysis has shown that juvenile salmonids make up 75% of food consumed by Caspian terns on Rice Island. Roby et al. (1998) estimated Rice Island terns consumed between 6.6 and 24.7 salmonid smolts in the estuary in 1997, and that avian predators consumed 10-30% of the total estuarine salmonid smolt population in that year. However, there are no data to compare historical and modern predation rates or predator populations; thus, effects of these unique predator populations in relation to historical losses of juvenile salmon to predation cannot be adequately quantified (Bottom et al. 2001). Also, recent management actions have been successful in discouraging Caspian tern breeding on Rice Island while encouraging breeding on East Sand Island, which may decrease predation on juvenile salmonids. Further, current predation studies are limited because of the unknown effects hatchery rearing and release programs have had on salmon migration behavior and predator consumption. Nevertheless, evidence suggests that current predator populations could be a substantial limiting factor on juvenile salmon survival (Bottom et al. 2001).

Pikeminnow have been estimated to consume millions of juveniles per year in the lower Columbia, as outlined in the following table.

Table 2-17. Projected abundance of northern pikeminnow, salmonid consumption rates, and estimated losses of juvenile salmonids to predation (NMFS 2000b).

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

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

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

Seals and sea lions (particularly harbor seals [*Phoca vitulina*], Steller sea lion [*Eumetopias jubatus*], and California sea lion [*Zalophus californianus*]) are common in and immediately upstream of the Columbia River estuary and are regularly observed up to Bonneville Dam. Seals and sea lions are regularly reported to prey on adult salmon and steelhead, although diet studies indicate that other fish comprise the majority of their food. Large numbers of pinnipeds might translate into significant salmon mortality despite this occasional use. However, it is difficult to interpret the significance of this mortality factor for salmon, considering that large pinniped populations have always been present in the Columbia River. However, current marine mammal predation may be proportionally more significant, since all sources of mortality on depressed stocks become more important. Their numbers were reduced by hunting (including bounty hunters) and harassment from the late 1800s until the Federal Marine Mammal Protection Act (FMMPA) was adopted in 1972. Their numbers have significantly increased since the adoption of FMMPA. Fishers historically viewed seals and sea lions as competitors and the old Columbia River Fisherman Protection Associations funded a control program. These mammals can be troublesome to sport and commercial fishers by taking hooked or net-caught fish before they can be landed.

2.5.1.2 Competition

The productivity of the Columbia River estuary likely has decreased over time as a result of habitat degradation, which initially would appear to increase the likelihood for competition among salmonids in the estuary especially during times of high juvenile abundance. However, historical natural abundance of juvenile salmonids in the lower mainstem and estuary was far greater than the current abundance, even considering large hatchery releases of juvenile salmonids. Thus, it is possible that decreases in estuary habitat productivity are of the same magnitude as decreases in salmon abundance, suggesting that salmonid density dependent mechanisms in the estuary are no more likely today than they were historically.

Because ocean-type chinook salmon spend more time in the estuary, they may be sensitive to changes in the productivity of the estuary environment than stream-type chinook salmon. Estuaries may be “overgrazed” when large numbers of ocean-type juveniles enter the estuary en masse (Reimers 1973, Healey 1991). Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000). Reimer (1971) suggested a density dependant mechanism affects growth rate and hypothesized that fall chinook growth in the Sixes River was poor from June to August because of the large population in the estuary at this time and that the increased growth rate in September to November resulted from reduction in population size and a better utilization of the whole estuary.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type chinook salmon to overwhelm the production capacity of estuaries (Lichatowich and McIntyre 1987). However, Witty et al. (1995) could not find any papers or studies that evaluated specific competition factors between hatchery and wild fish in the Columbia River estuary. Simenstad and Wissmar (1983) cautioned that the estuary condition may limit rearing production of juvenile chinook, and many other studies have demonstrated the importance of the estuary to early marine survival and population fitness. However, rivers such as the Columbia, with well-developed estuaries, are able to sustain larger ocean-type populations than those without (Levy and Northcote 1982).

The intensity and magnitude of competition in estuaries depends in part on the duration of residence of hatchery and natural juvenile salmonids. One would expect summer/fall chinook from the mid-Columbia region to use the estuary for a period that probably depends upon their size when they arrive (Chapman et al. 1994). Chapman et al. (1994) conclude that the survival of juveniles transported to below Bonneville Dam at a size too small to ensure high survival at sea may depend upon growth in the estuary for successful ocean entry. Meanwhile, some workers (Reimers 1973; Neilson et al. 1985) have suggested that the amount of time spent in estuaries may relate to competition for food. Chapman et al. (1994) suggested that, if large numbers of hatchery fish are present in the Columbia River estuary, growth and survival of wild subyearling chinook could be reduced. However, Levings et al. (1986) reported that the presence of hatchery chinook salmon did not affect residency times and growth rates of wild juveniles in a British Columbia estuary and that hatchery fish used the estuary for about half the length of time that wild fry were present (40-50 days).

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

There is substantial overlap in estuarine habitat usage among chum and chinook salmon fry (Levy and Northcote 1982), suggesting significant potential for competition between these two salmonids. However, possible interactions between chum and chinook seems to be minimized by differences in migration timing and estuary residence periods; chum fry typically precede chinook in the estuary and spend a relatively short amount of time in the estuary compared to chinook (Levy and Northcote 1982).

2.5.2 Non-Indigenous Species Interactions

Introductions of aquatic non-indigenous species has become the focus of increasing concern and research; their increasing predominance in species assemblages indicate major changes in aquatic ecosystems (OTS 1993, Cohen and Carlton 1995, Smith 2001 as cited in Waldeck et al. 2003). Globally, there is an increasing rate of aquatic non-indigenous species introductions; this increase has been attributed to the increased speed and range of world trade, which facilitates the volume, variety, and survival of intentionally or unintentionally transported species. All aquatic non-indigenous species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites (Waldeck et al. 2003). Further, it has been hypothesized that changes in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have affected the successful establishment of aquatic non-indigenous species (Cordell et al. 1992 as cited in Draheim et al. 2002, Weitkamp 1994). The lower Columbia River ecosystem may still be adjusting to these major flow alterations; this adjustment period may benefit aquatic non-indigenous species (Weitkamp 1994).

Draheim et al. (2002) performed a literature review of aquatic non-indigenous species introductions in the Columbia River estuary and lower mainstem to Bonneville Dam; the authors also presented a 2001-2003 sampling plan for aquatic non-indigenous species. A final report on these sampling efforts was not available at the time of publication of this report, however, an interim report has been produced (Waldeck et al. 2003). A complete list of aquatic non-indigenous and cryptogenic (i.e. obscure or unknown origin) species to date was compiled in Draheim et al. 2002; the non-indigenous list includes plants (16), mammal (1), amphibians (1), fish (37), Annelida (2), Amphipoda (3), Cirripedia (1), Copepoda (3), Cumacea (1), Decapoda (4), Isopoda (1), Bivalvia (2), and Gastropoda (1), and the cryptogenic list includes Annelida (29), Amphipoda (3), Copepoda (1), Isopoda (1), Nemertea (1), and plants (2). However, limited information is available regarding the ecological interactions of many of these species; thus, only a select few are discussed in the sections below. In general, non-native fish species are dominated by species that have been intentionally introduced, whereas, most invertebrates are the result of unintentional introductions (Draheim et al. 2002). Further, fish introductions in the lower Columbia River increased in a linear fashion in the 1900s while non-indigenous invertebrate introductions seem to be increasing exponentially (Waldeck et al. 2003).

2.5.2.1 Predation

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

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

2.5.2.2 Competition

American shad (*Alosa sapidissima*) have grown to substantial populations since introduction into the Columbia River system in 1885 (Welander 1940, Lampman 1946); in recent years, 2-4 million adults have been counted annually at Bonneville Dam. Although the construction of dams in shad-producing streams has been blamed in part for the decimation of East Coast stocks of American shad (Walburg and Nichols 1967 as cited in Weitkamp 1994), Weitkamp (1994) suggested that dams in the Columbia River system may partially be responsible for the shad’s rapid population growth. American shad can successfully navigate some dams (Miller and Sims 1983 as cited in Weitkamp 1994); the completion of the Dalles Dam in 1956 (and subsequent inundation of Celilo Falls) extensively expanded the range of American shad into the upper Columbia and Snake Rivers (Stober et al. 1979 as cited in Weitkamp 1994). Further, the transition of the estuarine food web from a macrodetritus to microdetritus base (i.e. increased importation of plankton from upstream reservoirs) has benefited zooplanktivores, including American shad (Sherwood et al. 1990).

Because of the abundance of American shad in the Columbia River, system studies have been launched to investigate species interactions between shad, salmonids, and other fish species such as northern pikeminnow, smallmouth bass, and walleye (Petersen et al. In press). A pattern is slowly emerging that suggests the existence of American shad is changing trophic relationships with the Columbia River. Because of their abundance, consumption rates and patterns of American shad may have modified the estuarine food web. One study found that in the Columbia River estuary and lower mainstem (up to RKm 62) shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Juvenile shad and subyearling salmonids also utilize similar heavily-vegetated backwater habitats (McCabe et al. 1983). Another study examined the abundance of shad as prey on the faster growth rates of northern pikeminnow, which in turn are significant predators of juvenile salmonids (Petersen et al. In press).

In the Columbia River estuary, American shad were described as year-round residents (Bottom et al. 1984). Subyearling shad were captured in all areas of the estuary, primarily from August to December (Bottom et al. 1984). Yearling shad were captured throughout the year in all areas of the estuary with all gear types (Bottom et al. 1984), indicating widespread temporal and spatial distribution. Two-year old American shad were also captured throughout the year in all areas of the estuary, but they were more common in the freshwater and estuarine regions (Bottom et al. 1984). In the January, yearling American shad were distributed throughout the freshwater and estuarine areas of the estuary in water column and channel bottom habitats while 2-year olds were also present in freshwater and estuarine areas, primarily in water column habitats (Bottom et al. 1984). In the spring (April to June), a large pelagic assemblage was identified that included subyearling and yearling American shad, subyearling and yearling salmonids, and Pacific herring (Bottom et al. 1984); thus, there is overlap in habitat usage by American shad and juvenile salmonids during the season of high juvenile salmonid abundance. In August, yearling and 2-year old American shad were associated with water column habitats in the marine, estuarine, and freshwater areas of the estuary (Bottom et al. 1984). Diet analysis indicated that subyearling American shad most frequently preyed upon calanoid, cyclopoid, and harpacticoid copepods and *Daphnia spp*. (Bottom et al. 1984). Meanwhile, yearling and 2-year old American shad most frequently consumed calanoid copepods, *Corophium salmonis,* and harpacticoid copepods; to a lesser extent, cyclopoid copepods and *Corbicula manilensis* were also consumed (Bottom et al. 1984). In the spring, yearling American shad consumed primarily calanoid copepods, although up to 25% of their diet consisted of *Corophium salmonis*; *Corophium salmonis* was the primary prey item (up to 75%) of subyearling and yearling salmonids present in the estuary during the same season (Bottom et al. 1984). In the summer, *Daphnia spp.* are a major prey item of subyearling and yearling American shad; *Daphnia spp*. are also the primary prey item of subyearling chinook salmon during the summer, comprising over 75% of the diet (Bottom et al. 1984).

Commercial harvest has been considered as a means to reduce the abundance of American shad in the Columbia River, however, harvest has been restricted because the shad spawning run coincides with the timing of depressed runs of summer and spring chinook, sockeye, and summer steelhead (WDFW and ODFW 2002).

The banded killifish (*Fundulus diaphanous*) was likely introduced illegally into the Columbia River basin (Farr and Ward 1993 as cited in Weitkamp 1994) sometime around 1970 (Weitkamp 1994). Although not abundant initially, densities of 375 fish per hectare have been observed at Miller Sands in summer and fall (Hinton et al. 1990 as cited in Weitkamp 1994). In its native range, the banded killifish is a midwater and surface feeder, preying primarily on cladocerans and ostracods, although, it consumes mollusks and flatworms to a lesser extent (Smith 1985 as cited in Weitkamp 1994). Although there may be some diet overlap among banded killifish, salmonids, and other fish in the estuary and lower mainstem, its impacts on native fish and the estuarine ecosystem are largely unknown (Weitkamp 1994). Changes to the estuary ecosystem resulting from development and operation of the hydropower system may have contributed to increased survival and range extension of banded killifish (Weitkamp 1994). Weitkamp (1994) suggested that the banded killifish’s limited distribution in shallow water habitats and its small size may limit the potential ecological impact in the estuary; however, continued growth of the population would warrant further investigation.

2.5.2.3 Ecosystem Alteration

Significant changes in estuary faunal communities have occurred through species introductions, but, for the most part, the effects of these species introductions have not been assessed. Several nonnative invertebrate species have expanded their populations dramatically since introduction, particularly the Asian bivalve, *Corbicula fluminea*. First discovered in the Columbia River estuary in 1938 (Ingram 1948), it was likely unintentionally introduced from ship ballast (Weitkamp 1994). This bivalve has expanded from the estuary far into the lower mainstem reservoirs and tributaries (Bottom et al. 2001). Densities exceeding 10,000 m^2 have been recorded in Cathlamet Bay, however, densities of 100-3,000 m^2 are more typical in the estuary (Emmett et al. 1986, Hinton et al. 1990 as cited in Weitkamp 1994); density elsewhere in the basin is not known. *C. fluminea* has been shown to outcompete native bivalves and are very tolerant of variable environmental conditions (i.e. can withstand considerable ranges and fluctuations in temperature, dissolved oxygen, flow velocity, water level, and contaminant concentrations) (Sinclair 1971, Gardner et al. 1976). Lauritsen (1986) suggests that large numbers of *C. fluminea* can have an affect on phytoplankton biomass and nutrient cycling. Because of their abundance, consumption rates and patterns of *C. fluminea* may have modified the estuarine food web. However, the influences of *C. fluminea* in the Columbia River estuary ecosystem and on native bivalves are poorly understood. Unpublished data from the California Department of Fish and Game showed that while these nonindigenous species were never prominent in the diets of juvenile salmonids, they seasonally made up the principle stomach contents of other pelagic fishes, such as American shad, herring, stickleback and smelt species (Bottom et al. 2001).

The calanoid copepod *Pseudodiaptomus inopinus* was recently introduced (around 1990) in the Columbia River estuary, likely from cargo ship ballast water originating from the Indo-Pacific region (Weitkamp 1994). The moderated peak flows and warmer water temperatures resulting from hydrosystem operation and other anthropogenic activities has facilitated success of this copepod in the estuary (Cordell et al. 1992 as cited in Weitkamp 1994). Cordell et al. (1992 as cited in Weitkamp 1994) identified *P. inopinus* as the third most abundant zooplanktor in the estuary; densities of 17,000 m^2 were recorded. *P. inopinus*, as well as other zooplanktors, is associated with the ETM, although ETM sampling has shown that *P. inopinus* is associated with different physical attributes of the ETM than the two most abundant zooplanktors in the estuary, *Eurytemora affinis* and *Scottolana canadensis* (Cordell et al. 1992 as cited in Weitkamp 1994). This spatial segregation suggests a reduced potential for competition between these native and exotic zooplankton (Cordell et al. 1992 as cited in Weitkamp 1994); however, the abundance of *P. inopinus* suggests that it may have substantial impact on the estuary ecosystem (Weitkamp 1994).

Ecosystem effects of non-indigenous aquatic plants are a concern for many resource managers. Of particular interest in the Columbia River estuary and lower mainstem are four plants considered noxious weeds: purple loosestrife (*Lythrum salicaria*), Eurasian water milfoil (*Myriophyllum spicatum*), parrot feather (*Myriophyllum aquaticum*), and Brazilian elodea (*Egeria densa*). Because much of the information regarding these aquatic nuisance plants was derived from the Washington Department of Ecology webpage, the following paragraphs identify known distribution within Washington. These, and other non-indigenous macrophytes, may also be a significant concern on the Oregon side of the lower mainstem and estuary, however, specific information regarding the status and distribution within Oregon was not found. Additionally, Wahkiakum County, Washington, recently published a management plan that discusses in detail the issue of aquatic vegetation management as well as known distribution of select non-indigenous aquatic plants in the Columbia River estuary (AquaTechnex 2003).

Purple loosestrife, native to Eurasia, was originally introduced to the eastern seaboard of North America in the early 1800s from European ship ballast and as a valued medicinal herb; expansion westward coincided with increased transportation systems and various commercial uses, such as horticulture and forage cultivation for beekeepers. In Washington, purple loosestrife was first collected in 1929 from Lake Washington; it has since spread to most areas of the state. Purple loosestrife generally occurs in shallow, fresh and brackish water, and may grow in wetlands, ponds/lakes, stream banks, and ditches. Purple loosestrife is a successful colonizer of any wet, disturbed site; it quickly adapts to environmental changes and can expand its range rapidly. The primary ecological effect of purple loosestrife is that it disrupts wetland ecosystems by displacing native plants and eventually displacing the animals that rely on the native flora for food, nesting, or cover. Purple loosestrife spreads aggressively and is very difficult to control; combinations of cutting and herbicide application have produced mixed results, depending on the season and duration of treatment. Biological control agents through the use of leaf-eating beetles or root-mining weevils show considerable promise for controlling purple loosestrife (WDOE 2003).

Eurasian water milfoil, native to Europe, Asia, and northern Africa, may have first been introduced to North America in the late 1800s at Chesapeake Bay; expansion of the plant throughout much of North America is thought to largely be a result of boating activity from one waterbody to the next. In Washington, the first known record of Eurasian water milfoil was a 1965 herbarium specimen from Lake Meridian in King County. Eurasian water milfoil is extremely adaptable and thrives in a variety of environmental conditions, such as still or flowing water, salinity up to 15 parts per thousand, water depth up to 10 meters, pH from 5.4-11, and survival under ice; it appears to grow best on fine-textured, inorganic substrates. Eurasian water milfoil negatively affects aquatic ecosystems in a number of ways. First, the dense canopies produced by Eurasian water milfoil shade out native vegetation, creating monospecific stands that provide poor habitat for fish and wildlife. Second, plant sloughing, leaf turnover, and decomposition at the end of the growing season increases phosphorus and nitrogen loading to the water column, affecting water quality. Third, dense canopies of Eurasian water milfoil affect water quality by increasing pH, increasing water temperature, and decreasing oxygen under the dense mats. Eurasian water milfoil also has many societal impacts; it often disrupts recreational activities such as fishing, boating, or water skiing. Further, Eurasian water milfoil can negatively impact power generation or irrigation withdrawals by clogging dam trash racks or water intake pipes. Numerous methods have been effectively used to control Eurasian water milfoil; success of each method depends on a number of factors, including duration of application and appropriateness of the method to the local environment. For example, covering sediments with an opaque fabric works well in localized areas but is not appropriate for large scale control programs. Water level drawdown has proven effective at dessicating plants in cold or dry climates, but this method is not effective in wet climates, such as western Oregon and Washington. Numerous herbicides have effectively controlled Eurasian water milfoil, provided the duration and concentration of application is sufficient. Finally, biological controls, particularly a native North American weevil, have been successfully used to control Eurasian water milfoil (WDOE 2003).

Parrot feather, native to the Amazon River in South America, has naturalized worldwide, particularly in warmer climates; its worldwide introduction has resulted primarily because of widespread use as an indoor/outdoor aquaria or aquatic garden plant. In the United States, parrot feather is present throughout the southern states and along both coastlines. In Washington, presence of parrot feather was first reported in 1944; parrot feather appears to be present in coastal lakes and streams, as well as the Southwest Washington portion of the Columbia River. Parrot feather is prevalent throughout the Longview/Kelso area drainage system, as well as many drainage ditches in Wahkiakum County. Able to colonize slow moving or still water, parrot feather is commonly found in freshwater lakes, ponds, streams, or canals. Parrot feather is well adapted to high nutrient environments and grows best when rooted in shallow water, although it is known to occur as a floating plant in nutrient-rich lakes. Although parrot feather provides cover for some aquatic organisms, generally it negatively alters the physical and chemical characteristics of its environment. Dense parrot feather stands alter aquatic ecosystems by shading the water column algae that previously served as the base of the aquatic food web. Further, parrot feather provides choice mosquito larvae habitat, which has created substantial problems in areas of high parrot feather occurence. Parrot feather is difficult to control; combinations of herbicides and mechanical controls (i.e. cutting or water drawdown) have produced mixed results. Further, because of its high tannin content, most grazers find parrot feather unpalatable. At present, biological control agents are not available, although research on multiple beetles and weevils show promise for parrot feather control. Additionally, fungal control options are currently under development (WDOE 2003).

Brazilian elodea, native to South America, is now distributed virtually worldwide, particularly because of its popularity as an aquarium plant. First reported in the United States in 1893 on Long Island, New York, Brazilian elodea has spread rapidly in fresh inland water throughout the U.S.; it was first reported in Washington in the early 1970s at Long Lake, Kitsap County. Brazilian elodea is distributed throughout many lakes, sloughs, and drainage ditches of western Washington, however, it has not been reported growing in eastern Washington lakes. Brazilian elodea may be rooted in water depths up to 20 feet or can be found drifting; it is adapted to both still and flowing water and thus can be found in lakes, ponds, ditches, and slow moving streams. Brazilian elodea forms dense monospecific stands that likely provide little benefit to native fish and wildlife; the dense stands restrict water movement and trap sediments, which affects water quality. Numerous methods have been effectively used to control Brazilian elodea; success of each method depends on a number of factors, much like that of Eurasian water milfoil. Thus, covering sediments with an opaque fabric works well in localized areas but not large scale control programs. Also, water level drawdown is not effective in wet climates, such as western Oregon and Washington. Numerous herbicides have effectively controlled Brazilian elodea. Additionally, a fungus that damaged Brazilian elodea in laboratory tests shows promise as a biological control. Finally, grass carp find Brazilian elodea particularly palatable and have been successfully employed as a management tool; however, use of grass carp has been limited because they are generally considered unsuitable for waterbodies where inlets and outlets cannot be screened (WDOE 2003).

Invasions of exotic cordgrasses (*Spartina alterniflora*, *S. anglica*, *S. densiflora*, and *S. patens*) have caused ecosystem changes in estuaries worldwide; each of these species are known to occur along the West coast of North America (Ayres et al. 2003). These species thrive in areas of accreting sediments, where they out-compete native vegetation (Daehler and Strong 1996). Although not known to be an immediate concern in the Columbia River estuary, *S. alterniflora* and *S. anglica* have caused significant changes in Willapa Bay, WA (Ayres et al. 2003). Cordgrasses disperse by floating seed and clonal fragments (Huiskes et al. 1995); such dispersal has been observed in Washington where *S. alterniflora* has spread from Willapa Bay to Grays

Harbor 30 km to the north (Ayres et al. 2003). Thus, significant potential exists for dispersal of these exotic cordgrasses to the Columbia River estuary.

Although not currently known to occur anywhere in the Columbia River basin, zebra mussels (*Dreissena polymorpha*) are a concern of Federal and State agencies throughout the Pacific Northwest (BPA 2002). Zebra mussels are an extremely prolific, freshwater mollusk native to the Caspian Sea (USGS 2002). In North America, they were first discovered in the Great Lakes in 1988 and have since spread to all the Great Lakes, as well as the major river systems in the Midwest (Hebert et al. 1991 as cited in USGS 2002). Introduction to the Great Lakes was likely a result of ballast water discharge; dispersal to river systems outside the Great Lakes may be a result of zebra mussels attaching to boats that are trailed from infested waters to other locations (USGS 2002). Under cool, humid conditions, zebra mussels can stay alive for several days out of water (USGS 2002), thus are capable of being transported long distances. During routine inspections at agricultural inspection stations, zebra mussels have been found attached to the hull or in the motor compartment of trailered boats crossing into California (USGS 2002). Many biological impacts of zebra mussels in North America are not yet known, primarily because many effects may still be developing (USGS 2002). However, zebra mussels have the potential to outcompete and eliminate native mussels (Nalepa 1994 and Schloesser and Nalepa 1994, as cited in USGS 2002), consume sizeable amounts of algae and increase water clarity, and alter macrophyte plant communities as a result of changes in water clarity (Skubinna et al. 1995 as cited in USGS 2002). In the Great Lakes, zebra mussels initially appear to be having little effect on fish populations, although it may be soon to determine because of their recent introduction (USGS 2002). Zebra mussels are well known for their ability and affinity to colonize and foul water supply pipes to many different types of industrial facilities; this colonization reduces effective pipe diameter and flow through these water pipes (USGS 2002). Although many methods have been used to control zebra mussels, each has varying levels of success under specific applications (USGS 2002).

2.6 Knowledge Gaps

There is an abundance of knowledge gaps in our current understanding of the physical processes of the estuary and lower mainstem and how these processes relate to the biological requirements of focal species. Faced with the challenge of recovering ESA-listed populations, recovery efforts need to progress in the face of uncertainty, recognizing our current limitations. Section 2.6.1 Uncertainty reminds us that there are many things we do not know regarding focal species relationships to the estuary and lower mainstem ecosystem. Section 2.6.2 Physical Process Models briefly describes the ongoing research efforts to increase our understanding of estuarine physical processes. Section 2.6.3 Current Research Needs identifies the future direction necessary to increase our understanding of the biological requirements of salmonids in relation to the estuary and lower mainstem ecosystem.

2.6.1 Uncertainty

Habitat requirements of non-salmonid fishes and wildlife focal species as they relate to Columbia River estuary habitat conditions and the processes that form and maintain those habitats are largely understudied. A considerable amount of information is available in the Pacific Northwest regarding habitat classification, habitat conservation, and wildlife-habitat relationships (Brown 1985, Ruggiero et al. 1991, WDNR 1996, WDNR 1998, Johnson and O'Neil 2001), however, none of these efforts have focused specifically on the interaction of wildlife focal species and the Columbia River estuary and lower mainstem. Gaumer et al. (1985) and Buchanon et al. (2001) generally discussed the dynamics of estuary habitats and relationship of different wildlife species to this habitat; again, the relationship of wildlife focal species and the Columbia River estuary were not specifically addressed.

Throughout this qualitative analysis, there are multiple inferences regarding the expected or likely relationship between salmonids and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on salmon and habitat relationships in non-tidal freshwater.

The issue of uncertainty is a significant challenge; as a result, US Army Corps of Engineers organized a workshop in March 2003 to review past and ongoing research in the Columbia River estuary, identify data gaps and key future research needs, and prioritize the identified research needs related to Columbia River salmonids (R2 2003). Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment.

The key biological relationships in which we need a clearer understanding include:

- Specific relationships between salmonid life history strategies and habitat requirements, especially for ESA-listed species.
- Juvenile salmon usage and ecology in the tidal freshwater portion of the Columbia River estuary (i.e. Puget Island [rm 46] to Bonneville Dam [rm 146]).
- Specific linkages between biological and physical processes in various estuary habitat types.
- Inventory of current size, quality, and accessibility of habitat preferred by juvenile salmonids.

- Survival rates and growth indices for various salmonid life history types and the relationship to estuary habitats.
- Food web structure and linkages to estuary habitat types.
- Habitat forming processes required to maintain habitat types utilized by salmon.
- Relationship of structural and functional ecosystem components, including the natural variability associated with each.

2.6.2 Physical Process Models

Considerable effort has focused on developing predictive capabilities to describe the physical processes in the Columbia River estuary and lower mainstem. Considerable knowledge has been gained through this effort, however, connection of physical process models to biological requirements of salmonids and other focal species remain largely based on professional assumptions. The programs described below are not strictly physical process models, as identified in each program's description available on the internet. Note that the LCFRB was not involved in the development of the physical process models outlined here; these models are merely presented as an introduction to our current level of understanding of physical processes within the Columbia River estuary and lower mainstem and to highlight our current inability to connect physical process models with biological processes.

2.6.2.1 CORIE

The CORIE program is administered through the Oregon Graduate Institute, School of Science and Engineering, which is part of the Oregon Health and Science University. The following exerpts describing the CORIE program were taken directly from the CORIE website (http://www.ccalmr.ogi.edu/CORIE/):

> *CORIE is a pilot environmental observation and forecasting system (EOFS) for the Columbia River. It integrates a real-time sensor network, a data management system and advanced numerical models. Through this integration, we seek to characterize and predict complex circulation and mixing processes in a system encompassing the lower river, the estuary and the near-ocean. The acquired knowledge is transformed into data products designed to provide objective insights on the spatial and temporal variability of the Lower Columbia River.*
>
> *As a scientific tool, CORIE is designed to advance the emerging field of environmental information systems, and the understanding of river-dominated estuaries and plumes.*
>
> *The scientific objectivity and breadth of products of CORIE also gives the region's natural resource management and regulation community powerful new planning and analysis tools to improve policies and decisions.*
>
> *Early applications of CORIE have, in particular, addressed issues combining salmon habitat and passage, hydropower management, navigation improvements and habitat restoration. These applications show that there is a role for objective science to engender consensus across agencies with conflicting mandates. They also suggest that coordinating resources of multiple users of a waterway in the development of a shared scientific infrastructure, readily adaptable to evolving needs, might be a practical way to develop affordable management tools.*

> *Rapidly advancing performance and declining costs of electronic and computer technology will soon make EOFS economically feasible. The experience of systems like CORIE will encourage and provide paradigms for the development of national and international networks of EOFS, to the benefit of science and society.*
>
> *The CORIE modeling system integrates models and field controls. Focus is on the simulation of 3D circulation, in a region centered in the estuary and plume, but extending from Bonneville Dam to the Eastern North Pacific.*
>
> *CORIE simulations include (a) short term forecasts, (b) actual past conditions (referred to as hindcasts), (c) characteristic climatology conditions, and (d) scenario conditions. River, atmospheric, and ocean forcings are complied, in some cases in quasi-real time, from a variety of sources.*

2.6.2.2 Columbia River Estuary Turbidity Maxima Research Project

The Columbia River Estuary Turbidity Maxima (CRETM) is a US National Science Foundation (NSF) Land-Margin Ecosystem Research (LMER) Project; the project is an ecosystem-scale, interdisciplinary investigation of the role of estuarine turbidity maxima (ETM) in shaping the food web of the Columbia River estuary. The following exerpt describing the CRETM program was taken directly from the CRETM website (http://depts.washington.edu/cretmweb/CRETM.html):

> *Our fundamental research goal is to understand how circulation phenomena in the estuary, called estuarine turbidity maxima (ETM), trap particles and promote biogeochemical, microbial and ecological processes that sustain a dominant pathway in the estuary's food web. To study this relationship between the physics of ETM and these various processes requires a resolutely interdisciplinary approach, and a complex, highly-orchestrated suite of field and laboratory measurements and experiments. The CRETM-LMER team involves scientists from six distinct disciplines-geophysics, sedimentology, geochemistry, microbiology, primary production biology, and zooplankton and food web ecology-to characterize ETM process. But, we depend upon hydrodynamic and ecosystem process modelers to help us synthesize our understanding about how the ETM and associated estuarine processes act as a "living" system that is fundamental to the way the estuary behaves.*

2.6.3 Current Research Needs

A research, monitoring, and evaluation (RME) plan for the Columbia River estuary and plume was recently developed (Johnson et al. 2003a) for the purpose of fulfilling certain requirements of Reasonable and Prudent Alternatives 160, 161, and 163 of the 2000 Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000c). The three primary goals of this RME plan are: 1) Status Monitoring – quantify status/trends in listed salmonid usage/survival in the Columbia River estuary and plume, 2) Action Effectiveness – quantify effects of habitat restoration efforts on listed salmonids in the Columbia River estuary and plume, and 3) Uncertainties – resolve uncertainties regarding salmonid recovery efforts in the Columbia River estuary and plume (Johnson et al. 2003a). To the extent possible, future development of an RME plan for the lower Columbia River and estuary by the LCFRB should attempt to be consistent with and not duplicate the work of Johnson et al. (2003a).

During the recent lower Columbia River and estuary research needs workshop (R2 2003), research needs were categorized by priority and expected time needed for completion. Note that the LCFRB was not involved in the development of the research needs presented here, but we are simply presenting the findings of the collaborative workshop. Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment. Four categories of research were identified: high priority/immediate, high priority/10-year window, high priority/long term, and medium priority. The following research topics were taken directly from the workshop proceedings report (R2 2003):

High priority research needs that could be addressed now include:

- *Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.*
- *Implement selected restoration projects as experiments, so that we can learn as we go.*
- *Implement pre- and post-restoration project monitoring programs, to increase the learning.*
- *"Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.*
- *Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.*
- *Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.*
- *Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.*
- *Identify and implement off-site mitigation projects in CRE tributaries.*
- *Establish a data and information sharing network so that all researchers have ready and up-to-date access.*
- *Increased genetic research to identify genotypic variations in habitat use.*

High priority research needs that appear to be feasible within the present 10-year window of opportunity, but may not be implemented immediately or lead directly to projects in the near term include:

- *Understanding salmonid estuarine ecology, including food web dynamics.*

- *Understanding sediment transport and deposition processes in the estuary.*

- *Understanding juvenile and adult migration patterns.*

- *Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.*

The following items were identified as high priority, but are considered long-term efforts (i.e. will likely take the longest to complete before a tangible product is developed):

- *Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.*

- *Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.*

- *Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.*

- *Improve our understanding of the role between micro- and macro-detrital inputs, transport, and end-points.*

- *Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.*

- *Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.*

The following research needs were identified as medium priority (i.e. they may provide additional insights, but we currently have a reasonable idea of the most important features based on preceding work):

- *Increasing our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.*

2.7 Hypothesis Statements

The ultimate goal of this subbasin assessment is to assemble the technical information necessary to develop biological objectives for the Columbia Estuary and Lower Columbia Subbasins. The subbasin assessment concludes with the develop a working hypothesis that establishes the basis for the future management plan. The NPPC defines the working hypothesis as follows:

> *The working hypothesis is a collection of component hypotheses – a set of key assumptions that are based on assessment data and analysis. The overall working hypothesis describes a scientific understanding of the subbasin and contains the key assumptions relating to species-habitat relationships and/or the effectiveness of strategies to modify the elements of the environment. A working hypothesis summarizes a scientifically based understanding of the subbasin at the time the management plan is developed and begins to bridge the gap between the science and strategies. By developing a working hypothesis, you will have an explicit scientific rationale to considering alternative biological objectives and strategies. It will be used to evaluate and derive biological objectives and strategies in relation to the subbasin vision. Finally, the working hypothesis provides the elements necessary for scientific review of the subbasin plan by the Council and the Independent Scientific Advisory Board.*

The NPPC suggests that the working hypothesis is best developed around a scientific model such as Ecosystem Diagnosis and Treatment (EDT; NPPC 2001); however, EDT, or other similar models have not been parameterized for the estuary or lower mainstem. Therefore, in this assessment, hypotheses were developed based on scientific evidence and professional judgement. The hypothesis statements collectively represent our current understanding of the primary issues in the estuary and lower mainstem. Because the hypotheses are supposed to serve as the foundation of the management plan and directly link to biological objectives, in some cases the hypothesis statements needed to make a quantum leap to bridge the gap between our current level of understanding and the desired conditions in the subbasins.

As part of the implementation process of the subbasin plan, the working hypothesis will be tested and refined through research, monitoring, and evaluation. It is vital that subbasin planners reach an agreement on the working hypothesis, or set of alternative hypotheses, in order to develop the management plan. The following series of component hypothesis statements are intended to collectively serve as the NPPC 'working hypothesis' for the Columbia Estuary and Lower Columbia Subbasins based on the currently available scientific information. Note that the hypothesis statements do not take the classic form of a scientific hypothesis (i.e. if…then); they are formulated to address the NPPC hypothesis definition.

Hypothesis Statement 1 – Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities, affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.

Habitat formation in the lower Columbia River mainstem and estuary is controlled by opposing hydrologic forces: ocean processes (tides) and river processes (discharge). These processes may be disturbed by storms, extreme hydrologic events, or catastrophic events such as earthquakes or volcano eruptions. Tides introduce marine-derived sediments to the estuary while river discharge carries freshwater sediments via bedload and suspended sediment. This supply of sediments influences the bathymetry of the estuary through the processes of erosion and accretion. Suspended sediment, along with the production of organic matter, determine the degree of water turbidity. The opposing processes of estuary outflow (river discharge) and inflow (tides) determine the salinity gradient and the type and location of available nutrients. River discharge also directly affects the level of woody debris recruitment to the estuary. Finally, the main components of the habitat formation process (bathymetry, water turbidity, salinity, nutrients, and woody debris) determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

As described in section 2.6.2, numerous on-going research projects are focused on describing the physical processes within the Columbia River estuary. For example, the CORIE program is an environmental observation and forecasting system for the Columbia River that seeks to characterize and predict complex circulation and mixing processes in the ecosystem encompassing the lower river, the estuary, and the near-ocean. Another project (CRETM) has focused its research efforts on understanding how circulation processes in the Columbia River estuary trap particles and promote biogeochemical, microbial, and ecological processes that comprise a dominant pathway in the estuarine food web.

Tide cycles (magnitude and periodicity) are natural processes that are partially influenced by storms and wind action but are largely beyond the dominion of human actions. However, the effects of tide cycles and tidal action have been altered by human intervention. For example, construction of the north and south jetties at the mouth of the Columbia River has decreased wave action in the lower river and has altered the hydrologic regime at the river/ocean interface; the result has been varying patterns of erosion and accretion compared to historical conditions.

River discharge is affected by precipitation, temperature, and water regulation/withdrawals. Sherwood et al. (1990) [as cited in Bottom et al. 2001] estimated that the 40% decrease in maximum spring freshet flow compared to historical conditions is because of water regulation (75%), irrigation withdrawal (20%), and climate change (5%). Changes in river discharge has decreased the freshwater-derived sediment supply and woody debris as well as altered the salinity gradient and nutrient distribution throughout the estuary (Sherwood et al. 1990 as cited in Williams et al. 2000, Bottom et al. 2001, USACE 2001). Artificial channel confinement has altered river discharge and hydrology, as well as disconnected the river from much of its floodplain, thereby eliminating much of the woody debris supply. Additionally, channel manipulations for transportation or development have also had substantial influence on river discharge and hydrologic processes in the river.

Evaluation of anthropogenic factors is complicated by climate effects. Variations in Columbia River discharge as a result of climate effects occur in time scales from years to centuries (Chatters and Hoover 1986, 1992 as cited in Bottom et al. 2001). The Columbia Basin’s climate response to climatic cycles is governed by the basin’s latitudinal position; climate in the region displays a strong response to both the PDO and ENSO cycles (Mantua et al. 1997 as cited in Bottom et al. 2001). The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather pattern is typified by cool ocean temperatures and cool/wet weather patterns on land. Climate directly affects river flow and observed changes to flow are often substantial. Further, El Niño patterns result in poor ocean productivity in the Pacific Northwest and California, as was observed in the mid 1990s. The effects of poor estuary and mainstem habitats are exaggerated during periods of low ocean productivity.

Current climate projections predict gradual warming of the region, potentially with higher precipitation, particularly in winter (Hamlet and Lettenmaier 1999). The predicted future climate conditions will possibly reduce the likelihood of spring freshets caused by heavy spring rain on late snowpack because warmer temperatures will not allow the accumulation of snow late into the spring. This freshet style (rain on snow) has historically produced the most substantial increases in river discharge (Bottom et al. 2001). However, despite our ability to measure changes in climate, Bottom et al. (2001) discussed the difficulty in separating climate versus anthropogenic effects on river discharge and the habitat-forming processes it governs.

Hypothesis Statement 2 – Human activities have altered how the natural processes interact, changing habitat conditions for fish and wildlife in the Columbia River estuary and lower mainstem.

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

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

Flow regulation in the Columbia has decreased spring freshet magnitude and increased flows over the rest of the year as a result of winter drawdown of reservoirs and filling of the reservoirs during the spring runoff season. The historical flow records at the Dalles, Oregon, Bonneville Dam, and Beaver, Oregon, demonstrate that spring freshet flows have been reduced by about 50% and winter flows have increased about 30% (Figure 2-13, Figure 2-14, and Figure 2-15, respectively). Most of the spring freshet flow reduction is attributed to flow reduction, about 20% is a result of irrigation withdrawals, and only a small portion (5%) is connected to climatic change (Bottom et al. 2001).

Reduction of maximum flow levels, dredged material deposition, and diking measures have all but eliminated overbank flows in the Columbia River (Bottom et al. 2001), resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Overbank flows were historically a vital source of new habitats. Moreover, historical springtime overbank flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands. Historical bankfull flow levels were common prior to 1975 but are rare today; current bankfull flows have only been exceeded four times since 1948 (Figure 2-16). Further, the season when overbank flow is most likely to occur today has shifted from spring to winter, as western subbasin winter floods (not interior subbasin spring freshets) are now the major source of peak flows (Bottom et al. 2001, Jay and Naik 2002).

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

Development and maintenance of the shipping channel has greatly affected the morphology of the estuary. The extensive use of jetties and pile dikes to maintain the shipping channel has impacted natural flow patterns and large volumes of sediments are dredged annually. Dredged materials are disposed of in-water (in the ocean or in the flow adjacent to the shipping channel), along shorelines, or on upland sites. Dredge disposal in upland or deepwater sites reduces the amount of sediment available for habitat formation in the estuary as well as sediments that supply shoreline areas in the Columbia River littoral cell. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year in the estuary. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays.

Sediments in the estuary may be marine or freshwater derived; sediments are transported via sediment suspended in the water column or bed load movement. Riverine sediments available for transport has decreased as a result of dam construction: reservoirs restrict bedload movement and trap upstream supply of sediments. Sand sediments are vital to natural habitat formation and maintenance in the estuary; dredging and disposal of sand and gravel have been one of the major causes of estuarine habitat loss over the last century (Bottom et al. 2001). Conversely, the USACE (2002) suggests that sediment deposition conditions exist in the estuary, particularly shoaling in the navigation channel and deposition/accumulation of sand in low energy areas in the estuary and along the coast. Shoaling in the navigation channel is a redistribution of bed sediments, rather than an accumulation of sediments, because it does not change the volume of bed material within a given reach (USACE 2002).

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

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

River discharge, tidal processes, and channel depth determine the salinity gradient and the type and location of available nutrients. Altered estuary bathymetry and flow have affected the extent and pattern of salinity intrusions into the Columbia River; stratification has increased and mixing has decreased (Sherwood et al. 1990 as cited in Williams et al. 2000). The dependence of salinity intrusion on channel depth is strong; the controlling channel depth has doubled over the last 120 years. Bathymetric changes have likely caused the greatest changes in salinity intrusion and stratification, but reduced spring freshet flows have also substantially altered salinity intrusion length (Bottom et al. 2001). The combination of tidal energy and river discharge determine the location, size, shape, and salinity gradients of the Columbia River ETM; the organic matter accumulation and cycling associated with the ETM is especially important in the current imported microdetritus-based food web.

Industrial development in the lower Columbia River has resulted in pollutants accumulating in the estuary habitats; in general, contaminants affect survival by increasing stress, predisposing fish to disease, and interrupting physiological processes. Accumulation of contaminants in the lower mainstem and estuary have been exacerbated by tributary water quality problems (NMFS 2000c) and reduced peak and sustained flood flows in the lower river (Sherwood et al. 1990 as cited in Nez Perce et al. 1996). In the lower 150 miles of the mainstem Columbia River, many contaminants have been detected above guidance or regulatory levels for fish tissue, sediment, and water (Nez Perce et al. 1995, Tetra Tech 1996). However, two of the more widely known contaminants, DDT and PCBs, were much more prevalent in the lower Columbia River in the 1960s and early 1970s than they are today; their concentrations have continued to decline since 1972, when the use of DDT was banned (USACE 2001).

The degree to which habitat forming processes and anthropogenic factors determine the present day abundance of different habitat types depends on the habitat type and the processes by which they are formed. Further, total change in habitat acreage represents the sum of habitat loss and habitat formation throughout the estuary. Thus, the significance of loss of certain habitat types has been partially masked by the formation of these habitats elsewhere. Further, the geographic movement of estuary habitats is not clear from the quantification of total acreage change. For example, the total acreage of a certain habitat type within a particular estuary area may not have changed considerably from historical to current conditions, however, the location of this habitat type within the estuary area may be completely different.

Thomas (1983) documented substantial changes to estuary habitats from historical to current condtions as summarized below. Estuary-wide tidal marsh and tidal swamp acreage has decreased 43% and 77%, respectively, from 1870 to 1983 (Table 2-5), primarily as a result of dikes and levees that have disconnected the main channel from these floodplain habitats and also from water regulation that has decreased historical peak flows that previously provided water to these habitats. Losses of tidal marsh habitat has been most extensive in Youngs Bay, where a loss of over 6,000 acres was observed (Table 2-5). Extensive tidal swamp habitat losses have been observed in all estuary areas that this habitat was historically present (Table 2-5). Losses of medium and deep water habitat acreage have been less severe (25% and 7%, respectively; Table 2-5). Acreage of medium depth water habitat was lost in all areas of the estuary except the upper estuary, where a slight increase in acreage was observed; acreage loss was highest in the entrance, Cathlamet Bay, and Baker Bay areas of the estuary (Table 2-5). Similarly, deep water habitat acreage was lost in most areas of the estuary; losses were highest in the Baker Bay and upper estuary areas (Table 2-5). Meanwhile, approximately 1,700 acres of deep water habitat were added to the entrance area of the estuary (Table 2-5). The only estuary habitat type that realized a net increase in acreage from 1870 to 1983 was shallows/flats habitat (10%; Table 2-5). This increase in acreage was primarily a result of water regulation that has decreased historical peak flows that often eroded tidal flat habitats and also from decreased wave action and erosion after construction of the jetties at the mouth of the river. A substantial loss of shallows/flats habitat was observed in entrance area of the estuary; much of this habitat was converted to medium or deep water habitat. In total, 36,970 acres (23.7%) of the estuarine habitat acreage has been lost from 1870 to 1983. During this period, lost estuarine habitats were converted to the following non-estuarine habitats: developed floodplain (23,950 acres), natural and filled uplands (5,660 acres), non-estuarine swamp (3,320 acres), non-estuarine marsh (3,130 acres), and non-estuarine water (910 acres; Table 2-10).

Hypothesis Statement 3 – Although rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years, current physical and biological processes are likely still changing such that current habitat conditions represent a degraded state of equilibrium.

It is likely that the trends in wetland habitat loss have slowed in recent years; partially because much of the available habitat has already been removed and partially because current day development is highly scrutinized for potential effects on ESA-listed species and their habitats. Further, some restoration efforts are specifically focused on restoring or preserving tidal wetlands and other key salmon habitats, thus, the potential exists for reversing the habitat loss trend for this habitat type. Conversely, current water regulation practices continue to encourage the habitat-forming processes responsible for the 10% increase in tidal flat habitat.

Garono et al. (2003a) described the Columbia River estuary as “a shifting mosaic of land cover types”. Although Garono et al. (2003a) observed considerable movement from one habitat cover class to another from 1992 to 2000, specific wetland habitats were generally categorized as other wetland habitats while specific upland habitat classes remained within the general upland class (i.e. wetlands remained wetlands and uplands remained uplands, although dominant vegetation or other distinguishing characteristic may have changed). Further, Garono et al. (2003a) indicated that some of the observed habitat changes from 1992 to 2000 were likely a result of differences in mapping accuracy or were consistent with successional transition. Thus, most habitat changes in recent years can be characterized as an alteration of one wetland habitat type to another as opposed to the complete loss of wetland habitats that were observed historically.

The habitat alterations that have occurred since pre-development times have degraded the quality and quantity of habitat in the estuary and lower mainstem. Because this historical trend in habitat loss appears to have slowed recently, the estuary and lower mainstem habitat conditions are in a degraded state of equilibrium. This emphasizes the urgency of the current need to implement habitat restoration actions to reverse the trend of habitat loss.

Hypothesis Statement 4 – Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and does not offer sufficient resolution to allow managers to make informed decisions to benefit recovery and sustainability of natural resources.

Habitat requirements of non-salmonid fishes and wildlife focal species as they specifically relate to Columbia River estuary and lower mainstem habitat conditions and the processes that form and maintain those habitats are largely understudied. For example, Buchanon et al. (2001) generally discussed the dynamics of estuary habitats and relationship of different wildlife species to this habitat, however, this work was not specific to the Columbia River estuary.

Our current understanding of causal relationships between salmonids and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem are only slightly clearer than that of wildlife or non-salmonid fishes. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on known salmon and habitat relationships in non-tidal freshwater. For example, researchers have developed considerable predictive capabilities to describe the physical processes in the Columbia River estuary and lower mainstem through projects such as CORIE or CRETM (section 2.6.2), however, connection of physical process models to biological requirements of salmonids and other focal species remain largely based on professional assumptions.

To address the issue of uncertainty, a scientific workshop was convened in March 2003 to review past and ongoing research in the Columbia River estuary, identify data gaps and key future research needs, and prioritize the identified research needs related to Columbia River salmonids (R2 2003). Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment. Specific research needs that have repeatedly been identified include the need for: linkages of physical process models with biological processes, clearer understanding of sediment transport, hydrology, and bathymetry, connectivity of estuary habitats, connectivity of research efforts, and collaboration among researchers.

In summary, continued research is vital to the progress and success of restoration and recovery efforts in the Columbia River estuary and lower mainstem. Research and monitoring can provide a clearer understanding of the relationships between biological and physical processes in the estuary and lower mainstem; it also serves as a tool for evaluating and recalibrating implemented restoration and recovery actions. However, there is a limit to our ability to understand certain complex biological interactions as discussed below.

Hypothesis Statement 5 – Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.

The increasing predominance of exotic species in species assemblages indicates major changes in aquatic ecosystems (OTS 1993, Cohen and Carlton 1995, Smith 2001 as cited in Waldeck et al. 2003). Globally, there is an increasing rate of aquatic non-indigenous species introductions; this increase has been attributed to the increased speed and range of world trade, which facilitates the volume, variety, and survival of intentionally or unintentionally transported species. This observation appears to hold true in the Columbia River where fish introductions in the lower Columbia River increased in a linear fashion in the 1900s while non-indigenous invertebrate introductions seem to be increasing exponentially (Waldeck et al. 2003). The nature of exotic species introductions in the lower Columbia River are changing from the historical intentional introduction of game or food fish species to the unintentional introduction of species that have unknown or negative impacts on the ecosystem (Draheim et al. 2002). Future prevention of exotic species introductions is vital to maintaining the current balance of ecological relationships in the Columbia River estuary and lower mainstem.

The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. All exotic species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites (Waldeck et al. 2003). Although the list of known exotic species in the lower Columbia River is currently greater than 70 (Draheim et al. 2002), limited information is available regarding the ecological interactions of many of these species.

Altered habitats in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have facilitated the successful establishment of aquatic non-indigenous species (Cordell et al. 1992 as cited in Draheim et al. 2002, Weitkamp 1994). The lower Columbia River ecosystem may still be adjusting to these major flow alterations and this adjustment period may benefit aquatic non-indigenous species (Weitkamp 1994).

There are many opposing philosophies regarding the control and/or eradication of exotic species based on differing political or social values. For example, some believe that introduced game fish should be removed from the Columbia River to restore the historical fish species assemblage, while others believe that introduced game fish should be protected and enhanced to ensure future social and economic benefits from recreational fisheries. Regardless of differing social values, there is often little that can be done to eradicate exotic species once a population has been established. The greatest success for removing exotic species occurs if the species is detected shortly after introduction and a population has not yet become established. Otherwise, the most we can generally expect from exotic species control efforts is to maintain the current community structure, attempt to limit the current abundance levels of exotic species, and diligently establish controls to prevent future exotic species introductions.

Hypothesis Statement 6 – Of all native fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear the most distressed.

Despite substantial changes to the Columbia River estuary and lower mainstem ecosystem, many species have stable or increasing abundance trends. Some of these species may be considered a conservation concern as outlined in the body of this chapter. Regardless of their current abundance trend, implementation of an ecosystem-based approach to recovery of ESA-listed species indicates that an evaluation of effects of each recovery action on these species is warranted. The status and abundance trends of these species in the Columbia River estuary and lower mainstem is summarized below:

- The lower Columbia white sturgeon population is among the largest and most productive in the world. The deep water habitats in which sturgeon are commonly associated remain available throughout the lower mainstem and estuary. Hydrosystem development and operation has artificially created what functionally amounts to white sturgeon spawning channels downstream from Bonneville Dam, resulting in reliable annual recruitment (L. Beckman USGS (retired), G. McCabe Jr. NMFS (retired), M. Parsley, USGS, Cook Washington. personal communication). Further, sturgeon have demonstrated substantial variability in feeding locations; white sturgeon have potentially benefited from changes to the estuarine food web.

- NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted. Green sturgeon spend most of their life in near-shore marine and estuarine waters from Mexico to southeast Alaska (Houston 1988; Moyle et al. 1995). While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. These fish may be seeking warmer summer river waters in the northern part of their range.
- The northern pikeminnow population has flourished with habitat changes in the mainstem Columbia River and its tributaries. The highest density of northern pikeminnow in the mainstem Columbia River below the Snake River confluence is found in the lower mainstem from the Dalles to the estuary. A pikeminnow management program has been implemented in the Columbia and Snake rivers in an attempt to reduce predation mortality of juvenile salmonids by reducing numbers of the large, old pikeminnow that account for most of the losses. A bounty fishery program for recreational anglers is aimed at balancing pikeminnow numbers rather than eliminating the species and has also stimulated development of a popular fishery.
- Eulachon numbers and run patterns can be quite variable; low runs during the 1990’s were a source of considerable concern by fishery agencies. Current patterns show a substantial increase in run size compared to the 1990’s. The low returns in the 1990’s are suspected to be primarily a result of low ocean productivity. Eulachon support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gillnet fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Nevertheless, hydropower development on the Columbia River has decreased the available spawning habitat for eulachon. Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon (Smith and Saalfeld 1955). Additionally, dredging has the potential to impact adult and juvenile eulachon (Larson and Moehl 1990); dredging operations in the lower Columbia River have made local substrate too unstable for the incubation of eulachon eggs. Thus, future dredging operations should be scheduled to avoid eulachon spawning areas during peak spawning times (Romano et al. 2002).
- Field observations and trapper data indicate the river otter population abundance in the lower Columbia River mainstem and estuary was relatively low in the early 1980s (Howerton et al. 1984); low abundance may be the normal equilibrium level for river otters in this region. River otters are concentrated in shallow water tidal sloughs and creeks associated with willow-dogwood and Sitka spruce habitats located primarily in the Cathlamet Bay area. Although dikes throughout the estuary have disconnected substantial amounts of side channel and floodplain habitats from the mainstem, the Cathlamet Bay area remains as one of the most intact and productive tidal marsh and swamp habitat

throughout the entire estuary. Further, because river otters are capable of traveling over land, it is not understood how the loss of habitat connectivity of side channel and floodplain habitat has affected species' behaviors such as foraging, resting, mating, and rearing. Contaminants in river otter tissue may have adverse physiological effects, however, data suggests that the effects may be temporary (Tetra Tech 1996).

- Habitat conversion, losses, and isolation coupled with the low productivity of the population are the currently the most important threats to Columbian white-tailed deer population viability. Nevertheless, the Columbian white-tailed deer population appears stable at low numbers and shows initial indicators of increasing abundance and productivity. In 1999, the USFWS proposed to delist the Columbian white-tailed deer throughout the entire range, however, public concern over delisting motivated USFWS to withdraw the delisting proposal. Columbian white-tailed deer are present in low-lying mainland areas and islands in the Columbia River upper estuary and along the river corridor. They are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; acreage of this habitat type has decreased substantially from historical to current conditions. Restoration of contiguous preferred habitat is vital to population recovery.
- The Caspian tern breeding population in the estuary has increased significantly from historical to current conditions as a result of the formation of mid-channel islands, primarily from dredge spoil disposal. The largest breeding colony of Caspian terns in North America is currently located in the Columbia River estuary, a location where terns historically did not breed. Terns are a conservation concern because very few breeding colonies exist; thus, terns are susceptible to catastrophic events, disease, or other factors that may affect terns during the breeding season.
- The Washington and Oregon bald eagle populations were included for federal listing as endangered under the Endangered Species Act in 1978. In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized. Bald eagle population in the Columbia River estuary and lower mainstem have suffered from low reproductive success because of contaminants in the ecosystem that have caused eggshell thinning. Despite this, the population has been slowly increasing, presumably as a result of adult recruitment from adjacent populations. Bald eagles are strongly associated with large trees during nesting, perching, and roosting; thus, the loss of mature forest habitats in the Columbia River estuary and lower mainstem has likely decreased the acreage of potential eagle territories.
- The osprey population along the lower Columbia River mainstem has increased slightly in recent years. Although forest habitats used for nesting have likely decreased, osprey have adapted to nesting on man-made structures. Contaminant levels in osprey tissue are high enough to result in decreased egg thickness, however, the increasing population in recent years suggests that young production is not a limiting factor.
- The lower Columbia River mainstem and estuary is not a historical breeding or overwintering area for sandhill cranes. Sandhill cranes currently do not breed in the area, but agricultural development throughout the lower Columbia River floodplain has attracted overwintering sandhill cranes. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February

2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas (Ivey et al. in prep.). Though not known to be a historical wintering area, an average of few hundred, but up to 1,000 cranes have wintered in the area during the last seven or eight years (J. Engler, personal communication). Reclamation of agricultural land for habitat restoration projects may discourage overwintering by sandhill cranes, although future development of herbaceous wetlands may provide adequate winter habitat for sandhill cranes currently using the region.

- Within Washington, yellow warblers are apparently secure and are not of conservation concern; likewise, the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The yellow warbler and red-eyed vireo are both riparian obligate species; warblers prefer shrub-dominated habitats and vireos prefer dense, closed canopy forests. Habitat alterations along the lower Columbia River corridor have likely been more damaging to the possible presence of red-eyed vireos as opposed to yellow warblers because dense riparian forests along the lower Columbia River are likely less abundant than shrub-dominated wetland habitat. However, there are no data to compared historical and current breeding populations in the Columbia River estuary and lower mainstem.
- The only non-salmonid focal species population currently experiencing a decreasing trend is that of Pacific lamprey. However, Pacific lamprey life history suggests that survival and production through the estuary has principally been unaffected by changing habitat conditions. For example, juvenile lamprey feeding during the outmigration is thought to be limited. The sand and silt substrates important to juvenile survival remain available. The estuary may provide juvenile lamprey with cues that facilitate successful adult return migrations, as has been observed in salmonids. Adults are expected to use the estuary and mainstem primarily as a migration corridor. The Columbia River estuary and lower mainstem altered habitat conditions is not expected to be the primary factor in declining Pacific lamprey populations.

Hypothesis Statement 7 – The Columbia River estuary and lower mainstem ecosystem is critical to expression of salmon life history diversity and spatial structure which support population resilience and production.

Estuaries have important impacts on juvenile salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995, Aitkin 1998 as cited in USACE 2001). Juvenile chinook salmon growth in estuaries is often superior to river-based growth (Rich 1920a, Reimers 1971, Schluchter and Lichatowich 1977). Estuarine habitats provide young salmonids with a productive feeding area, free of marine predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment.

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

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

The importance of proximate availability of feeding and refuge areas may hold true even for species that move more quickly through the estuary. For example, radio tagged coho in Grays Harbor estuary moved alternatively from low velocity holding habitats to strong current passive downstream movement areas (Moser et al. 1991). Consistent with these observations, Dittman et al. (1996) suggest that habitat sequences at the landscape level may be important even for species and life history types that move quickly through the estuary during the important smoltification process, as salmon gather the olfactory cues needed for successful homing and these cues may depend on the environmental gradients experienced during migrations.

Hypothesis Statement 8 – Changes in Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem for salmonids and contributed to their imperiled status.

Natural and anthropogenic factors have negatively altered the habitat-forming processes, available habitat types, and the estuarine food web, resulting in decreased salmonid survival and production. Studies conducted by Emmett and Schiewe (1997) in the early 1980s have shown that favorable estuarine conditions translate into higher salmonid survival. The most significant habitat effects have resulted from modified river flow, channel manipulations, and contaminant effects. River flow, although influenced by many factors, will be discussed in detail in the next hypothesis statement addressing hydropower system effects; the other habitat effects will be addressed below.

Salmonid production in estuaries is supported by detrital food chains (Healey 1979, 1982). Therefore habitats that produce and/or retain detritus, such as tidal wetlands emergent vegetation, eelgrass beds, macro algae beds and epibenthic algae beds, are particularly important (Sherwood et al. 1990). Diking and filling activities in the estuary have likely reduced the rearing capacity for juvenile salmonids by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore (Bottom et al. 2001, NMFS 2000c). Dikes throughout the lower Columbia River and estuary have disconnected the main channel from a significant portion of the wetland and floodplain habitats. Further, filling activities (i.e. for agriculture, development, or dredge material disposal) have eliminated many wetland and floodplain habitats. Thus, diking and filling activities have eliminated the emergent and forested wetlands and floodplain habitats that many juvenile salmonids rely on for food and refugia, as well as eliminating the primary recruitment source of large woody debris that served as the base of the historical food chain. The current estuary food web is microdetritus based, primarily in the form of imported phytoplankton production from upriver reservoirs that dies upon exposure to salinity in the estuary (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). The historical macrodetritus-based food web was distributed throughout the lower river and estuary, but the modern microdetritus-based food web is focused on the spatially confined ETM region of the estuary (Bottom et al. 2001). This current food web is primarily available to pelagic feeders and is a disadvantage to epibenthic feeders, such as salmonids (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001).

Habitat alterations in the lower Columbia River mainstem and estuary have increased the abundance of predators of juvenile salmonids (see Hypothesis Statement 11, section 0). Evidence suggests that predation related mortality of juvenile salmonids during outmigration is substantial, thereby limiting survival and abundance of salmonids.

Juvenile salmon collected by NOAA Fisheries at East Sand Island near the mouth of the Columbia River contained relatively high concentrations of DDTs and PCBs. Studies of sub-lethal exposure of juvenile salmon to contaminants in urban estuaries suggest that these contaminants could affect the survival, growth, and fitness of salmon (Casillas et al. 1996). Water quality issues could reduce productivity for species that make extensive use of estuarine habitats for rearing, such as ocean-type salmonids like fall chinook and chum salmon. Further, proposed future dredging operations in the lower Columbia River and estuary may locally force contaminants into the water column or expose contaminanted sediments, which may have detrimental effects if juvenile salmonids were present.

Additionally, the decreased habitat diversity and modified food web has decreased the ability of the lower Columbia River mainstem and estuary to support the historical diversity of salmonid life history types. Historically, chinook salmon in the Columbia River exhibited a wide diversity of life history types, using streams, rivers, the estuary, and perhaps the Columbia River plume as potential rearing areas. Bottom et al. (2001) identified several forms of ocean-type chinook life histories, based on the scale pattern, length, and time of capture data collected by Rich (1920). Wissmar and Simenstad (1998) and Bottom et al. (2001) suggest there may be as many as 35 potential ocean-type chinook salmon life history strategies. Bottom et al. (2001) suggested that human affects on the environment have caused chinook life history patterns to be more constrained and homogenized than historical data show. Most modern day ocean-type chinook fit into one of three groups: subyearling migrants that rear in natal streams, subyearling migrants that rear in larger rivers and/or the estuary, yearling migrants. Today, ocean-type chinook with estuarine rearing life histories are not a primary life history form observed by managers and resource users; most chinook are yearlings with a homogeneous size distribution. Abundance patterns of juvenile chinook in the estuary now reflect hatchery management practices more than historical migration behavior. Further, food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000).

Hypothesis Statement 9 – Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions that have reduced salmonid population resilience and inhibited recovery.

Contruction and operation of the hydropower system has had profound effects on Columbia River estuary and lower mainstem habitats. The primary effects of the hydropower system include decreased mean annual river flow, reversal of the historical hydrograph, reduction of the amount and type of sediments available for transport, and alteration of the type of nutrients and organic material available for transport.

Hydrologic effects of the Columbia River hydrosystem include water level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. Altered flow regimes can affect the migratory behavior of juvenile and adult salmonids. For example, water level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and strand juveniles during the downstream migration. Reservoir drawdowns reduce available habitat which concentrates organisms, potentially increasing predation and disease transmission (Spence et al. 1996 as cited in NMFS 2000c).

Water regulation, as part of hydropower system operations, has drastically reduced historical spring freshet flows and altered juvenile salmon outmigration behavior. Often, historical lower Columbia River spring freshet flows were approximately four times the winter low flow levels. Today, spring freshet flows are only about twice the winter low flow level, which is now generally higher as a result of reservoir drawdown in winter. Spring freshets are very important to the outmigration of juvenile salmonids; freshet flows stimulate salmon downstream migration and provide a mechanism for rapid migrations. Also, spring freshets (especially overbank flows) provide habitat, increase turbidity thereby limiting predation, and maintain favorable water temperatures during spring and early summer. Further, organic matter supplied by the river during the freshet season is a major factor maintaining the detritus-based food web. Today, the contribution of imported detritus is controlled primarily by reservoir production and flow rates from Bonneville Dam.

Because of changes to flow and sediment transport and the various habitat alterations that have occurred in the estuary, the availability of shallow (10cm-2m depth), low velocity (<30 cm/s) habitats appears to decrease at a steeper rate with increasing flow compared to historical conditions. These conditions have decreased the shallow water refugia for juvenile salmonids and likely contribute to decreased survival during high flow conditions (NMFS 2000c).

Altered flow regimes can also affect the spawning success of mainstem Columbia River spawners. For example, reservoir drawdowns in the fall for flood control produces high flow for fall spawners; fish may spawn in areas that are dewatered during the winter or spring, potentially resulting in complete egg mortality (NMFS 2000c).

Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon access to a wide expanse of low-velocity marshland and tidal channel habitats (Bottom et al. 2001). Flooding occurred frequently and was important to habitat diversity and complexity. Historical flooding also allowed more flow to off channel habitats (i.e. side channels and bays) and deposited more large woody debris into the ecosystem. Historically, seasonal flooding increased the potential for salmonid feeding and resting areas in the estuary during the spring/summer freshet season by creating significant tidal marsh vegetation and wetland areas throughout the floodplain (Bottom et al. 2001). These conditions rarely exist today as a result of hydropower system water regulation.

Columbia River mainstem reservoirs trap sediments and nutrients, as well as reduce sediment bedload movement, thereby reducing sediment and nutrient supply to the lower Columbia River. The volume and type of sediment transported by the mainstem Columbia River has profound impacts on the estuary food web and species interactions within the estuary. For example, organic matter associated with the fine sediment supply maintains the majority of estuarine secondary productivity in the food web (Simenstad et al. 1990, 1995 as cited in Bottom et al. 2001). Also, turbidity (as determined by suspended sediments) affects estuary habitat formation, regulates primary production via affects on light penetration, and decreases predation on juvenile salmonids via decreased predator efficiency. Further, the type of sediment transported has profound effects on habitat formation. The reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001). Sand and gravel substrates are important components of preferred salmonid habitat in the estuary.

Hypothesis Statement 10 – Predation has always been a significant source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary but habitat changes resulting from human activities have substantially altered predator concentration and distribution, particularly Caspian terns and northern pikeminnow.

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation has always been a substantial source of mortality but is expected to have increased significantly in recent years because of increased abundance of predator populations that have responded to habitat changes resulting from human activities. For example, piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of outmigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some avian predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary.

Caspian terns are native to the region but were not historically present in the lower Columbia River mainstem and estuary; they have recently made extensive use of dredge spoil habitat and are a major predator of juvenile salmonids in the estuary. The terns are a migratory species whose nesting season coincides with salmonid outmigration timing. Since 1900, the tern population has shifted from small colonies nesting in interior California and southern Oregon to large colonies nesting on dredge spoil islands in the Columbia River and elsewhere (NMFS 2000c). Caspian terns did not nest the estuary until 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds (and others) moved to Rice Island (constructed from dredge spoils) in 1987 and the colony expanded to 10,000 pairs. Diet analysis has shown that juvenile salmonids make up 75% of food consumed by Caspian terns on Rice Island. However, there are no data to compare historical and modern predation rates or predator populations; thus, effects of this unique predator population in relation to historical losses of juvenile salmon to predation cannot be adequately quantified (Bottom et al. 2001). Further, recent management actions have been relatively successful in discouraging Caspian tern breeding on Rice Island while encouraging breeding on East Sand Island, which may decrease predation on juvenile salmonids. Also, current predation studies are limited because of the unknown effects hatchery rearing and release programs have had on salmon migration behavior and predator consumption. Nevertheless, evidence suggests that current predator populations could be a substantial limiting factor on juvenile salmon survival (Bottom et al. 2001).

Native fishes, particularly northern pikeminnow, prey on juvenile salmonids during outmigration. Pikeminnow numbers likely have increased as favorable slack-water habitats have been created by hydropower system water impoundment and flow regulation. In unaltered systems, pikeminnow predation is limited by smolt migratory behavior; the smolts are suspended in the water column away from the bottom and shoreline habitats preferred by pikeminnow. However, dam passage has disrupted juvenile migratory behavior and provided low velocity refuges below dams where pikeminnow gather and feed on smolts. The diet of the large numbers of pikeminnow observed in the forebay and tailrace of Bonneville Dam is composed almost entirely of smolts. Pikeminnow also concentrate at dam bypass outfalls and hatchery release sites to prey on injured or disoriented fish, and pikeminnow eat many healthy smolts as well. Northern pikeminnow have been estimated to consume millions of juvenile salmon per year in the lower Columbia River; an estimated 9.7 million juvenile salmonids are consumed annually from Bonneville Dam to the estuary (NMFS 2000b). Predation rates on salmonids are often much lower in areas away from the dams, although large numbers of predators in those areas can still impose significant mortality.

Hypothesis Statement 11 – Density dependent factors might affect salmonid productivity in the Columbia River estuary and lower mainstem under some conditions, but their current significance is unclear.

The productivity of the Columbia River estuary likely has decreased over time as a result of habitat degradation, which initially would appear to increase the likelihood for competition among salmonids in the estuary especially during times of high juvenile abundance. In situations of decreased habitat availability, reducing access to habitat at critical stages may be a limiting factor in production and recovery of depressed salmonid populations (Fresh et al. 2003). However, historical natural abundance of juvenile salmonids in the lower mainstem and estuary was far greater than the current abundance, even considering the large hatchery releases of juvenile salmonids that occur today. Thus, at our current level of understanding, the importance of density dependent mechanisms in the estuary, if they exist, are not clear.

Recent research in the Skagit River, WA, suggests that density dependent mechanisms are operating in the estuarine portion of that system (Greene et al. *in press* as cited in Fresh et al. 2003). For example, research has identified a density dependent limit to the number of juveniles in the estuary relative to the abundance of juvenile salmonids in the entire system. Greene et al. (*in press* as cited in Fresh et al. 2003) further demonstrated that variability in nearshore Puget Sound conditions (i.e. extension of the Skagit Bay estuary) accounted for significant variability in adult returns of Skagit Bay chinook salmon; moreover, incorporating density dependence helped to clarify the relationship between nearshore conditions and adult returns. Although research in the Skagit River estuary points toward density dependent mechanisms, applicability to the Columbia River estuary is unknown; Fresh et al. (2003) indicated that this information was forthcoming for the Columbia River estuary.

Estuaries may be “overgrazed” when large numbers of ocean-type juveniles enter the estuary en masse (Reimers 1973, Healey 1991). Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000). Reimer (1971) suggested a density dependant mechanism affects growth rate and hypothesized that fall chinook growth in the Sixes River was poor from June to August because of the large population in the estuary at this time and that the increased growth rate in September to November resulted from reduction in population size and a better utilization of the whole estuary.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type chinook salmon to overwhelm the production capacity of estuaries (Lichatowich and McIntyre 1987). However, Witty et al. (1995) could not find any papers or studies that evaluated specific competition factors between hatchery and wild fish in the Columbia River estuary. Rivers such as the Columbia, with well-developed estuaries, are able to sustain larger ocean-type populations than those without (Levy and Northcote 1982).

Natural populations of salmon and steelhead migrate from natal streams over an extended period (Neeley et al. 1993; Neeley et al. 1994); they also enter the estuary over an extended period (Raymond 1979). Hatchery fish are generally—but not always—released over a shorter period resulting in a mass emigration into natural environments. Managed releases of water combined with large releases of hatchery fish result in large numbers of juvenile salmon and steelhead in the estuary during spring months when the estuary productivity is low. Some workers (Reimers 1973; Neilson et al. 1985) have suggested that the amount of time spent in estuaries may relate to competition for food. Fish that arrive in the estuary later in the season may benefit from increased food supplies. Chapman et al. (1994) note that subyearling chinook released later in the summer returned at significantly higher rates than subyearlings released early in the summer.

In summary, the existence of density dependent mechanisms among salmonids in the Columbia River estuary and lower mainstem are equivocal. Although capacity of the estuary to support juvenile salmonids has decreased from historical conditions (see section 2.4.2.8), abundance of salmonids has also decreased substantially. To date, we have limited ability to quantify the lower mainstem and estuary capacity and, therefore, have limited knowledge of how many salmonids can be present in the estuary/mainstem at any given time (i.e. different seasons, flow conditions, nutrient levels, macroinvertebrate abundance, etc.) before significant competition for resources results. It is clear that the capacity of the estuary/mainstem ecosystem has decreased relative to historical conditions, however, it is not clear whether this decreased habitat capacity has resulted in density dependent mechanisms that limit salmonid production at current salmonid abundance levels.

Hypothesis Statement 12 – Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

Habitat actions proposed in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (BiOp; NMFS 2000c) are intended to accelerate efforts to improve survival in priority areas while laying the foundation for long-term habitat strategies. The overarching objectives of the habitat strategy are: protect existing high quality habitat, restore degraded habitats and connect them to functioning habitats, and prevent further degradation of habitat and water quality. Specifically, Reasonable and Prudent Alternative (RPA) Actions 158 through 163 of the BiOp detail specific actions related to estuarine habitat while RPA Actions 156 and 157 address habitat issues within the lower mainstem (NMFS 2000c). An "Action Plan" has recently been published that outlines a plan for implementing the above RPA actions related to estuary and mainstem habitat restoration, as well as RPA actions that address planning, modeling, and research, monitoring, and evaluation needs described in the BiOp (BPA and USACE 2003).

Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. Reasonable and Prudent Alternative Action 160 in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000c) called for an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, with the intention of rebuilding productivity for ESA-listed salmonid populations in the lower 46 miles of the Columbia River. There is considerable uncertainty whether the 10,000 acres is the precise amount needed to produce desired increases in salmonid productivity or if the 10-year schedule is an appropriate time scale for recovery efforts. Thus, NMFS (2000c) identified the importance of continued monitoring and evaluation of the estuary restoration program and the 10,000-acre goal to ensure that habitats being restored are important for salmon survival and recovery. NMFS (2000c) also suggested examples of acceptable habitat improvement efforts, including but not limited to: acquiring diked lands, breaching levees, improving plant communities, reestablishing flow patterns, or enhancing connections between lakes, sloughs, side channels, and the main channel.

Dike removal could provide a sizable increase in shallow water habitat, even without restoration of historical flow regimes (Kukulka and Jay 2003). Dike removal alone provided more of an increase in shallow water habitat than flow restoration without dike removal. Restoration of natural flows increases the duration of shallow water habitat inundation in high-flow years, but individually does not restore the large size of the area historically inundated.

Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids (Bisbal and McConnaha 1998). For example, changes in hydrosystem water management should attempt to provide benefits for the full range of historical salmonid life history patterns and not just the primary life history patterns currently observed. Restoration efforts need to move from the practice of management for average biological conditions to management for the full spectrum of possible biological variation (Williams et al. 1996 as cited in Bisbal and McConnaha 1998).

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Volume II, Chapter 3
Columbia River Estuary Tributaries

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3.0 COLUMBIA RIVER ESTUARY TRIBUTARIES

3.1 Subbasin Description

3.1.1 Topography & Geology

The Columbia Estuary Tributaries Planning watershed drains 26,100 acres (41 mi^2) of the coastal estuary and lowlands in the far southwest corner of Washington. Tributaries to the Columbia River estuary include the Chinook and Wallacut Rivers, as well as several smaller streams that flow into the estuary between the Chinook River and the Deep River to the east. The Chinook and Wallacut Rivers originate in the Willapa Hills and flow through wide valley bottoms before emptying into broad estuaries and then into Baker Bay. Their basins have a combination of sedimentary and volcanic geology.

The shoreline is interspersed with rocky, forested cliffs and floodplain lowlands that have been diked. Most estuarine areas at the river mouths are made up of island complexes, tidal marshes, and tidewater sloughs. Substrate is silt and sand, and vegetation consists of emergent and forested wetlands. These areas provide not only important habitat for local fish populations, but also important estuary rearing habitat for a host of other Columbia River and marine fish populations.

3.1.2 Climate

Average annual rainfall across the estuary in Astoria, Oregon, is 67 inches (1701.8 mm), ranging from 1.22 inches (30.9 mm) in July to 10.53 inches (267.5 mm) in December. Temperatures are mild due to coastal influence and range from 44°-58°F (7°-15°C) (WRCC 2003).

3.1.3 Land Use/Land Cover

Private land ownership dominates the watershed, which is only 4% publicly owned. Residential and commercial uses increase at the west end of the watershed, spreading east from the tourist communities of Long Beach and Sea View, WA to the town of Ilwaco, WA. Lower elevation areas provide space for agriculture, and the higher elevation areas support a small amount of timber harvesting. Much of the estuary habitat at the mouth of the rivers has been converted to agricultural uses, with significant diking and filling of off-channel habitats. Fishing, timber, agriculture, and tourism provide the economic base for area residents. The area is sparsely populated, and the fishing port of Ilwaco and the small rural communities of Chinook and Megler are the only population centers on the Washington side. Astoria is the largest population center in the area.

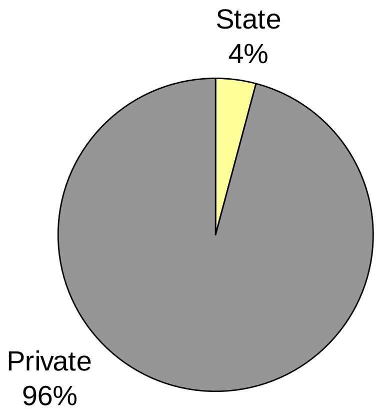


Figure 3-1.Estuary tributaries subbasin land ownership

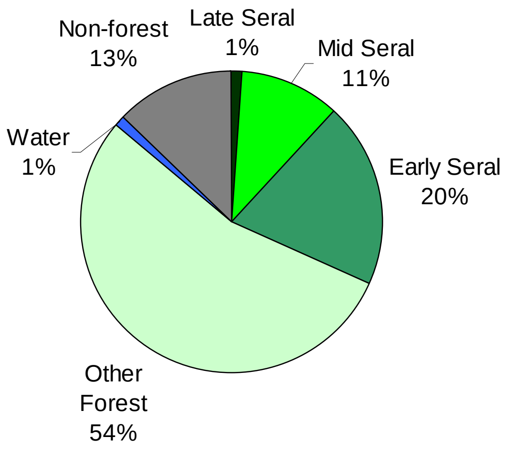


Figure 3-2. Estuary tributaries subbasin land cover

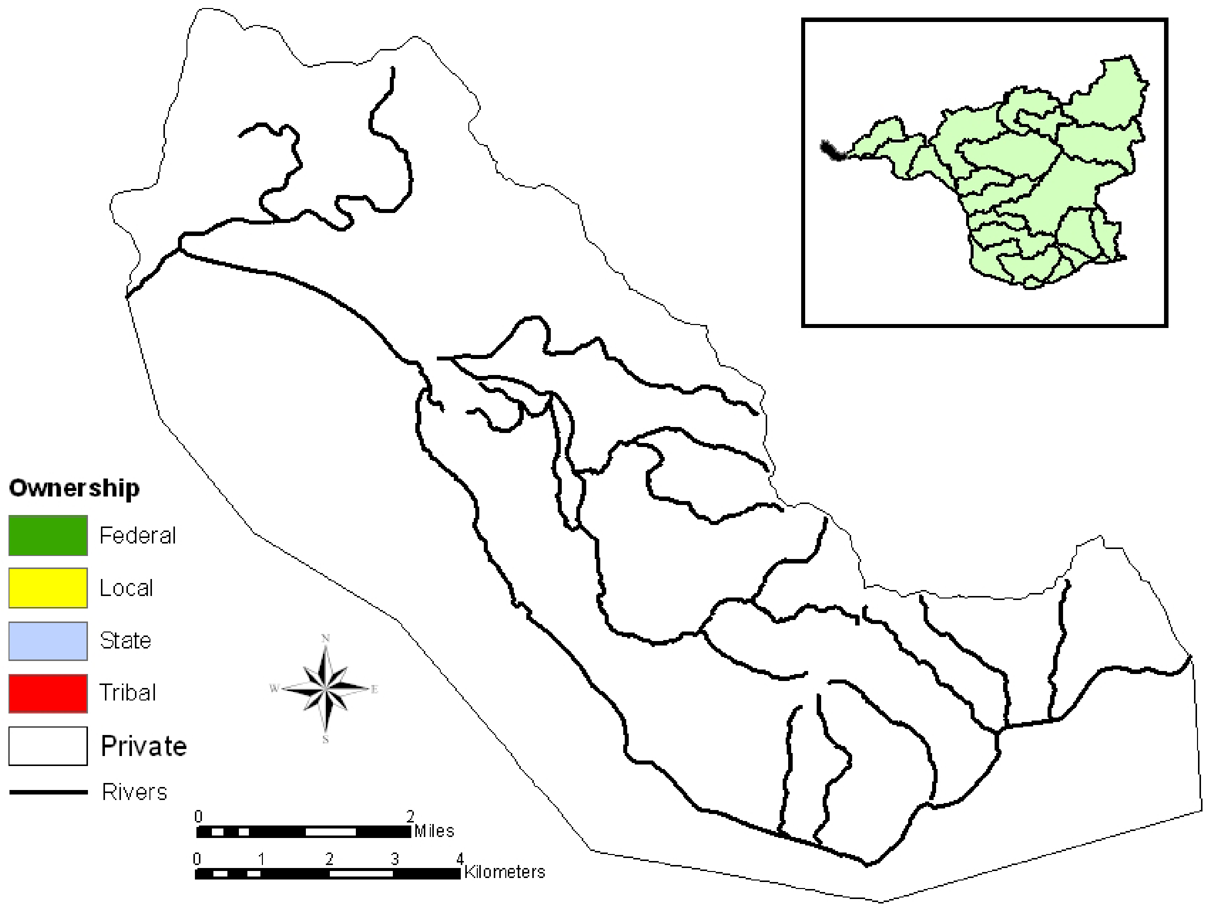


Figure 3-3. Landownership within the Columbia River Estuary tributaries subbasin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

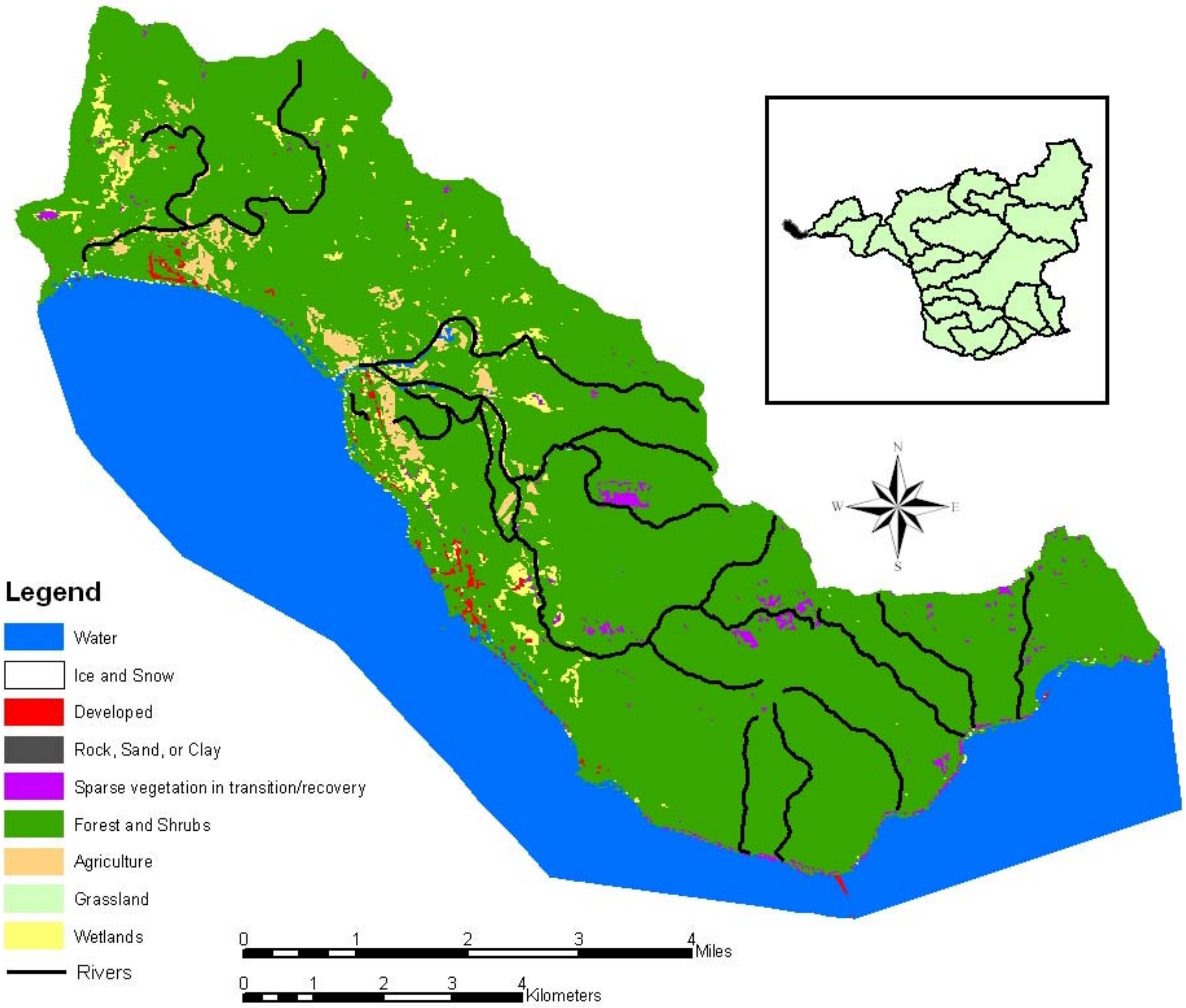
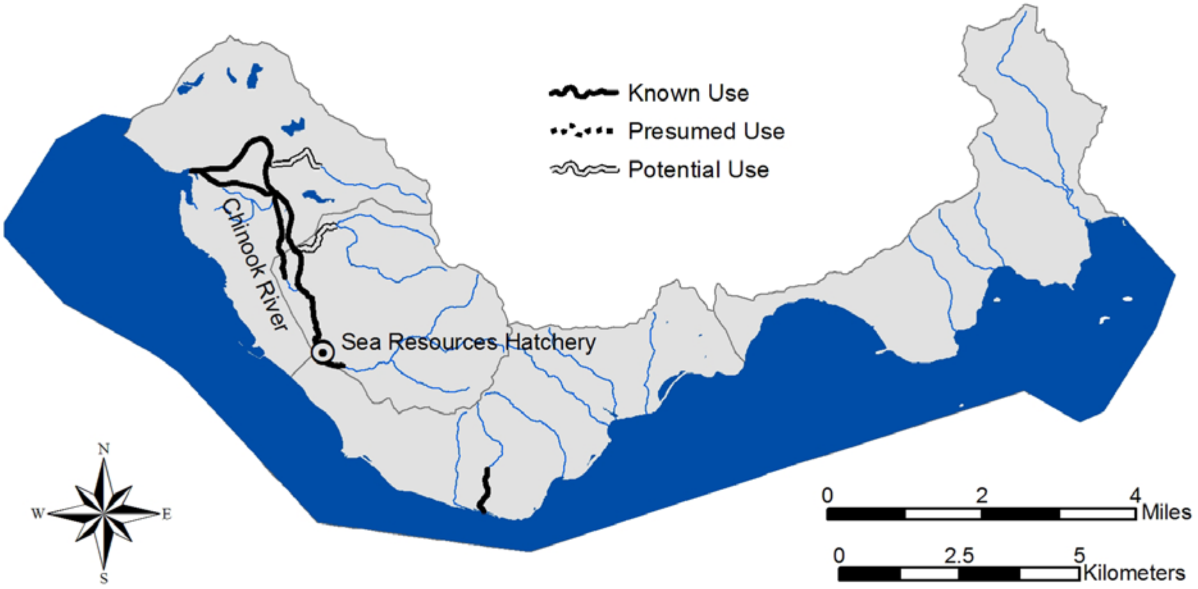


Figure 3-4. Land cover within the Columbia River Estuary tributaries subbasin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

3.2 Focal Fish Species

3.2.1 Chum—Columbia River Estuary Tributaries Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Distribution data are not available for the Chinook River

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater time

Diversity

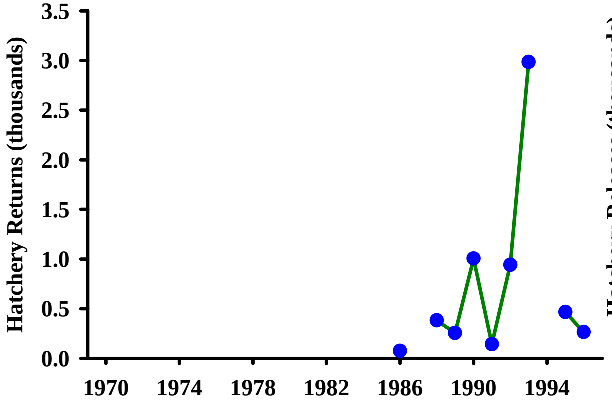
- Sea Resources Hatchery (on the Chinook River) brood stock has been taken from the Chinook, Nemah, Bear, and Naselle Rivers and other unknown stocks; current program produces only Grays River stock

Abundance

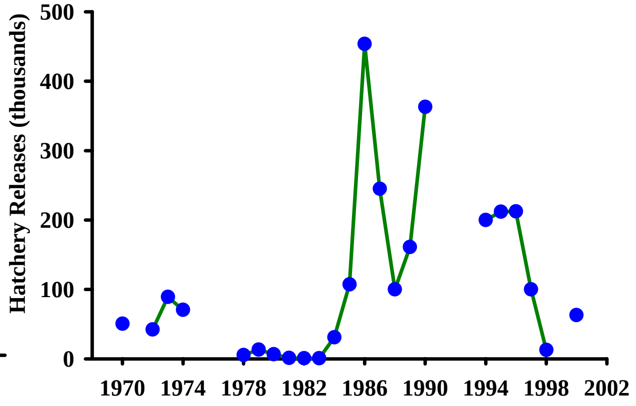
- In 1951, estimated escapement to Crooked and Jim Crow Creeks was 1,200 chum

Productivity & Persistence

- Chum salmon fecundity averaged 2,241 eggs per female at the Sea Resources Hatchery on the Chinook River between 1984–87



Sea Resources Hatchery rack returns, 1986-1996



Chum salmon releases in the Chinook River, 1969-2000

Hatchery

- Returns to the Sea Resources Hatchery from 1986–96 have ranged from 35 to 1,597 chum
- Sea Resources Hatchery began releasing chum salmon in the Chinook River in 1969; with local brood stock and also eggs transferred from Naselle, Nemah, and Bear Rivers
- Currently, Grays River stock is used at Sea Resources Hatchery and outside stocks are no longer transferred in

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

3.3 Potentially Manageable Impacts

The Potentially Manageable Impacts were not assessed for the Columbia Estuary Tributaries

3.4 Hatchery Programs

The Sea Resources Hatchery on RM 4.8 of the Chinook River is operated by the non-profit Sea Resources Watershed Learning Center. The facility has produced fall chinook, coho, and chum salmon.

- Tule fall chinook were released in the basin as early as 1893; the program was discontinued in 1935, restarted in 1968, and is ongoing today. Current release goals are approximately 110,000 fall chinook fingerling; larger releases occur if hatchery incubation and rearing mortality is less than the expected 25%.
- Coho salmon hatchery program release goal is 52,500 yearling coho smolts.
- Chum salmon from the Willapa Bay broodstock were released into the basin from 1969 to 1993: beginning in 1999, chum salmon from Grays River broodstock have been released. Annual releases of chum salmon into the Chinook River generally have been around 100,000-200,000; the largest release of chum salmon (~450,000) occurred in 1986. The current production goal for this program is 147,500 juveniles per year. Hatchery rack returns have generally been under 1,000 adults; the current chum population is not self-sustaining.

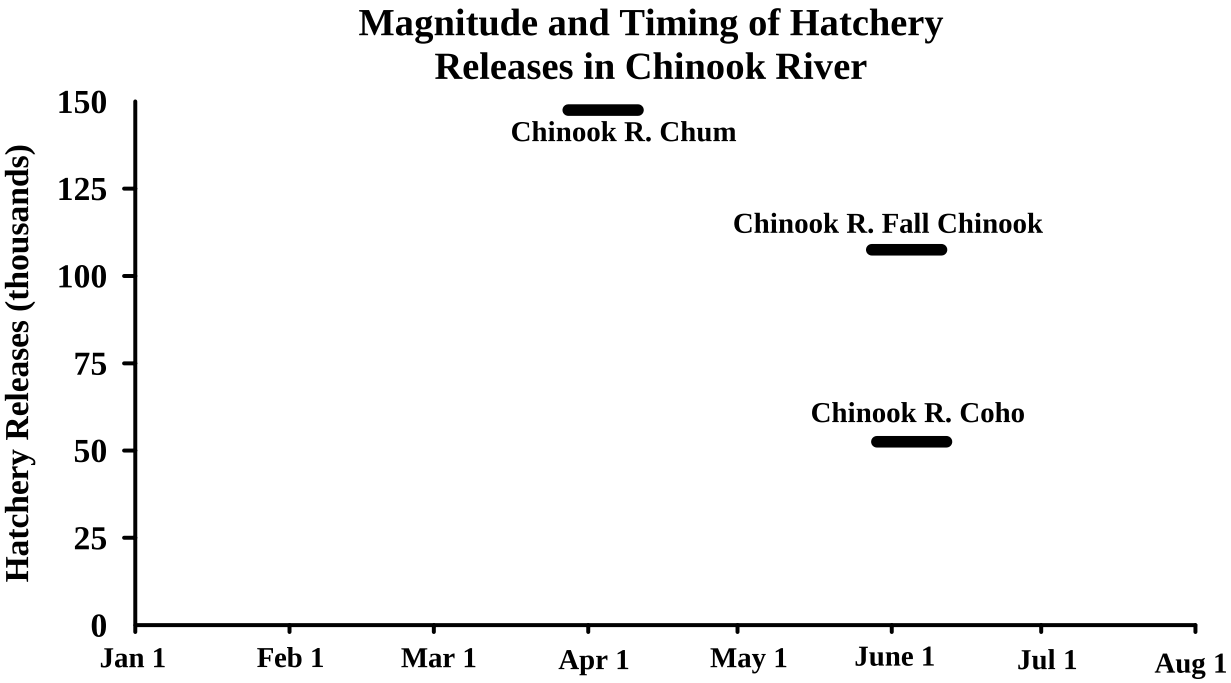


Figure 3-5. Magnitude and timing of hatchery releases in the Chinook River basin by species, based on 2003 brood production goals.

Genetics—Broodstock for the historical (late 1800s/early 1900s) fall chinook hatchery program at the Sea Resources Hatchery was obtained from fish traps distributed on the lower Columbia River. There is some uncertainty in the origin of broodstock for the fall chinook hatchery program that restarted in 1968; Spring Creek National Fish Hatchery (NFH) tule fall chinook may have been used to start the program. Current broodstock collection comes from adults returning to the hatchery, except in years of hatchery return shortfalls. In 1989 and 1994, eggs were transferred from the Washougal River Hatchery to meet hatchery production goals.

There is some uncertainty about the origin of broodstock for the coho salmon hatchery program at the Sea Resources Hatchery; current broodstock collection likely comes from adults returning to the hatchery.

Chum salmon broodstock for the Sea Resources Hatchery had been taken from the Chinook, Nemah, Bear, Naselle, and other unknown rivers. Use of multiple broodstocks over time can result in one homogenous population with some characteristics from each broodstock. However, most chum stocks used in the Sea Resources Hatchery have been from local rivers, which likely had similar characteristics originally. Currently, the program only uses Grays River chum stock and thus has reduced any genetic mixing among broodstock from multiple locations and eliminated stocks from outside the Columbia basin. The Grays River chum stock is one of the primary wild chum salmon populations remaining in the lower Columbia River.

Interactions—Historical hatchery fall chinook and coho returns to the Sea Resources Hatchery have been low, despite large releases of hatchery smolts. Prior to 1996, all fall chinook and coho salmon captured at the hatchery were utilized for broodstock or surplused; no fish were returned to the river and allowed to spawn naturally. Beginning in 1996, approximately half of the small hatchery return has been allowed to spawn naturally in the Chinook River but competition with wild fall chinook or coho adults is likely to be limited because few wild fish are present.

Wild chum salmon are at low levels throughout the lower Columbia River and few wild chum salmon have been observed in the Chinook River. Most of the hatchery chum return is utilized for broodstock and few hatchery fish escape to spawn naturally so wild and hatchery chum salmon interactions in the Chinook River are likely minimal. Predation by chinook and coho smolts on naturally produced chum fry is likely negligible because releases are made in June after chum juveniles have left the watershed.

Water Quality/Disease—Water for the facility comes entirely from the Chinook River; the water intake is located approximately 0.6 miles upstream of the facility and is piped via gravity flow. Hatchery effluent is released to a settling pond to remove most of the suspended solids before the water is discharged to the Chinook River.

Fish health is monitored through compliance with the Co-Managers Fish Health Policy procedures. Fish receive a pathology screening by a WDFW pathologist prior to release.

Mixed Harvest—Historically, exploitation rates of hatchery and wild fall chinook and coho were likely similar. Fall chinook and coho are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. Regulations for wild fish release have been in place for coho fisheries in recent years, and all coho released from the hatchery are adipose fin-clipped to allow for selective harvest. Specific hatchery-selective commercial and recreational fisheries in the lower Columbia target hatchery coho. Therefore, in recent years the exploitation rates of coho by commercial and recreational fisheries are higher for Sea Resources Hatchery coho than wild fish. Hatchery and wild fall chinook harvest rates remain similar and are constrained by ESA harvest limitations.

There are no directed chum salmon fisheries on lower Columbia River chum stocks. Minor incidental harvest occurs in fisheries targeting fall chinook and coho. Retention of wild chum salmon in the lower Columbia River is prohibited. There probably is little difference in fishery exploitation rates of lower Columbia River wild and Sea Resources Hatchery chum salmon.

Passage—The adult collection facility at the Sea Resources Hatchery consists of a 12'x12' weir trap with a "V" entrance; fish are transferred from the trap to holding pens for broodstock collection. During low flow conditions, the weir captures the majority of adults returning to the hatchery. During high flow conditions, there is a channel where returning adults can bypass the hatchery weir trap and continue upstream.

Supplementation—Prior to 1996, Sea Resources' hatchery management practices were based on the premise that the hatchery could compensate for the nearly complete lack of natural production in the Chinook River system. However, in spite of significant hatchery releases, the numbers of returning adults were consistently poor, averaging about 0.1%. In 1996, the hatchery management strategy shifted from mass production towards rearing smaller numbers of fish, preparing them for the natural environment, and restoring conditions in the watershed to better support juvenile salmon rearing and natural production. The goal of the hatchery programs at the Sea Resources Hatchery is to restore naturally reproducing populations of salmonids in the Chinook River in conjunction with habitat restoration projects.

3.4.1.1 Deep River

While there are no hatcheries in Deep River, two net pen programs are operating. The Deep River spring chinook net pen program works in conjunction with the Cowlitz and Lewis Salmon Hatcheries; current release goals are 200,000 yearling spring chinook (Figure 3-6). The Deep River early run coho net pen program works in cooperation with the Grays River Hatchery; current release goals 400,000 (type-S) yearling coho (Figure 3-6).

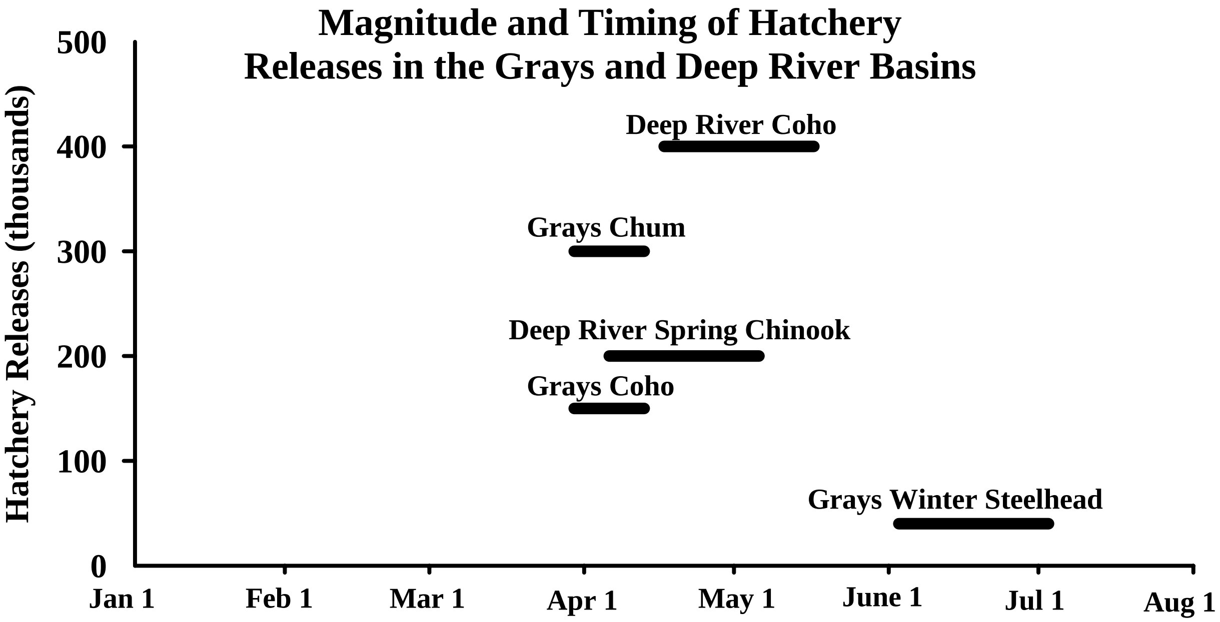


Figure 3-6. Magnitude and timing of hatchery releases in the Deep River and Grays River basins by species, based on 2003 brood production goals.

Genetics—The Deep River spring chinook net pen program receives juvenile spring chinook from the Cowlitz and Lewis salmon hatcheries. The WDFW management plan for the spring chinook program precludes the use of other stocks (such as Willamette spring chinook) to assure that outside stocks do not have the opportunity to spawn in Washington tributaries of the lower Columbia River. The Deep River coho net pen program receives juvenile coho salmon from the Grays River Hatchery; broodstock comprises adults returning to the hatchery. Specific information on broodstock development for these hatcheries can be found in the appropriate sections below describing hatchery activities in the Grays and Cowlitz River basins.

Interactions—The presence of wild spring chinook and early run coho in the Deep River basin is nominal (Figure 3-7). Hatchery juvenile spring chinook and coho are contained in net pens and released into the system as smolts. The Deep River is a short river basin and hatchery smolts are expected to migrate through the basin rapidly and disperse throughout the lower Columbia River mainstem. Interaction and competition between hatchery and wild adults or juveniles in the Deep River basin is expected to be minimal. To limit the potential for predation, surveys are conducted to determine when chum fry have emigrated from the area, prior to coho release from the net pens.

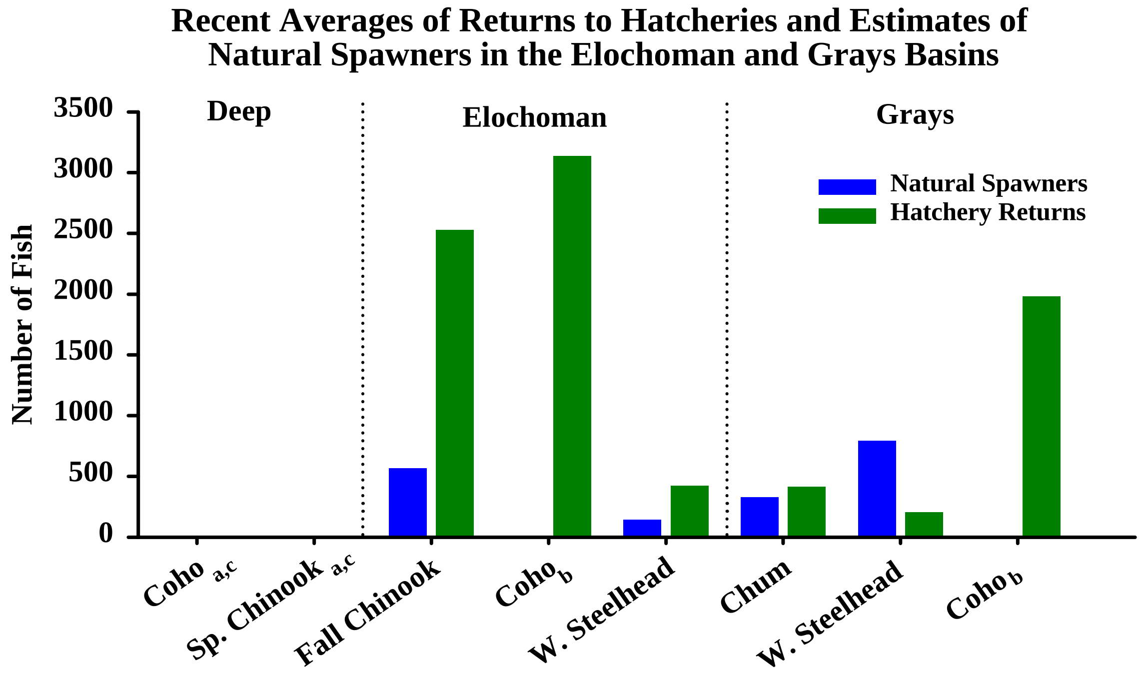


Figure 3-7. Recent average hatchery returns and estimates of natural spawning escapement in the Deep, Grays, and Elochoman River basins by species. The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from 1992 to the present. Calculation of each average utilized a minimum of 5 years of data, except for Grays chum (1998–2000) and Grays winter steelhead (1998 and 2000).

[a] There is no hatchery facility in the basin to enumerate and collect returning adult hatchery fish. All hatchery fish released in the basin are intended to provide harvest opportunity.

[b] A natural stock for this species and basin has not been identified based on populations in WDFW’s 2002 SASSI report; to date, escapement data are not available.

[c] Although a natural population of this species in the identified basin exists based on populations identified in WDFW’s 2002 SASSI report, escapement surveys have not been conducted and the stock status is unknown.

Water Quality/Disease—The Deep River Net Pens are located directly in the Deep River and the river supplies all water to these programs. Specific information on disease occurrence and treatment in the adult collection, incubation, and early rearing phases can be found in the Cowlitz and Grays River sections below for the spring chinook and coho programs, respectively.

Mixed Harvest—The purpose of each Deep River net pen program is to provide fish for isolated harvest opportunity in the Deep River basin. However, these hatchery programs benefit other fisheries as well. Spring chinook are an important target species in Columbia River commercial and recreational fisheries and tributary recreational fisheries. All Deep River net pen spring chinook and coho are adipose fin-clipped. Coho salmon are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. Wild fish release regulations are in place for commercial and recreational fisheries in the lower Columbia River, as well as some ocean fisheries. Specific hatchery-selective commercial and recreational fisheries in the lower Columbia target hatchery spring chinook and coho. Therefore, recent exploitation rates by commercial and recreational fisheries are higher for Deep River Net Pen spring chinook and coho compared to wild fish. However, recent commercial and sport harvest in the terminal areas has not been as high as desired so the programs are being reviewed.

Passage—Adult hatchery fish are not collected in the Deep River, so there are no adult passage concerns. Description of the adult collection facilities at the Grays River and Cowlitz Salmon hatcheries can be found in the sections on those basins.

Supplementation—Supplementation is not the purpose of the spring chinook or coho net pen programs in Deep Creek; these fish are produced for harvest opportunities.

3.5 Fish Habitat Conditions

3.5.1 Passage Obstructions

Tidegates on the Chinook and Wallacut Rivers restrict passage. Efforts are underway to remove the tidegate at the mouth of the Chinook River (Figure 3-8). On Freshwater Creek, the City of Chinook's water supply dam restricts passage. The Sea Resources hatchery at river mile (RM) 4 on the Chinook River restricts passage during fall runs. A mix of wild and hatchery fish are passed above the hatchery. Many of the small streams between the towns of Knappton and Chinook once supported significant runs of salmon but access is currently blocked by culverts under Highways 401 and 101. Eight culverts in this area are currently scheduled for removal.

Figure 3-8. Tide gate at the mouth of the Chinook River.

3.5.2 Stream Flow

The Chinook and Wallacut Rivers exhibit a rain-dominated flow regime, with high flows during fall and winter months and the lowest flows in late summer.

Intensive logging and road building in the 1970s potentially increased peak flow volumes in the Chinook and Wallacut River basins, though conditions are expected to improve as the forest matures. Low flow volumes are believed to be a natural condition in summer months. The impacts of flow diversions at the Sea Resources Hatchery and at the City of Chinook water supply intake are largely unknown (Wade 2002).

Results of the Integrated Watershed Assessment (IWA), which are presented in greater detail later in the chapter, indicate that the Wallacut and lower Chinook River subwatersheds are "moderately impaired" with respect to landscape conditions influencing runoff. The upper Chinook basin is rated as "impaired" and the remainder of the estuary tributary basins are rated as functional. Hydrologic impairments are related to the immature forest vegetation and the moderately high road densities in these basins (>2 mi/mi^2).

3.5.3 Water Quality

Little information exists on water quality conditions in the Chinook and Wallacut Rivers. Temperatures in excess of 68°F (20°C) have been measured in the Chinook just above the tidegates, but temperature monitoring at the hatchery has not exceeded 61°F (16º C) in recent years. Turbidity is believed to be a problem in the upper basin. The reduction in the number of returning fish may be limiting nutrient levels in the system (Wade 2002).

3.5.4 Key Habitat

No data has been collected on pool habitat in the Chinook and Wallacut Rivers. Common evaluation criteria would not apply in the tidally-influenced reaches. Pool habitat in the middle and upper Chinook basin is believed to be fair to good, with beavers playing a large role in pool creation and maintenance (Wade 2002). Side channel habitat has been mostly eliminated in the lower reaches of the Chinook due to diking and filling. Side channels are present above tidal influence to the hatchery (RM 4), but side channel habitat is considered poor up to the headwaters (Wade 2002). Data on pools and side channel habitat on other estuary tributaries is lacking.

3.5.5 Substrate & Sediment

In the Chinook River, excessive fine sediment concentrations are considered a problem in the chum spawning area between tidal influence and the hatchery. Spawning substrates above the hatchery are believed to be in fair condition with regard to fines. Information is lacking for other areas (Wade 2002).

Extensive road building and logging occurred in the upper Chinook basin in the 1970s and more than 30 landslides and debris flows visible on 1974 aerial photographs contributed large volumes of sediment to stream channels (Dewberry 1997 as cited in Wade 2002). The Limiting Factors Analysis Technical Advisory Group (TAG) noted that continuing stream sediment delivery may still be related to these activities, with current sediment problems related to ATV recreational vehicle use (Wade 2002).

Results of the IWA, which are presented in greater detail later in the chapter, indicate that 1 of the 4 estuary tributary subwatersheds are “impaired” with respect to landscape conditions influencing sediment supply. The remaining 3 subwatersheds are rated as “moderately impaired”. The greatest impairments are in the small tributary basins between the towns of Knappton and Chinook, where road densities are the highest.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

3.5.6 Woody Debris

Accumulations of large woody debris (LWD) were once common in the lower Chinook River but few remain (Dewberry 1997 as cited in Wade 2002). Poor riparian conditions in the upper basin and the tidegate at the mouth of the Chinook River restrict potential recruitment. Data for other tributaries is lacking, though LWD conditions are believed to be poor (Wade 2002).

3.5.7 Channel Stability

Standard metrics of bank stability do not apply to the lower, estuarine portion of the Chinook River. What was once a tidal marsh is now a single-thread stable channel confined by dikes. Cattle have access to portions of the lower river and in places may impact bank stability. Bank erosion is high in agricultural land due to incision, alluvial soils, and a lack of vegetation on the streambanks. Little information exists for bank stability in upstream reaches, although conditions are believed to be fair to good (Wade 2002).

3.5.8 Riparian Function

The large trees in the lower riparian areas of the Chinook River were cut in the early days of settlement (Dewberry 1997 as cited in Wade 2002), and riparian forests in the upper basin were harvested heavily in the 1970s. Today, riparian conditions are poor throughout the basin, with agricultural lands in the lower basin and young stands in the upper basin. Deciduous species and reed canary grass dominate (Wade 2002).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

3.5.9 Floodplain Function

The installation of a tidegate at the mouth of the Chinook River in the 1920s and subsequent diking, dredging, and removal of logjams has degraded floodplain connectivity. Before these activities, the lower portion of the river consisted of a wide lowland marsh with numerous ponds (Dewberry 1997 as cited in Wade 2002). Diking is prevalent upstream to RM 4, and problems with channel incision extend to the headwaters (Wade 2002). A coalition of non-profit groups and government agencies is attempting to restore 80% of the original Chinook River estuary habitat (Wade 2002).

3.6 Fish/Habitat Assessments

No Fish/Habitat Assessments have been completed for the Columbia River Estuary Tributaries.

3.7 Integrated Watershed Assessment

The Columbia Estuary Tributaries Subbasin is divided into 4 IWA subwatersheds. The westernmost subwatershed encompasses the Wallacut River basin. The Chinook River basin lies within the 2 middle subwatersheds and the easternmost subwatershed contains several small tributaries between the communities of Chinook and Knappton.

3.7.1 Results and Discussion

IWA results for each subwatershed are presented in Table 3-1.As indicated, IWA results are calculated for each subwatershed at the local level (i.e., within a subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A reference map showing the location of each subwatershed in the basin is presented in Figure 3-9. Maps of the distribution of local and watershed level IWA results are displayed in Figure 3-10.

Table 3-1. WA results for the Columbia Estuary Tributaries Watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30501	M	M	ND	M	M	none
30502	M	M	ND	M	M	none
30503	F	I	ND	F	I	none
30504	I	M	ND	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired
ND: Not evaluated due to lack of data

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

Figure 3-9. Map of the Columbia Estuary tributaries watershed showing the location of the IWA subwatersheds

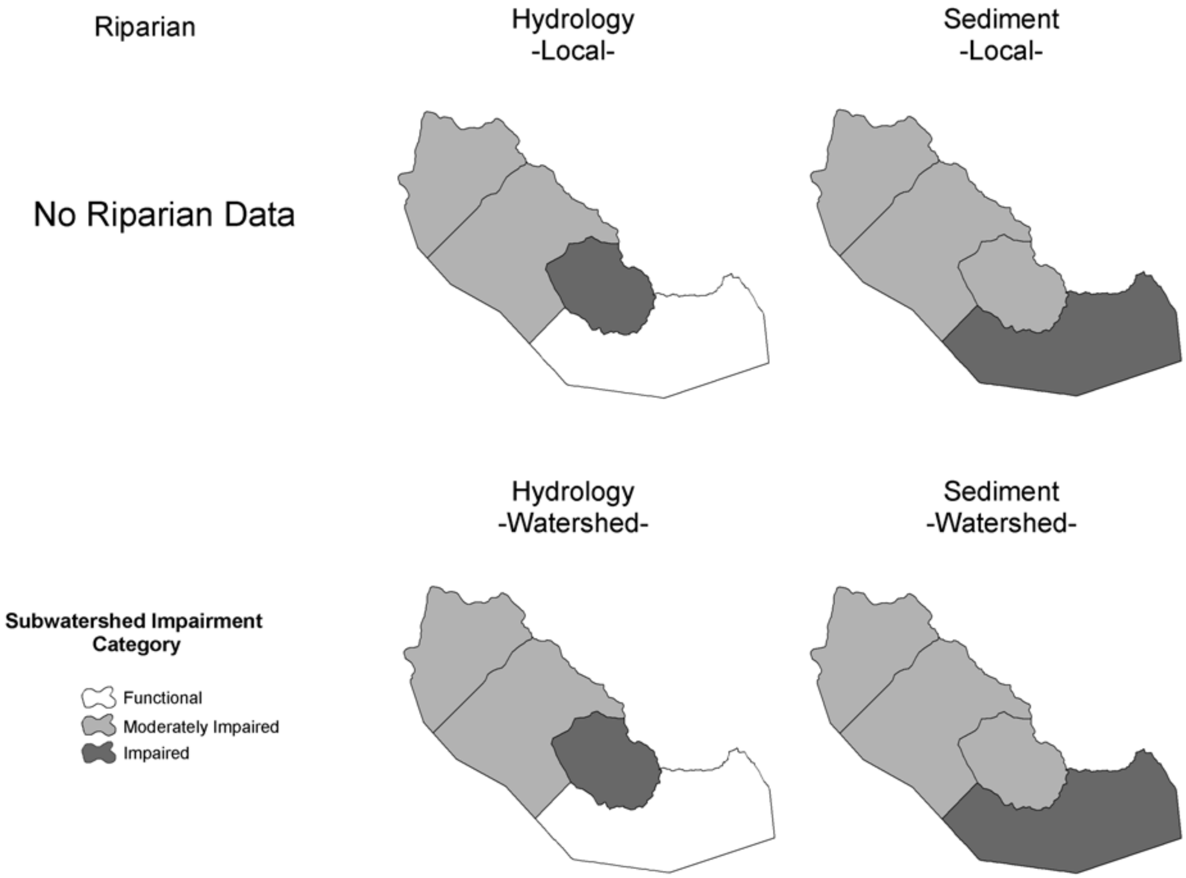


Figure 3-10. IWA subwatershed impairment ratings by category for the Columbia Esturary tributaries watershed.

3.7.1.1 Hydrology

Of the four subwatersheds comprising the Columbia Estuary Tributaries Unit, one is rated functional for IWA hydrologic conditions, two are moderately impaired, and one is classified as impaired. Overall, the watershed has very low mature vegetation cover (less than 10%), and hydrology conditions are primarily driven by road densities. The functional subwatershed (30503) is comprised of small independent streams lying at the east end of the basin, and has few roads. The upstream portion of the Chinook River has the highest road density (3.3 mi/mi^2), hence its impaired rating. Lastly, the moderately impaired subwatersheds situated in the west have road densities between 2 and 3 mi/mi^2. Because the drainages associated with these subwatersheds are small, independent, and primarily terminal systems, watershed level results matched the results from the local level analysis.

3.7.1.2 Sediment Supply

Local sediment conditions fall primarily into the moderately impaired category, with one case of impaired conditions. The impaired subwatershed is located at the east end of the subbasin (30503). As with hydrologic conditions, the IWA watershed level sediment conditions are the same as the local level ratings.

3.7.1.3 Riparian Condition

Riparian condition data was not available for the four subwatersheds in the Columbia Estuary Tributaries watershed, including the Chinook River drainage.

3.7.2 Predicted Future Trends

3.7.2.1 Hydrology

Low levels of public ownership, low levels of mature forest cover, moderate to high road densities, and increasing development pressure are likely to lead to more degradation within this watershed. However, the subwatersheds are also highly influenced by tidal processes and are covered by large areas of wetland and floodplain. These factors will help dampen impacted hydrology, and control residential, commercial, and agricultural expansion. Overall, the trend in hydrologic conditions for the Columbia Estuary Tributaries watershed is expected to remain stable or slightly decline over time. Public and private actions to encourage wetland protection, road retirement, reconnection of the floodplain and riparian and wetland restoration should be encouraged.

3.7.2.2 Sediment Supply

Although sediment conditions are rated as moderately impaired or impaired in these subwatersheds, the estuarine character, coupled with moderate road densities, low to moderate stream side road density and stream crossings suggest that conditions in this subwatershed may well improve on the 20 year timescale. Management recommendations include those actions discussed for hydrology.

3.7.2.3 Riparian Condition

Due to a lack of riparian data for this watershed, riparian conditions were not analyzed as part of IWA. However, additional knowledge of the basin allows for some speculation about streamside trends.

The majority of the lower Chinook River mainstem has been channelized through diking. The dikes and ditches have resulted in drained wetlands and lost side-channel habitat. Similar issues exist for the lower portions of the Wallacut, although to a lesser degree. While dikes and other channel revetments remain in place, the potential for riparian recovery will be severely constrained. However, conservation easements and other public-private partnerships (such as those already being developed by the Columbia Trust in the Grays River system) offer some promise that floodplain dynamics and riparian conditions in these critical estuarine areas may in fact improve over the next 20 years.

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Grays River Subbasin

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4.0 Grays River Subbasin

4.1 Subbasin Description

4.1.1 Topography & Geology

For the purposes of this analysis, the Grays River subbasin includes the Grays River and other tributaries to Grays Bay, including the basins of Deep Creek and Crooked Creek. The Grays River originates in southeast Pacific County, flows southwest through Wahkiakum County, and enters the Columbia River estuary at river mile (RM) 21. Tidal influence extends upriver for 6 miles. The entire basin encompasses 124 mi^2.

The upper reaches of the Grays River flow through steep valleys in the Willapa Hills, and the lower reaches flow through the relatively flat terrain of the plains of the Columbia Valley. In general, the topography consists of low rolling hills and undulating glacial drift plains. The maximum elevation is 2,840 ft. and the minimum elevation is 5 ft. Approximately 49% of the underlying rock in the Grays River watershed is sedimentary, and 35% is of volcanic origin. Soils in the Grays River watershed are mostly of the Lytell-Astoria (43%) and Bunker-Knappton (36%) soil types according to data from the Cowlitz and Wahkiakum Conservation Districts (CCD/WCD). Based on NRCS criteria that incorporates soil type and terrain slope, approximately 26% of the area in the Grays River watershed has high erodability (Wade 2002).

4.1.2 Climate

The subbasin has a typical northwest maritime climate. Summers are dry and cool and winters are mild, wet, and cloudy. Nearly the entire Grays River watershed is in the rain-dominated or lowland precipitation zones according to DNR classification (Wade 2002). Mean temperature at the Grays River Hatchery (on the West Fork) ranges from 33°-47°F (1°-8°C) in the winter to 50°-74° F (10°-23°C) in summer. Average annual precipitation is 110 inches at the hatchery, with less than 2 inches in July and more than 17 inches in December (WRCC 2003). Data from the CCD/WCD lists a mean annual precipitation of 88.3 inches for the entire Grays River watershed (Wade 2002).

4.1.3 Land Use/Land Cover

Approximately 95% of the subbasin is forested. In the Grays River watershed, commercial timber companies own 73% of the land; 3% is in agriculture, 4% is rural residential development, and 19% is non-industrial forestland (CCD/WCD data). State ownership comprises the bulk of the remaining lands. The only population centers are the unincorporated towns of Grays River, Rosburg, and Chinook. Projected population change from 2000-2020 for unincorporated areas in WRIA 25 is 37% (LCFRB 2001). Potential natural vegetation includes western hemlock, western red cedar, Sitka spruce, and Douglas fir. Much of the basin has been impacted by timber harvest and is primarily composed of young forest stands. Approximately 500 acres of the lower Grays River has been acquired by the Columbia Land Trust for protection of natural resources. A breakdown of land ownership and land cover in the Grays basin is presented in Figure 4-1 and Figure 4-2. Figure 4-3 displays the pattern of landownership for the basin. Figure 4-4 displays the pattern of land cover / land-use.

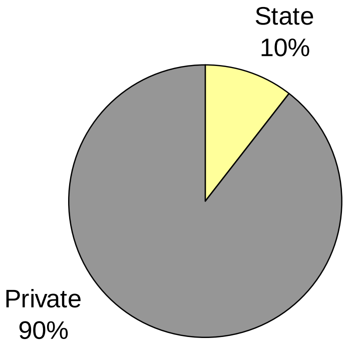


Figure 4-1. Grays River subbasin land ownership

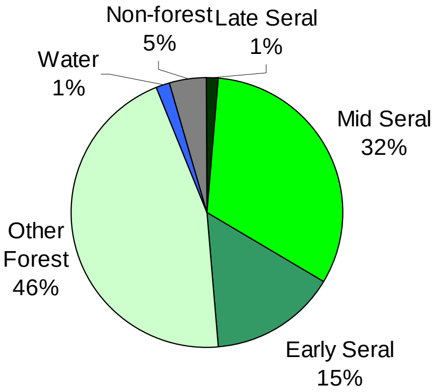


Figure 4-2. Grays River subbasin land cover

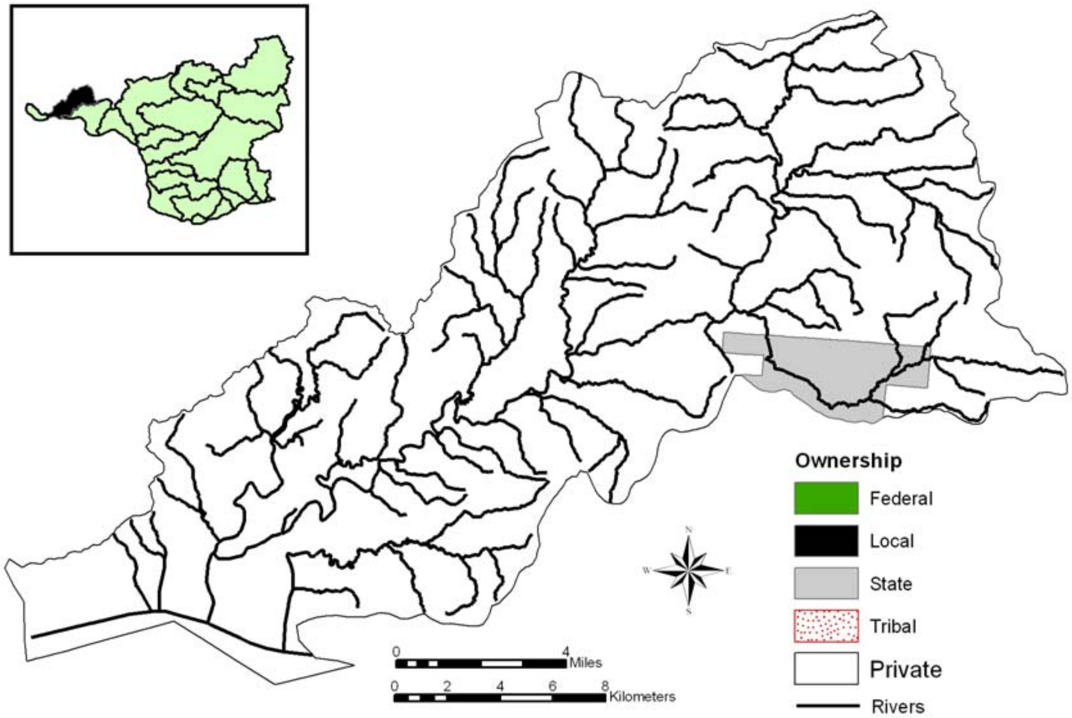


Figure 4-3. Landownership within the Grays basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

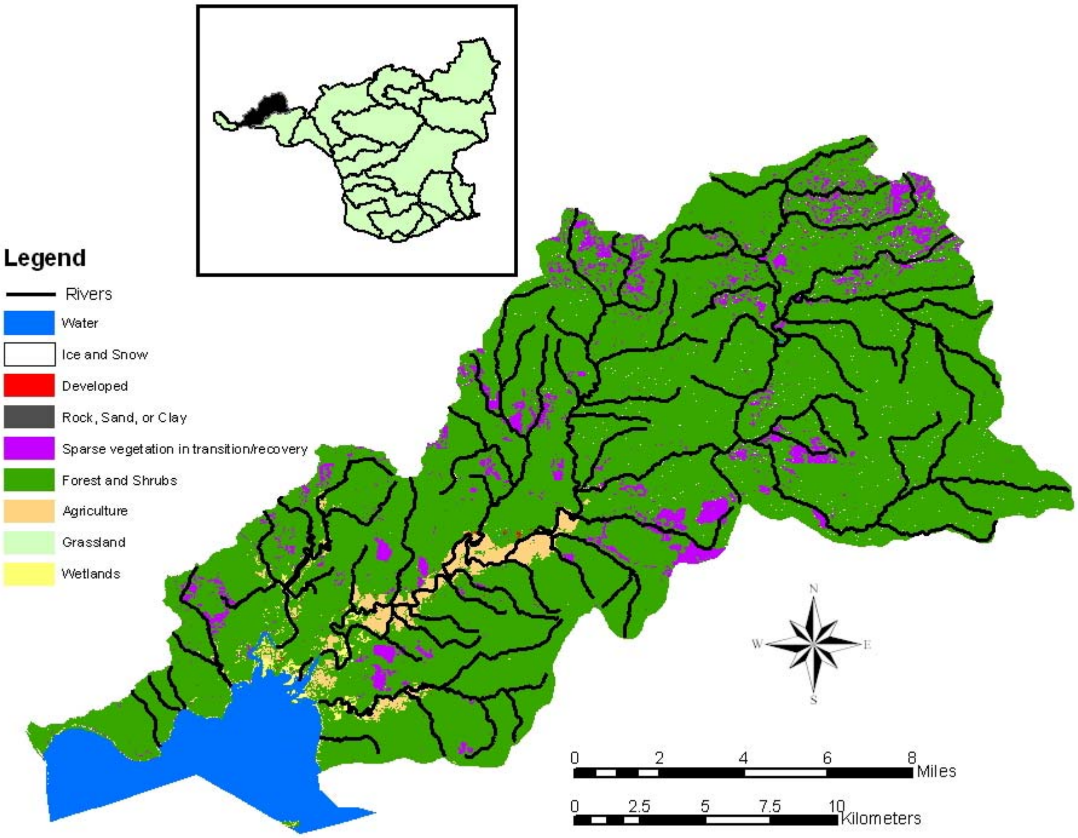
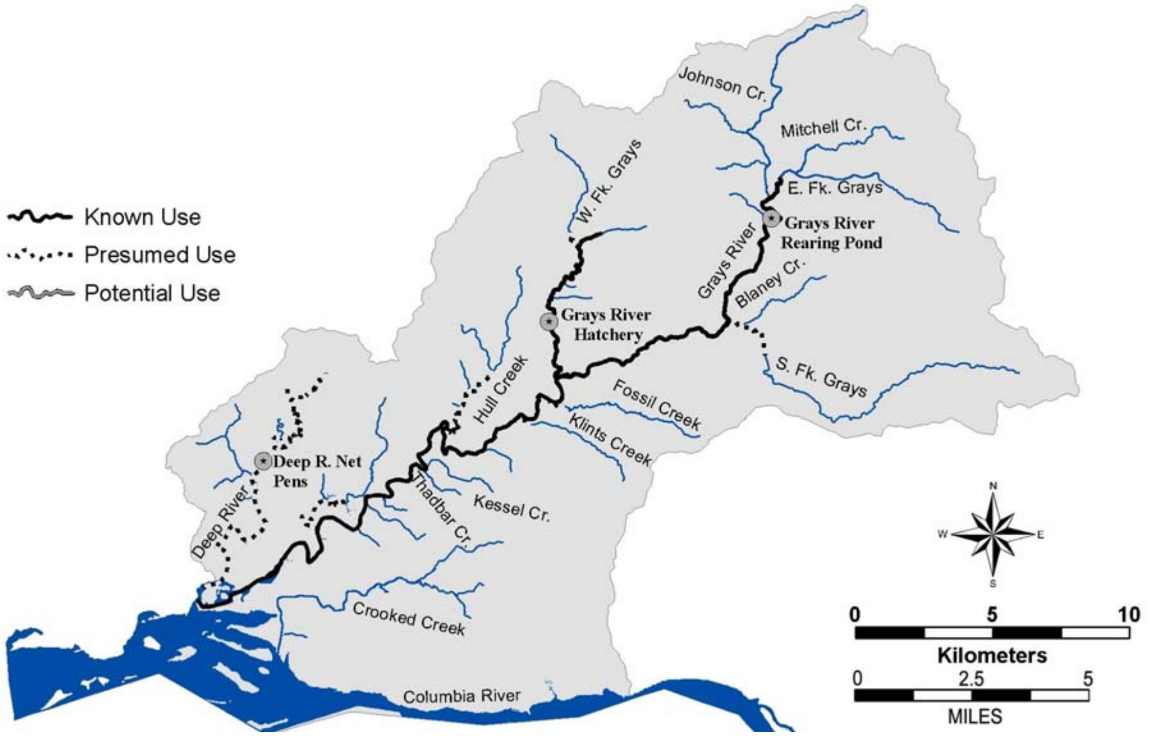


Figure 4-4. Land cover within the Grays basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

4.2 Focal Fish Species

4.2.1 Fall Chinook—Grays Subbasin

ESA: Threatened 1999 **SASSI: Depressed 2002**



Distribution

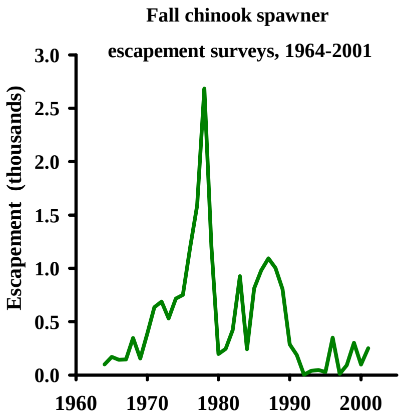
- Spawning occurs in the West Fork below the Grays River Salmon Hatchery (RM 1.4) and in the mainstem Grays River from the area of tidal influence to above the confluence of the West Fork (RM 8-14)

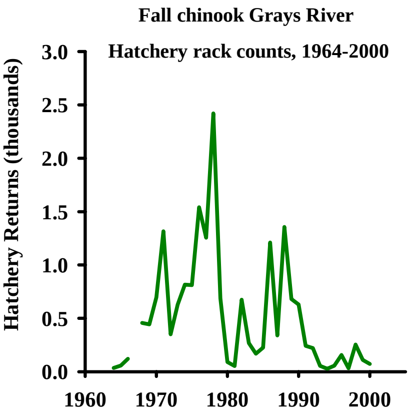
Life History

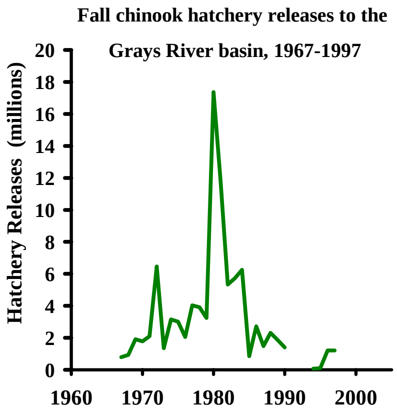
- Columbia River tule fall chinook migration occurs from mid August to mid September, depending partly on early fall rain
- Natural spawning occurs between late September and late October, peaking in mid-October
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult ages of 3 and 4 (averages are 27% and 57% respectively)
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the summer in fresh water, and emigrate in the late spring/summer as sub-yearlings

Diversity

- Considered a component of the tule population in the lower Columbia River Evolutionarily Significant Unit (ESU)
- Stock designated based on distinct spawning distribution







Abundance

- In 1951, WDF estimated fall chinook escapement to the Grays River was 1,000 fish
- Spawning escapements from 1964-2001 ranged from 4 to 2,685 (average 523)

Productivity & Persistence

- NMFS Status Assessment indicated a 0.52 risk of 90% decline in 25 years and a 0.72 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.58
- Evidence suggests few natural fall chinook juveniles are produced annually

Hatchery

- Grays River Hatchery located about RM 2 on the West Fork; hatchery began operation in 1961
- Hatchery releases of fall chinook in the basin began in 1947; Release data are displayed for 1967-97
- The Grays River Hatchery was used as an egg bank facility for North Toutle Hatchery fall chinook stock for several years after the eruption of Mt. St. Helens
- The Grays River Hatchery fall chinook program was discontinued in 1998 because of federal funding cuts
- A significant portion of past years fall chinook spawners in the Grays River were first generation hatchery fish from the Grays River Hatchery; the Grays River Hatchery adult returns were eliminated beginning in 2002

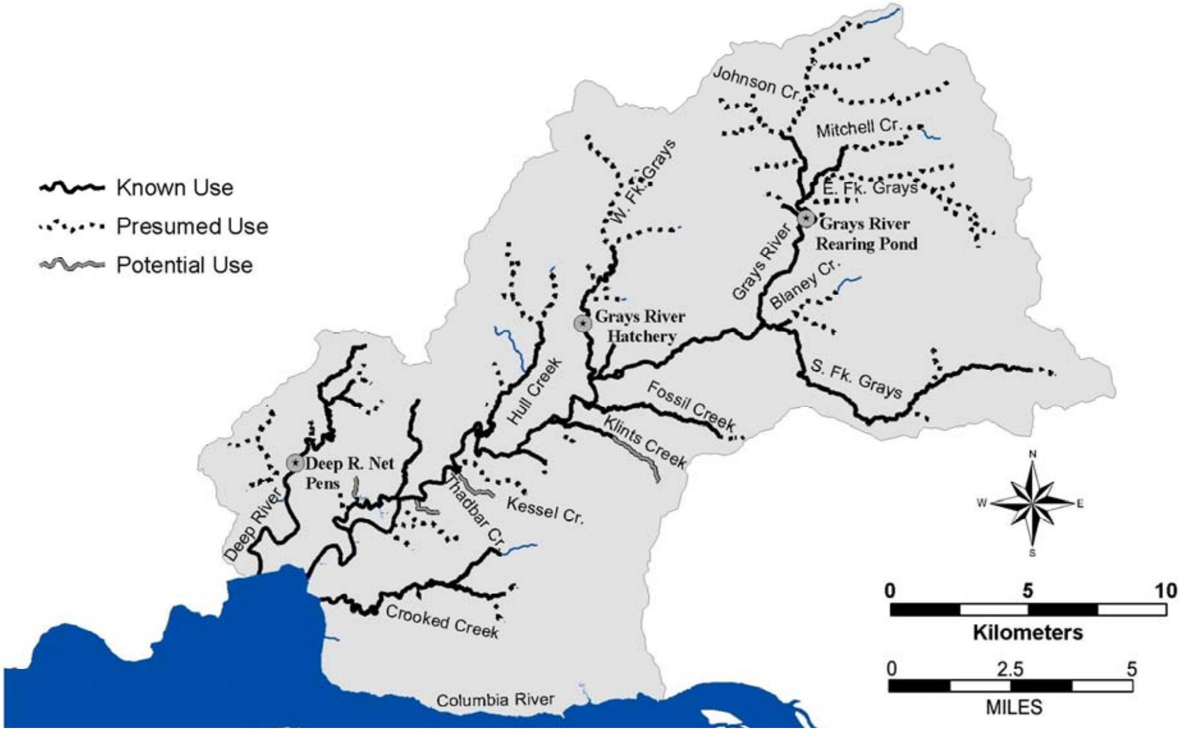
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are an important contributor to Washington ocean troll and sport fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once they move from salt water; price is low compared to higher quality bright chinook
- CWT data analysis of the 1991-94 brood Grays River Hatchery chinook indicate a harvest rate of 54% of the Grays River stock
- The majority of the Grays River Hatchery fall chinook stock harvest occurred in Southern British Columbia (51.0%), Washington ocean (12.0%), and Columbia River (25.0%) fisheries

- Current annual harvest rate is dependent on management response to annual abundance in PSC (US/Canada), PFMC (US ocean), and Columbia River Compact forums
- Sport harvest in the Grays River averaged 156 fall chinook annually from 1981-1988
- Ocean and mainstem Columbia River fisheries are limited to a 49% harvest due to ESA limits onCoweeman tule fall chinook

4.2.2 Coho—Grays Subbasin

ESA: Candidate 1995 **SASSI: Unknown 2002**

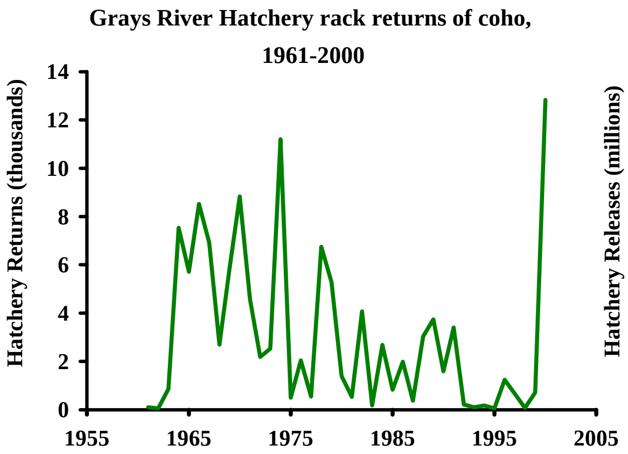


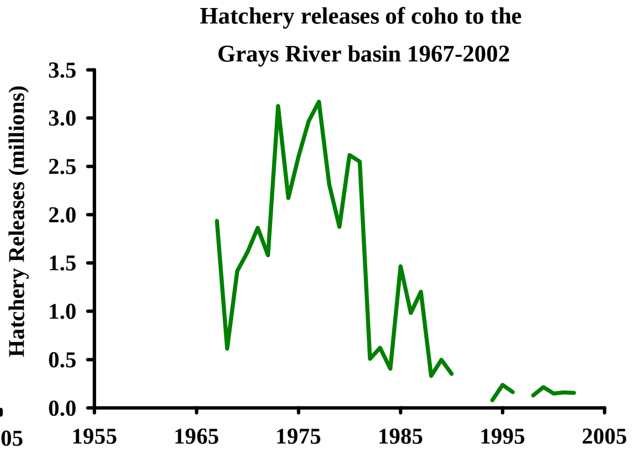
Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late coho as Type N due to their ocean distribution generally north of the Columbia River
- Potential natural spawning areas include the upper Grays, South Fork, West Fork, Crazy Johnson Creek, and Hull Creek
- Vicinity streams with coho spawning potential include Crooked Creek, Hitchcock Creek, and Jim Crow Creek

Life History

- Adults enter the Grays River from mid-August through February (early stock primarily from mid-August through September and late stock primarily from late September through November)
- Peak spawning occurs in late October for early stock and late November to January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge in spring, spend one year in fresh water, and emigrate as age-1 smolts in the following spring





Diversity

- Late stock coho (or Type N) were historically present in the Grays basin with spawning occurring from late November into March
- Early stock coho (or Type S) are also present in the basin and are produced at Grays River Hatchery
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Grays River wild coho run is a fraction of its historical size
- USFWS surveys in 1936 and 1937 indicated coho presence in all accessible areas of the Grays River and its tributaries; no population estimate was made
- WDF estimated 2,500 natural spawning late coho in the Grays River in 1951
- Hatchery production accounts for most coho returning to Grays River

Productivity & Persistence

- Natural spawning of early stock coho is presumed to be very low; natural production of late stock coho is likely less then 15% of smolt density estimate
- Smolt density model estimated basin potential to be 125,874 smolts

Hatchery

- Grays River Hatchery is located about 2.5 miles upstream of Highway 4 on the West Fork; hatchery was completed in 1961; hatchery produces early stock coho
- Grays River Hatchery releases of early coho smolts ranged from about 500,000 to 3 million per year during 1967-87; the current program is reduced to 160,000 early coho smolts released annually

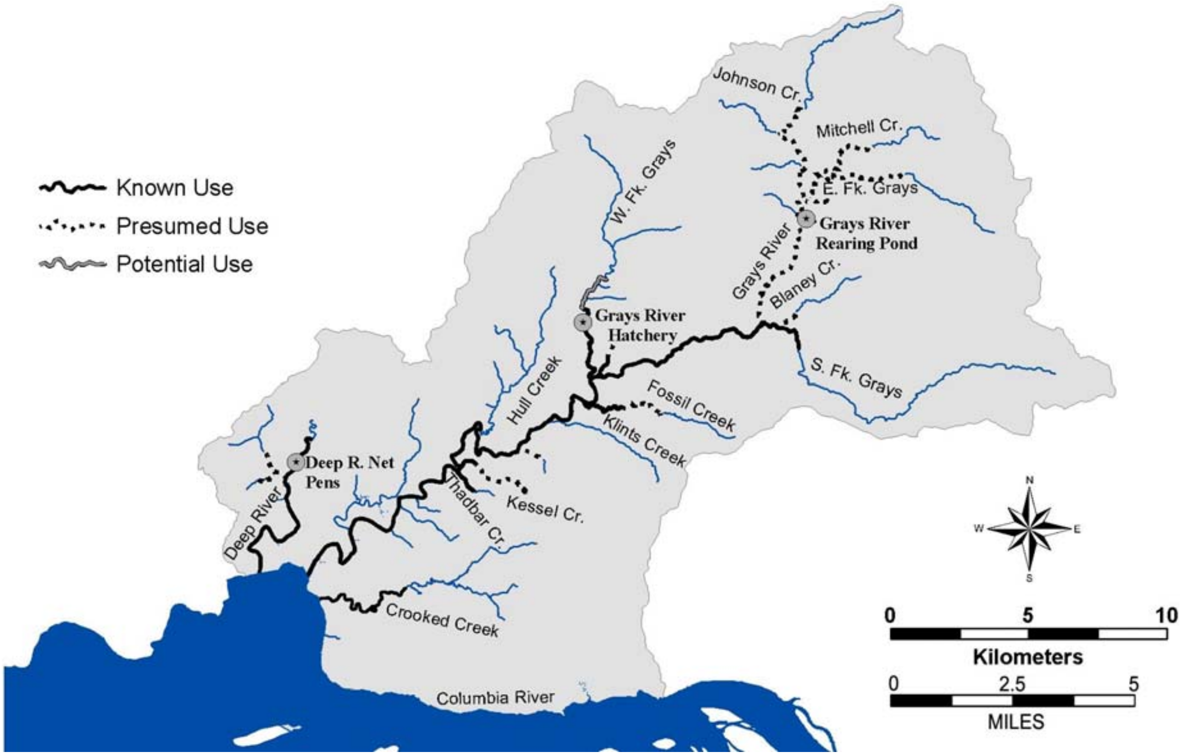
Harvest

- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations

- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas wild coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by status of fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early coho, but late coho harvest can also be substantial
- An average of 94 coho (1978-1986) were harvested annually in the Grays River sport fishery
- CWT data analysis of 1994, 1996, and 1997 brood early coho releases from Grays River Hatchery indicates 43% were captured in a fishery and 57% were accounted for in escapement
- Fishery CWT recoveries of 1994, 1996, and 1997 brood Grays early coho were distributed between Columbia River (58%), Oregon ocean (21%), Washington ocean (19%), and California ocean (1%) sampling areas

4.2.3 Chum—Grays Subbasin

ESA: Threatened 1999 **SASSI: Depressed 1992**



Diversity

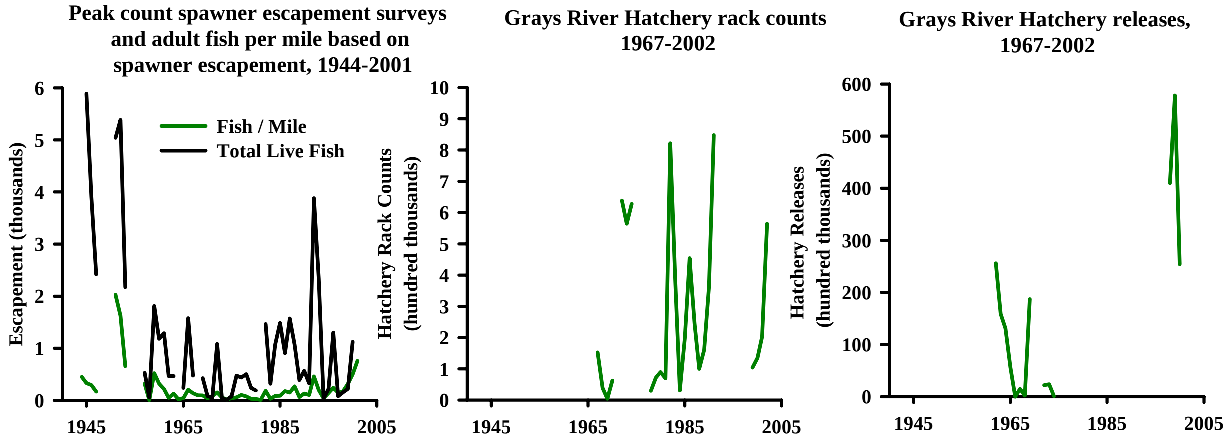
- One of two genetically distinct populations in the Columbia ESU
- Stock designated based on geographic distribution
- Outside stocks used for hatchery brood in the 1980s from Hood Canal and Japan failed to produce significant adult returns
- Outside stock use was discontinued and only Grays Stock currently exists in the hatchery program

Life History

- Adults enter the Grays River from mid-October through November
- Peak spawning occurs in late November
- Dominant adult ages are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts, generally from March to may with peak migration from mid-April to early May

Distribution

- Spawning occurs in the mainstem Grays River from RM 9.5-13.0, the lower 1.4 miles of the West Fork of the Grays River, the lower 0.5 miles of Crazy Johnson Creek, and in Gorley Creek at RM 12 of the Grays River.



Peak count spawner escapement surveys and adult fish per mile based on spawner escapement, 1944-2001

Grays River Hatchery rack counts 1967-2002

Grays River Hatchery releases, 1967-2002

Abundance

- Peak escapement counts in 1936 were 7,674 chum; peak counts from 1945-2000 ranged from 12 to 5,887 chum (average 1,149)
- Adult fish/mile generally ranges from 0-500 from 1944-2000 as estimated from escapement ground spawner surveys, except for 4 years during the 1950s
- Recent survey results (since 1999) indicate a small but increasing chum population

Productivity & Persistence

- NMFS Status Assessment indicated a 0.18 risk of 90% decline in 25 years and a 0.38 risk of 90% decline in 50 years; the risk of extinction was not applicable

Hatchery

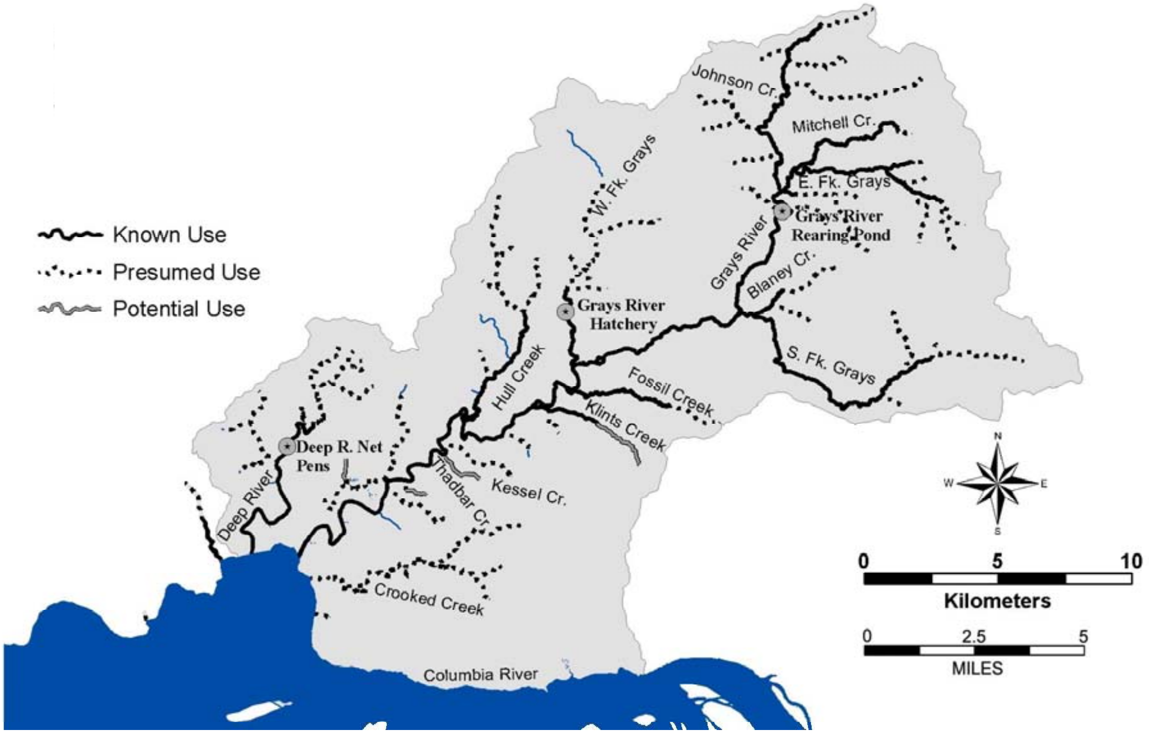
- Grays River hatchery located about RM 2 on the West Fork; hatchery primarily releases chinook and coho; chum are captured annually in the hatchery rack
- Small chum releases have been made with little success
- Hatchery program goal since 1998 is to produce Grays stock chum to augment and reduce risks to naturally spawning Grays River chum

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

4.2.4 Winter Steelhead—Grays Subbasin

ESA: Not Warranted **SASSI: Depressed 2002**



Distribution

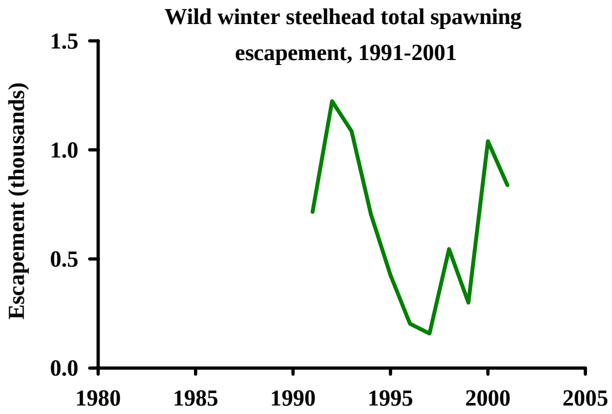
- Winter steelhead are distributed throughout the mainstem above tidal influence and throughout the East, West, and South Forks
- In 1957, Grays River Falls (RM 13) was lowered with explosives, providing easier upstream migration; during the 1950s numerous other natural and man-made barriers above Grays Falls were cleared to improve steelhead access to the upper watershed

Life History

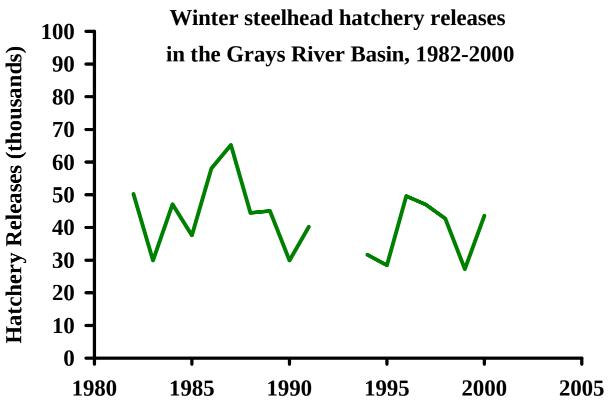
- Adult migration timing for Grays River winter steelhead is from December through April
- Spawning timing on the Grays River is generally from early March to early June
- Age composition data for Grays River winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Stock designated based on distinct spawning distribution
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- Allele frequency analyses of Grays River winter steelhead in 1994 and 1995 were unable to determine the distinctiveness of this stock compared to other lower Columbia steelhead stocks



Wild winter steelhead total spawning escapement, 1991-2001



Winter steelhead hatchery releases in the Grays River Basin, 1982-2000

Abundance

- Steelhead abundance in the Grays River during the 1920s and 1930s was estimated at 2,000 fish annually
- In 1936, more than 100 steelhead were documented in the Grays River during escapement surveys
- Wild winter steelhead run size in the early 1990s was estimated to be 400-600 fish
- Total escapement counts from 1991-2001 ranged from 158-1,224 (average 658)
- Escapement goal for the Grays River is 1,486 wild adult steelhead; this goal has not been met in recent years)

Productivity & Persistence

- The smolt density model estimated potential winter steelhead smolt production was 45,300

Hatchery

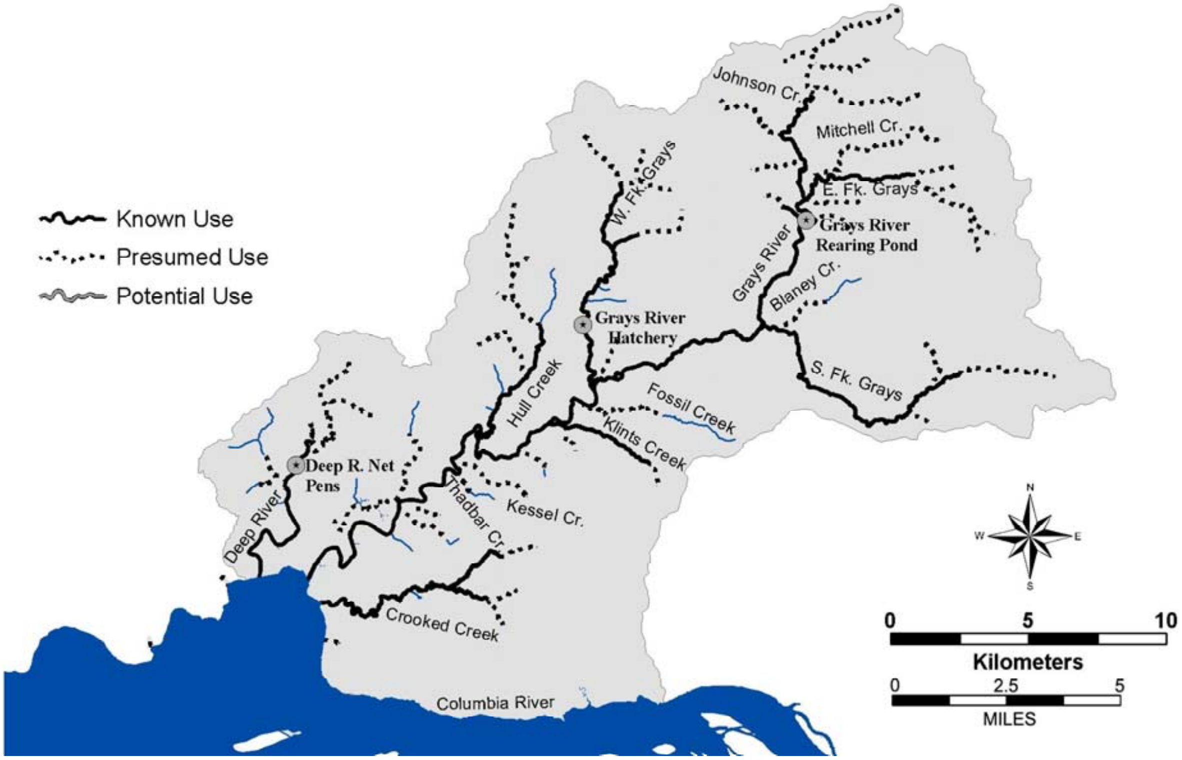
- The Grays River Hatchery, located on the West Fork, does not produce winter steelhead
- Hatchery winter steelhead have been planted in the Grays River basin since 1957; brood stock from the Elochoman and Cowlitz Rivers and Chambers Creek have been used; release data are displayed from 1982-2000
- Hatchery fish contribute little to natural winter steelhead production in the Grays River basin

Harvest

- No directed commercial or tribal fisheries target Grays winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Grays River basin
- Winter steelhead sport harvest in the Grays River from 1980-1990 ranged from 354-1,031 (average 533); since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact of wild winter steelhead in the mainstem Columbia River and in the Grays River

4.2.5 Cutthroat Trout—Grays River Subbasin

ESA: Not Listed	SASSI: Depressed 2000



Distribution

- Anadromous, fluvial, and resident forms distribute themselves throughout the basin
- Anadromous forms have access to the entire subbasin but are not believed to use steep gradient upper tributary reaches
- Resident forms are documented throughout the system

Life History

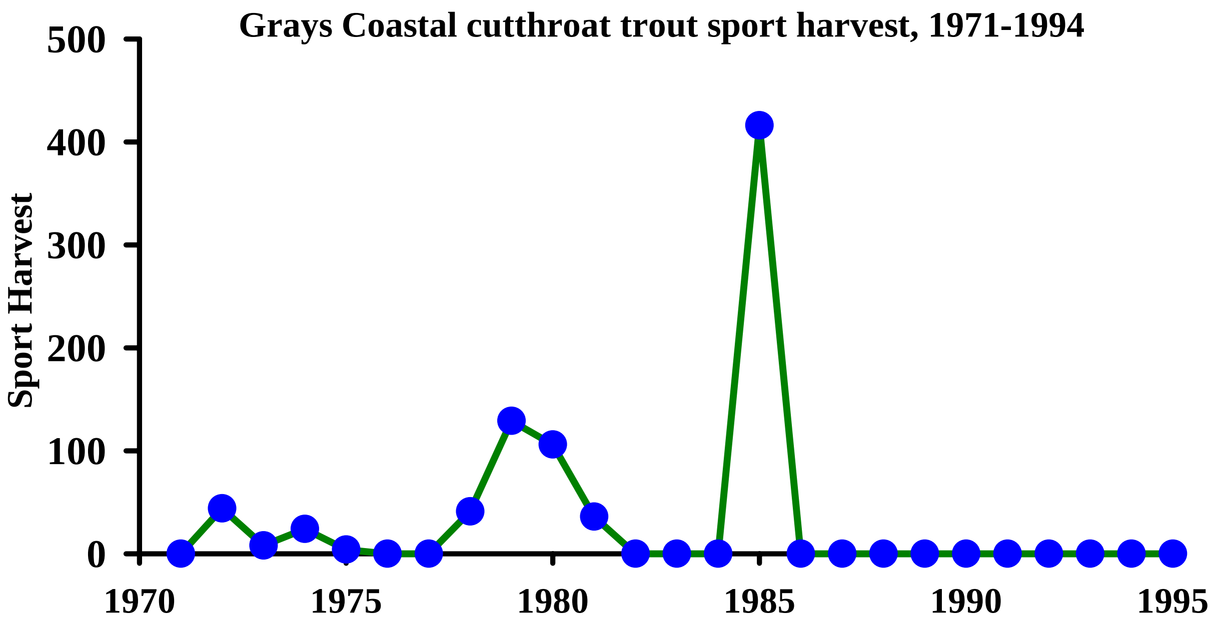
- Anadromous, fluvial, and resident forms are present
- Anadromous adults enter the Grays River from late July through mid-April
- Anadromous spawning occurs from January through mid-April
- Fluvial and resident spawn timing is not documented but is believed to be similar to anadromous timing

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown

Abundance

- No total abundance or anadromous run size data are available
- Some incomplete historical sport catch data are available



Hatchery

- Grays River Hatchery (RM 2 of the West Fork) does not produce or release coastal cutthroat

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Grays River
- Wild Grays River cutthroat (unmarked fish) must be released in mainstem Columbia and Grays River sport fisheries

4.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quality and quantity accounts for the largest relative impact on all species. Loss of estuary habitat quality and quantity is also relatively important for all species, but less so for coho.
- Harvest has a sizeable effect on fall chinook, but is relatively minor for chum and winter steelhead; harvest impact on coho is intermediate.
- Hatchery impacts are substantial for coho, moderate for fall chinook, and relatively low for chum salmon and winter steelhead.
- Predation impacts are moderate for all species.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

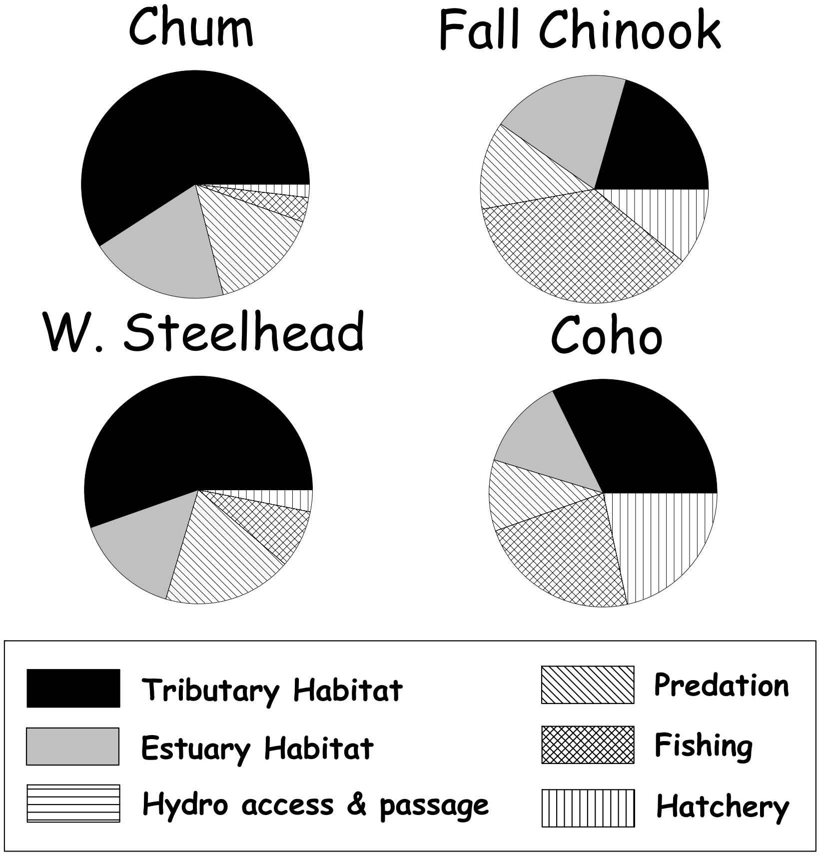


Figure 4-5. Relative index of potentially manageable mortality factors for each species in the Grays subbasin.

4.4 Hatchery Programs

The Grays River Hatchery is located about RM 2 on the West Fork Grays River and primarily has produced fall chinook and early run coho (type-S), and in recent years, chum salmon. The Grays River Hatchery was completed in 1961, although releases of hatchery fall chinook occurred in the basin as early as 1947. The fall chinook hatchery program was discontinued in 1998 because of federal funding cuts. The chum salmon program began collecting adults for broodstock in fall of 1998. While the current annual chum salmon production goal for the Grays River Hatchery is 300,000 chum fry, chum releases to the Grays River in 2002 totaled 555,000 fry (Figure 4-6). An additional 150,000 chum fry produced at the Grays River Hatchery are scheduled for annual release in the Chinook River. Winter steelhead produced at the Elochoman Hatchery have been planted in the Grays River since at least the early 1980s; annual release goal is 40,000 winter steelhead (Figure 4-6).

Genetics—Broodstock for the new chum salmon hatchery program in the Grays River has been from native Grays River chum stock trapped in Gorley Creek, leading to expectations of minimal genetic effects on wild fish from these releases. Winter steelhead releases in the basin have been from Elochoman and Cowlitz rivers, and include Chambers Creek broodstock. Early coho broodstock is trapped at the Grays River Hatchery. Historical releases have included substantial out-of-basin transfers, although all transfers came from within the lower Columbia basin. The largest donor was Toutle Hatchery early coho. In past years, the discontinued fall chinook program also collected broodstock at the Grays River Hatchery. The program included substantial transfers from Lower Columbia ESU basins to fill shortfalls. The primary donors to the Grays River fall chinook program were Spring Creek Hatchery and Kalama Hatchery. The Grays River will be an interesting test case of a lower Columbia stream which will be without first generation local hatchery fall chinook influence on the spawning grounds beginning in 2003.

Interactions—Specific wild/hatchery fish interactions in the Grays River have not been documented. For chum salmon, wild and hatchery adult fish may interact upon return although the hatchery program is intended to augment runs of wild chum. The amount of hatchery fish spawning in the wild is being monitored by otolith marking of hatchery releases. Recent natural chum returns to the Grays are substantially larger then hatchery returns (Figure 4-7). Competition between juvenile wild and hatchery chum may occur as well, although the Grays River is unlikely to be rearing-limited at current production levels. Wild and hatchery chum fry may be susceptible to predation by hatchery coho smolts, as well as numerous other predators. The following hatchery practices are employed to minimize chum fry losses during outmigration: 1) hatchery chum are released during darkness on a falling tide to reduce their visibility and expedite emigration, 2) fish are released in areas away from known concentrations of predatory warm water fishes, and 3) hatchery fish are released during a similar time frame of natural salmonid emigration.

For fall chinook, a significant portion of past years' spawners in the Grays River were first-generation hatchery fish. Few wild fish were present, so hatchery/wild adult fish interactions likely were limited. With past years' annual releases of fall chinook usually between 1 and 6 million, there was significant potential for competition between hatchery-released and naturally produced juvenile fall chinook. However, few natural fall chinook were produced annually and most hatchery releases are smolts that migrate shortly after release, which minimizes potential freshwater competition. In most years, hatchery-released juvenile fall chinook considerably outnumbered naturally produced juveniles. Further, because the Grays

River Hatchery fall chinook program stopped releasing smolts in 1998, adult hatchery returns are expected to cease beginning in 2002.

Spawning of wild coho is presumed to be low so there is little interaction between wild and hatchery fish (Figure 4-7). Also, indigenous wild coho in the Grays River are believed to be late run coho while the hatchery broodstock has been from early run coho; adult coho interaction therefore is minimized through temporal segregation. Hatchery winter steelhead contribute very little to natural production and interaction between hatchery and wild winter steelhead is expected to be minimal (Figure 4-7).

Water Quality/Disease—Water for the Grays River Hatchery is obtained from two sources; Grays River and nearby wells. Grays River water is utilized for holding adults before broodstock collection and for the final stages of rearing before release. Well water is used during incubation and most of the rearing phase; water is supplied to the rearing raceways at a rate of 946 to 1,325 liters/min. Beginning 3 weeks before release, Grays River water is gradually added to the raceway water supply so that fish are exposed to 100% Grays River water for at least 10 days before they are released.

Fish health is continuously monitored in accordance with the Co-Manager Fish Health Policy standards. No disease outbreaks occurred during the incubation-to-ponding period of the 1998 brood; mortality levels were lower than the program standards.

Mixed Harvest—There are no directed chum salmon fisheries on lower Columbia River chum stocks. Minor incidental harvest occurs in fisheries targeting fall chinook and coho. Retention of wild chum salmon is prohibited in lower Columbia River and tributary sport fisheries. There probably is little difference in fishery exploitation rates of lower Columbia River wild and Grays River Hatchery chum salmon.

The purpose of the coho and winter steelhead hatchery programs in the Grays River basin is to mitigate the loss of natural salmonid production as a result of hydroelectric and other development in the Columbia River basin and to provide harvest opportunity. Historically, fishery exploitation rates of Grays River Hatchery fall chinook, coho, and winter steelhead were likely similar to wild fish. However, in recent years, regulations for wild fish release have been in place for coho and steelhead fisheries. All hatchery coho and steelhead are adipose fin-clipped to provide for selective fisheries. Therefore, recent commercial and recreational exploitation rates are higher for Grays River Hatchery coho and winter steelhead than for wild fish.

Passage—The Grays River Hatchery adult collection facility consists of a ladder system; coho salmon collected for broodstock enter the ladder volitionally. Chum salmon for the hatchery program either volunteer into the hatchery adjacent to a temporary weir or are seined from the mainstem and West Fork Grays River from early November to December and transferred to the Grays River Hatchery.

Supplementation—Since 1998, the Grays River Hatchery program goal has been to produce Grays River stock chum to augment and reduce extinction risks to naturally spawning Grays River chum; the hatchery program occurs in conjunction with habitat restoration efforts in the Grays River basin. Recent releases of chum salmon are the largest on record and returning hatchery fish exceeding broodstock needs are allowed to spawn naturally.

The fall chinook hatchery program has been discontinued and the coho program has been reduced to the release of 150,000 smolts annually; this program is not intended for supplementation. Winter steelhead hatchery releases have been from out-of-basin sources and contribute very little to natural spawning; the winter steelhead hatchery program goal provides tributary recreational fishing opportunity rather than supplementation.

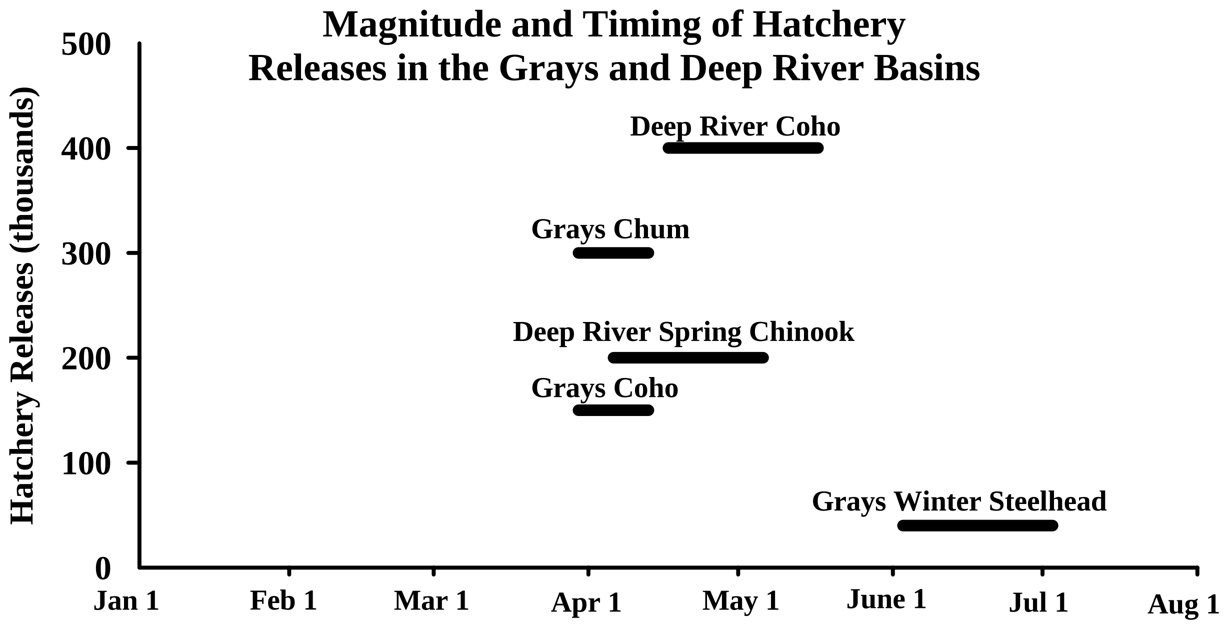


Figure 4-6. Magnitude and timing of hatchery releases in the Deep River and Grays River basins by species, based on 2003 brood production goals.

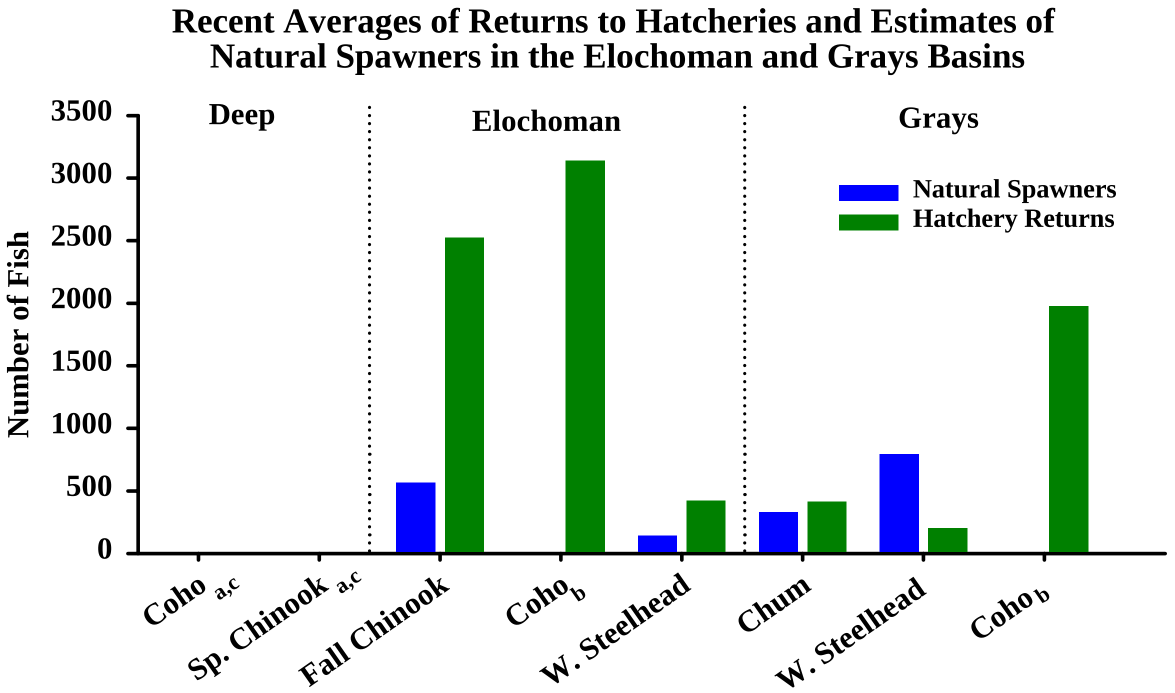


Figure 4-7. Recent average hatchery returns and estimates of natural spawning escapement in the Deep, Grays, and Elochoman River basins by species. The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from 1992 to the present. Calculation of each average utilized a minimum of 5 years of data, except for Grays chum (1998–2000) and Grays winter steelhead (1998 and 2000).

4.5 Fish Habitat Conditions

4.5.1 Passage Obstructions

Low flow passage problems are a concern at the mouth of the Grays and on lower Seal River. Flow alterations on the middle mainstem that are related to the breaching of a dike at Gorley Springs in 1999 may create passage problems at certain times of the year. Sediment accumulations on lower Shannon Creek (West Fork tributary) create subsurface flow during the summer. A natural falls at approximately RM 13 was blasted in 1957 to improve fish passage. The numerous tide gates on tributaries and sloughs that connect to Grays Bay present potential passage problems. Various other culvert, low flow, and tidegate concerns are discussed in detail in Wade (2002).

4.5.2 Stream Flow

From west to east, the major stream systems in the subbasin are the Sisson Creek, Deep River, Grays River, and Crooked Creek basins. Major tributaries to the Grays River include Hull Creek, the West Fork Grays, the South Fork Grays, and Mitchell Creek. Peak flows are associated with fall and winter rains and low flows typically occur in late summer. The USGS collected streamflow data at several sites in the subbasin for various periods, though no data exists since 1979.

Results of the Integrated Watershed Assessment (IWA), which are presented in greater detail later in the chapter, indicate that nearly all of the Grays Subbasin is ‘impaired’ with regards to an increased risk of elevated peak flows. Only subwatersheds within the South Fork Grays River basin are rated as ‘moderately impaired’ and there are no ‘functional’ subwatersheds. These results are corroborated by an analysis conducted by Lewis County GIS (2000), which identified ‘impaired’ peak flow conditions throughout most of the subbasin, with ‘likely impaired’ peak flow conditions in the South Fork Grays River. The lack of mature vegetation, combined with high road densities (many subwatesheds have greater than 5 miles of road per square mile), contribute to hydrologic impairment.

Low flow volumes are also a concern in the subbasin. As part of an instream flow analysis, Toe-Width flows were estimated for the Grays River in 1998. The results showed that fall flows for salmon spawning and spring flows for steelhead spawning were sufficient; but that summer rearing flows were inadequate (Caldwell et al. 1999). A similar study on Crooked Creek indicated that flows were below optimum for rearing in mid-September and were below optimum for spawning into the first part of November (Caldwell et al. 1999).

Current and future effects of flow withdrawals on stream flow were estimated as part of watershed planning efforts by the LCFRB. Combined surface water and groundwater demand in the Grays subbasin, which totaled 1,264 acre-feet per year in 2000, is expected to increase 9.8% by 2020. Based on the population projections and the estimated total groundwater use in the subbasin, groundwater withdrawal does not appear to be significant compared to groundwater baseflow within the subbasin (LCFRB 2001).

4.5.3 Water Quality

High water temperatures are a concern throughout the subbasin. The West Fork Grays was listed on the state’s 303(d) list of impaired water bodies due to elevated temperatures (WDOE 1998). Summer temperature monitoring conducted by the WCD on the mainstem and the West Fork Grays indicates that stream temperatures commonly exceed 16ºC. Stream temperature in the upper Grays River near the South Fork confluence regularly exceeded 16ºC in the summer of 2000. This may be due to its width and north-south orientation. High temperatures (>17ºC) have also been recorded in Hull Creek in the lower basin and in Crooked Creek (Wade 2002).

Problems other than water temperature also exist in the subbasin. Fecal coliform standards were exceeded on the Grays River in 1998. Malone Creek may have fecal coliform problems associated with failing residential septic systems. This stream also appears turbid at high flows. Turbidity is an observed problem in tributaries to Klints and King Creeks. Various sources of increased turbidity have been identified in the West Fork and the South Fork basins. High summer turbidity levels have been observed in the Grays Bay tributary of Hendrickson Creek, likely associated with mass wasting in the upper watershed. Nutrient levels are likely lower than they were historically due to lower salmonid escapement levels compared to historical conditions (Wade 2002).

4.5.4 Key Habitat

Side channel habitat has been removed from most of the lower Grays River mainstem and lower mainstem tributaries as a result of diking. Side channel habitats in the upper Grays River basin are limited by naturally confined valleys and steep stream gradients, with generally adequate side channel habitats where they exist. The Deep River and Crooked Creek have few side channels, partly due to channelizaton associated with agriculture. On most other Grays Bay tributaries, tidegates limit access to side channel habitat in the lower reaches. Information on side channels is lacking for much of the subbasin (Wade 2002).

WCD surveys rated nearly the entire subbasin as having inadequate pool habitat. In each of the major Grays River basins, over 77% of surveyed reaches contained less than 40% pools, and 100% of the reaches in the West Fork and South Fork basins were identified as having a lack of pools. The percentage of the channel in pool habitat generally increases as gradient increases. Inadequate pool habitat is concentrated in the mainstem and in the lower reaches of tributaries, where agricultural practices and channel straightening have reduced pool quality and quantity. Good pool habitat generally corresponds with the presence of logjams (Wade 2002). In Grays Bay tributary streams, most streams had over 50% of reaches with less than 40% of the stream surface area in pools (Wade 2002).

4.5.5 Substrate & Sediment

Fine sediments naturally exist in the tidally influenced lower reaches of most streams. Reaches above tidal influence have a higher percentage of gravels but they are generally of soft rock and are highly embedded with fine sediment. This is in part due to the presence of sedimentary rock that breaks down quickly once delivered to stream channels. WCD surveys using visual estimates of fine sediment revealed that within the Grays River basin over 76% of surveyed reaches had greater than 17% fines.

High road densities and road crossings over streams can increase the potential for sediment production and delivery to streams. The Grays River basin contains a very high 7.32 miles of road / square mile, over twice as much as is considered high by NMFS standards. The number of stream crossings is also high, with 34.1 stream crossings per mile in the Mitchell Creek basin (upper watershed), the second highest value in the lower Columbia region. The results of the IWA, which are presented in greater detail later in the chapter, indicate that high road densities and naturally unstable soils have contributed to ‘moderately impaired’ sediment supply conditions throughout the subbasin, with a few areas experiencing ‘impaired’ conditions (lower Grays subwatershed and West Fork Grays subwatersheds). A preponderance of mass failures also provides a source for increased fine and coarse sediment production. A study by the WCD identified greater than 4 mass failures/mi^2 in several areas, including the West Fork Grays River basin, the lower Grays River basin, the Deep River Basin, and the Crooked Creek basin (Wade 2002).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

4.5.6 Woody Debris

WCD stream surveys found that LWD was virtually non-existant in the lower mainstem Grays River. Throughout the entire lower basin 75% of surveyed reaches had inadequate LWD. LWD abundance is also low in the middle Grays, with over 74% of surveyed reaches below accepted standards. Only middle Klints Creek has decent wood quantities. All surveyed reaches in the West Fork basin were rated “poor” for LWD. Most of the LWD that is present is located in large logjams. Logging debris and debris flows have contributed to these jams. LWD quantities are low throughout the South Fork basin. All surveyed reaches rated “poor” for LWD. Wood in the South Fork is transported out of the system due to high gradient channels or it is deposited on the floodplains during high flows. Sixty-one percent of reaches in the upper Grays basin had “poor” LWD numbers. Most of the LWD that was present was in large logjams or deposited on the flooplain (Wade 2002).

In other Grays Bay tributaries, WCD stream surveys identified 89.7% of surveyed channels as lacking adequate LWD. Where LWD existed it was often deciduous and/or of small diameter (Wade 2002).

4.5.7 Channel Stability

The WCD recorded areas of bank instability in the subbasin during 1994 stream surveys. Areas of concern were identified on the lower Grays (along some of the dikes), upper Impie Creek, lower Thadbar Creek, lower Hull Creek, lower Silver Creek, and Honey Creek. Many of these sites have cattle access to the stream. Bank stability is low along the middle mainstem in the Gorley Springs area, where a dike breach in 1999 created a highly unstable channel. Portions of King and Fossil Creeks, primarily in the lower reaches, have bank stability concerns. Debris flows occur frequently in the West Fork and South Fork systems. Many of these events are related to shallow landslides on steep, geologically unstable slopes in confined river valleys. Areas of instability in the South Fork basin may be contributing to elevated turbidity levels. Only a handful of areas in the upper Grays have been noted for bank stability concerns. Railroad grades along the East Fork have experienced numerous slope failures that have caused debris flows (Wade 2002).

Grays Bay tributaries also have some bank stability concerns. According to WCD Surveys, reaches of Ragilla, Anderson, and Person Creeks had extensive streambank erosion. Lower Hendrickson Creek, lower Crooked Creek, and the North Fork Deep River had localized areas of unstable banks. A WCD assessment identified mass failure frequencies of 4.67 and 6.25 failures / mi^2 in the Deep River and Crooked Creek, respectively (Wade 2002).

4.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 3 of 17 subwatersheds in the Grays subbasin are rated as ‘impaired’ for riparian function, 12 are rated as ‘moderately impaired’, and 2 are rated as ‘functional’. The greatest impairments are in the lower basin and the least amount of impairment is located in the northeast portion of the basin. These results are consistent with the generally impaired condition of riparian forests identified in surveys conducted by the WCD.

WCD’s riparian surveys in 1994 measured tree size, composition, and buffer width. Areas with small trees, an abundance of hardwoods, and narrow buffer widths were rated as having poor conditions. Based on the WCD’s criteria, riparian forests were in poor shape throughout the basin. Eighty-eight percent of reaches in the West Fork, 90% in the Lower basin, and 98% in the middle basin were rated as having “poor” riparian conditions. Most riparian forests along low gradient reaches lack coniferous cover or adequate buffer widths, whereas steeper reaches in the upper watershed suffer primarily from immature forests. Agricultural practices and cattle access were noted by the WCD as sources of riparian problems in the lower basin and timber harvest was cited as the primary cause of problems in the upper basin. The West Fork basin in particular is almost entirely (99%) composed of private and state forestland, with 77% of the area having forest stands less than 50 years old.

Poor conditions were identified for most reaches of the Deep River and the lower portions of the Crooked River. All of the surveyed streams had at least 33% of riparian areas in the “poor” category, except for the North Fork Deep River. Poor conditions were attributed primarily to agricultural practices and livestock access (Wade 2002).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

4.5.9 Floodplain Function

The lower Grays River mainstem and most lower mainstem tributary streams have been diked, armored, drained, and/or relocated, primarily for agricultural purposes (WCD surveys). A project is underway by Columbia Land Trust to preserve over 500 acres of degraded floodplain habitat and restore tidal function to 200 acres of the Grays River estuary.

Portions of the middle Grays have been diked for agricultural purposes and armored to protect streambanks from erosion. Streambed aggradation in Klints Creek is associated with bedload supplied during winter 1996 flooding, which may have actually improved floodplain connectivity. Significant aggradation occurred in lower Fossil Creek in 1996 as well, reducing sediment transport out of this tributary. Efforts to reconnect Fossil Creek to the Grays River have caused erosion of the aggraded sediment, and flooding problems still exist (Wade 2002).

The lower reaches of Deep Creek (up to RM 3.9) have been diked and the lower 2 miles of Crooked Creek is channelized and entrenched, reducing access to off-channel habitats. The effect of tidegates on floodplain connectivity on Grays Bay tributaries has not been assessed (Wade 2002).

4.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Grays River steelhead, chum, fall chinook and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

4.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Grays River subbasin for winter steelhead, fall chinook, coho, and chum (Table 4-1). Chum in the Grays River make up one of the few remaining chum populations in the Columbia River. The other intact population is Hardy, Hamilton, and Duncan Creeks—lower Columbia Gorge tributaries. Despite the relatively healthy population of chum in the Grays, this population has witnessed the greatest decline in numbers compared to other Grays River populations (Figure 4-8). Model results indicate that chum abundance has decreased by more than 84% from historical levels (Table 4-1). Similarly, winter steelhead abundance shows a near 70% decrease from historical levels, while fall chinook shows just under a 40% decrease (Table 4-1). Change in diversity (as measured by the diversity index) is the smallest for fall chinook and the greatest for winter steelhead and coho (Table 4-1). Coho and winter steelhead diversity has been negatively impacted by reduced and/or degraded tributary spawning habitat.

Modeled historical-to-current changes in smolt productivity and abundance reveal different trends when compared to the adult figures. For fall chinook, coho and winter steelhead, current smolt productivity is only 20- 25% of historical productivity levels (Table 4-1). However, in the case of chum, smolt productivity is still approximately 60% of historical levels (Table 4-1). This seems counter-intuitive due to the fact that chum adult abundance has declined the most out of the four species. However, this relatively higher productivity is merely an artifact of the way the EDT model calculates productivity. That is, the higher productivity of chum smolts is because Grays chum now have many less trajectories (life history pathways) that are viable (those that result in return spawners), but the few trajectories that remain have higher productivities than historical trajectories (many of which were only marginally viable). Modeled adult chum productivity does not follow this same trend due to recent poor estuary and ocean survival.

Current smolt abundance is substantially less than the historical level for all species (Table 4-1), reflecting the significant loss of trajectories (which is also reflected in the life history diversity index). Historical-to-current change in fall chinook, coho and chum smolt abundance shows a 72%, 64%, and a 72% decrease, respectively, from historical levels. Winter steelhead smolt abundance appears to have declined less dramatically, with a modeled 46% decrease from past levels.

Model results indicate that restoration of properly functioning habitat conditions (PFC) would substantially increase adult abundance for all species (Table 4-1). Chum and coho would benefit most from restoration of PFC, with chum showing a 255% increase from current adult abundance, and coho a 205% increase. Chinook and winter steelhead would experience a 45% and a 57% increase, respectively. Restoration of PFC would also increase smolt abundance and productivity for all species (Table 4-1). Chum and winter steelhead would benefit from an approximate 120% and 55% increase, respectively, in smolt abundance due to restoration of PFC, while both fall chinook and coho would see a greater than 200% increase.

Table 4-1. Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	550	795	869	3.5	6.7	7.9	0.97	0.98	0.98	22,538	68,778	79,245	70	225	293
Chum	1,569	5,575	10,174	2.5	7.3	10.5	0.96	1.00	1.00	441,069	963,068	1,209,737	530	762	891
Coho	1,239	3,773	4,344	3.9	12.7	16.6	0.76	0.93	0.94	22,538	68,778	79,245	70	225	293
Winter Steelhead	1,201	1,885	3,716	4.4	13.5	35.9	0.72	0.78	0.94	16,436	25,530	30,556	60	181	290

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

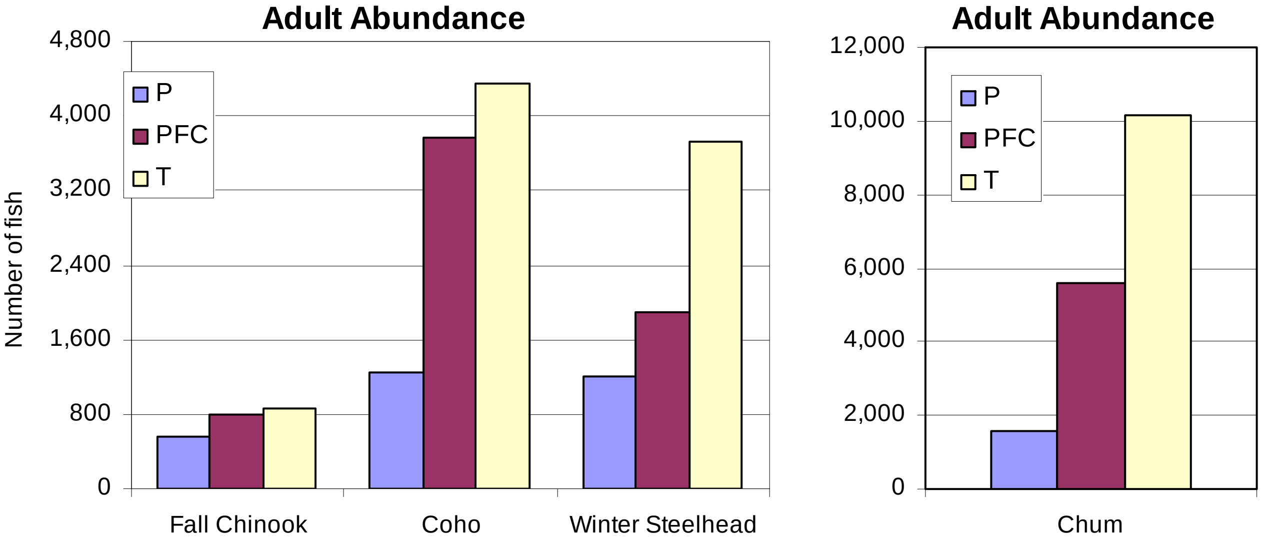


Figure 4-8. Adult abundance of Grays River fall chinook, coho, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

4.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin. For the purpose of this EDT analysis, the Grays subbasin was divided into approximately 60 reaches. Reach locations are displayed in Figure 4-9.

Winter steelhead utilize the greatest proportion of Grays River subbasin habitats. Historically, only winter steelhead were able to ascend a falls located on the mainstem just upstream of its confluence with the West Fork Grays. This falls was lowered in 1957 to facilitate passage, and coho now commonly access the portion of the basin upstream of this former barrier. Chum primarily utilize the mainstem up to the West Fork confluence and the major tributaries Hull Creek and Seal Creek. Most of the spawning occurs in the mainstem in reach Grays 2 to 2C and the small tributary Crazy Johnson Creek, which flows into reach Grays 2C just upstream of the West Fork confluence. There is also dense chum spawning in the Gorley Creek spawning channel. Fall chinook have a similar distribution to chum but are unable to access Hull Creek due to their earlier run timing. Chinook also utilize the lower West Fork Grays.

Some of the high priority reaches for winter steelhead include the EF, WF and SF Grays 1, and the SF and WF Grays 2 (Figure 4-10). High priority reaches also exist in the upper Grays and the headwaters, including WF, EF, and SF Grays 3, and Grays 4A and 4B. These upper areas represent some of the main spawning and rearing sites for winter steelhead. The middle mainstem is important as a rearing area for age 1 juveniles that originate from upstream spawning areas. High priority reaches for chum include Grays 2B, 2C, and 2D, and spawning reaches such as Crazy Johnson Creek (a tributary to Grays 2C) and Grays 2 (Figure 4-11). For fall chinook, the higher priority areas are in the lower river, including Grays 2, 2A and 2C (Figure 4-12). High priority reaches for Grays River coho also seem to be in the lower river. These reaches consist of Grays 2, 2A, 2B, 2C and Grays 1G tidal (Figure 4-13).

Many of the above mentioned reaches currently support significant production and therefore have high preservation value. They also have considerable restoration potential. The important steelhead reaches in the upper basin have been affected by intense forestry activities and currently have low instream LWD and degraded riparian conditions. The lower river (including the tidal reaches) have experienced heavy agricultural use that affects riparian and sediment conditions. Lower river reaches have also experienced a loss of historical off-channel habitats due to hydromodifications.

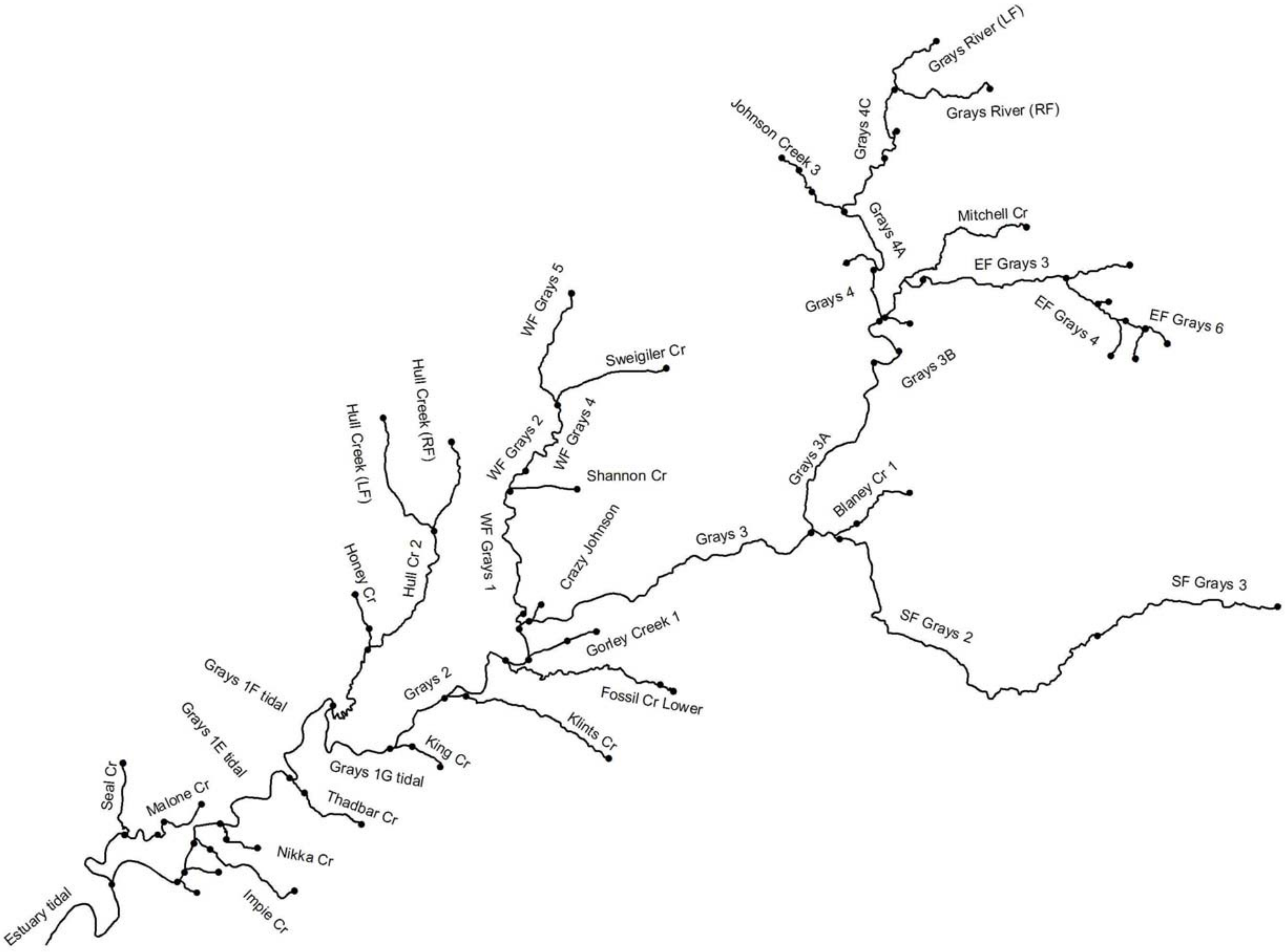
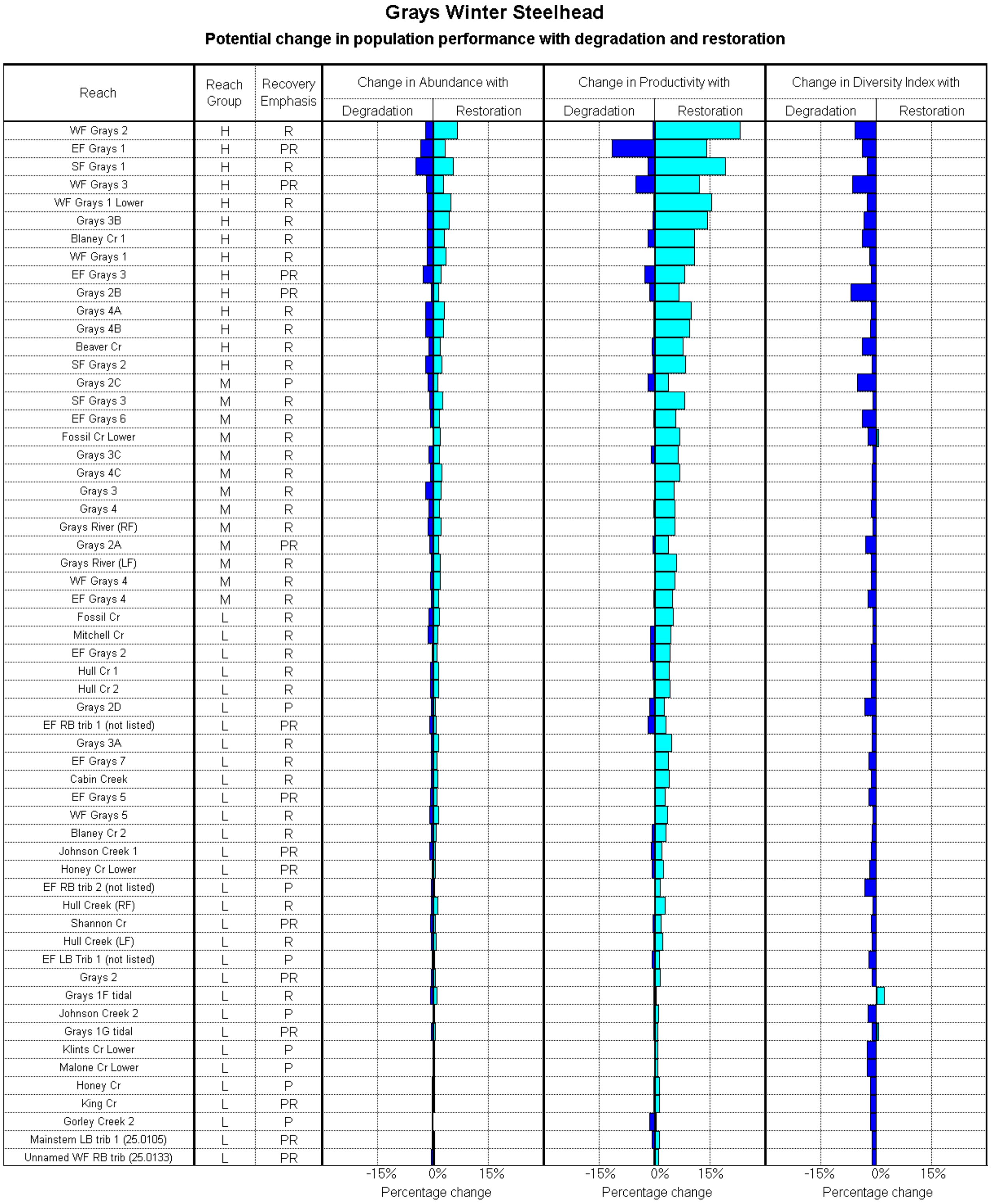


Figure 4-9. Grays subbasin with EDT reaches identified. For readability, not all reaches are labeled.



Reach	Reach Group	Recovery Emphasis
WF Grays 2	H	R
EF Grays 1	H	PR
SF Grays 1	H	R
WF Grays 3	H	PR
WF Grays 1 Lower	H	R
Grays 3B	H	R
Blaney Cr 1	H	R
WF Grays 1	H	R
EF Grays 3	H	PR
Grays 2B	H	PR
Grays 4A	H	R
Grays 4B	H	R
Beaver Cr	H	R
SF Grays 2	H	R
Grays 2C	M	P
SF Grays 3	M	R
EF Grays 6	M	R
Fossil Cr Lower	M	R
Grays 3C	M	R
Grays 4C	M	R
Grays 3	M	R
Grays 4	M	R
Grays River (RF)	M	R
Grays 2A	M	PR
Grays River (LF)	M	R
WF Grays 4	M	R
EF Grays 4	M	R
Fossil Cr	L	R
Mitchell Cr	L	R
EF Grays 2	L	R
Hull Cr 1	L	R
Hull Cr 2	L	R
Grays 2D	L	P
EF RB trib 1 (not listed)	L	PR
Grays 3A	L	R
EF Grays 7	L	R
Cabin Creek	L	R
EF Grays 5	L	PR
WF Grays 5	L	R
Blaney Cr 2	L	R
Johnson Creek 1	L	PR
Honey Cr Lower	L	PR
EF RB trib 2 (not listed)	L	P
Hull Creek (RF)	L	R
Shannon Cr	L	PR
Hull Creek (LF)	L	R
EF LB Trib 1 (not listed)	L	P
Grays 2	L	PR
Grays 1F tidal	L	R
Johnson Creek 2	L	P
Grays 1G tidal	L	PR
Klints Cr Lower	L	P
Malone Cr Lower	L	P
Honey Cr	L	P
King Cr	L	PR
Gorley Creek 2	L	P
Mainstem LB trib 1 (25.0105)	L	PR
Unnamed WF RB trib (25.0133)	L	PR

Figure 4-10. Grays River subbasin winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams. Some low priority reaches are not included for display purposes.

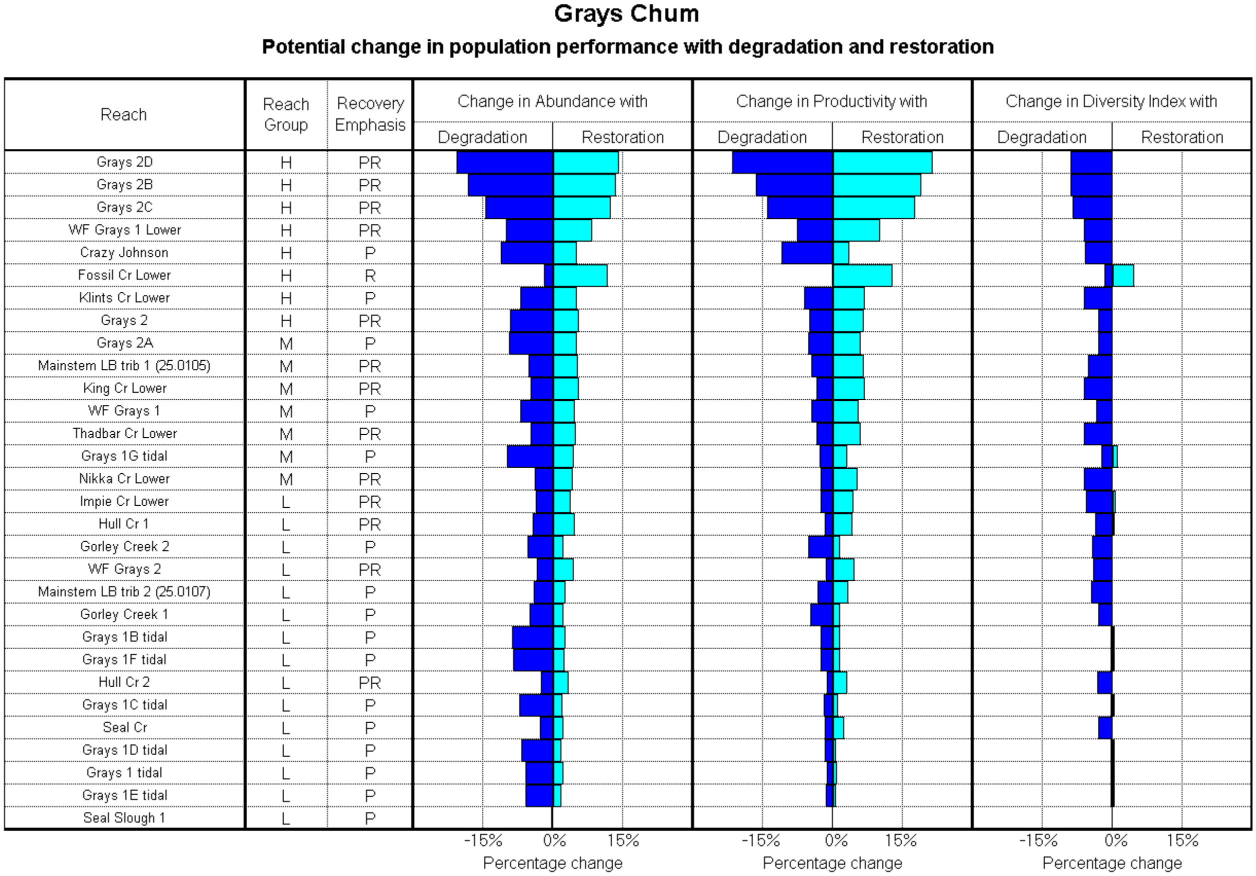


Figure 4-11. Grays River subbasin chum ladder diagram.

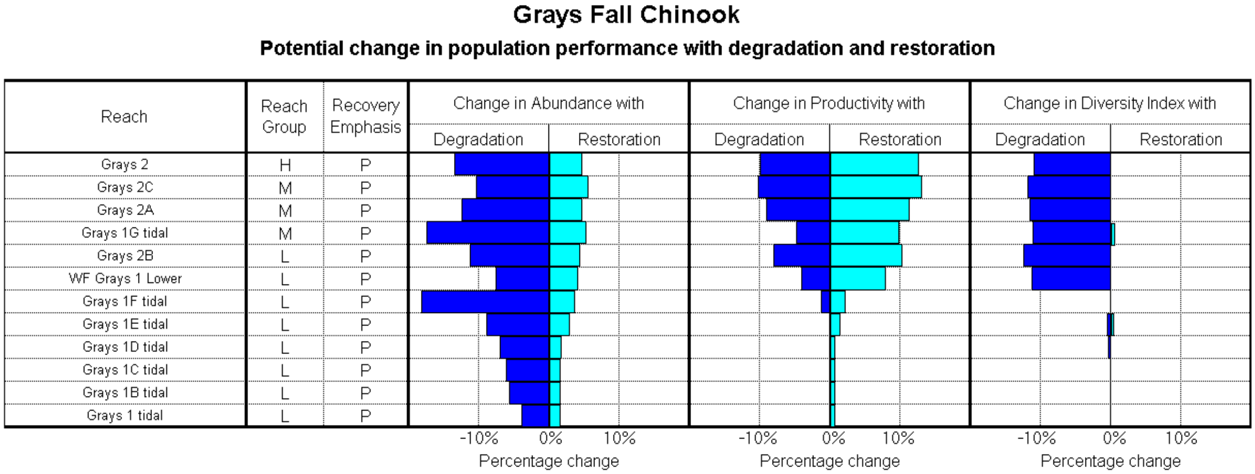
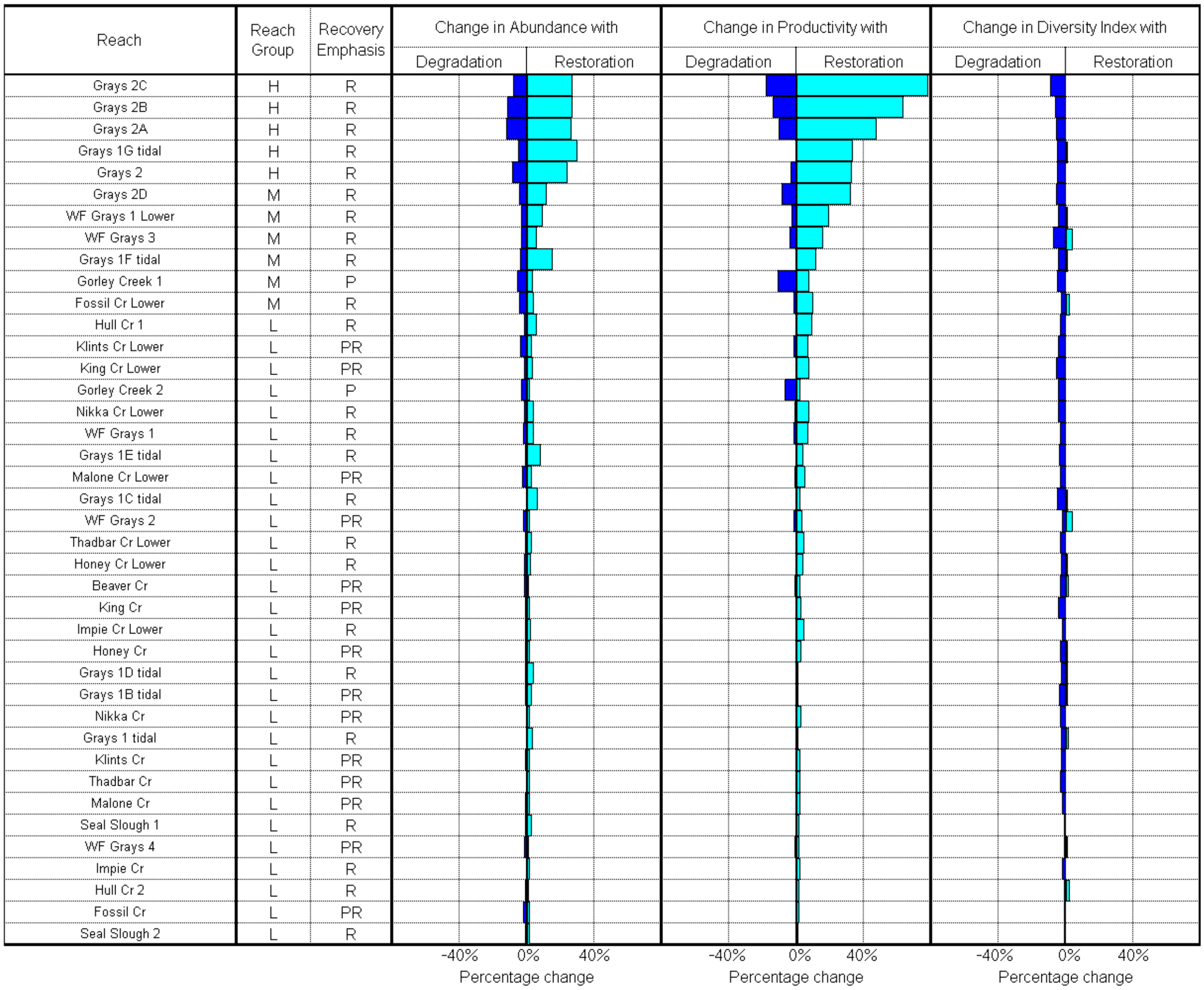


Figure 4-12. Grays River subbasin fall chinook ladder diagram.

Grays Coho

Potential change in population performance with degradation and restoration



Reach	Reach Group	Recovery Emphasis
Grays 2C	H	R
Grays 2B	H	R
Grays 2A	H	R
Grays 1G tidal	H	R
Grays 2	H	R
Grays 2D	M	R
WF Grays 1 Lower	M	R
WF Grays 3	M	R
Grays 1F tidal	M	R
Gorley Creek 1	M	P
Fossil Cr Lower	M	R
Hull Cr 1	L	R
Klints Cr Lower	L	PR
King Cr Lower	L	PR
Gorley Creek 2	L	P
Nikka Cr Lower	L	R
WF Grays 1	L	R
Grays 1E tidal	L	R
Malone Cr Lower	L	PR
Grays 1C tidal	L	R
WF Grays 2	L	PR
Thadbar Cr Lower	L	R
Honey Cr Lower	L	R
Beaver Cr	L	PR
King Cr	L	PR
Impie Cr Lower	L	R
Honey Cr	L	PR
Grays 1D tidal	L	R
Grays 1B tidal	L	PR
Nikka Cr	L	PR
Grays 1 tidal	L	R
Klints Cr	L	PR
Thadbar Cr	L	PR
Malone Cr	L	PR
Seal Slough 1	L	R
WF Grays 4	L	PR
Impie Cr	L	R
Hull Cr 2	L	R
Fossil Cr	L	PR
Seal Slough 2	L	R

Figure 4-13. Grays River subbasin coho ladder diagram.

4.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The top priority restoration areas for winter steelhead are in upper sections of the subbasin, which suffer primarily from impacts to flow, sediment, temperature, and habitat diversity (Figure 4-14). Flow and sediment impacts are believed to originate primarily from upper basin timber harvest, roads, and naturally unstable soils. The land ownership in the basin is predominantly private (90%) and most of the upper basin is in timber production. Road densities in upper basin subwatersheds are between 4 and 7 mi/mi^2. This area represents one of the highest concentrations of densely roaded subwatersheds in the entire lower Columbia region. Roads and timber harvest, combined with unstable sedimentary soils, result in a proliferation of mass wasting. Soil survey reports have indicated as many as 4.22 mass failures/mi^2 in the basin (Wade 2002). Channel stability, temperature, and habitat diversity are largely influenced by the poor condition of riparian forests. There is little shade provided by tree canopies and there is low LWD recruitment. The moderate impact from predation is due to a recently discontinued (2000) steelhead and coho rearing facility in Grays 3B. The population is expected to be recovering from these impacts. The South Fork Grays has high sediment impacts from channel and upslope sources. The South Fork basin is steep, with unstable soils, and has experienced intensive timber harvest. High flow impacts in the South Fork basin are related to high road densities and young vegetation. Approximately 17% of the basin is in early seral conditions and 0% is in late seral. Road densities are over 4 mi/mi^2. Temperature and habitat diversity impacts are related primarily to degraded riparian zones and lack of LWD. Key habitat has been impacted by sedimentation and loss of instream LWD that is important for maintaining habitat.

The top chum restoration priority is in the lower river (Grays 2B, 2C and 2D). Sediment and habitat diversity are the major factors (Figure 4-15). Sediment and the moderate flow impact are from upstream sources and contribute to sediment aggradation and bed scour that reduce channel stability. The lower gradient, alluvial nature of these channels makes them prone to excess sedimentation. Habitat diversity is due to artificially confined channels, low quantities of LWD, and denuded riparian conditions. Local agricultural practices have confined channels, reduced riparian vegetation, and reduced floodplain function. Seventy-nine percent of the subwatersheds that encompasses reaches Grays 1 tidal upstream into Grays 2 are either non-forest (pavement, bare soil, structures) or other forest (shrubs, lawns, pasture, cropland). Low to moderate predation and competition impacts stem from Grays River Hatchery releases.

Fall chinook restoration priorities are similar to chum, as many of the same habitats are utilized (Figure 4-16). Sediment and temperature are the major factors. The major land uses affecting chinook are the same as the ones discussed above for chum.

As for coho, restoration priorities again focus in the lower river (Grays 2, 2A, 2B, 2C, 2D, and Grays 1G tidal (Figure 4-17). In these areas channel stability, temperature, sediment, and key habitat quantity are the major factors affecting coho.

Grays Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
WF Grays 2	●	⬤	⬤	•					⬤	⬤	•			●		●
EF Grays 1	●	●	●	●					⬤	⬤	•			•		•
SF Grays 1	●	⬤	⬤	●					⬤	⬤	•			●		●
WF Grays 3		●	⬤	•					●	⬤	•			•		●
WF Grays 1 Lower	●	⬤	⬤	●					⬤	⬤	•			⬤		•
Grays 3B	●	⬤	⬤	•		•			⬤	⬤	•			●		•
Blaney Cr 1	●	⬤	●	•					⬤	⬤	•			•		●
WF Grays 1	•	●	●	●		●			●	⬤	•			●		●
EF Grays 3	●	●	●	•					⬤	⬤	•			•		●
Grays 2B	•	●	●	●		•			•	●	•			•		
Grays 4A	●	⬤	●	•					●	⬤	•			•		●
Grays 4B	●	⬤	●	•					⬤	⬤	•			•		●
Beaver Cr	•	⬤	•	•					●	⬤	•			•		⬤
SF Grays 2	●	●	●	•					●	⬤	•			•		⬤
Grays 2C	•	●	●	●		•			•	●	•			•		
SF Grays 3	●	⬤	●	•					●	⬤	•			•		⬤
EF Grays 6	•	●	•	•					●	⬤	•					●
Fossil Cr Lower	•	●	●	•		•			●	●	•			•		•
Grays 3C	•	●	●	•					●	⬤	•			•		●
Grays 4C	•	⬤	●	•					●	⬤	•			•		⬤
Grays 3	•	●	●	•		•			●	●	•			•		●
Grays 4	•	●	●	•					●	●	•			•		•
Grays River (RF)	•	⬤	•	•					●	⬤	•			•		⬤
Grays 2A	•	●	●	●		•			•	●	•			•		
Grays River (LF)	•	●	●	•					●	⬤	•			•		⬤
WF Grays 4	•	⬤	•						●	●						●
EF Grays 4	•	●	•	•					●	●	•					•
Fossil Cr	•	●	●	•		•			●	⬤	•			•		⬤
Mitchell Cr	•	●	●	•					●	⬤	•			•		●
EF Grays 2	•	●	●	•					●	●	•					•
Hull Cr 1	●	●	●	•	•	•		•	●	●	•			•		•
Hull Cr 2	•	●	●	•		•			●	●	•			•		●
Grays 2D	•	•	•	•					•	●				•		
EF RB trib 1 (not listed)	•	•	•	•					●	⬤	•					●
Grays 3A	•	●	●	•		•			●	●	•			•		•
EF Grays 7	•	●	•	•					●	⬤	•					●
Cabin Creek	•	●	•	•					●	●	•					●
EF Grays 5	•	●	•	•					●	●	•					•
WF Grays 5	•	●	•						●	●						⬤
Blaney Cr 2	•	●	•	•					●	●	•					●
Johnson Creek 1	•	•	•	•					●	⬤	•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ＋ High Positve Impact ✚

Figure 4-14. Grays River subbasin winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Grays Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Grays 2D	●	⬤	•	•					●	⬤	●					+
Grays 2B	●	⬤	•	●					●	⬤	●				●	•
Grays 2C	●	⬤	•	●					●	⬤	●				●	•
WF Grays 1 Lower	•	⬤	•						●	●	•				•	⬤
Crazy Johnson																●
Fossil Cr Lower	•	⬤							●	●	•					•
Klints Cr Lower	•	●	•						●	⬤	●					•
Grays 2	●	●	•	•	•				●	●	•				•	•
Grays 2A	●	●	•	•					●	⬤	•				•	•
Mainstem LB trib 1 (25.0105)	•	⬤							●	●	•					●
King Cr Lower	•	⬤			•				●	●	•					•
WF Grays 1	•	●	•	•					●	●	•					⬤
Thadbar Cr Lower	•	●			•				●	●	•					•
Grays 1G tidal	•	●	•	•	•				•	●	•				•	•
Nikka Cr Lower	•	●			•				•	●	•					•
Impie Cr Lower	•	●			•				•	●	•					•
Hull Cr 1	•	●			•				•	●	•					●
Gorley Creek 2																•
WF Grays 2	•	●							•	●	•					⬤
Mainstem LB trib 2 (25.0107)	•	●							•	●	•					•
Gorley Creek 1			●							⬤	●					•
Grays 1B tidal	•	●		•	•				•	•	•				•	•
Grays 1F tidal	•	•		•	•				•	•	•				•	•
Hull Cr 2	•	●							•	•	•					●
Grays 1C tidal	•	•		•	•				•	•	•				•	•
Seal Cr	•	●			•				•	●	•					•
Grays 1D tidal	•	•		•	•				•	•	•				•	•
Grays 1 tidal	•	●		•	•				•	•	•				•	•
Grays 1E tidal	•	•		•	•				•	•	•				•	•
Seal Slough 1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 4-15. Grays subbasin chum habitat factor analysis diagram.

Grays Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Grays 2	●	•	●	•					•	⬤	•					✚
Grays 2C	●	•	⬤						•	⬤						✚
Grays 2A	●	•	⬤	•					•	⬤	•					✚
Grays 1G tidal	●	•	⬤	•	•	•			•	⬤	•					+
Grays 2B	●	•	⬤	•					•	⬤	•					✚
WF Grays 1 Lower	●	●	●	•					•	⬤						⬤
Grays 1F tidal	●	●	•	●	•	•			●	●	●				•	•
Grays 1E tidal	●	•	•	●	•	•			•	●	•				•	•
Grays 1D tidal	•	•	•	•	•	•			•	●	•				•	•
Grays 1C tidal	•	•	•	•	•	•			•	•	•				•	•
Grays 1B tidal	•	•	•	•	•	•			•	•	•				•	•
Grays 1 tidal	•	•	•	•	•	•			•	•	•				•	•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 4-16. Grays fall chinook habitat factor analysis diagram.

Grays Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Grays 2C	⬤	●	⬤	●		●			●	⬤	●			•		⬤
Grays 2B	⬤	●	⬤	●		●			●	⬤	●			•		●
Grays 2A	⬤	●	⬤	●		●			●	⬤	●			•		⬤
Grays 1G tidal	⬤	●	⬤	⬤	•	●		•	●	⬤	●			•		●
Grays 2	⬤	●	⬤	●	•	●			●	⬤	●			•		⬤
Grays 2D	⬤	●	●	•		•			●	⬤	•			•		
WF Grays 1 Lower	●	⬤	•						•	●	•			•		●
WF Grays 3	●	●	•						•	●						●
Grays 1F tidal	●	●	●	●	•	●		•	●	●	●			•		●
Gorley Creek 1			●	•					•	●	•					●
Fossil Cr Lower	•	●	•						•	●	•					
Hull Cr 1	●	●	•						•	●	•					●
Klints Cr Lower	•	•	•						•	●	•					•
King Cr Lower	•	●	•						•	●	•					•
Gorley Creek 2			•	•					•		•					●
Nikka Cr Lower	•	●	•			•			•	●	•					•
WF Grays 1	•	●	•	•		•			•	●	•			•		●
Grays 1E tidal	•	●	●	●	•	•			●	•	•			•		•
Malone Cr Lower	•	•	•						•	●	•					•
Grays 1C tidal	•	•	●	●	•	•			•	•	•			•		•
WF Grays 2	•	•							•	•						•
Thadbar Cr Lower	•	●	•						•	●	•					•
Honey Cr Lower	•	•	•						•	●	•					•
Beaver Cr	•	•							•	•						•
King Cr	•	•	•						•	●	•					●
Impie Cr Lower	•	•	•						•	●	•					•
Honey Cr	•	•							•	●	•					●
Grays 1D tidal	•	•	●	●	•	•			•	•	•			•		•
Grays 1B tidal	•	•	•	•		•			•	•	•			•		•
Nikka Cr	•	•	•						•	●	•					●
Grays 1 tidal	•	•	•	•		•			•	•	•			•		•
Klints Cr	•	•							•	•	•					●
Thadbar Cr	•	•							•	•	•					●
Malone Cr	•	•	•						•	●	•					●
Seal Slough 1	•	•	●	•	•				•		•					•
WF Grays 4	•	•							•	•						•
Impie Cr	•	•	•						•	•	•					●
Hull Cr 2	•	•							•	•						•
Fossil Cr	•	•							•	●						●
Seal Slough 2	•	•	•	•	•				•		•					

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positive Impact ✛ High Positive Impact ✚

Figure 4-17. Grays coho habitat factor analysis diagram.

4.7 Integrated Watershed Assessment

The Grays River Subbasin encompasses 124 mi^2, making up 17 subwatersheds. The dominant land-use in the subbasin is private commercial timber production. Less than 10% of the land is under public ownership and the highest amount of public ownership within any individual subwatershed is only 55%. Most of the public land lies in the Hull Creek (30402) and SF Grays (30301 and 30303) drainages, and nearly all of it is under WDNR management. Other land-uses include small amounts of rural residential and commercial/industrial.

4.7.1 Results and Discussion

IWA results for the Grays River watershed are shown in Table 4-2. As indicated, IWA results are calculated for each subwatershed at the local level (i.e., within a subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A reference map showing the location of each subwatershed in the basin is presented in Figure 4-18. Maps of the distribution of local and watershed level IWA results are displayed in Figure 4-19.

Table 4-2. IWA results for the Grays River Watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30101	I	M	M	M	M	30104
30102	I	I	M	I	I	30105
30103	I	M	M	I	M	30101, 30102, 30104, 30105
30104	M	M	F	M	M	none
30105	I	M	M	I	M	none
30201	I	I	M	I	M	30202
30202	I	I	M	I	I	none
30301	I	M	M	M	M	30303
30302	I	M	M	I	M	30101, 30102, 30103, 30104, 30105, 30301, 30303
30303	M	M	F	M	M	none
30401	I	I	I	I	M	30101, 30102, 30103, 30104, 30105, 30201, 30202, 30301, 30302, 30303, 30402, 30403
30402	I	M	M	I	M	none
30403	I	M	M	I	M	30101, 30102, 30103, 30104, 30105, 30201, 30202, 30301, 30302, 30303
30404	I	M	M	I	M	none
30405	F	M	M	F	M	none
30406	F	M	I	I	M	30101, 30102, 30103, 30104, 30105, 30201, 30202, 30301, 30302, 30303, 30401, 30402, 30403
30407	I	I	I	I	I	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

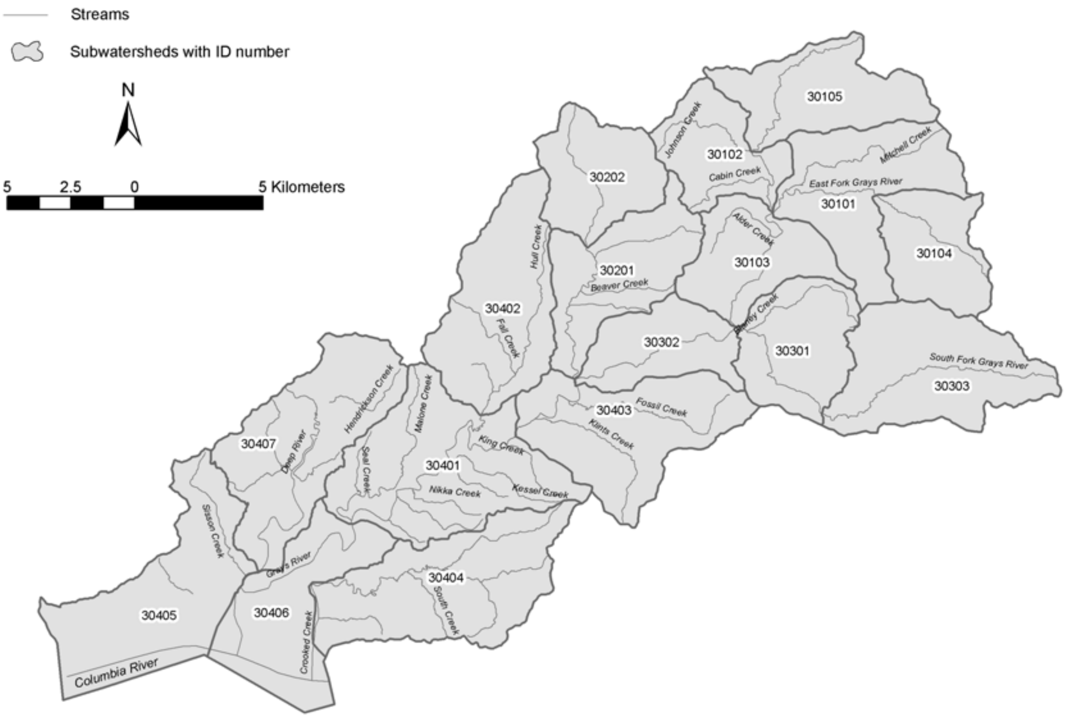


Figure 4-18. Map of the Grays basin showing the location of the IWA subwatersheds.

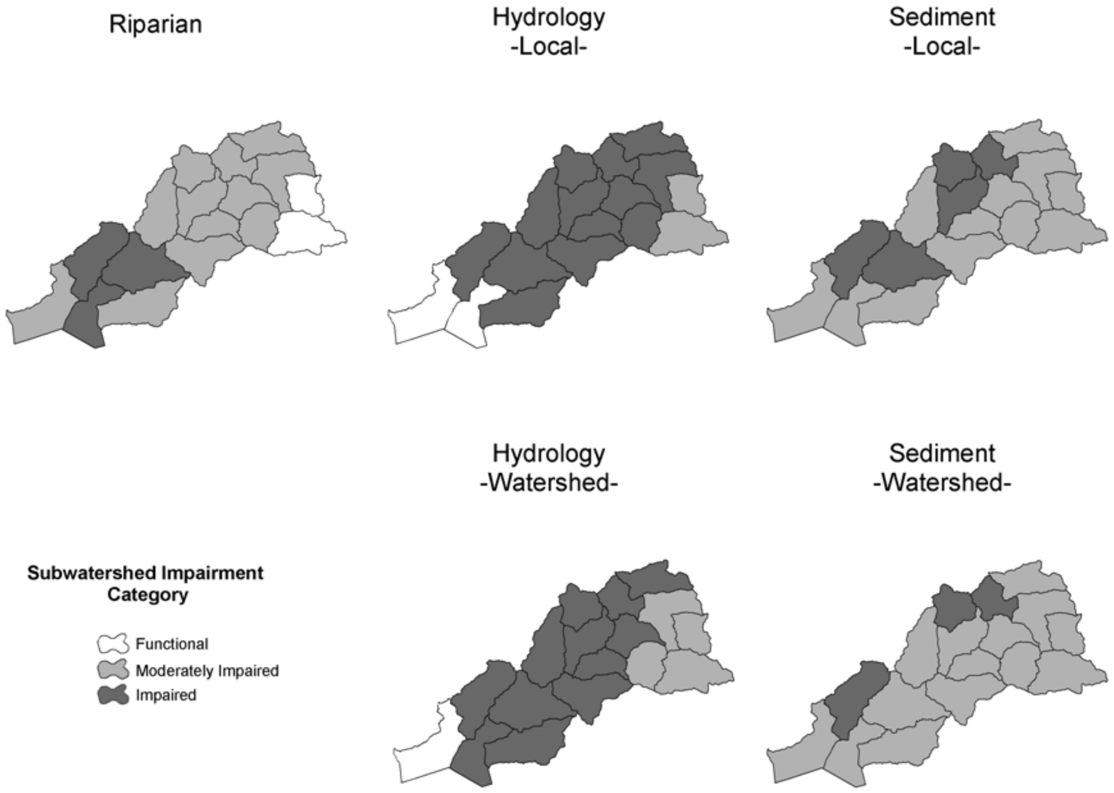


Figure 4-19. IWA subwatershed impairment ratings by category for the Grays basin

4.7.1.1 Hydrology

Functional hydrologic conditions are distributed exclusively along the mainstem Columbia, incorporating the lower reaches of the Grays River, Deep River, and assorted small tributaries (30503, 30405, 30406). Moderately impaired hydrologic condition ratings are located within the upper reaches of the East Fork and South Fork of the Grays River (30104, 30303). The rest of the subwatersheds have an impaired IWA hydrology rating.

For the most part, the watershed level hydrology ratings are consistent with the local ratings. Possibly the most significant watershed level effect is apparent in subwatershed 30406, at the mouth of the Grays River. The hydrologic condition rating is downgraded to impaired from a functional rating at the local level. This is due to the overwhelming predominance of impaired hydrologic conditions upstream. However, it should be noted that the subwatershed is largely within the slough-like, tidally influenced portion of the river. This suggests that upstream effects may not be as severe as the IWA watershed level rating may suggest. A second, notable change in hydrologic rating occurs in the upper East and South Forks of the Grays River, where two downstream subwatersheds are upgraded into the moderately impaired category (30101, 30301) due to effects from their headwater subwatersheds.

4.7.1.2 Sediment Supply

With respect to sediment conditions, there are no subwatersheds within the Grays River Planning watershed classified as functional. The large majority (12) are characterized as moderately impaired, with the balance rated as impaired (5). Impaired conditions can be found throughout the WF Grays River drainage (30201 and 30202), the Deep River drainage (30407), and in the Grays mainstem – Malone Creek subwatershed (30401). It should be noted that the natural levels of erodability are low to moderate within the watershed, scoring an area-adjusted composite rating of 16 on a scale of 0-126. Current, “managed” conditions have elevated that value substantially to near 40, but the overall erodability is still moderate

As with hydrologic conditions, watershed level sediment conditions do not change drastically from the local level. The lower West Fork Grays subwatershed (30201) improves to a moderately impaired rating, as does the Grays – Malone Creek subwatershed (30401) due to upstream inputs.

4.7.1.3 Riparian

Functional riparian conditions are found in two subwatersheds, while 12 subwatersheds are rated as moderately impaired, and three are classified as impaired. As with hydrologic conditions, the headwaters of the South and East Forks of the Grays River (30308 and 30101) have functional ratings, whereas the Deep River subwatershed (30407) is categorized as impaired. According to IWA, the estuarine subwatershed at the mouth of Crooked Creek and the Grays River also has impaired riparian conditions.

4.7.2 Predicted Future Trends

4.7.2.1 Hydrology

All of subwatershed 30101 (Mitchell Creek and East Fork Grays River) is in private holdings, and primarily used for timber production. Hydrologic conditions are unlikely to improve in the short term with existing high road densities (6.0 mi/mi^2), stream crossing densities (4.3 crossings/stream mile), and only moderate mature forest coverage (45%). Improved forest practices may lead to improved conditions over the long term.

Approximately one third of subwatersheds 30301 and 30303 on the South Fork are in public hands, managed by the WDNR. Road densities on these timberlands are high, although streamside road density is relatively low. Hydrologic conditions are likely to improve or remain stable.

The upper mainstem subwatersheds (30105, 30102, 30103, 30302) are uniformly rated as hydrologically impaired. These subwatersheds have very high stream crossing densities (5.0-7.6 crossings/stream mile), high road densities, and roughly 33% mature forest cover. These key subwatersheds likely will take a long time to recover from past forestry and road building activities.

Lower mainstem subwatersheds are also almost exclusively under private ownership with variable stream crossing densities, ranging from a high of 5.1 crossings/stream mile in 30403 to a low of 2.2 in the tidally influenced area within 30406. Road densities in general show a similar pattern. Conditions in subwatersheds 30403 and 30401 are substantially degraded and hydrologic conditions will take some time to recover. Subwatershed 30406 is composed primarily of wetlands (86%), lending hydrologic integrity and resilience to this subwatershed if wetlands are adequately protected. It should be noted, however, that despite a functional rating in the IWA, 30406 contains extensive diking and other channel revetments. The Columbia Land Trust is actively negotiating on over 800 acres of land in the lower Grays River and Deep River watershed, including subwatershed 30406. Restoration goals include removing tidegates and dikes to reconnect the river with the floodplain to benefit salmon and a host of other fish and wildlife species. These projects have been identified as some of the most important conservation work in the Columbia River estuary.

4.7.2.2 Sediment Supply

Watershed level sediment condition ratings are moderately impaired in all subwatersheds encompassing important anadromous stream reaches, with the exception of 30102 along the upper mainstem where conditions are rated as impaired. Along the East and South Fork, as well as in the upper mainstem subwatersheds, natural erodability levels are quite low, ranging from 5-18 on a scale of 0-126. Managed erodability levels are certainly higher, but all remain in the low or moderate categories, ranging from 3-43 on the erodability index. As described in the hydrology section above, land-use intensity is quite high in these upper areas, as measured by the density of roads, stream crossings and the level of timber harvest activities. Sediment conditions are unlikely to improve over the short term, with the possible exception of certain publicly managed timber parcels on the South Fork (30301, 30303).

Along the lower mainstem, current condition ratings are exceptionally poor in subwatersheds 30403 and 30401 with respect to land-use intensity as described above. Managed erodability is exceedingly high in subwatershed 30401 at 97 points on the index (scale of 0-126). Sediment conditions in these subwatersheds are unlikely to improve in the near future.

Although sediment conditions are rated as moderately impaired in subwatershed 30406, the estuarine character of the subwatershed, coupled with low road and stream side road density, high proportion of wetlands and ongoing efforts to protect the tidal areas, suggest that conditions in this subwatershed may improve over the next 20 years.

4.7.2.3 Riparian Condition

Riparian conditions are rated moderately impaired to impaired throughout the majority of the Grays River Subbasin, with only two subwatersheds rated as functional (30303- SF Grays headwaters & 30104- EF Grays headwaters). New forestry regulations should allow for recovery of riparian corridors over time.

The most impaired ratings are found in the estuary and lower river (30406, 30401), where the majority of the mainstem has been channelized through diking and most side-channel habitat has been lost. The presence of dikes and other channel revetments reduces the potential for riparian recovery. However, conservation easements and other public-private partnerships (such as those already being developed by the Columbia Trust) offer some promise that floodplain dynamics and riparian conditions in this estuarine area may improve over the next 20 years.

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Volume II, Chapter 5
Elochoman Subbasin

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5.0 Elochoman Subbasin

For the purposes of this analysis, the Elochoman subbasin includes the Elochoman, Skamokawa, Mill, Abernathy, Germany, and other smaller tributaries in the vicinity.

5.1 Subbasin Description

5.1.1 Topography & Geology

Streams in the Elochoman Subbasin originate in the Willapa Hills in southwest Lewis County and northeast Cowlitz County, and flow generally south to the Columbia. The subbasin area is approximately 315 mi^2. From west to east, the stream systems include Jim Crow Creek, the Skamokawa River, Brooks Slough, the Elochoman River, Birnie Creek, Mill Creek, Abernathy Creek, Germany Creek, Fall Creek, Coal Creek, Clark Creek, and the Longview Ditch network. The highest elevation lies at the head of the Elochoman basin at 2,673 feet and the lowest is near sea level on the Columbia. The surface geology is a combination of volcanic and sedimentary materials. Less than 20% of the soils are classified as highly erodible.

5.1.2 Climate

The subbasin has a typical northwest maritime climate. Summers are dry and cool and winters are mild, wet, and cloudy. Most precipitation falls between October and March, with mean annual precipitation ranging from 45-118 inches with an average mean of 70-85 inches. Snowfall is light and transient owing to the relative low elevation and moderate temperatures. Less than 10% of the basin area is within the rain-on-snow zone or higher (WDNR data).

5.1.3 Land Use/Land Cover

Forestry is the predominant land use in the Elochoman subbasin. Considerable logging occurred in the past without regard for riparian and instream habitat, resulting in sedimentation of salmonid spawning and rearing habitat (WDF 1990). Nearly 0% of the forest cover is in late-seral stages, however, as the forest matures, watershed conditions are recovering. Agriculture and residential land use is located along lower alluvial stream segments of the Skamokawa, Elochoman, Mill, Abernathy, and Germany Creeks. Skamokawa and Cathlamet are the two largest population centers. Projected population change from 2000 to 2020 for unincorporated areas in WRIA 25 is 37% (LCFRB 2001). The subbasin is primarily in private ownership, as shown in the following chart. The bulk of the private land is industrial forestland and road densities are high. The extent of the road network has important implications for watershed processes such as flow generation, sediment production, and contaminant transport. A breakdown of land ownership and land cover in the Elochoman basin is presented in Figure 5-1 and Figure 5-2. Figure 5-3 displays the pattern of landownership for the Elochoman basin and Figure 5-4 displays the pattern of land cover / land-use.

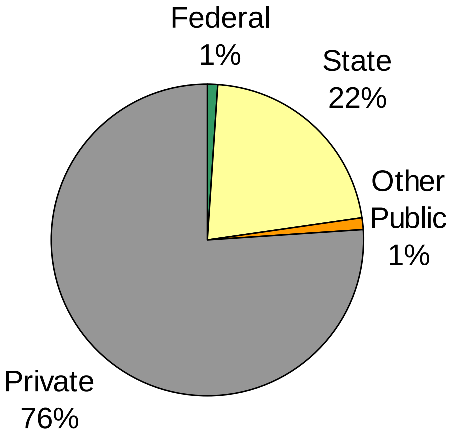


Figure 5-1. Elochoman River subbasin land ownership (includes Skamokawa, Elochoman, Mill, Abernathy, and Germany Creeks)

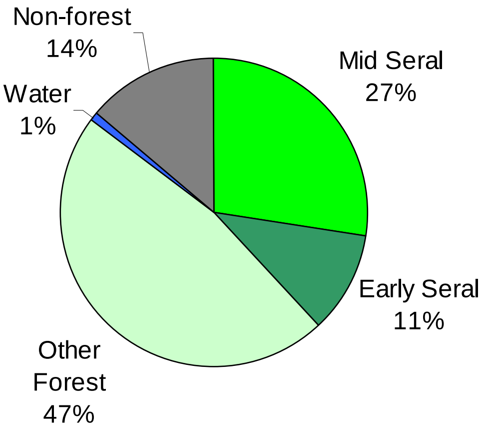


Figure 5-2. Elochoman River subbasin land cover. (includes Skamokawa, Elochoman, Mill, Abernathy, and Germany Creeks)

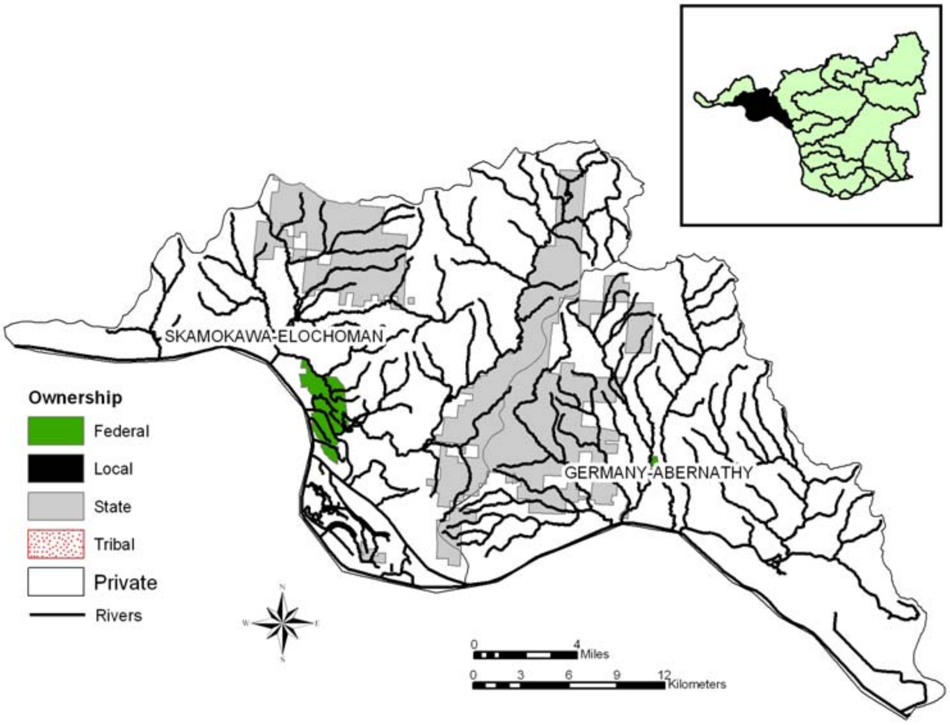


Figure 5-3. Landownership within Elochoman basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

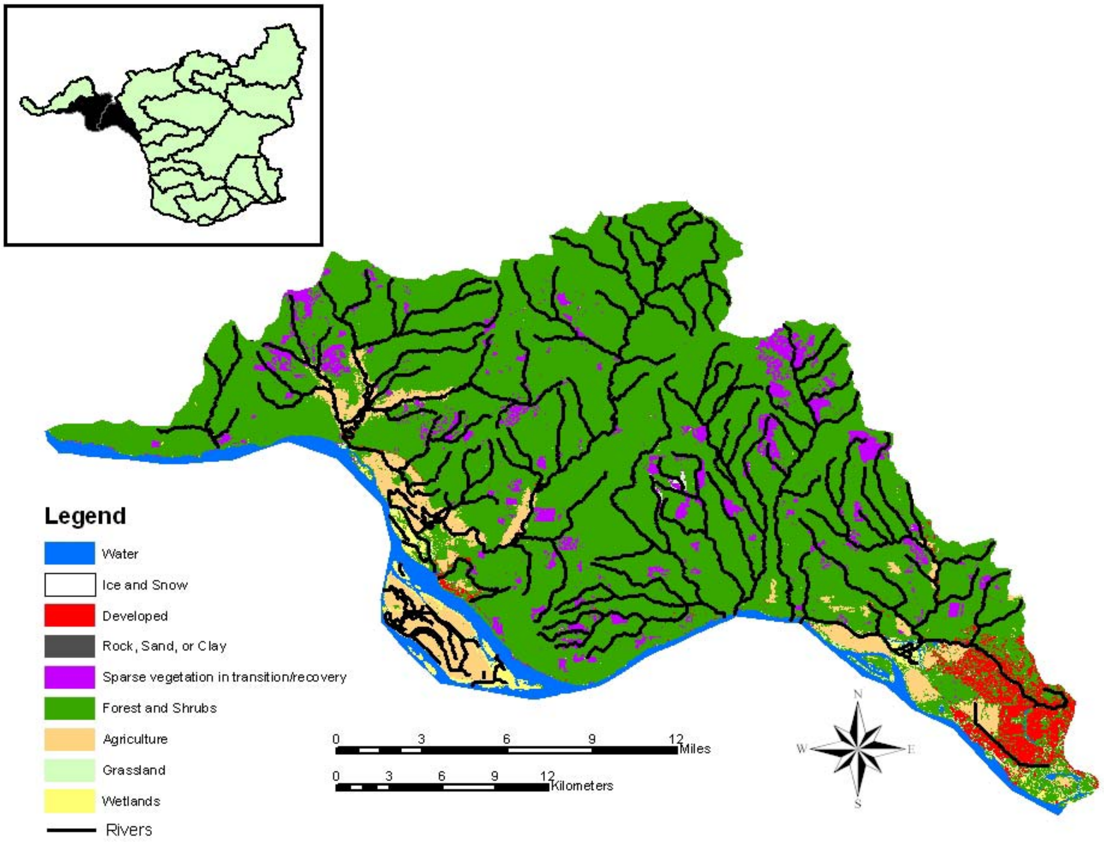
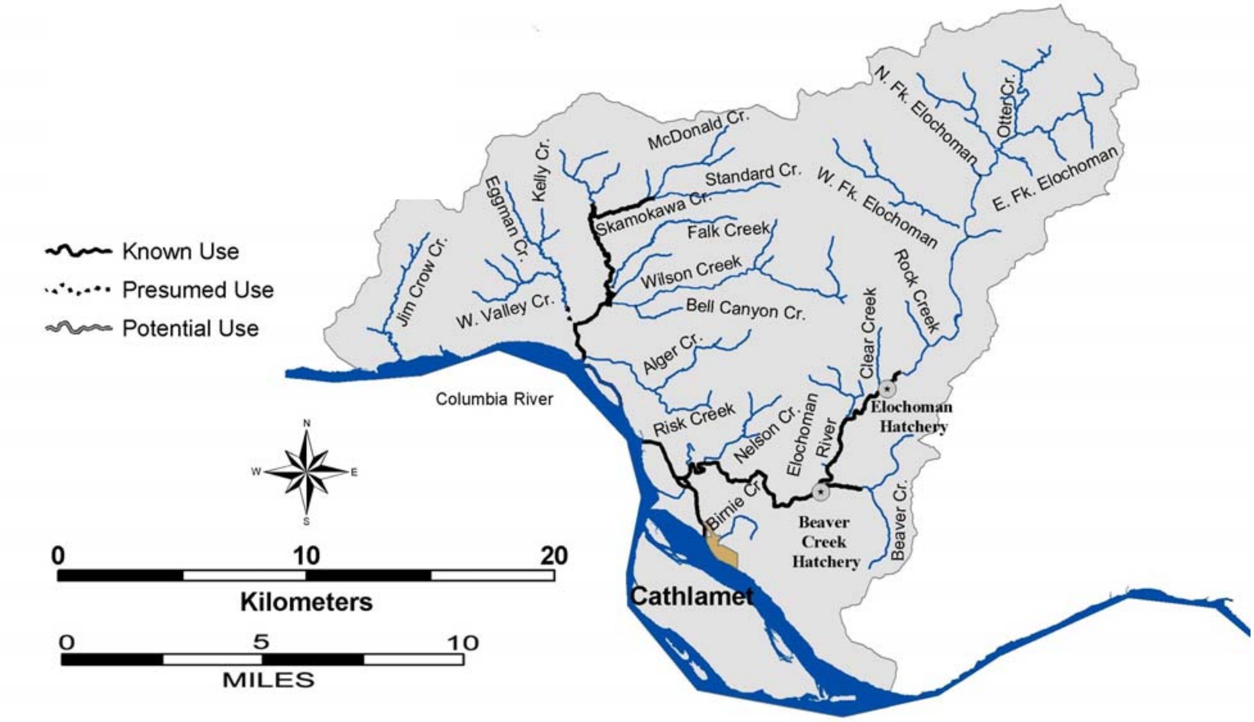


Figure 5-4. Land cover within the Elochoman basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

5.2 Focal Fish Species

5.2.1 Fall Chinook—Elochoman Subbasin (Elochoman/Skamokawa)

ESA: Threatened 1999 **SASSI: Elochoman—Healthy; Skamokawa - Depressed 2002**



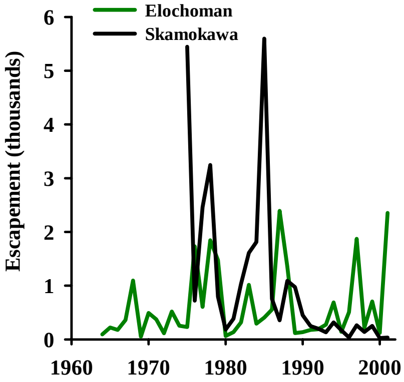
Distribution

- Spawning occurs in the lower mainstem Elochoman between RM 4 and 9 (downstream of the Elochoman Hatchery)
- Spawning occurs in the mainstem Skamokawa from Wilson Creek upstream to Standard and McDonald Creeks (4.5 miles)

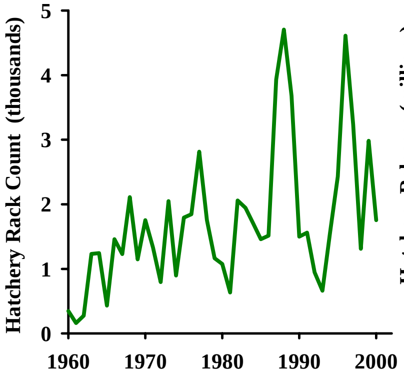
Life History

- Columbia River tule fall chinook migration occurs from mid August to mid September, depending partly on early fall rain
- Natural spawning occurs between late September and late October, peaking in mid-October
- Elochoman fall chinook age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4 (averages are 46.7% and 38.4%, respectively)
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the late spring/summer as sub-yearlings

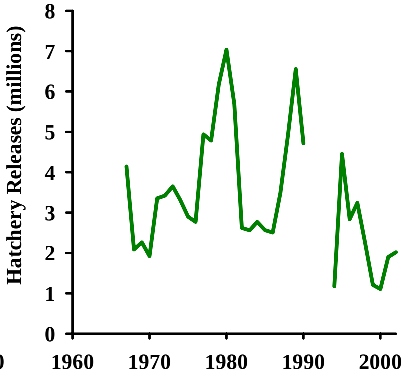
Fall chinook spawner escapement surveys for the Elochoman and Skamokawa Rivers, 1964-2001



Fall chinook Elochoman Salmon Hatchery rack counts, 1960-2000



Fall chinook Elochoman Salmon Hatchery release data, 1967-2002



Diversity

- Considered a tule population in the lower Columbia River Evolutionarily Significant Unit
- Elochoman fall chinook were historically native to the system while the Skamokawa chinook population is likely a result of stray hatchery produced spawners from recent decades
- Allozyme analyses indicate Elochoman fall chinook allele frequencies are similar but distinct from other lower Columbia River fall chinook stocks

Abundance

- In 1951, WDF estimated fall chinook escapement to the Elochoman River was 2,000 fish
- Elochoman River spawning escapements from 1964-2001 ranged from 53 to 2,392 (average 624)
- Skamokawa Creek spawning escapements from 1964-2001 ranged from 25 to 5,596 (average 1,065); natural spawners were primarily hatchery origin strays from other Columbia basin systems

Productivity & Persistence

- NMFS Status Assessment for the Elochoman River indicated a 0.13 risk of 90% decline in 25 years and a 0.14 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.03
- Juvenile production from natural spawning is presumed to be low
- Skamokawa production is presumed to be very low as most adult spawners can be accounted for as first generation hatchery fish

Hatchery

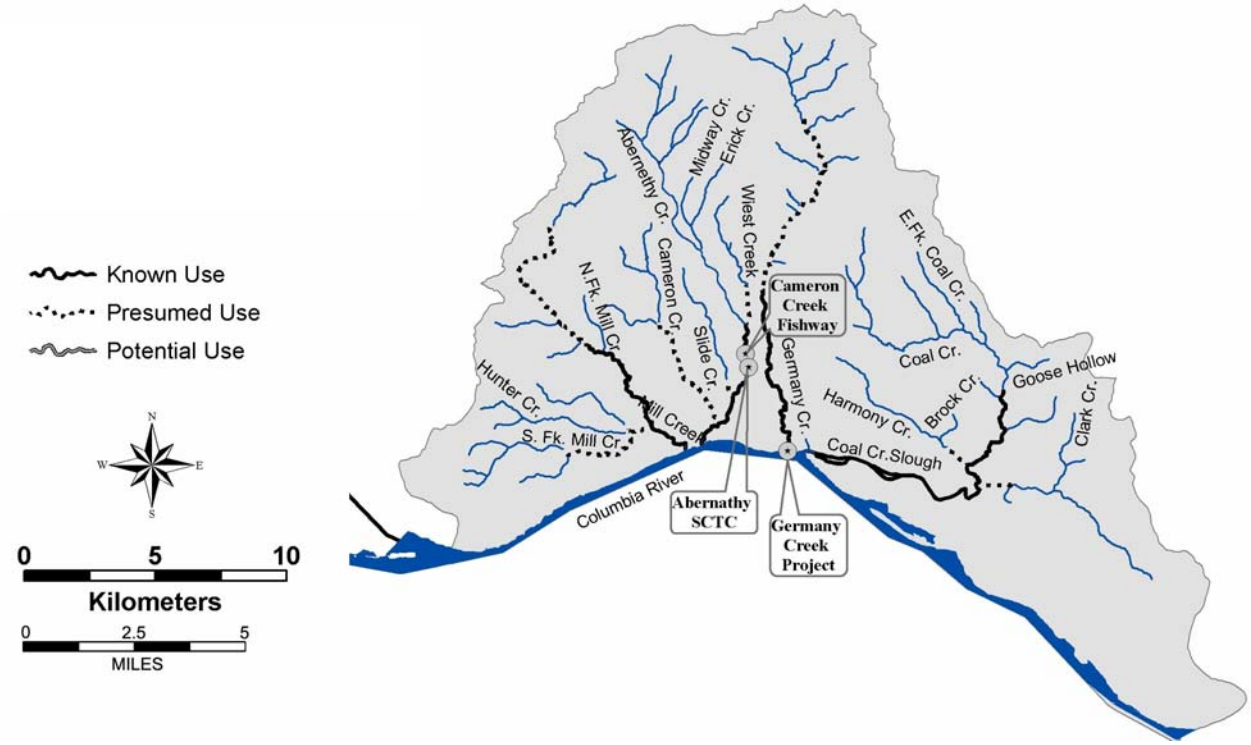
- Elochoman Hatchery located about RM 9; hatchery completed 1953
- Hatchery releases of fall chinook in the basin began in 1950; release data is displayed for the years 1967-2002
- The current program releases 2 million fall chinook juveniles annually into the Elochoman River; there are no hatchery fish released into Skamokawa Creek
- The majority of recent year natural spawners in the Elochoman River can be accounted for as hatchery produced adults that were passed above a weir in the lower river and spawned naturally (82% hatchery produced spawners estimated in 1997)
- Abernathy Hatchery is not utilized by USFWS as a fishery research facility

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are an important contributor to Washington ocean troll and sport fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; the price is low compared to higher quality bright stock chinook
- CWT data analysis of the 1991-94 brood years from the Elochoman Hatchery indicates a total harvest rate of 35% of the Elochoman fall chinook stock
- The majority of the Elochoman fall chinook harvest occurred in Southern British Columbia (34%), Alaska (36%), Washington ocean (11%), and Columbia River (9%) fisheries
- Sport harvest in the Elochoman River averaged 95 fall chinook annually from 1981-1988
- Annual harvest is variable dependent on management response in PSC (U.S./Canada), PFMC (U.S. ocean), and Columbia River Compact Forums
- Ocean and mainstem Columbia harvest of Elochoman fall chinook is limited by an ESA harvest limit of 49% for Coweeman tule fall chinook

5.2.2 Fall Chinook—Elochoman Subbasin (Mill/Abernathy/Germany)

ESA: Threatened 1999 **SASSI: Mill/Germany - Depressed 2002; Abernathy - Healthy 2002**

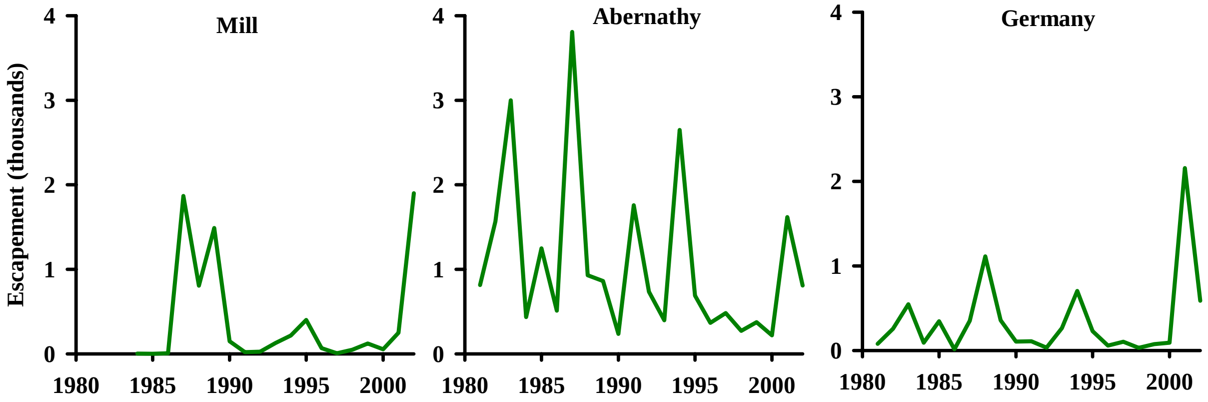


Distribution

- Spawning in Mill Creek occurs from the Mill Creek Bridge downstream to the mouth (2 miles)
- Spawning in Abernathy Creek occurs from the Abernathy Creek NFH to the mouth (3 miles)
- Spawning in Germany Creek occurs from the mouth to 3.5 miles upstream

Life History

- Columbia River fall chinook migration occurs from mid August to early September, depending partly on early fall rain
- Natural spawning occurs between late September and mid October, usually peaking in early October
- Age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4 (averages are 39.9% and 43.4%, respectively); sexually mature 1-year old males have been found in Abernathy and Germany Creeks
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the late sring/summer as sub-yearlings
- Based on life history and run timing, fall chinook in these creeks resemble Spring Creek Hatchery stock more then lower Columbia fall chinook



Fall chinook spawner Escapement for Mill, Abernathy, and Germany creeks, 1981-2002

Diversity

- Considered a tule fall chinook population in the lower Columbia River Evolutionarily Significant Unit
- Records indicate that fall chinook may not have been present historically in these tributaries. Natural spawning returns have been highly influenced by Spring Creek Hatchery stock released from Abernathy hatchery during 1974-94
- Mill, Abernathy, and Germany Creek stocks designated based on distinct spawning distribution
- Allele frequencies of Abernathy Creek chinook from 1995, 1997, and 1998 were significantly different from other lower Columbia River chinook stocks, except Kalama Hatchery fall chinook

Abundance

- Fall chinook may not be native to Mill, Abernathy, or Germany Creeks; hatchery production
Fall chinook may not be native to Mill, Abernathy, or Germany Creeks; hatchery production and straying has contributed heavily to returns
- Mill Creek spawning escapements from 1986-2002 ranged from 2 to 1,900 (average 409)
- Abernathy Creek spawning escapement from 1981-2002 ranged from 200 to 3,807 (average 1,081)
- Germany Creek spawning escapement from 1981-2002 ranged from 15 to 2,158 (average 340)
- WDFW captured 910 fall chinook juveniles in ten seining trips to Abernathy Creek in 1995

Productivity & Persistence

- NMFS Status Assessment for Mill Creek indicated a 0.53 risk of 90% decline in 25 years and a 0.77 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.4
- NMFS Status Assessment for Abernathy Creek indicated a 0.01 risk of 90% decline in 25 years and a 0.17 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- NMFS Status Assessment for Germany Creek indicated a 0.09 risk of 90% decline in 25 years and a 0.15 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- Juvenile production from natural spawning is presumed to be low

Hatchery

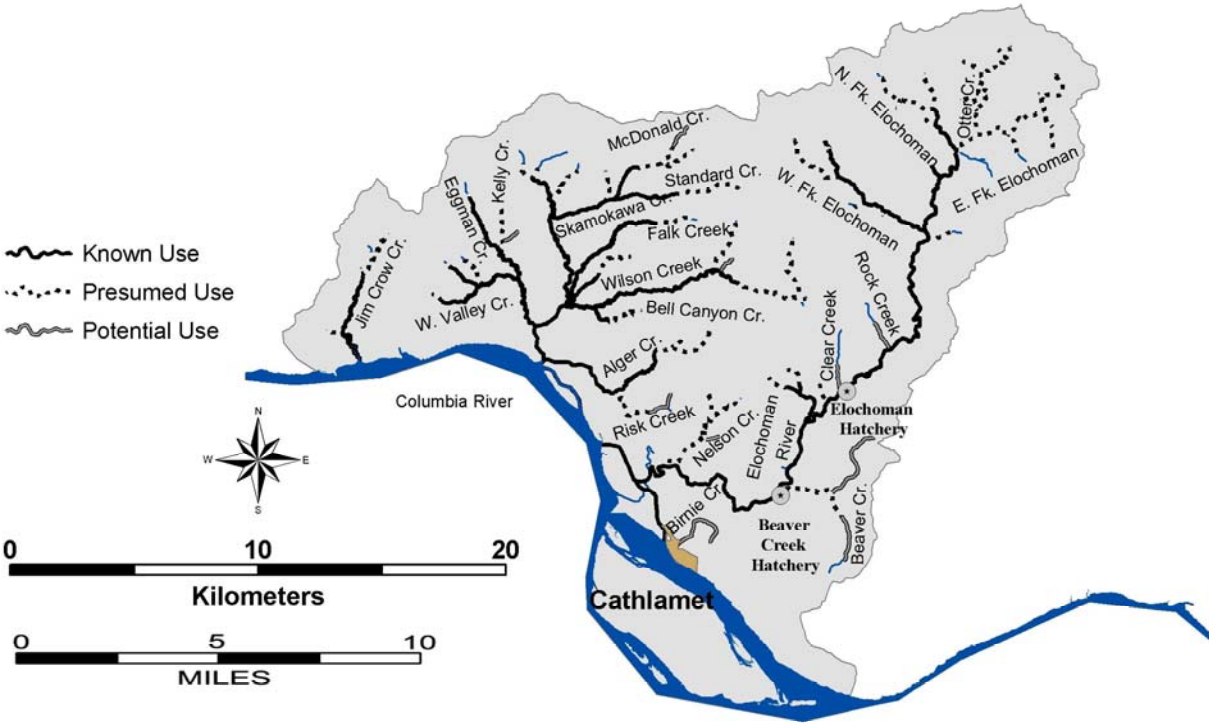
- The Abernathy Creek NFH released about 1 million fall chinook per year over a 21 year period (1974-1994); another 15,278,638 fall chinook were released in Abernathy Creek from 1960-1977 from other hatchery programs; broodstock largely derived from Spring Creek NFH chinook
- The Abernathy Creek NFH fall chinook program was discontinued in 1995 because of federal funding cuts

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Lower Columbia River tule fall chinook are an important contributor to Washington ocean sport and troll fisheries and to the lower Columbia estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; price is low compared to higher quality bright chinook stocks
- CWT data analysis of the 1976 brood year suggests that the majority of the lower Columbia River Hatchery fall chinook stock harvest occurred in Southern British Columbia (40%), Columbia River (18.0%), and Wahington ocean (17%) fisheries
- Annual harvest is dependent on management response to annual abundance in PSC (U.S./Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- Harvest is constrained by Coweeman fall chinook total ESA exploitation rate of 49%

5.2.3 Coho—Elochoman Subbasin (Elochoman/Skamokawa)

ESA: Candidate 1995 **SASSI: Unknown 2002**



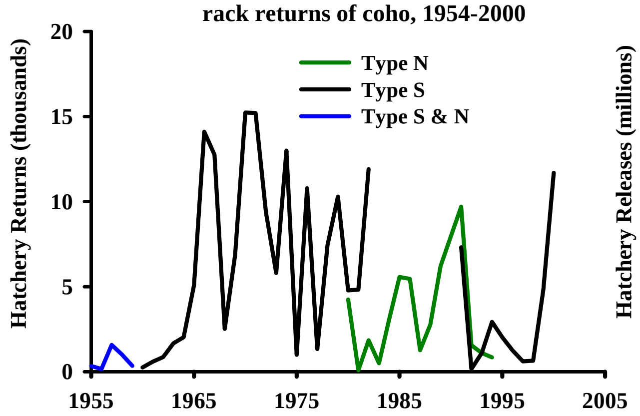
Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho. Duck Creek in the lower basin is an important coho spawning area, but the majority of the spawning area is in the upper basin above the Salmon hatchery, in particular the West Fork of the Elochoman
- Coho in the Skamokawa basin spawn in the mainstem Skamokawa and Wilson, Left Fork, Quartz, Standard, and McDonald Creeks

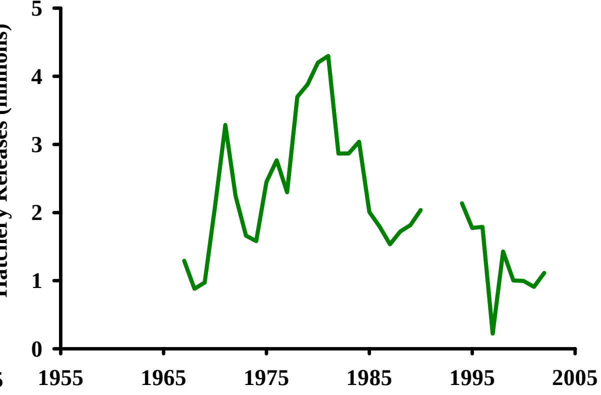
Life History

- Adults enter the Elochoman River from mid-August through February (early stock primarily from mid-August through September and late stock primarily from late September to November)
- Peak spawning occurs in late October for early stock and late November to January for late stock
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in spring, spend one year in fresh water, and emigrate as age-1 smolts in the following spring

Elochoman River Hatchery rack returns of coho, 1954-2000



Hatchery releases of coho to the Elochoman River basin 1967-2002



Diversity

- Late stock coho (or Type N) were historically present in the Elochoman basin with spawning occurring from late November into March
- Early stock coho (or Type S) are also present and are currently produced in the Elochoman Hatchery program
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Elochoman River wild coho run is a fraction of its historical size
- USFWS surveys in 1936 and 1937 indicated coho presence in all accessible areas of the Elochoman River and its tributaries; 371 coho documented in Elochoman River; coho designated as ‘observed’ in Skamokawa
- In 1951 WDFW estimated an annual escapement of 2500 late coho to the Elochoman River and 2,000 late coho to Skamakowa Creek
- Hatchery production accounts for most coho returning to Elochoman River

Productivity & Persistence

- Natural coho production is presumed to be very low
- Smolt density model estimated Elochoman basin production potential of 43,393 smolts

Hatchery

- The Elochoman Hatchery was built in 1953
- The Elochoman Hatchery is currently programmed for an annual release of 550,00 late coho and 360,000 early coho smolts

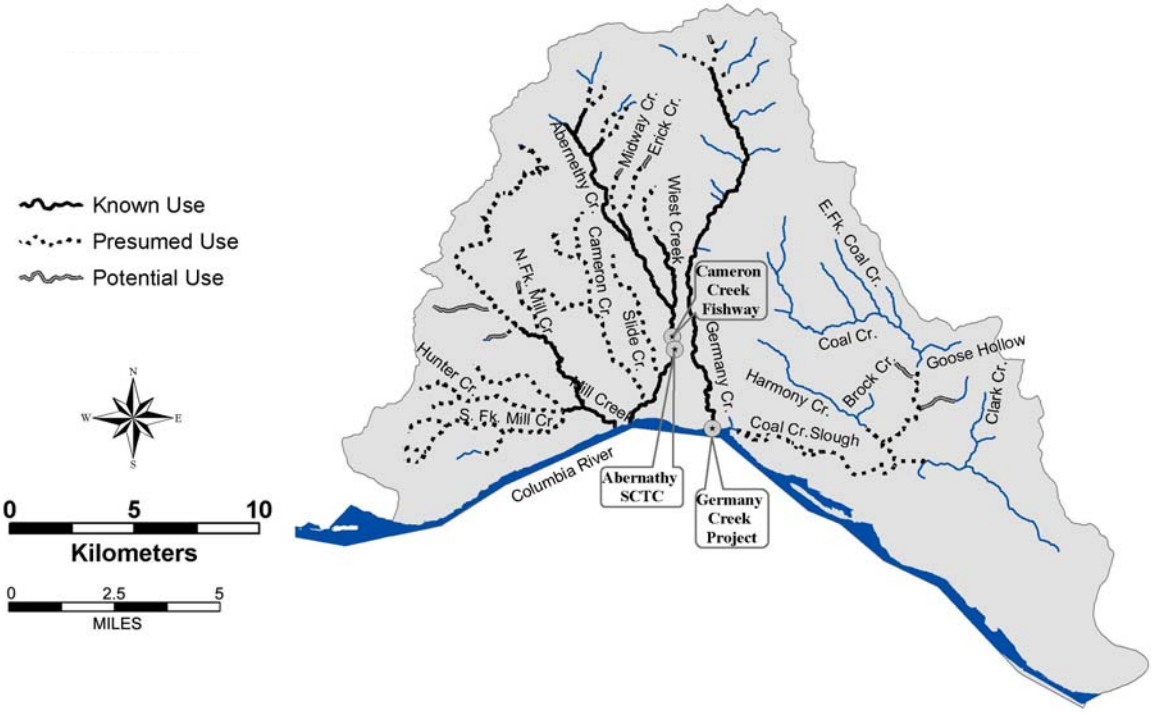
Harvest

- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas coho

- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon state listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery Coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early coho, but late coho harvest can also be substantial
- An average of 1,183 coho (1981-1988) were harvested annually in the Elochoman River sport fishery
- CWT data analysis of 1995-97 early coho released from Elochoman Hatchery indicates 49% were captured in a fishery and 51% were accounted for in escapement
- CWT data analysis of 1995-97 brood late coho released from Elochoman Hatchery indicates 61% were captured in a fishery and 39% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 brood Elochoman early coho were distributed between Columbia River (53%), Washington ocean (40%), and Oregon ocean (7%) sampling areas
- Fishery CWT recoveries of 1995-97 brood Elochoman late coho were distributed between Columbia River (59%), Washington ocean (29%), and Oregon ocean (11%) sampling areas

5.2.4 Coho—Elochoman Subbasin (Mill/Abernathy/Germany)

ESA: Candidate 1995 **SASSI: Unknown 2002**



Distribution

- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho in Mill, Abernathy (including Cameron Creek), Germany, and Coal Creeks

Life History

- Production is late stock coho and adults enter these tributaries from late September through February
- Peak spawning occurs in December and January
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in spring, spend one year in fresh water, and emigrate as age-1 smolts in the following spring

Diversity

- Late stock coho (or Type N) were historically present in the Mill, Abernathy, and Germany Creek basins with spawning occurring from late November into March
- There was also late coho produced historically in nearby Coal Creek
- Early stock hatchery coho have been planted in these tributaries in some years, but not in recent years
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar
- Stocks in Mill, Germany, and Abernathy Creeks are designated based on distinct spawning distribution

Abundance

- During USFWS escapement surveys in 1936 and 1937, coho designated as ‘observed’ in Germany Creek and ‘reported’ in Mill Creek
- WDFW (1951) estimated an annual escapement of 800 late coho spawners to Mill, Abernathy, Germany, and Coal Creeks combined
- Recent year stream surveys have been conducted in September and early October to count fall chinook and have shown minor numbers of coho

Productivity & Persistence

- Natural coho production is presumed to be very low
- A 1995 electrofishing survey in Mill Creek revealed low coho juvenile presence
- Ten seining trips were made in Abernathy Creek in 1995 and captured only 29 coho juveniles

Hatchery

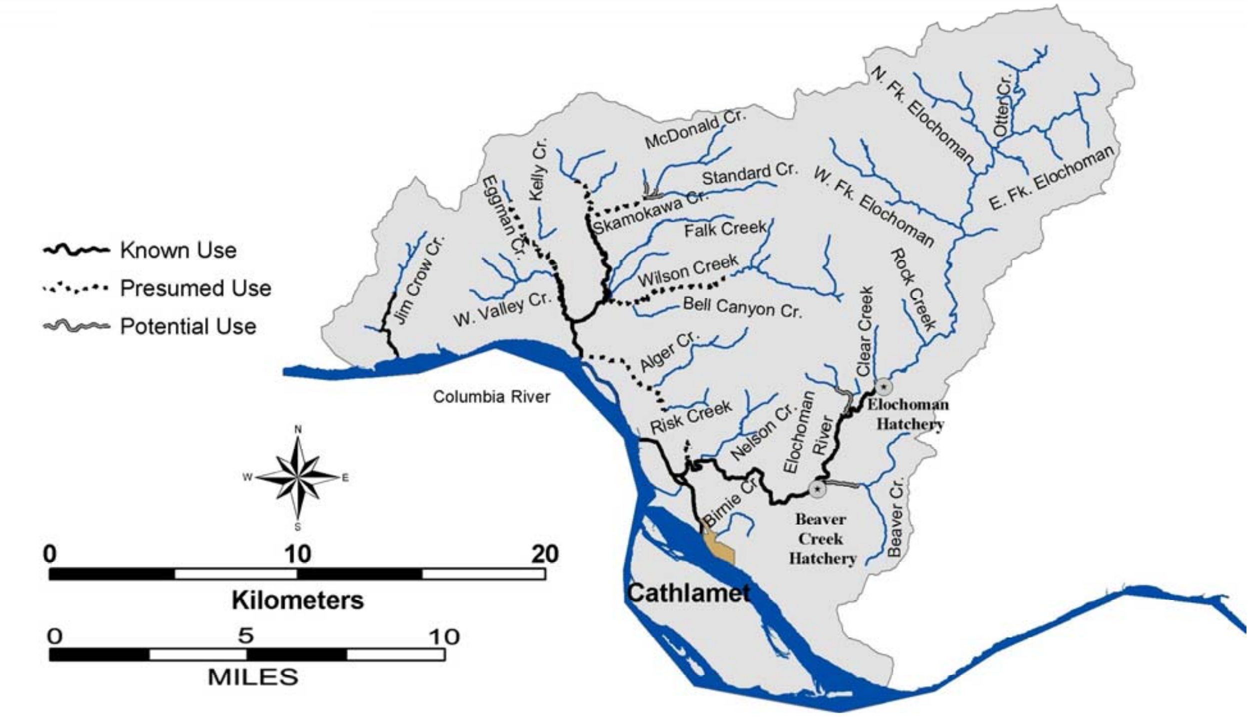
- There are no production hatcheries located within these creeks, although out-of-basin plants have occurred in some past years

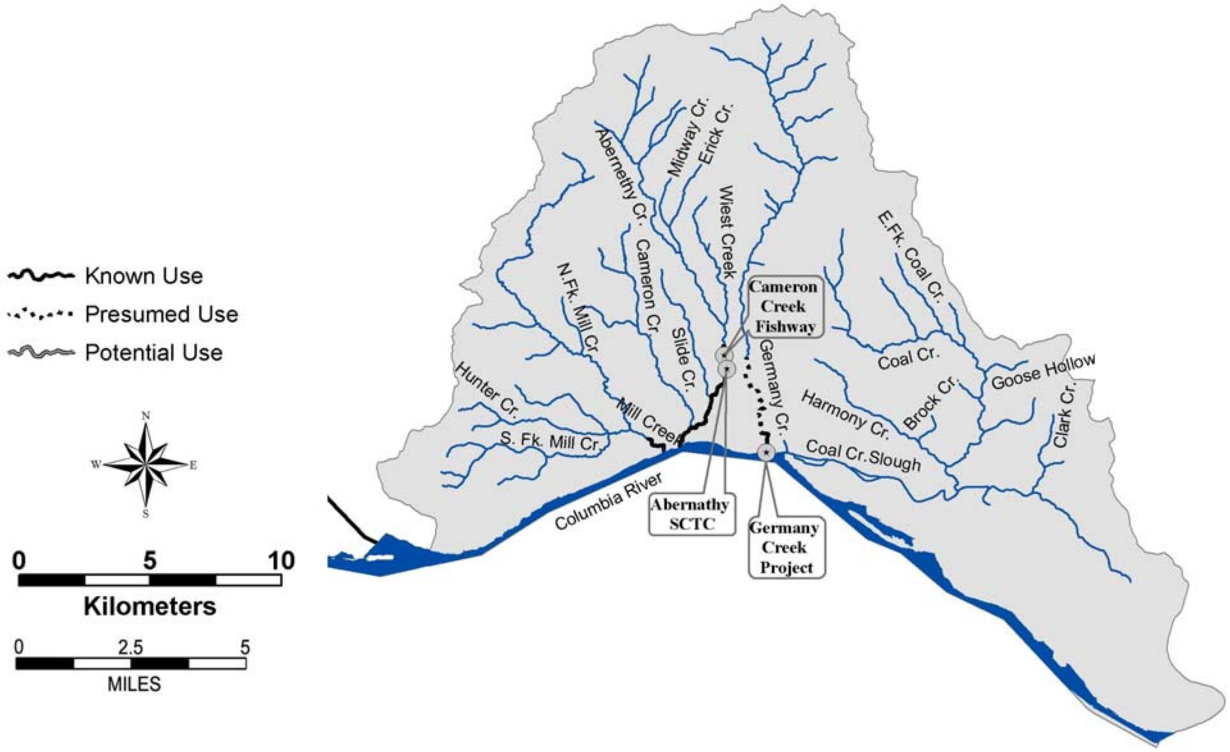
Harvest

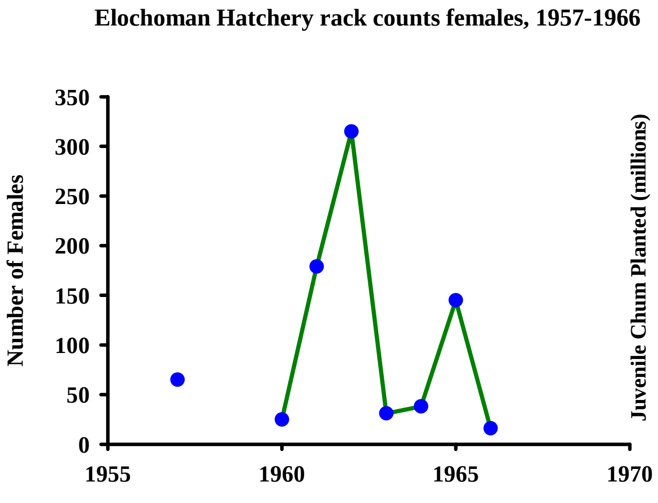
- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon state listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early coho, but late coho harvest can also be substantial
- These streams are not open to sport fishing for coho

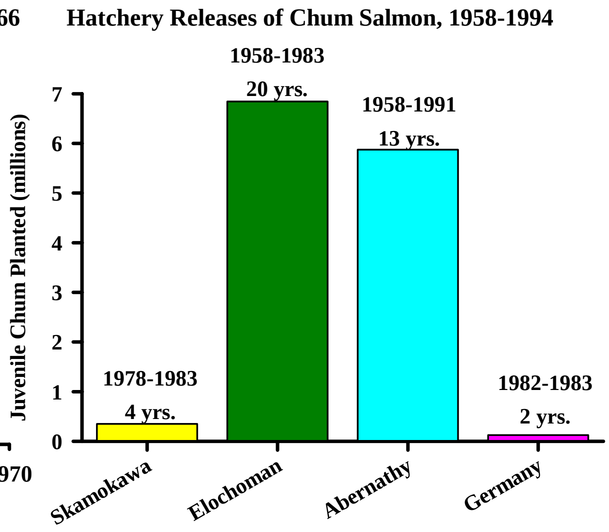
5.2.5 Chum—Elochoman Subbasin

ESA: Threatened 1999	SASSI: NA









Distribution

- Spawning occurs in the lower mainstem Elochoman River above tidal influence
- Spawning occurs in the lower 0.4 miles of Abernathy Creek and in the lower parts (above tidewater) of Skamakowa Creek, Mill Creek and Germany Creek

Life History

- Adults enter the Elochoman River, Skamokawa, Mill, Abernathy, and Germany Creeks from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- Periodic supplementation programs have used Hood Canal and Willipa Bay stocks

Abundance

- In 1936, escapement surveys documented 158 chum in Elochoman River, 92 in Abernathy Creek, and chum were “observed” in Germany Creek and “reported” in Skamokawa River and Mill Creek
- WDF 1951 report estimated escapement of approximately 1,000 chum to the Elochoman River and 3,000 chum to the Skamokawa River; 1973 survey reported “small” run
- WDF 1951 report estimated escapement to Abernathy/Mill/Germany Creeks area was 2,700 chum
- An estimated 100 chum spawned naturally in Abernathy Creek in 1990

Productivity & Persistence

- Natural chum production is expected to be low, although it is expected that some chum production continues in these streams
- A 1995 WDF seining operation in Abernathy Creek observed 7 chum juveiles

Hatchery

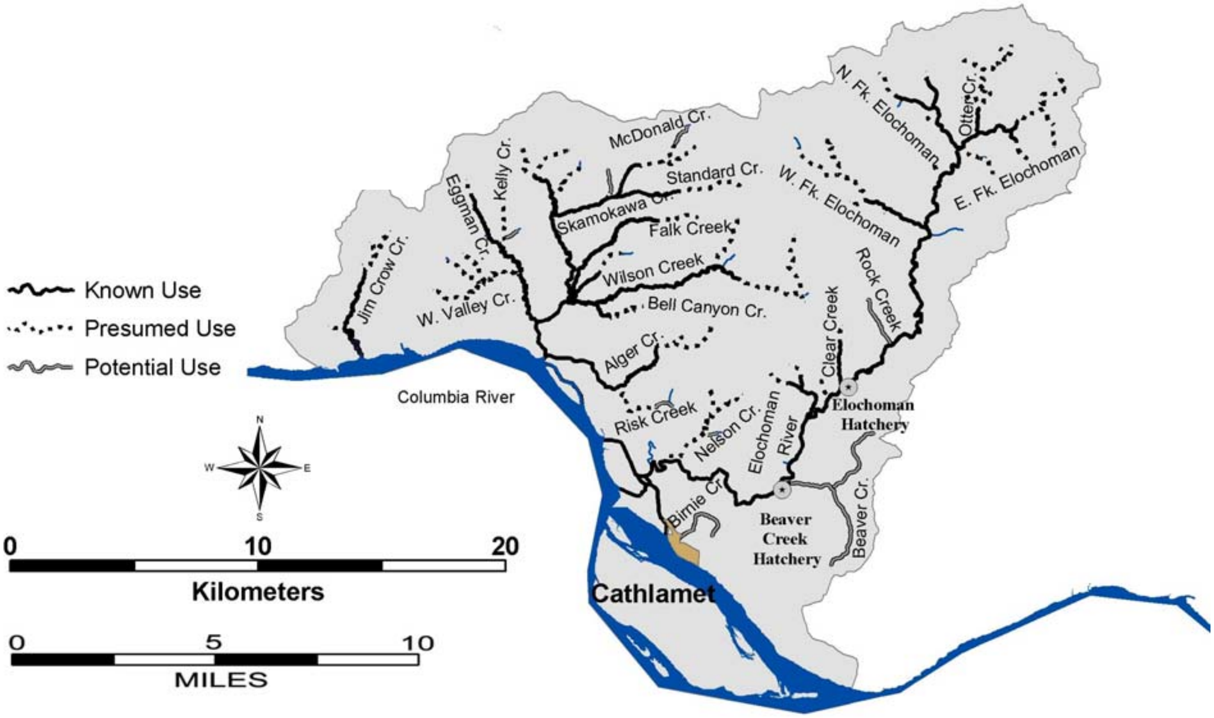
- Chum fry releases of various stocks occurred from 1958-1983 in the Elochoman River, 1958-1991 in Abernathy Creek, 1978-1983 in Skamokawa Creek, and 1982-1983 in Germany Creek
- Elochoman releases average 340,000 over 20 years, Skamokawa releases averaged 88,000 over four years, Germany Creek releases averaged 62,500 over 2 years, and Abernathy releases averaged 450,000 over 13 years
- Hatchery escapement accounts for most adults returning to the Elochoman

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

5.2.6 Winter Steelhead—Elochoman Subbasin (Elochoman/Skamokawa)

ESA: Not Warranted **SASSI: Depressed 2002**

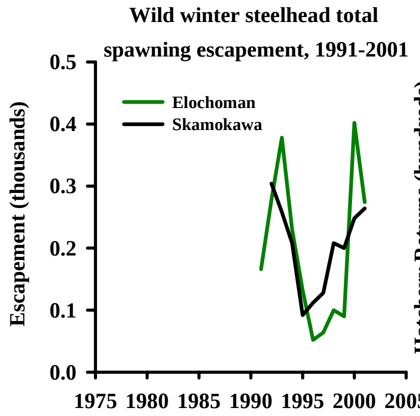


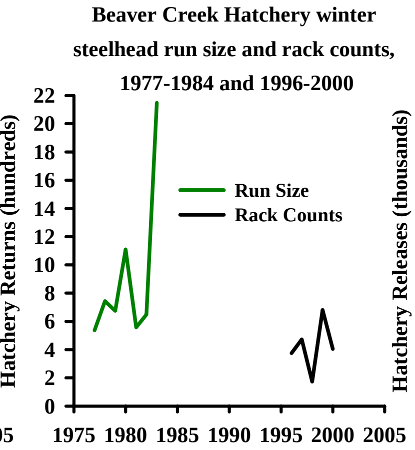
Distribution

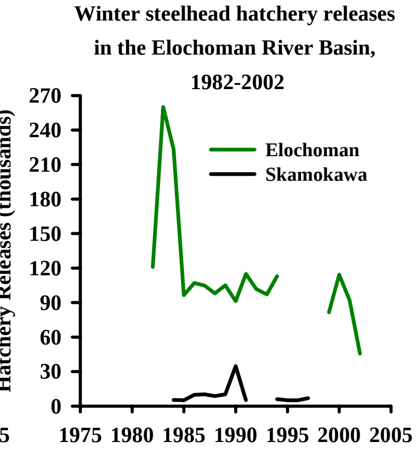
- Winter steelhead are distributed throughout the mainstem Elochoman and in the lower reaches of Beaver, Duck, Clear, Rock, and Otter Creeks and the East, North, and West Fork Elochoman
- In the Skamokawa, steelhead are distributed throughout the mainstem Skamokawa, Wilson Left Fork, Quartz, and McDonald Creeks, and smaller tributaries such as Bell Canyon, Pollard, and Standard Creeks

Life History

- Adult migration timing for Elochoman and Skamokawa winter steelhead is from December through April
- Spawning timing on the Elochoman and Skamokawa is generally from early March to early June
- Age composition data for Elochoman and Skamokawa River winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May


Wild winter steelhead total spawning escapement, 1991-2001


Beaver Creek Hatchery winter steelhead run size and rack counts, 1977-1984 and 1996-2000


Winter steelhead hatchery releases in the Elochoman River Basin, 1982-2002

Diversity

- Elochoman and Skamokawa winter steelhead stocks both designated based on distinct spawning distribution
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- Allele frequency analysis of Elochoman and Skamokawa winter steelhead in 1995 was unable to determine the distinctiveness of this stock compared to other lower Columbia steelhead stocks

Abundance

- In 1936, 7 steelhead were documented in the Elochoman River and steelhead were observed on the Skamokawa during escapement surveys
- Wild winter steelhead average run size in the 1960s was estimated to be about 8,000 fish
- Total escapement counts from 1991-2001 for the Elochoman ranged from 52 to 402 (average 197); redd counts from 1988-1999 ranged from 2.4 to 9.7 redds/mile; escapement goal for the Elochoman is 626 fish
- Total escapement counts from 1992-2001 for the Skamokawa ranged from 92 to 304 (average 202); redd counts from 1992-1999 ranged from 2.6 to 13.5 redds/mile; escapement goal for the Skamokawa is 227 fish

Productivity & Persistence

- Natural production in the basin is thought to be low

Hatchery

- The Elochoman Hatchery, located on the mainstem, does not produce winter steelhead
- The Beaver Creek Hatchery, located several hundred yards upstream on Beaver Creek (RM 4), produced winter steelhead until closed in 1999; average annual production was 400,000 to 500,000 smolts
- Hatchery winter steelhead have been planted in the Elochoman River basin since 1955; broodstock from the Elochoman and Cowlitz Rivers and Chambers Creek have been used; release data are displayed from 1983-2001
- Currently, about 50,000 winter smolts are released from Beaver Creek annually

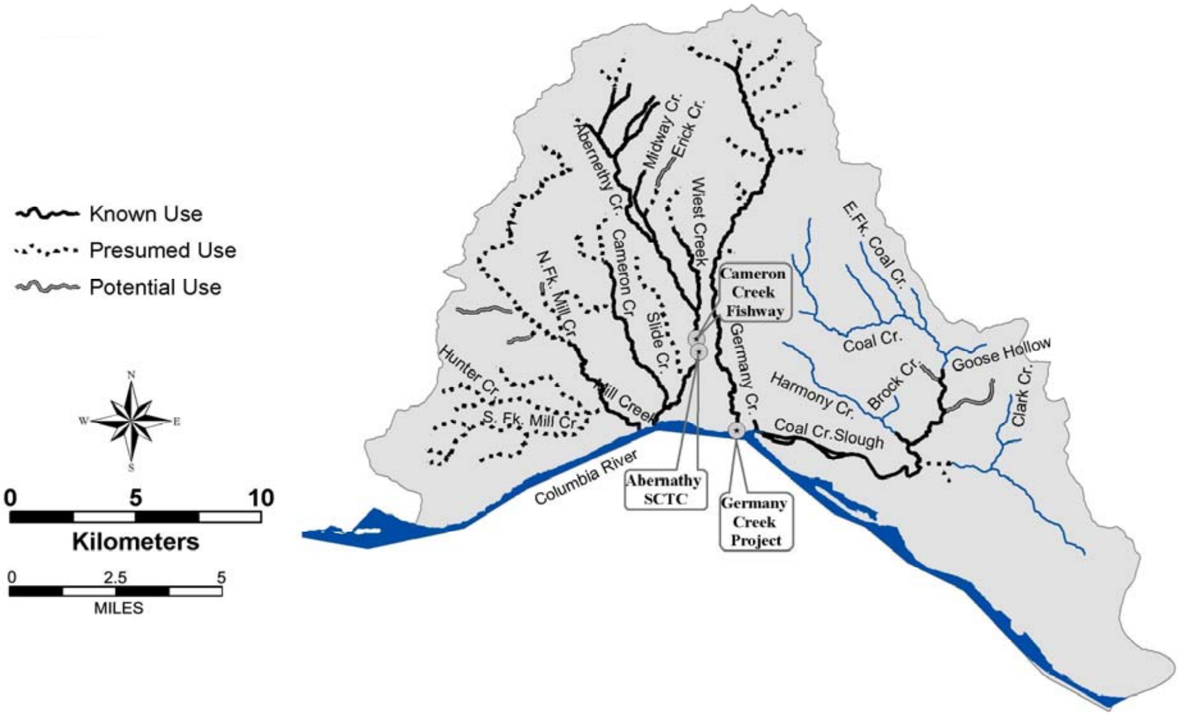
- Although hatchery winter steelhead constitute the majority of the run, hatchery fish contribute little to natural winter steelhead production in the Elochoman and Skamokawa River basins

Harvest

- No directed commercial or tribal fisheries target Elochoman or Skamokawa winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Elochoman River basin
- Winter steelhead sport harvest (hatchery and wild) in the Elochoman River from 1977-1984 ranged from 2,004 to 4,655; 75% were assumed to be hatchery fish; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in Elochoman basin

5.2.7 Winter Steelhead—Elochoman Subbasin (Mill/Abernathy/Germany)

ESA: Threatened 1998	**SASSI: Mill—Unknown 2002; Abernathy and Germany—Depressed 2002**



Distribution

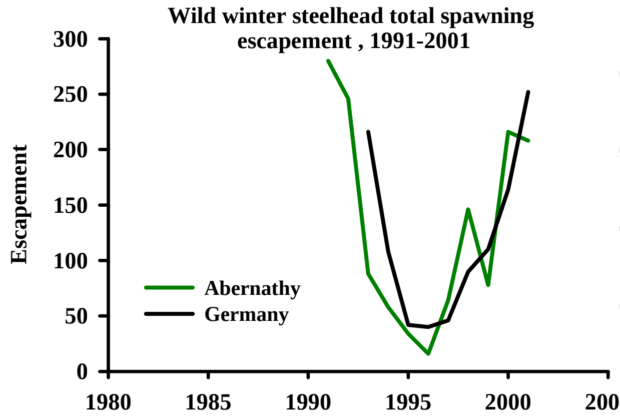
- In Mill Creek, winter steelhead spawn in the mainstem, North Fork Mill Creek, and unnamed tributaries
- In Abernathy Creek, spawning occurs in the mainstem, Slide Creek, and Cameron Creek
- In Germany Creek, winter steelhead spawn in the mainstem, Loper Creek, and John Creek

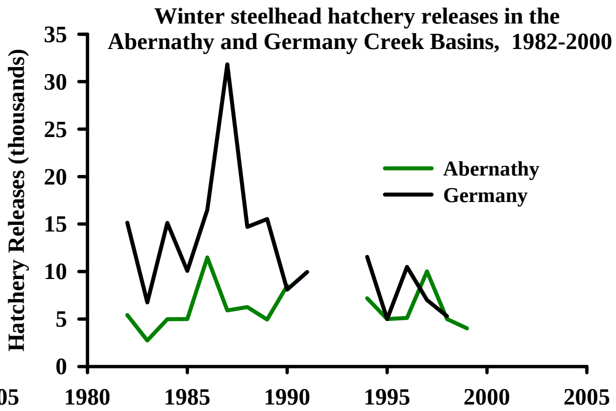
Life History

- Adult migration timing for Mill, Abernathy, and Germany Creek winter steelhead is from December through April
- Spawning timing on Mill, Abernathy, and Germany Creeks is generally from March to early June
- Age composition data for Mill, Abernathy, and Germany Creek winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Mill, Abernathy, and Germany winter steelhead stocks designated based on distinct spawning distribution
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- Genetic analyses have not been performed on any of these stocks





Abundance

- In 1936, 1 steelhead was documented in Mill Creek and steelhead were observed in Abernathy and Germany Creeks during escapement surveys
- Total escapement counts from 1991-2001 for Abernathy Creek ranged from 16 to 280 (average 130); redd counts from 1991-1999 ranged from 3.1 to 12.7 redds/mile
- Total escapement counts from 1993-2001 for Germany Creek ranged from 40 to 252 (average 119); redd counts from 1993-1999 ranged from 2.4 to 13.4 redds/mile
- Escapement goals have been set at 306 fish in Abernathy Creek and 202 fish in Germany Creek

Productivity & Persistence

- Natural production in the basin is thought to be low

Hatchery

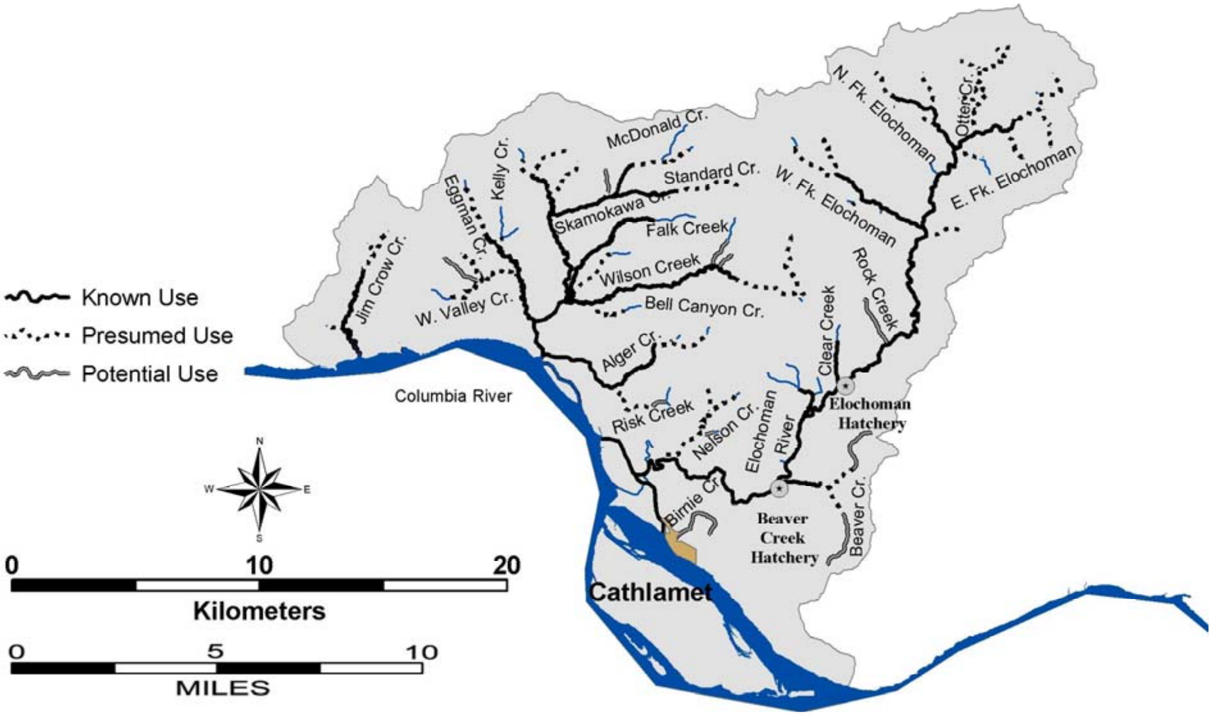
- There are no hatcheries located on any of these creeks; hatchery fish from the Beaver Creek Hatchery (Elochoman River) have been planted in the basin; hatchery brood stock has been from the Elochoman River, Chambers Creek, and the Cowlitz River
- Hatchery winter steelhead have rarely been planted in Mill Creek; hatchery winter steelhead have been planted in Abernathy and Germany Creeks since 1961; release data are displayed from 1982-2000
- Hatchery fish contribute little to natural winter steelhead production in Mill, Abernathy, or Germany Creek basins
- Native are stock still present in Germany Creek; native stock spawn later than non-native fish

Harvest

- No directed commercial or tribal fisheries target Mill, Abernathy, or Germany Creek winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in Mill, Abernathy, or Germany Creek basins
- Winter steelhead sport harvest (hatchery and wild) in Mill, Abernathy, or Germany Creeks from 1977-1986 averaged 18, 85, and 196, respectively; since 1990, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia and in Elochoman basin

5.2.8 Cutthroat Trout—Elochoman Subbasin (Elochoman/Skamokawa)

ESA: Not Listed **SASSI: Depressed**



Distribution

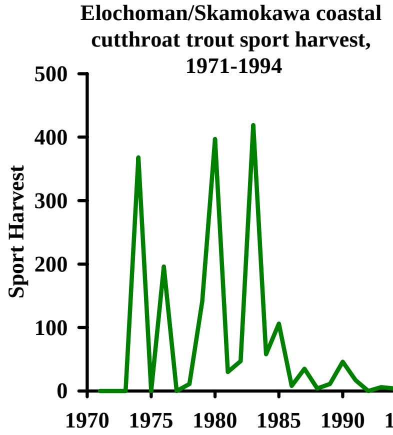
- Anadromous forms have access to most of the Elochoman except at Beaver Creek, where a weir blocks passage; at Duck Creek, where a falls blocks entry; and upper tributary reaches where gradients may limit access during high flows
- Anadromous cutthroat have access to all Skamokowa tributaries
- Resident forms are documented throughout the systems

Life History

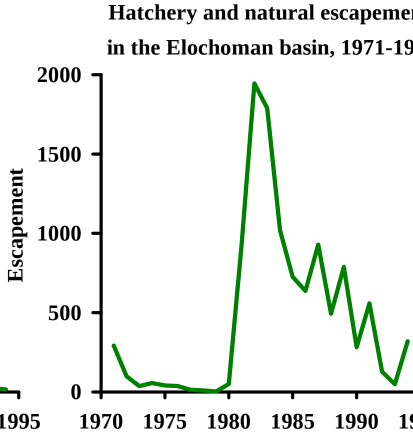
- Anadromous, resident and fluvial forms are present
- Anadromous river entry is from July through April
- Anadromous spawning occurs from December through June

Diversity

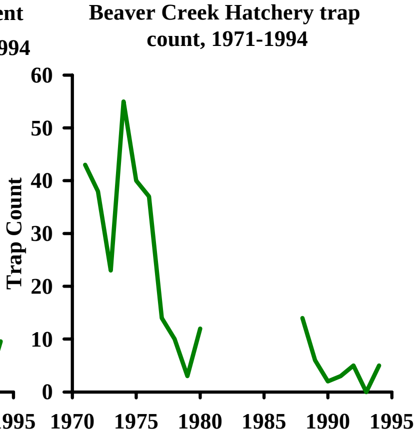
- The two drainages are defined as one stock due to their proximity, similar characteristics, and lack of biological data to distinguish them
- Genetic analysis has been conducted on samples taken at Beaver Creek Hatchery
- No significant genetic difference from Cowlitz stock
- Significant differences from Kalama and Lewis River collections



Elochoman/Skamokawa coastal cutthroat trout sport harvest, 1971-1994



Hatchery and natural escapement in the Elochoman basin, 1971-1994



Beaver Creek Hatchery trap count, 1971-1994

Abundance

- Beaver Creek Hatchery trap counts of unmarked fish originally included some unmarked hatchery origin fish
- By 1990 all hatchery releases were adipose-clipped
- From 1990-94 the annual number of unmarked returns has been no more than 5 fish, and has averaged 3 fish
- Long term decline in Columbia River sport catch from mouth to RM 48
- Declining trend in total hatchery returns from 1982-1994
- Spike in sea-run cutthroat numbers in the early 1980s likely related to strays from the Cowlitz basin due to eruption of Mt. St. Helens
- No abundance information is available for resident life history forms

Hatchery

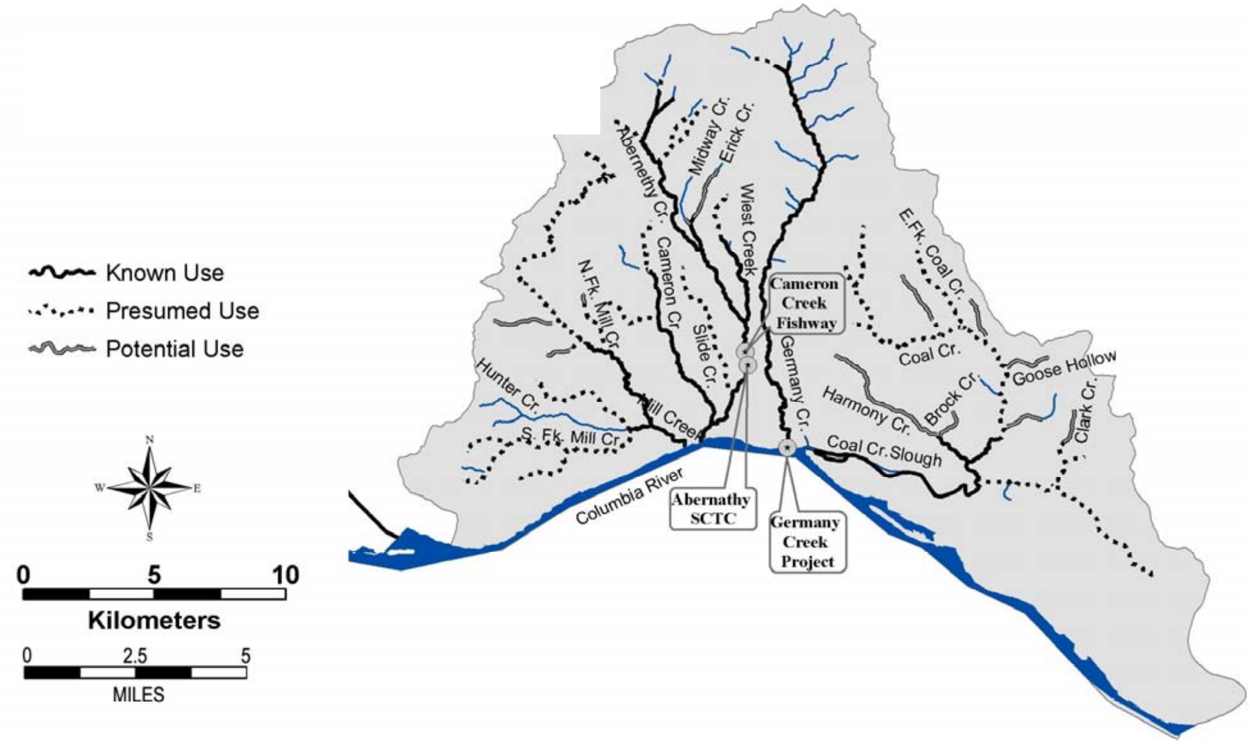
- Beaver Creek Hatchery (RM 6) released steelhead and anadromous cutthroat until its closure in 1999
- From 1989-1993 an average of 34,620 sea-run cutthroat smolts were released annually
- Elochoman Hatchery (RM 9) produces coho and fall chinook

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Elochoman River
- Wild Elochoman and Skamokawa Creek cutthroat (unmarked fish) must be released in mainstem Columbia, Elochoman and Skamokawa Creek sport fisheries

5.2.9 Cutthroat Trout—Elochoman Subbasin (Mill/Abernathy/Germany/Coal Creek)

ESA: Not Listed **SASSI: Depressed**



Distribution

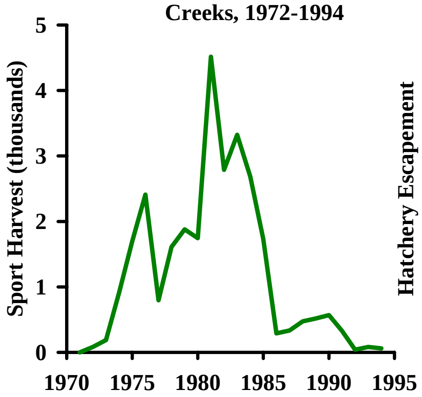
- Anadromous forms have access to the majority of the creek basins except for areas above falls on tributaries to Abernathy Creek
- Resident forms are documented throughout the system

Life History

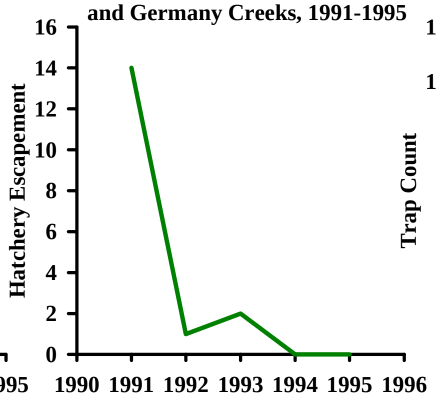
- Anadromous, fluvial and resident forms are present
- Anadromous river entry and spawn timing are unknown but are believed to be similar to Elochoman cutthroat trout
- Anadromous river entry is assumed to be from August through mid-April
- Anadromous spawning is assumed to be from January through mid-April
- Fluvial and resident spawn timing is not documented but is assumed to be similar to anadromous timing

Diversity

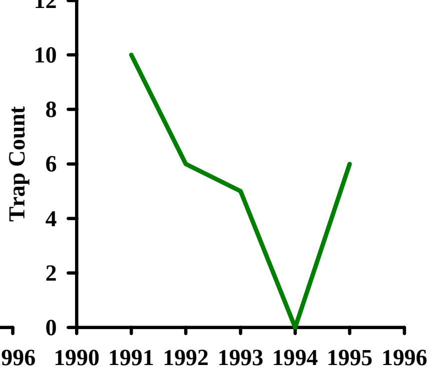
- These creeks are defined as one stock complex based on geographic proximity—all enter the Columbia River between RM 53 and RM 56
- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown
- As additional biological and genetic data become available it is possible that these creeks may be classified as separate stock complexes



Coastal cutthroat trout sport harvest in Abernathy, Mill and Germany Creeks, 1972-1994



Coastal cutthroat trout hatchery escapement in Abernathy, Mill and Germany Creeks, 1991-1995



Abernathy, Mill and Germany Creeks coastal cutthroat trout trap count 1991-1995

Abundance

- Chronically low counts at Abernathy fish trap—between zero and 15 fish since 1991
- Wild anadromous escapement has been between zero and ten fish since 1991
- Long-term decline in Columbia River sport catch from RM 48 to RM 66, particularly since 1986

Hatchery

- USFWS operates a research hatchery facility on Abernathy Creek
- WDFW released cutthroat into Mill, Germany and Abernathy Creeks in the 1970s and early 1980s to provide catchable fish for the opening day resident trout fishery in late May
- After 1981 WDFW focused on anadromous cutthroat, releasing between 5500 and 6000 smolts into Mill, Germany, and Abernathy Creeks annually
- The anadromous cutthroat hatchery release program is now discontinued

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Abernathy, Mill, and Germany Creeks
- Wild cutthroat (unmarked fish) must be released in the mainstem Columbia and in Abernathy, Mill, and Germany Creeks

5.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

Elochoman / Skamokawa

- Loss of tributary habitat quality and quantity is an important impact for all species, particularly for chum but less so for fall chinook. Loss of estuary habitat quality and quantity is also important, accounting for relative impacts of about 20% for chum and fall chinook, 15% for winter steelhead, and 10% for coho.
- Harvest accounts for the largest relative impact on fall chinook, but is a minor factor for other species.
- Hatchery impacts are substantial for coho and fall chinook and moderately important to coho, but of lesser importance for winter steelhead and chum.
- Predation impacts are moderate for winter steelhead and chum, but are relatively low for coho and fall chinook.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

Mill/Abernathy/Germany Subbasin

- Loss of tributary habitat quality and quantity is an important impact for all species, particularly for chum but less so for fall chinook. Loss of estuary habitat quality and quantity is also important, accounting for relative impacts of about 20% for chum, fall chinook and winter steelhead, and 10% for coho.
- Harvest accounts for the largest relative impact on fall chinook and is moderately important to coho, but is a relatively minor factor for other species.
- Hatchery impacts are substantial for coho and fall chinook, but of lesser importance for winter steelhead and chum.
- Predation impacts are moderate for winter steelhead and chum, but are relatively low for coho and fall chinook.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

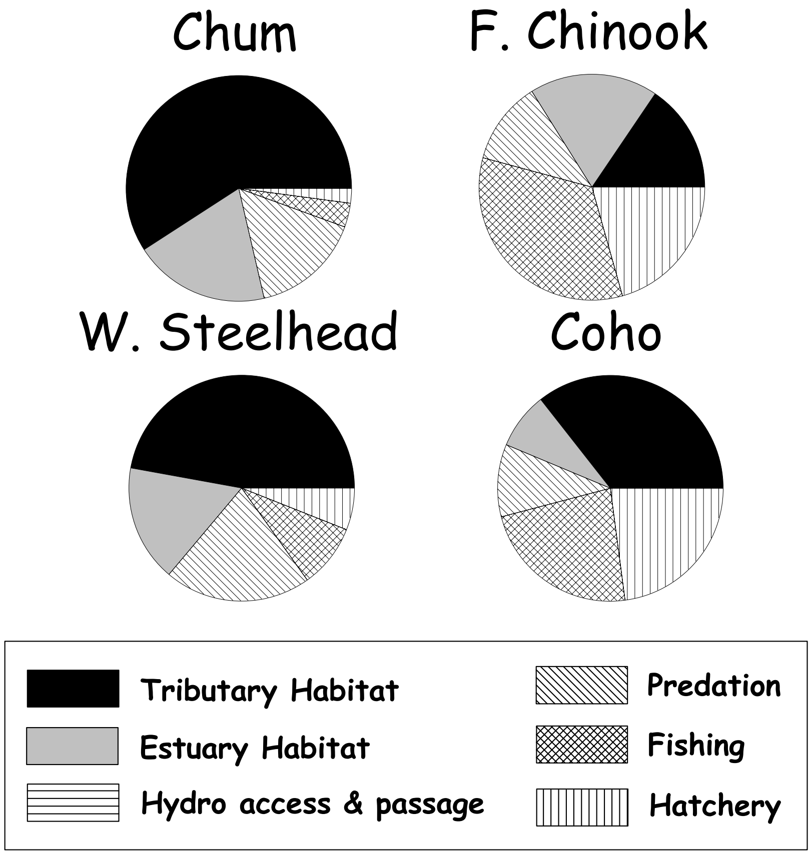


Figure 5-5. Relative index of potentially manageable mortality factors for each species in the Elochoman subbasin.

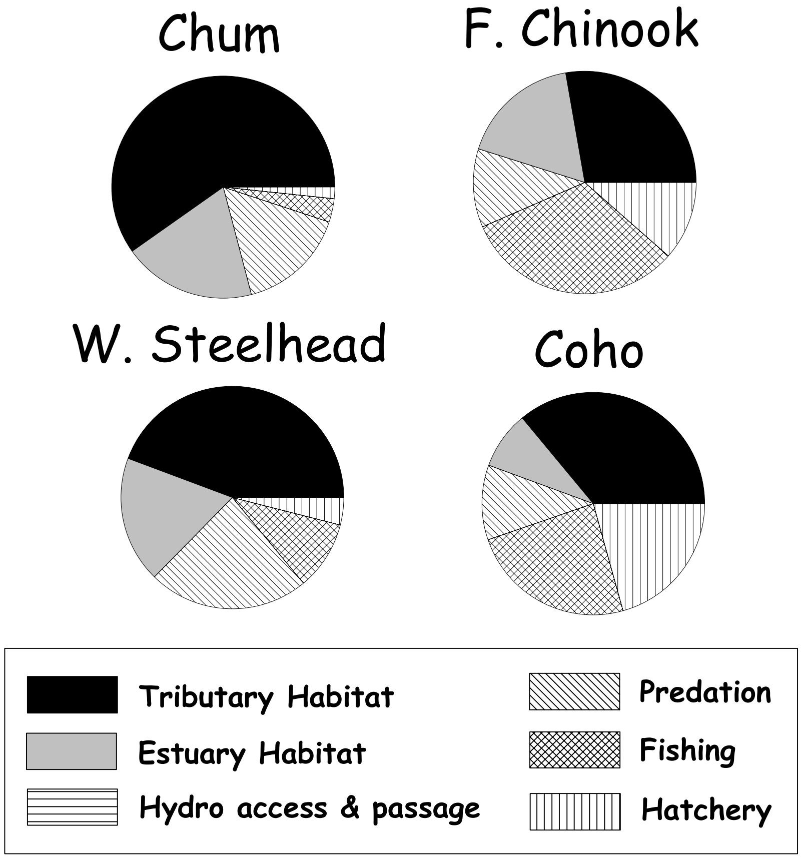


Figure 5-6. Relative index of potentially manageable mortality factors for each species in the Mill, Abernathy and Germany subbasin.

5.4 Hatchery Programs

5.4.1 Elochoman

Two hatcheries exist on the Elochoman River; the Beaver Creek Hatchery is located about RM 4 and the Elochoman Hatchery (completed in 1953) is located about RM 9.[1] The Beaver Creek Hatchery historically produced early-run winter steelhead, but was closed in 1999. The Elochoman Hatchery historically produced fall chinook, early-run coho, and late-run coho; current release goals are 2 million fall chinook, 418,000 early-run coho, and 512,000 late-run coho (Figure 5-7). The Elochoman Hatchery started an early run winter steelhead program in 2000 with an annual release goal of 60,000 smolts (Figure 5-7). The Elochoman Hatchery has also started a local broodstock late-run winter steelhead program with the goal of producing 30,000 smolts. The local broodstock production is expected to expand and may replace the current early-run steelhead program. The success of this program may be dependent on the repair of the weir at the hatchery. Additionally, there are 30,000 summer steelhead (Lewis River stock) planned for release from the hatchery.

The early-run coho hatchery program includes a collaboration of the Grays River Hatchery, Elochoman Hatchery and Steamboat Slough Net Pens. Coho are captured at the Grays Hatchery, where eggs are incubated; eyed eggs are transferred to the Elochoman Hatchery for final incubation and early rearing. The pre-smolt fish are transferred to Steamboat Slough Net Pens for final rearing and acclimation. Annual release goal for the net pen operation is 200,000 early-run coho smolts (Figure 5-7). Results of the fishery on returning coho have been very poor thus far.

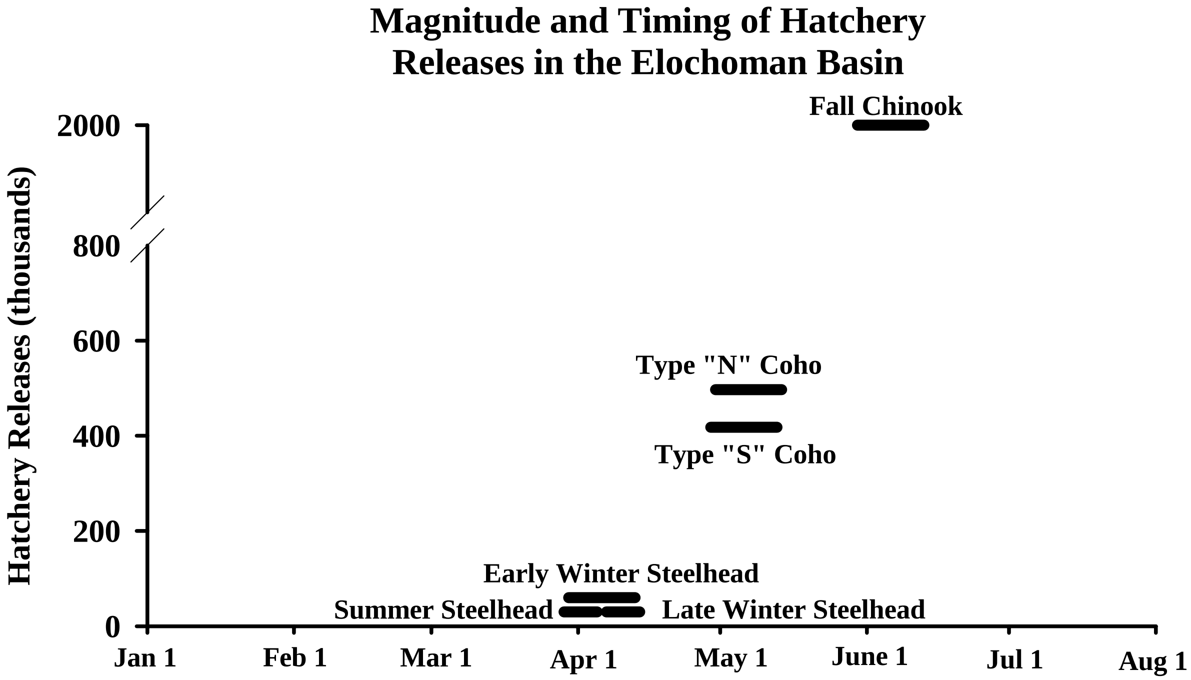


Figure 5-7. Magnitude and timing of hatchery releases in the Elochoman River basin by species, based on 2003 brood production goals.

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[1] Alternatively known as the Elokomin Hatchery.

Genetics—Broodstock for the fall chinook hatchery program comes from fish trapped near tidewater in the lower Elochoman River. Historical releases of fall chinook have included significant transfers from outside the Elochoman basin, although more then 99 percent of the releases have come from broodstock within the Lower Columbia ESU. The largest donor stocks have been Spring Creek Hatchery and Kalama Hatchery chinook. Allozyme analyses indicate that Elochoman fall chinook are similar but distinct from other lower Columbia River fall chinook stocks, although bright fall chinook net pen releases from the Rogue River (Select Area Brights) have been observed straying into the Elochoman River and genetic introgression may have occurred. However, the numbers have been low, and they are uniquely marked to prevent inclusion into the hatchery broodstock.

Broodstock for the early and late run coho hatchery programs are from coho adults trapped at the Elochoman Hatchery (except for the Steamboat Slough program which originates from Grays Hatchery early coho). Historical releases included substantial transfers, primarily early coho from Toutle Hatchery and late coho from Cowlitz Hatchery.

Early-run winter steelhead released from the Beaver Creek Hatchery originated from Elochoman and Cowlitz river and Chambers Creek (a Puget Sound Hatchery) stocks; there is some potential for wild Elochoman winter stock interbreeding with the out-of-basin hatchery stocks, however it may be minimized by temporal differences between the early returning hatchery fish and later returning wild fish. Allele frequency analysis of Elochoman and Skamokawa winter steelhead in 1995 was unable to distinguish this stock from other lower Columbia steelhead stocks. A new winter steelhead program at the Elochoman Salmon Hatchery will take broodstock only from wild Elochoman River late-run winter steelhead, with a release goal of 30,000 winter steelhead. The early-run program also has continued with a release of 60,000 winter steelhead.

Chum salmon released in the basin were developed from Willapa Bay and Hood Canal stocks; chum have not been released in the basin since 1983 so any adults presently returning to the Elochoman basin are considered natural Elochoman chum or strays from other basins.

Interactions—A significant portion of past years’ fall chinook spawners (estimated 82% in 1997) in the Elochoman River were first generation hatchery fish (Figure 5-8). With annual releases of 2 million fall chinook, there is potential for competition between hatchery-released and naturally produced juvenile fall chinook. However, most hatchery releases are smolts (not fry) that migrate shortly after release, which minimizes potential freshwater competition. In most years, hatchery-released juvenile fall chinook considerably outnumbered naturally produced juveniles. Northern pikeminnow, common merganser, and Caspian tern have been identified as important predators of juvenile salmonids in the Elochoman River. Large releases of hatchery smolts may attract additional predators causing increased predation on wild fish; wild fish may benefit, however, from the presence of large numbers of hatchery fish because wild fish usually have better predator avoidance capabilities.

Spawning of wild coho is presumed to be low so there may be little interaction between wild and hatchery fish (Figure 5-8). Also, most wild coho in the Elochoman River originated from late-run coho while the hatchery production is dominated by early-run coho and interaction is therefore minimized through the temporal segregation of the runs.

Hatchery winter steelhead fish contribute very little to natural production so interaction between hatchery and wild winter steelhead is expected to be minimal (Figure 5-8). The new winter steelhead program at the Elochoman Salmon Hatchery uses only wild Elochoman River winter steelhead, so the genetic effects of hatchery/wild fish interactions, with fish produced from this program, is expected to be minimal.

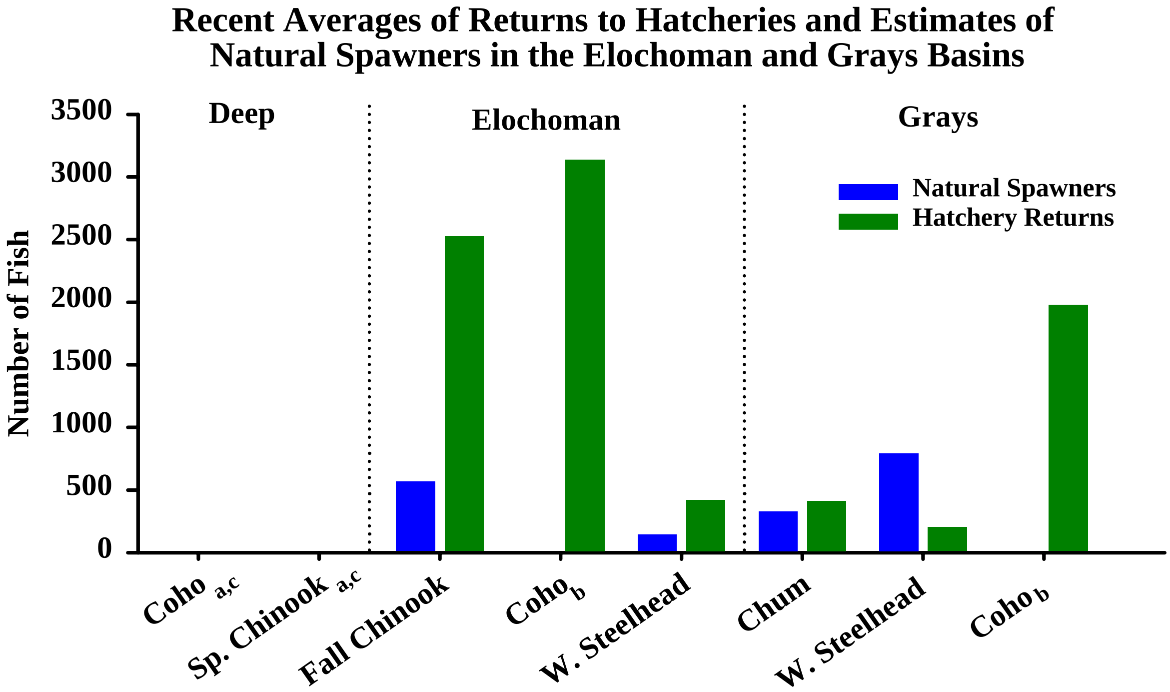

Figure 5-8. Recent average hatchery returns and estimates of natural spawning escapement in the Deep, Grays, and Elochoman River basins by species. The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from 1992 to the present. Calculation of each average utilized a minimum of 5 years of data, except for Grays chum (1998–2000) and Grays winter steelhead (1998 and 2000).

Water Quality/Disease—Water for the Elochoman Hatchery is drawn directly from the Elochoman River; thus, the natal water source for wild fish and the hatchery water source are the same. Water quality parameters and effluent discharge are monitored under an NPDES permit. Fish health is monitored daily and the area fish health specialist inspects monthly. Diseases are treated under the fish health specialist's advice according to the Co-Managers Fish Health Manual.

The Steamboat Slough Net Pens are located in Steamboat Slough; early-run coho salmon pre-smolts from the Elochoman Hatchery are transferred to the net pens for final rearing, acclimation, and release.

Mixed Harvest—Fall chinook and coho are important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. Historically, the fishery exploitation rates of Elochoman River Hatchery fall chinook and coho and Beaver Creek Hatchery winter steelhead likely were similar to wild fish. In recent years, regulations for wild fish release have been in place for coho and steelhead fisheries. All hatchery coho and steelhead are now adipose fin-clipped to allow for selective harvest. Specific hatchery-selective commercial and recreational fisheries in the lower Columbia target hatchery coho, and selective tributary fisheries target steelhead. Therefore, the exploitation rates for recent commercial and recreational fisheries are higher for Elochoman River Hatchery coho and steelhead than wild fish. Hatchery and wild fall chinook harvest rates remain similar but are constrained by ESA harvest limitations.

The purpose of the coho salmon program in the Steamboat Slough Net Pen is isolated harvest; these fish are produced specifically for harvest opportunity. Chum salmon are not targeted in lower Columbia or tributary fisheries and are prohibited from retention in all Columbia River basin sport fisheries. Winter steelhead are targeted mostly in tributary recreational fisheries. Historically, fishery exploitation rates of Beaver Creek Hatchery winter steelhead were likely similar to wild fish. The current incidental (catch and release) mortality of wild winter steelhead was estimated to range from 0-6% in lower Columbia River tributary fisheries; harvest rates on targeted hatchery winter steelhead stocks have averaged near 50%. The primary purpose of the wild winter steelhead hatchery program is to mitigate for the loss of wild winter steelhead as a result of development in the Columbia River basin and its goal is the provision of fish for harvest. The wild winter steelhead hatchery program at the Elochoman Hatchery is relatively new; a harvest management plan is under development, pending consultation between WDFW and NOAA Fisheries.

Passage—A tidewater weir set up near the mouth of the Elochoman River collects fall chinook for broodstock; the weir retains fall chinook but allows coho and steelhead to continue upstream. The diversion weir at the Elochoman Hatchery suffered flood damage and needs repair. Currently fish are able to bypass the hatchery ladder and trap, making collection of broodstock difficult. The Elochoman Hatchery adult collection facility consists of a step and pool ladder system by which fish are diverted into an earthen holding pond where they remain until they are ripe and ready for broodstock collection. Fish are able to bypass the hatchery collection facility and continue upstream to the upper Elochoman River basin.

Supplementation—Hatchery fall chinook and coho account for most spawners in the Elochoman River. These programs are not intended to produce self-sustaining runs; the hatchery program goal for fall chinook and coho salmon is to mitigate for the loss of wild fish resulting from development in the Columbia River basin. The purpose of the new Elochoman Hatchery winter steelhead program is to work towards replacement of the previous steelhead program with indigenous stock and provide fish for harvest opportunities. Additionally, this program serves as a risk management tool, maintaining wild broodstock in case of a catastrophic event that negatively effects the natural population. Supplementation is currently not the goal of the new winter steelhead program.

5.4.2 Mill, Abernathy, Germany

The Abernathy Creek NFH is the only hatchery in these basins. It primarily produced fall chinook, but the program was discontinued in 1995 because of federal funding cuts. Coho and chum salmon and winter steelhead have all been released in these basins; releases were produced out-of-basin. The Abernathy Fish Technology Center now operates at the former NFH facility; the major emphases of the Center's applied research programs are to assist in the repositioning of National Fish Hatcheries as tools in the conservation of natural populations, to examine the use of natural broodstocks by federal hatcheries to meet management objectives, and to promote and support propagation and management methods resulting in healthy Pacific salmon, steelhead/rainbow trout, cutthroat and bull trout, and white sturgeon populations.

Genetics—Most fall chinook released in Abernathy Creek originated from Spring Creek Hatchery broodstock, which was derived largely from Big White Salmon River fall chinook. Fall chinook may not have been native to Abernathy, Mill, or Germany creeks. If they were not native, then the effects of hatchery operations on indigenous wild fall chinook genetics would not be a major concern. Allele frequency analysis from multiple years in the late 1990s indicate that Abernathy Creek fall chinook are significantly different from other lower Columbia River fall chinook stocks, except for Kalama Hatchery fall chinook. Historically, early-run coho were planted in these basins, although releases did not occur every year and no coho have been released in recent years. Natural coho in these tributaries were principally late stock origin. It is presumed that genetic mixing between hatchery and wild coho is likely minimal. Chum salmon released in these basins originated from Willapa Bay and Hood Canal stocks; chum have not been released in Abernathy Creek since 1991 or in Germany Creek since 1983, so any adults now returning to these basins are considered naturally spawning chum or strays from other basins. Winter steelhead released in Abernathy and Germany creeks were produced in the Beaver Creek Hatchery, which used broodstock from the Elochoman and Cowlitz rivers and Chambers Creek. It is presumed that temporal segregation between the early returning hatchery steelhead and later returning wild winter steelhead minimized genetic interaction between hatchery and wild fish. Currently, no winter steelhead hatchery fish are planted in these streams.

Interactions—Interactions between wild and hatchery chum and coho salmon are expected to be minimal because few wild fish are present in these basins and hatchery fish have not been released in recent years. Wild fall chinook may not have been present historically in Abernathy, Mill, or Germany creeks. Winter steelhead have been released only rarely in Mill Creek; winter steelhead releases in Abernathy and Germany creeks did not occur every year and rarely exceeded 15,000 fish. Hatchery releases have now been discontinued. Hatchery fish contribute little to natural production in these basins and wild/hatchery fish interaction is expected to be minimal.

Water Quality/ Disease—Operational plans for the former Abernathy Creek NFH have not yet been obtained and the water source for the facility and disease treatments during the hatchery process are not yet known.

Mixed Harvest—There are no directed chum salmon fisheries on lower Columbia River chum stocks. Minor incidental chum harvest occurs in fisheries targeting fall chinook and coho. Retaining wild chum salmon is prohibited in lower Columbia River and tributary sport fisheries.

Historically, fishery exploitation rates of hatchery fall chinook, coho, and winter steelhead from these basins were likely similar to wild fish. Regulations for wild fish release have been in place in recent years for commercial and recreational fisheries for coho and steelhead. Specific hatchery-selective fisheries in the lower Columbia target hatchery coho and steelhead. Therefore, recent year exploitation rates for commercial and recreational fisheries are higher for hatchery coho and winter steelhead than for wild fish from these basins. Harvest rates for hatchery and wild fall chinook remain similar and are constrained by ESA harvest limitations.

Passage—Operational plans for the former Abernathy Creek NFH have not yet been obtained, so specifics regarding the adult collection facility and passage concerns are not yet known.

Supplementation—Supplementation has not been the goal of the hatchery programs that released fish in these basins and few hatchery fish are released in Abernathy, Germany, or Mill creeks.

5.5 Fish Habitat Conditions

5.5.1 Passage Obstructions

No passage barriers have been identified on Jim Crow Creek. Culverts and tidegates block 10% of presumed anadromous habitat on Skamokawa Creek. A tidegate and a few culverts need assessment on Alger and Risk Creeks. A pump station on Risk Creek blocks 1.4 miles of habitat. There are several culvert barriers on Birnie Creek. A fish screen associated with a high school fish-rearing pond has been a problem at the mouth of Birnie Creek in the past but efforts have been taken to correct the problem. There are many passage barriers associated with culverts in the Elochoman basin. The hatchery intake near Beaver Creek may also be a problem (Wade 2002).

The Mill Creek basin only has 1 culvert that is known to restrict passage. However, low flow passage problems are believed to be related to channel incision from past splash damming. There are several culverts and low flow issues on Abernathy Creek (see Wade 2002). Artificial fishways may create passage problems on Cameron Creek (Abernathy tributary) and need further assessment. There is approximately 3 miles of habitat above these structures. An electric weir at the Abernathy Fish Technology Center operates during the steelhead run, blocking passage to all but wild steelhead. Nine culverts and 1 puncheon restrict passage to over 6 miles of habitat in the Germany Creek basin. In the Coal Creek basin, a tidegate and culvert restrict passage from Coal Creek Slough into Clark Creek. A pump station on Coal Creek Slough also limits passage, as do several culverts throughout the watershed. Passage is completely blocked into and out of the Longview Ditches. The only exit is through pumping stations (Wade 2002).

5.5.2 Stream Flow

Peak flows are associated with fall and winter rains and low flows typically occur in late summer (Figure 5-9). Flow in the Elochoman averaged 375 cfs during the period of record (1941-1971), with a maximum of 8,530 cfs and a minimum of 9.8 cfs. The Elochoman is used as a domestic water supply for the City of Cathlamet. The intake is located at approximately RM 4. There are currently no stream gages operating on any of the major streams in the subbasin.

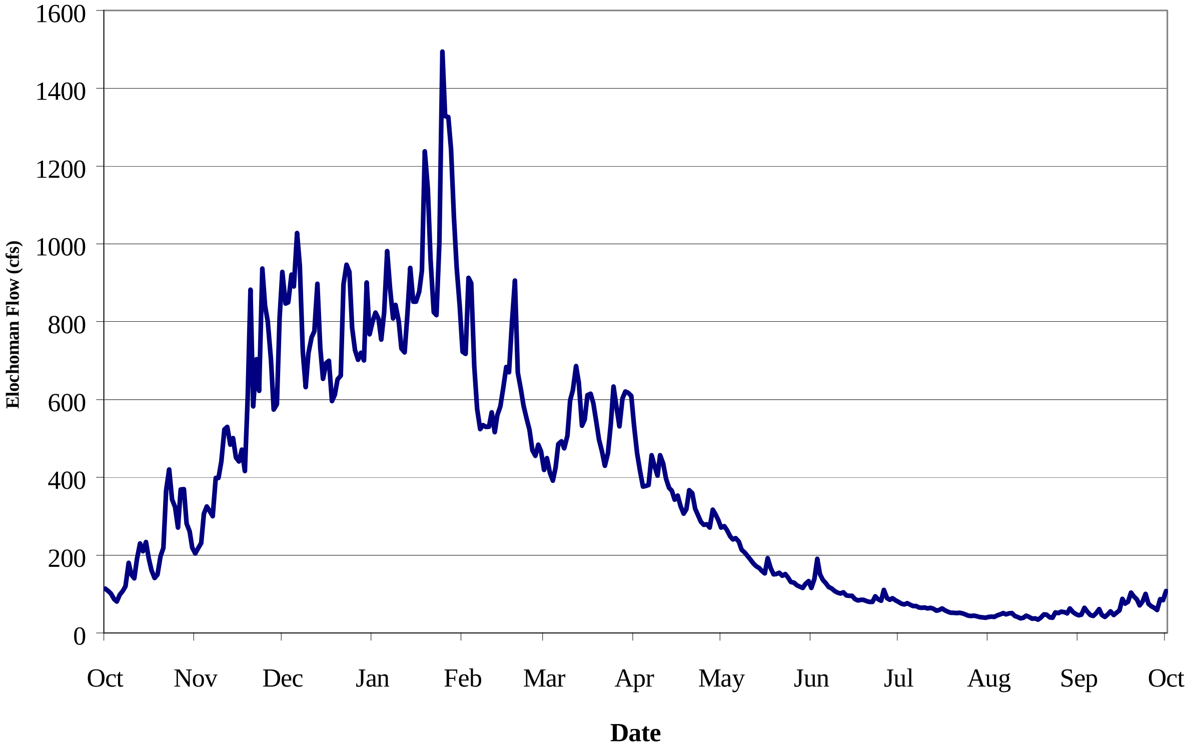

Figure 5-9. Elochoman River hydrograph (1962-1971). Elochoman River flows exhibit a fall through spring rainfall dominated regime, with flows less than 50 cfs common in late summer. USGS Stream Gage #14247500; Elochoman River near Cathlamet, Wash.

There has been a significant decrease in vegetative cover in the Elochoman subbasin, with potential impacts to runoff properties. Approximately 72% of the basin is either in early-seral stage forests, is cultivated land, or is developed land. Late-seral stage forests are virtually non-existent. High road densities are also a concern, with road densities greater than 5 miles/mi^2 throughout most of the basin. Forest and road conditions have potentially altered flow regimes. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 23 of 31 subwatersheds in the subbasin are 'impaired' with regards to runoff conditions; the remainder are 'moderately impaired'. These results are similar to those from a peak flow risk assessment conducted by Lewis County GIS (2000), which revealed 'impaired' conditions in 6 of 7 watersheds. Only the North Elochoman Watershed Administrative Unit (WAU) had a rating of 'likely impaired'.

Low flow assessments were conducted on several streams in the subbasin in 1997 and 1998 using the Toe-Width method (Caldwell et al. 1999). These assessments indicate that all of the basins may suffer from a lack of adequate flows for fish. On Wilson Creek (Skamokawa tributary) flows were adequate for salmon and steelhead rearing in the fall but were inadequate for salmon spawning. On the Elochoman at the Steel Bridge, flows were below suitable for spawning on October 1 but were adequate by November 1. Flows became less than suitable for summer rearing by July 1. On Mill Creek, Abernathy Creek, and Germany Creek fall flows in 1998 were considerably lower than optimum flows needed for salmonid spawning and rearing. Flows in Coal Creek became suitable for rearing by mid October but were below optimum for spawning through the first week in November (Caldwell et al. 1999).

Future surface and groundwater demand in the subbasin has been projected to increase by as little as 1% in the Coal Creek/Longview Slough basin and as much as 12.8% in the Elochoman basin over the next 20 years. The effect of withdrawals on stream flow is expected to be low on a subbasin scale (LCFRB 2001).

5.5.3 Water Quality

WCD temperature monitoring in the summer of 2000 recorded excursions beyond the state standard of 18ºC[2] in the Upper Skamokawa and Wilson Creek (Skamokawa tributary). Temperatures in lower Wilson Creek regularly exceeded the standard in August. An assessment of water quality by the Washington State Department of Ecology (WDOE) in response to a 1975 fish kill found elevated fecal coliform levels that were likely related to human and animal sources. Nevertheless, the fish kills were ultimately attributed to high fish numbers causing critically low dissolved oxygen levels. WCD monitoring of surface water and shallow groundwater in 1997 revealed elevated fecal coliform and nitrate levels. The source was believed to be septic systems and agricultural practices (Wade 2002).

The Elochoman was listed on the State's 303(d) list of impaired water bodies due to exceedance of temperature standards (WDOE 1998). Water temperature monitoring by WDFW on the Elochoman at the hatchery has recorded numerous excursions beyond temperature criteria. WCD monitoring in the summer of 2000 revealed that temperatures in the Lower Elochoman regularly exceed 18ºC in August and the first half of September. Monitoring in the Upper Elochoman and tributaries revealed cooler temperatures with no exceedance of state standards (Wade 2002).

Elevated water temperatures are a concern in Mill, Abernathy and Germany Creeks. The mainstems of Abernathy and Germany were listed on the state's 1998 303(d) list of impaired water bodies for exceedance of temperature standards (WDOE 1998). CCD Temperature monitoring in the summer of 2000 recorded exceedances of 18ºC on lower Mill Creek, on the South Fork Mill Creek, on the middle and lower mainstem of Abernathy Creek, on Wiest Creek (Abernathy tributary), at a few locations on mainstem Germany Creek, and on Coal Creek. Temperatures tend to be higher along reaches with agricultural uses and tend to be cooler in upper reaches. Stream temperatures generally cool down as water levels increase in the fall, however, high temperatures may be a problem for early-return salmon entering the system in the late summer (Wade 2002).

The WDOE identified a concern of aluminum toxicity in the biological communities in Mill Creek and Cameron Creek (Abernathy tributary), possibly related to bauxite deposits. In addition to elevated temperatures, Coal Creek has turbidity, landfill leachate, and sewage effluent concerns. The Longview Ditches have a glut of water quality concerns and are therefore listed on the state's 303(d) list. Specific concerns include elevated dissolved oxygen, fecal coliform, lead, and turbidity (WDOE 1998). Many water quality investigations have been conducted in the ditches and a TMDL study has been initiated. Lake Sacajawea, within the city of Longview, has concerns with several toxic substances including PCBs. Storm sewers and ditches contribute large amounts of sediment and nutrients to Lake Sacajawea, creating abundant algal growth. Restoration actions since the 1980s have improved conditions (Wade 2002).

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[2] 18°C (64°F) is the state standard for Class A streams; 16°C (61°F) is the state standard for Class AA streams.

In most of the basins, current escapement levels are considerably lower than historical levels. The lack of fish carcasses may create a nutrient deficit in the system. Carcass supplementation has occurred in a few places (Wade 2002).

5.5.4 Key Habitat

Information on side channel habitats is lacking in the Jim Crow and Skamokawa basins. Qualitative information from stream survey notes indicates that these systems are comprised primarily of single-thread channels with few side channels. Diking, roads/railroads, and channel incision in agricultural areas limit side channel development in the Elochoman basin, however, some portions of the Elochoman, in particular the West Fork, have abundant side channels. In a few areas, the presence of side channels appears to be related to the accumulation of sediments behind large log jams, but these side channels are believed to be transient (Wade 2002).

Pool habitat is considered poor in Jim Crow, the Skamokawa, and the Elochoman basin. Information is lacking for Alger, Risk, and Birnie Creeks. In Jim Crow Creek, 83% of surveyed reaches were given a “poor” pool habitat designation by the WCD. The few good pools were associated with beaver activity and the delivery of small diameter wood. In the Skamokawa and Elochoman basins pool habitat was less prevalent in the lower reaches where agriculture uses dominate and was more prevalent in the upper forested reaches. Pools were often associated with log jams (Wade 2002).

Only two side channels were observed during WCD surveys of Lower Mill Creek. In Abernathy Creek, side channels are virtually non-existent from the mouth to Slide Creek Bridge. Channel confinement limits side channel formation above tidal influence. In Germany Creek, debris jams that were creating a multi-thread channel in the lower 3000 feet were removed by residents, thereby returning the stream to a single-thread channel. In the agricultural section (RM 1.9 to RM 5.7) streambed aggradation is creating mid-channel bars and lateral bank erosion, potentially increasing habitat diversity, but also creating concerns to local landowners (Schuett-Hames 2000). Upper reaches have limited side channels due to natural channel and valley confinement.

Mill Creek has poor pool habitat (almost 90% of reaches, WCD surveys), with bedrock substrate limiting pool development. Abernathy has over 90% of surveyed reaches with inadequate pool habitat. The highest pool quantities are in the upper basin and are attributed to greater LWD numbers. Germany has over 98% of reaches lacking pools. In the agricultural portion (RM 1.9 to RM 5.7), excessive bedload may be filling pools. In 1990, it was noted that pools were being filled by excessive bedload in the upper reaches (Wade 2002). These channels may be recovering as sediment pulses move downstream (Schuett-Hames 2000). The Coal Creek basin is generally lacking in pool habitats. Channels are scoured to bedrock in many places. The tributary Boulder Creek has been reported as having excellent habitat by the Columbia River Flyfishers.

5.5.5 Substrate & Sediment

The majority (67%) of surveyed reaches (WCD surveys) on Jim Crow and Fink Creeks rated poor for substrate fines (>17% fines <0.85 mm). The Skamokawa basin also has poor substrate fine conditions. This is attributed to steep slopes underlain with sedimentary rock that is prone to landslides (Ludwig 1992). The Wilson Creek and West Fork Skamokawa basins have the highest and second highest mass failure rates per square mile in Wahkiakum County, respectively (Waterstrat 1994). The lower reaches of the mainstem and tributaries tend to have the highest levels of fines. Levels of fines decrease as gradient increases. In the Elochoman basin, substrate fine conditions are highly variable. Fines are generally high in the mainstem and in the lower reaches of tributaries. Gravel content increases as gradient increases. Especially high numbers of reaches in the Nelson Creek and North Fork Elochoman have elevated substrate fine conditions (WCD surveys, Wade 2002).

WCD stream surveys revealed excessive substrate fines in approximately 10% of surveyed reaches of Mill Creek. High fines were mainly found in the tidally-influenced area. The lower river up to RM 1.5 is predominantly bedrock. Abernathy Creek exhibits a similar pattern, with high fines in the tidal area and scoured bedrock channels in the reaches just upstream. Basin-wide, Abernathy has over 55% of surveyed reaches falling into the poor category for substrate fines. In particular, high fines are a concern in low gradient channels in the upper basin. Germany Creek has over 11% of surveyed reaches in the poor category. Excessive bedload, consisting primarily of gravels and cobbles, is found in the agricultural reaches between RM 1.9 and RM 5.7. Portions of this section also suffer from high fines, mostly in low gradient reaches adjacent to agricultural land that also exhibit degraded riparian conditions (CCD surveys). Excessive fines in the upper watershed are believed to originate from recent mass wasting events. The Coal Creek basin has mostly confined channels that are scoured to bedrock, with few substrate fines (Wade 2002).

High road densities and naturally unstable soils create a risk of elevated sediment supply from hillslopes. Road density in the Jim Crow basin is a high 5.14 mi/mi^2; however, Waterstrat (1994) reported that most of the roads are well-established and adequately designed, with few failures, thus limiting sediment delivery to streams. The Skamokawa basin has a road density greater than 4 mi/mi^2 and is composed of steep slopes with sedimentary rock that is prone to landslides. The basin has 2 watersheds with the highest mass failure rates in the county (Waterstrat 1994). These processes likely result in elevated volumes of sediment delivered to stream channels. In the Elochoman basin, forest practices have contributed to many mass failures, however, road erosion is probably responsible for most of the sediment delivery to streams (WDNR 1996). The Mill, Abernathy, and Germany basins all have road densities greater than 4 mi/mi^2.

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results suggest that nearly all (25 of 30) of the subwatersheds in the Elochoman subbasin are “moderately impaired” with respect to landscape conditions that influence sediment supply. Three subwatersheds are rated as “impaired” and three are rated as “functional”. The greatest impairments are located close to Longview. High road densities and naturally unstable soils are the primary drivers of the sediment supply impairment.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

5.5.6 Woody Debris

WCD surveys rated 97% of the Jim Crow basin as poor for LWD (<0.2 pieces/meter). Some woody debris was found in middle valley reaches but it was of small diameter. Most delivery was believed to occur through windfall. The Skamokawa basin was also mostly rated as poor for LWD. Where wood does exist it is typically small and deciduous. There are some log jams in places. Standard and McDonald Creeks have good LWD and recruitment potential, however, some areas have no wood whatsoever. The Elochoman had over 85% of reaches rated as poor. LWD is non-existent in many reaches and the number of large ("key") pieces is declining. Most of the wood that does exist is in jams. The majority of reaches with decent LWD quantities are in the upper reaches. The West Fork Elochoman basin has a few segments with good LWD conditions (WDNR 1996).

Approximately 90% of Mill Creek lacks adequate quantities of instream LWD. Wood is almost non-existent in the lower 1.5 miles and above this to RM 4 it is concentrated in debris jams. Single logs functioning in the channel are rare. Quantities increase slightly in the upper basin. Abernathy Creek has approximately 79% of surveyed reaches suffering from a lack of LWD. The lower reaches especially have very little LWD, with low recruitment potential. Quantities increase in the upper basin. Germany also has many reaches lacking instream wood (over 78%). Most wood is located in debris jams, some of which have been removed due to concerns by local residents. Upper basin reaches have slightly better conditions. LWD is virtually non-existent in the Coal Creek basin (Wade 2002).

5.5.7 Channel Stability

The Jim Crow and Skomokawa basins generally have good bank stability conditions. WCD surveys in the mid 1990s revealed that over 90% of the reaches on the mainstem Skamokawa had less than 10% actively eroding streambanks. Surveys in 1991 in the middle reaches of the Skamokawa revealed that 28% of surveyed banks were eroding; 34% in areas of agricultural use (Ludwig 1992). Bank erosion is high in agricultural land due to incision, alluvial soils, and a lack of vegetation on the streambanks. Bank stability in the Elochoman basin is generally good. There is some road related erosion on the mainstem and some erosion problems on the West Fork and on Nelson Creek and its tributaries. Mass wasting events are seen as the bigger problem in the Elochoman basin. In the West Fork, mass wasting is often associated with roads. In the North Elochoman basin, 205 of 383 surveyed landslides were related to forest practices activities (WDNR 1996).

Half of the reaches surveyed by the WCD in Mill Creek rated as "fair" or "poor" (80%-90% not actively eroding and <80% not actively eroding, respectively) for bank erosion. A particularly severe area of bank erosion is located at RM 0.6 on the outside bend of the channel. On Abernathy Creek, there are erosion concerns at the boat ramp and camping area. Bank erosion has also been identified between RM 1.5 and 3.4 where agriculture and residential uses have impacted riparian vegetation. In the tidally influenced portion of Germany Creek, debris jams have caused channel shifts and local residents have worked to remove these jams to decrease erosion. The channel between RM 1.5 and RM 6 has experienced streambed aggradation, causing bank erosion and lateral channel migration. This condition has also created landowner concerns (Wade 2002).

5.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 6 of the 31 subwatersheds in the Elochoman subbasin are rated as 'impaired' for riparian function, 24 are rated as 'moderately impaired', and only 1 is rated as 'functional'. The greatest impairments are located in and around the Longview, WA metropolitan area. Results from the IWA are consistent with impaired conditions that were identified throughout the subbasin in surveys conducted by the WCD.

Riparian conditions were evaluated by the WCD according to buffer widths and riparian composition. The Jim Crow, Skamokawa, and Elochoman basins have 94.5%, 74%, and 78% of surveyed riparian areas in “poor” condition, respectively. Nearly all of the basins are at least 95% commercial and state timberland and were heavily harvested in the mid 20th century (Waterstrat 1994). In most cases, poor riparian areas are found in the lower river segments due to the impacts of agriculture, livestock grazing, roads, and diking on buffer widths and species composition. Upper reaches tend to suffer from young timber stands, and to a lesser extent, high deciduous composition. Poor riparian conditions in the Elochoman basin have also been attributed to mass wasting and debris flows (WDNR 1996). The WCD is working with landowners to improve riparian conditions.

The lower 3 miles of Mill Creek suffer from narrow buffer widths due to a stream adjacent road and residential development. The upper basin was harvested extensively in the mid 20th century and is now maturing. According to Cowlitz Conservation District (CCD) surveys, over half of the reaches in the Abernathy basin have poor riparian conditions. The lower portion up to RM 1.5 has narrow buffers due to a roadway, residential development, and recreational use. River mile 1.5 to 3.4 is dominated by agricultural land with a predominance of deciduous species and narrow buffers. Above this to RM 10 is impacted by a stream-adjacent road and suffers from a narrow buffer of mixed hardwoods and conifers. None of the reaches surveyed by the CCD in the Germany basin rated as “good” and over half rated “poor”. A roadway limits buffer widths on the lower river and agricultural practices limit buffer widths and favor deciduous species between RM 1.9 and 5.7. The upper watershed was heavily harvested in the 1980s, which left narrow buffers. A stream-adjacent road in the upper basin also limits the development of a mature riparian forest. Roads and land use practices impact riparian areas in lower Coal Creek. The upper basin suffers from impacts related to historical agricultural practices (Wade 2002).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

5.5.9 Floodplain Function

The Skamokawa has been diverted from its natural meandering channel into a straightened channel from its mouth to RM 1.7. From RM 1.7 to 6.6 it is entrenched as it flows through agricultural land. The lower reaches of tributaries have been diked and are also entrenched in areas of agricultural use. Alger Creek has been diked along the first 1,700 feet. A project is underway by the Columbia Land Trust to improve floodplain connectivity in this reach. The Elochoman is diked for the first 1.4 miles and the lower part of the tributary Nelson creek is also diked and incised. Stream adjacent roads and railroads limit floodplain connectivity on the lower mainstem Elochoman and the lower portions of lower mainstem tributaries. There is high entrenchment within areas of agricultural use. Floodplain connectivity improves in the upper basin. Entrenchment from splash damming is apparent on the middle reaches of the Elochoman (Wade 2002).

Mill Creek Road restricts Mill Creek to an incised channel in the lower reaches. Splash damming has caused channel incision in lower Mill Creek, which has also impacted several tributaries. Conditions in the upper basin are believed to be better though data is lacking. Abernathy Creek has good connectivity in the tidally influenced area. Roads confine portions of lower Abernathy Creek and lower portions of tributaries. Lower reaches are highly incised due to agricultural practices and past splash damming. Floodplain connectivity improves above Erick Creek. Germany Creek has slight confinement from roads and slight entrenchment from agricultural practices, but has good floodplain connectivity overall. CCD surveys indicate that Coal Creek is highly entrenched throughout the entire basin. In many places residential development limits floodplain connectivity. Clark Creek is confined by Clark Creek Road along most of its length though the upper reaches have good floodplain connectivity. The Longview Ditches are maintained to ensure there is no connection with the floodplain (Wade 2002).

5.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Elochoman, Skamokawa, Mill, Abernathy, and Germany fall chinook, coho, chum, and winter stelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI. Model results are discussed in separate sections for the Skamokawa-Elochoman basins and for the Mill-Abernathy-Germany basins.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

5.6.1 Skamokawa-Elochoman

5.6.1.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for fall chinook, coho, chum, and winter steelhead in the Elochoman and Skamokawa basins. In the Elochoman, adult productivity for all four species has been reduced to 17-25% of historical levels (Table 5-1). Declines in adult abundance level have also been significant for all species (Figure 5-10), with the greatest decline seen for chum and coho. Current adult abundance of chum and coho is estimated at only 6% and 15% of historical levels, respectively. Abundance of both fall chinook and winter steelhead in the Elochoman has declined by approximately 60% (Figure 5-10). Diversity (as measured by the diversity index) has remained steady for fall chinook, but has declined by 20-50% for winter steelhead, coho and chum (Table 5-1).

Smolt productivity numbers in the Elochoman have declined by 46-76% for all four species (Table 5-1), though losses have not been as great as for adult productivity, suggesting that out of basin factors are contributing to losses in adult productivity. Declines in smolt abundance levels have been greatest for chum and coho (84% and 78% decrease respectively), but losses have also occurred for fall chinook and winter steelhead smolts (40% and 49% decrease respectively) (Table 5-1).

Adult productivity declines in the Skamokawa basin have also been severe, with current levels only one quarter of historical levels for chum, winter steelhead and coho (Table 5-2). Fall chinook adult productivity has declined by 50% (Table 5-2). Current adult chum and coho abundance is estimated at only 13-21% of historical levels, respectively (Figure 5-11). While not as severe as chum and coho, the decline in abundance of adult winter steelhead and fall chinook is such that current levels are estimated at 60% and 27% of historical levels (Figure 5-11). Diversity (as measured by the diversity index) of all species has been fairly well maintained, though chum, winter steelhead, and coho have experienced some loss (Table 5-2).

Reductions in smolt productivity and abundance in the Skamokawa have been similar to those in the Elochoman, though to a slightly lesser degree. Smolt productivity has declined by 36-66%, and abundance has decreased by 26-70% (Table 5-2). Productivity losses were greatest for coho, and abundance losses have been greatest for chum.

Model results indicate that restoration of PFC conditions in both of the basins would produce substantial benefits. Adult returns for chum would benefit the most, with runs increasing to 2-3 times current levels (Table 5-1 and Table 5-2). Similarly, fall chinook, winter steelhead, and coho returns would increase by 65-185%. Smolt abundance levels would benefit at similar rates, with chum smolts benefiting the most (Table 5-1 and Table 5-2).

Table 5-1. Elochoman River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	1,479	2,172	3,769	3.1	7.1	12.4	1.00	1.00	1.00	182,410	263,921	304,153	328	719	903
Chum	515	2,619	7,821	1.6	6.3	9.2	0.80	1.00	1.00	263,160	1,026,242	1,693,571	612	992	1,141
Coho	1,315	4,014	8,786	3.7	9.4	21.0	0.47	0.86	0.96	27,015	91,351	125,124	78	205	312
Winter Steelhead	335	574	850	3.8	10.7	20.1	0.80	0.89	0.96	6,265	10,328	12,391	68	186	283

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

Table 5-2. Skamokawa River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	581	762	795	4.2	6.9	8.7	1.00	1.00	1.00	95,719	130,225	129,940	509	826	1,024
Chum	1,125	3,269	8,499	2.3	6.0	9.3	0.94	1.00	1.00	564,503	1,277,833	1,898,123	739	994	1,148
Coho	1,081	1,773	5,099	5.2	10.2	22.4	0.79	0.84	0.91	19,736	38,648	54,514	116	235	347
Winter Steelhead	206	268	515	5.2	10.1	20.1	0.91	1.00	1.00	2,513	3,414	4,115	76	135	174

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

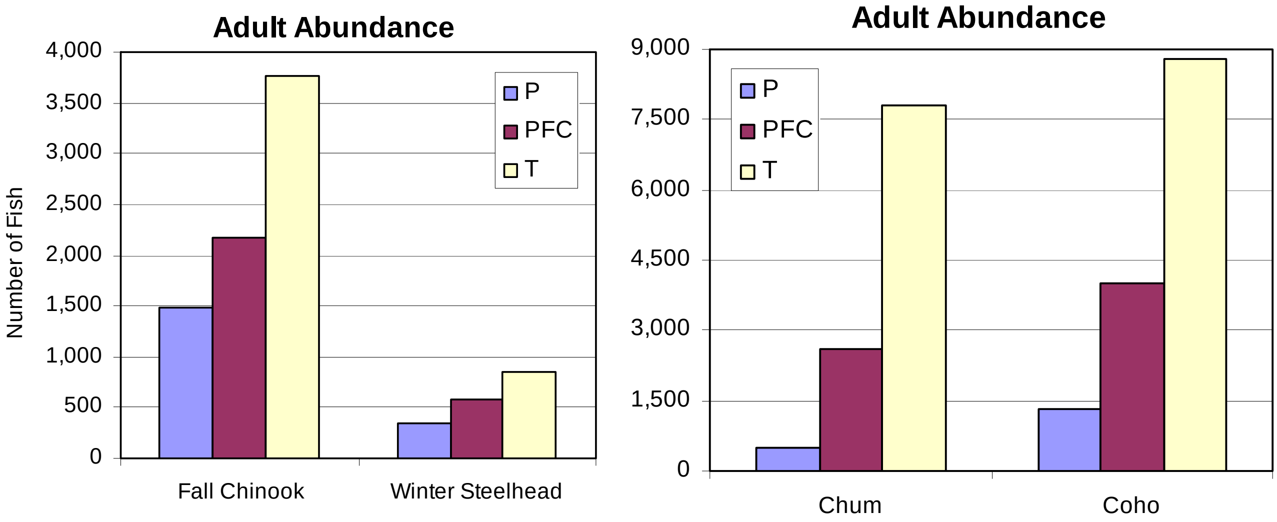


Figure 5-10. Adult abundance of Elochoman fall chinook, winter steelhead, chum and coho based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

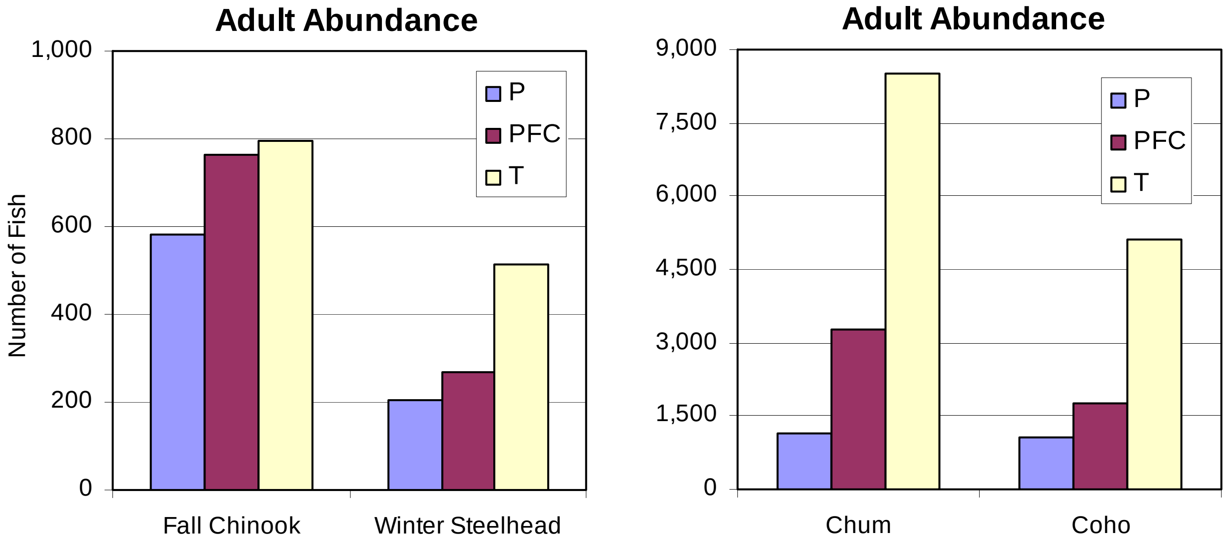


Figure 5-11. Adult abundance of Skamokawa fall chinook, chum, winter steelhead and coho based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

5.6.1.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Winter steelhead are distributed throughout the Elochoman Basin including the mainstem and the tributaries of Beaver, Duck, Clear, Rock and Otter creeks and the East, North, and West Fork Elochoman. Fall chinook are found in the lower mainstem between river miles 4 and 9. Chum distribution is primarily in the lower mainstem above tidal influence. Coho are suspected to use most of the basin that is accessible, but primary spawning areas include the upper basin and the West Fork Elochoman. (See Figure 5-12 for a map of the EDT stream reaches).

High priority areas for winter steelhead in the Elochoman include middle and upper mainstem reaches (Elochoman 8, 10, 11 and 13) and the lowest reaches of the West Fork Elochoman (WF Elochoman 1 and 2) (Figure 5-13). Some smaller tributaries also rank as high priority for steelhead (Rock 1, Beaver 2, and Clear 1 and 3). Each of the mainstem reaches (with the exception of Eloch 13), and both WF Elochoman 1 and 2 have a restoration emphasis. Eloch 13, however, has a combined preservation and restoration emphasis. The majority of the mainstem tributaries have a preservation emphasis. The reach with the highest preservation emphasis for steelhead is Rock 1.

High priority reaches for fall chinook (Figure 5-14) and chum (Figure 5-15) are found primarily in select areas of the lower and mid Elochoman (Elochoman 4, 6, 7 and 10 for fall chinook and Eloch 3 and 4 for chum). All high priority reaches for fall chinook have a combined preservation and restoration emphasis. For chum, Eloch 3 has a combined preservation and restoration emphasis while Eloch 4 has a restoration only emphasis.

For coho in the Elochoman basin, high priority reaches include multiple areas in the lower and mid mainstem Elochoman (Elochoman 4-6, 10 and 13) (Figure 5-16). Some smaller tributaries also rank as high priority for coho (Rock 1, Clear 1 and 3, and Duck 1). All mainstem reaches show a restoration emphasis, while the smaller tributaries have either a preservation or a combined preservation and restoration emphasis.

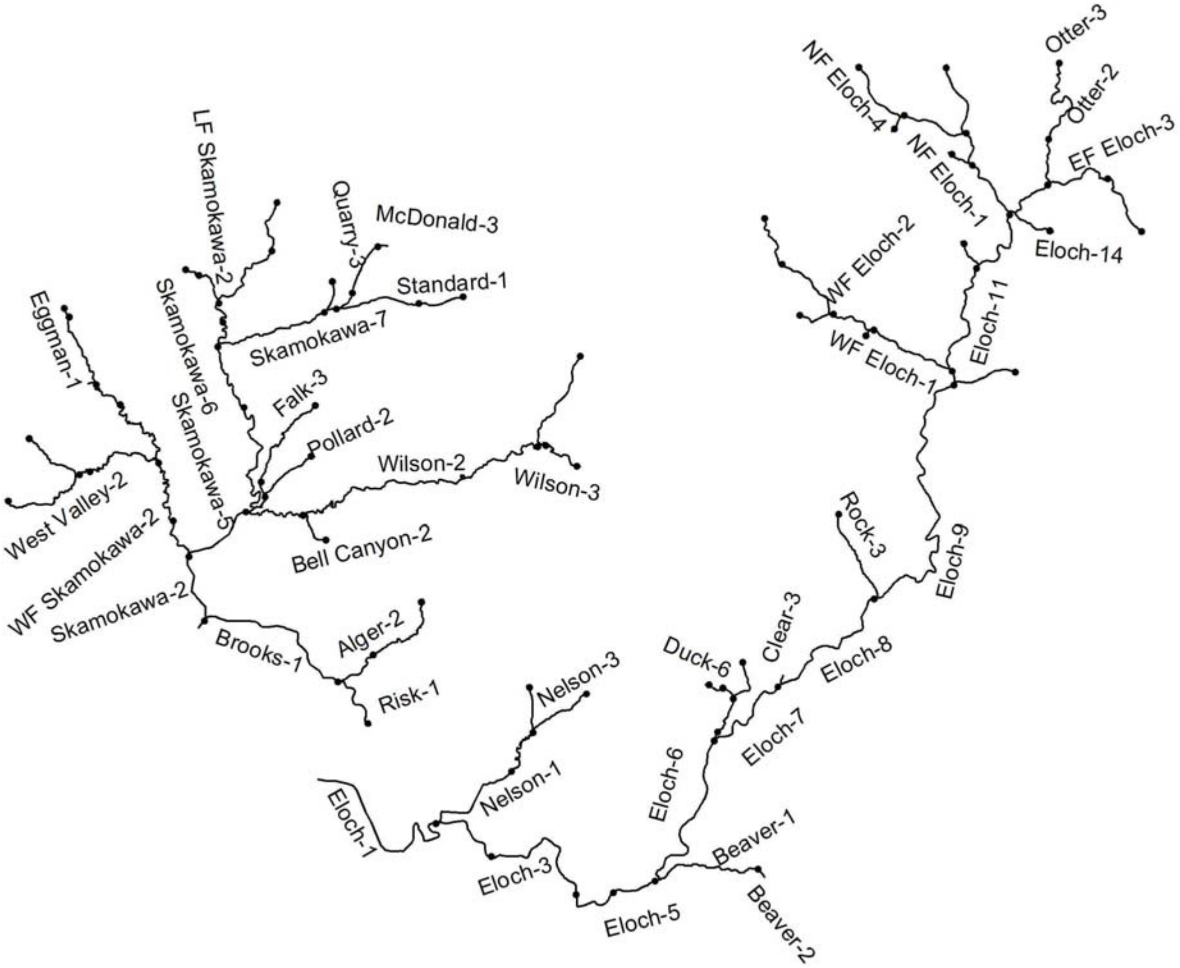
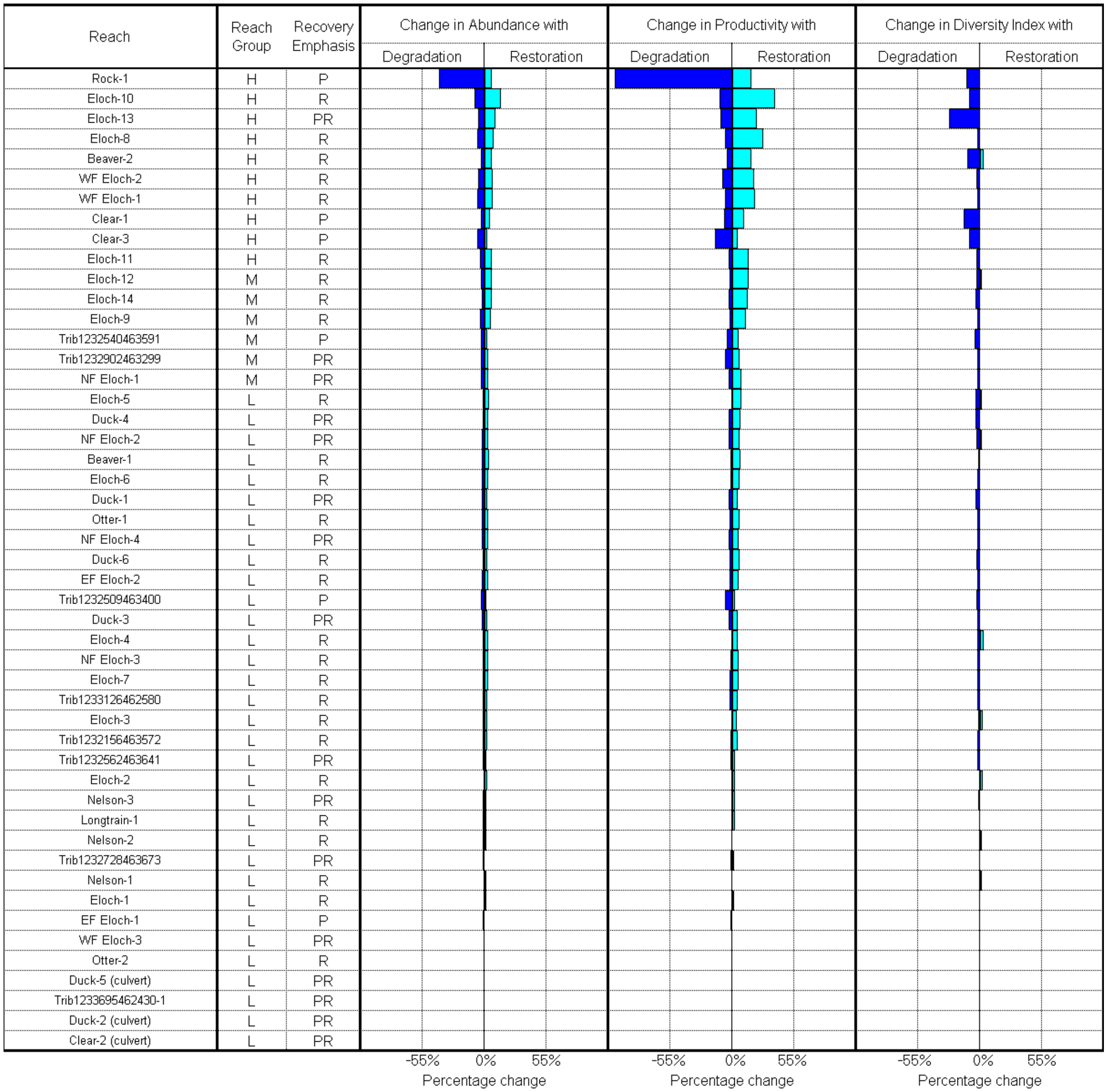


Figure 5-12. Elochoman and Skamokawa subbasin EDT reaches. Some reaches are not labeled for clarity.

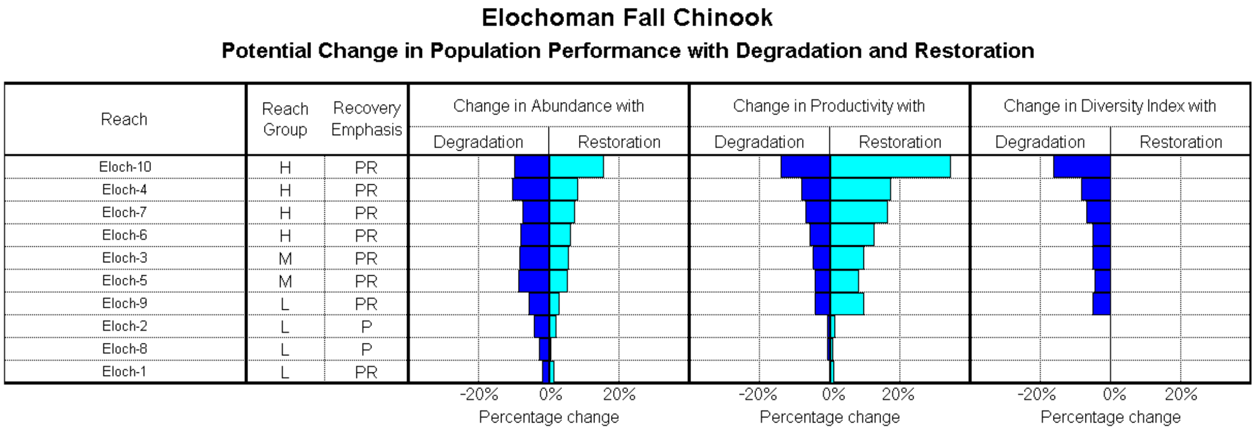
Elochoman Winter Steelhead

Potential Change in Population Performance with Degradation and Restoration



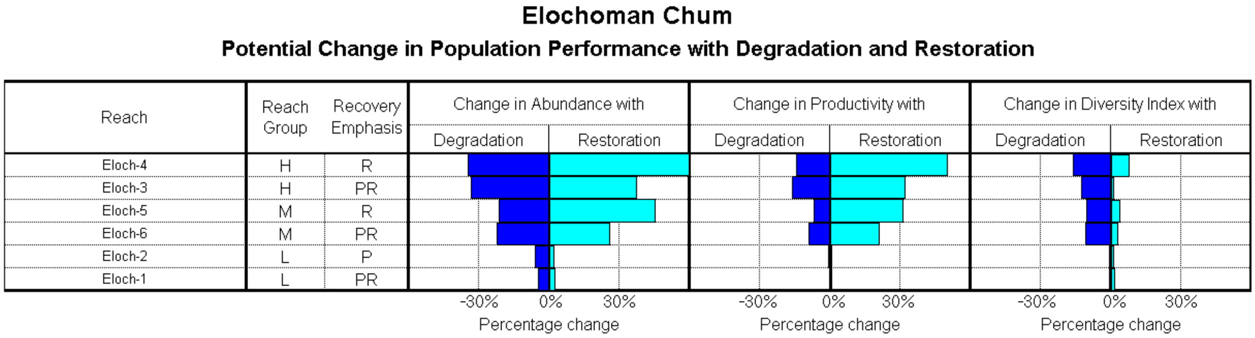
Reach	Reach Group	Recovery Emphasis
Rock-1	H	P
Eloch-10	H	R
Eloch-13	H	PR
Eloch-8	H	R
Beaver-2	H	R
WF Eloch-2	H	R
WF Eloch-1	H	R
Clear-1	H	P
Clear-3	H	P
Eloch-11	H	R
Eloch-12	M	R
Eloch-14	M	R
Eloch-9	M	R
Trib1232540463591	M	P
Trib1232902463299	M	PR
NF Eloch-1	M	PR
Eloch-5	L	R
Duck-4	L	PR
NF Eloch-2	L	PR
Beaver-1	L	R
Eloch-6	L	R
Duck-1	L	PR
Otter-1	L	R
NF Eloch-4	L	PR
Duck-6	L	R
EF Eloch-2	L	R
Trib1232509463400	L	P
Duck-3	L	PR
Eloch-4	L	R
NF Eloch-3	L	R
Eloch-7	L	R
Trib1233126462580	L	R
Eloch-3	L	R
Trib1232156463572	L	R
Trib1232562463641	L	PR
Eloch-2	L	R
Nelson-3	L	PR
Longtrain-1	L	R
Nelson-2	L	R
Trib1232728463673	L	PR
Nelson-1	L	R
Eloch-1	L	R
EF Eloch-1	L	P
WF Eloch-3	L	PR
Otter-2	L	R
Duck-5 (culvert)	L	PR
Trib1233695462430-1	L	PR
Duck-2 (culvert)	L	PR
Clear-2 (culvert)	L	PR

Figure 5-13. Elochoman basin winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



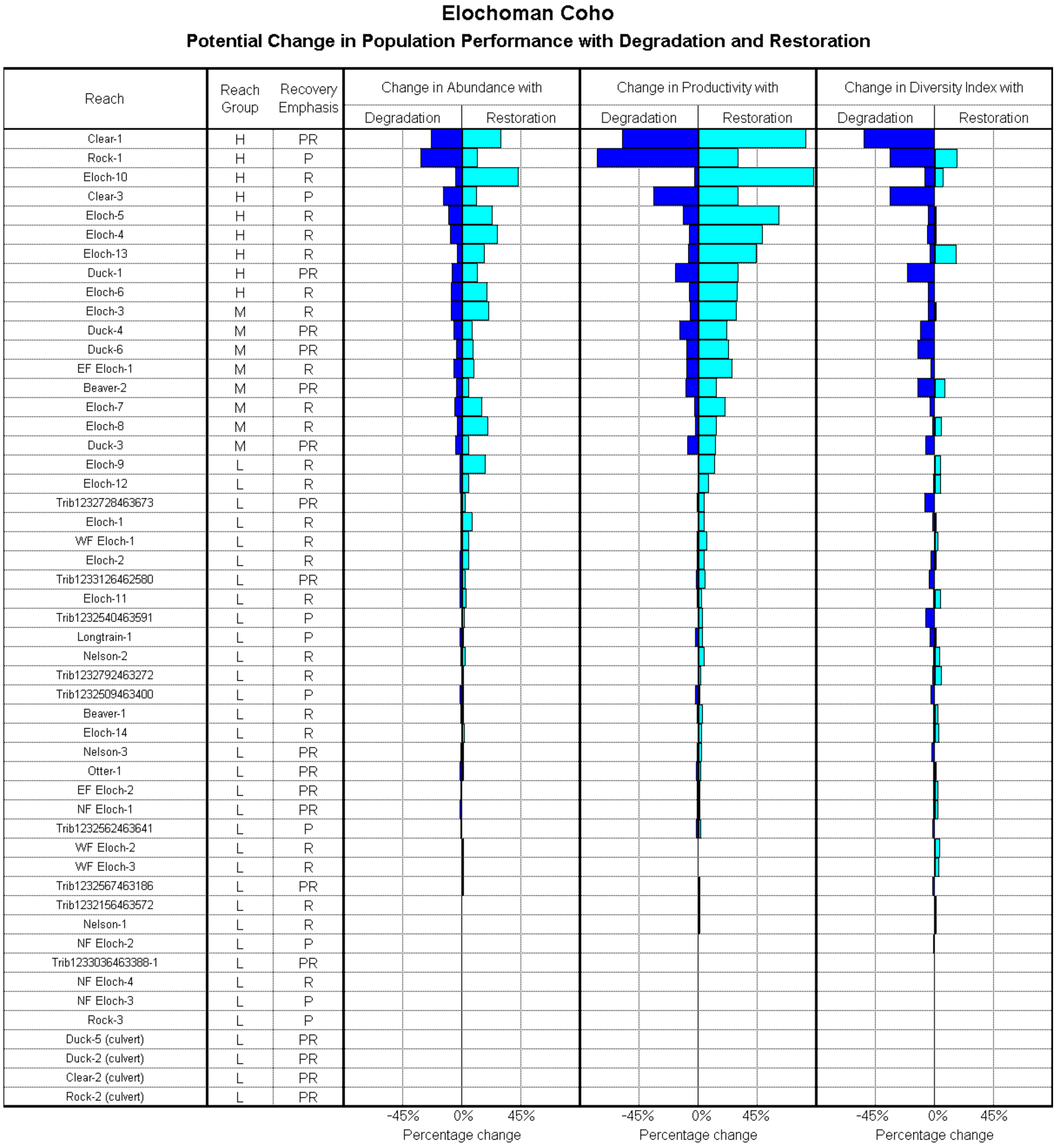
Reach	Reach Group	Recovery Emphasis
Eloch-10	H	PR
Eloch-4	H	PR
Eloch-7	H	PR
Eloch-6	H	PR
Eloch-3	M	PR
Eloch-5	M	PR
Eloch-9	L	PR
Eloch-2	L	P
Eloch-8	L	P
Eloch-1	L	PR

Figure 5-14. Elochoman fall chinook ladder diagram.



Reach	Reach Group	Recovery Emphasis
Eloch-4	H	R
Eloch-3	H	PR
Eloch-5	M	R
Eloch-6	M	PR
Eloch-2	L	P
Eloch-1	L	PR

Figure 5-15. Elochoman chum ladder diagram.



Reach	Reach Group	Recovery Emphasis
Clear-1	H	PR
Rock-1	H	P
Eloch-10	H	R
Clear-3	H	P
Eloch-5	H	R
Eloch-4	H	R
Eloch-13	H	R
Duck-1	H	PR
Eloch-6	H	R
Eloch-3	M	R
Duck-4	M	PR
Duck-6	M	PR
EF Eloch-1	M	R
Beaver-2	M	PR
Eloch-7	M	R
Eloch-8	M	R
Duck-3	M	PR
Eloch-9	L	R
Eloch-12	L	R
Trib1232728463673	L	PR
Eloch-1	L	R
WF Eloch-1	L	R
Eloch-2	L	R
Trib1233126462580	L	PR
Eloch-11	L	R
Trib1232540463591	L	P
Longtrain-1	L	P
Nelson-2	L	R
Trib1232792463272	L	R
Trib1232509463400	L	P
Beaver-1	L	R
Eloch-14	L	R
Nelson-3	L	PR
Otter-1	L	PR
EF Eloch-2	L	PR
NF Eloch-1	L	PR
Trib1232562463641	L	P
WF Eloch-2	L	R
WF Eloch-3	L	R
Trib1232567463186	L	PR
Trib1232156463572	L	R
Nelson-1	L	R
NF Eloch-2	L	P
Trib1233036463388-1	L	PR
NF Eloch-4	L	R
NF Eloch-3	L	P
Rock-3	L	P
Duck-5 (culvert)	L	PR
Duck-2 (culvert)	L	PR
Clear-2 (culvert)	L	PR
Rock-2 (culvert)	L	PR

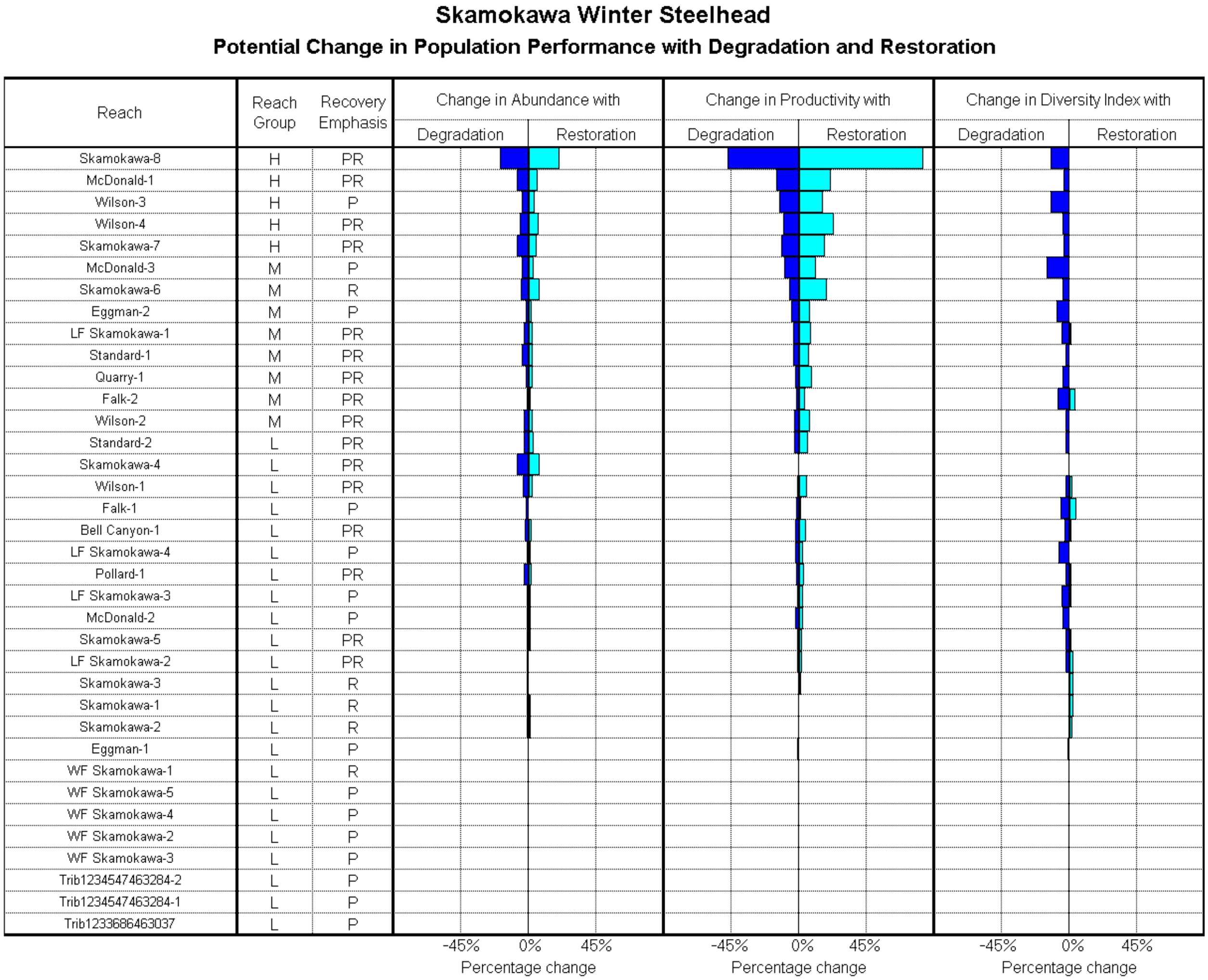
Figure 5-16. Elochoman coho ladder diagram.

In the Skamokawa, winter steelhead are found in the mainstem and in numerous tributaries. Fall chinook spawning is mainly between Wilson Creek and Standard and McDonald Creeks, a length of approximately 4.5 miles. Chum spawning in the Skamokawa is exclusively in the lowest reaches. Coho spawning in the Skamokawa is in the mainstem and in Wilson, Left Fork, Quartz, Standard, and McDonald Creeks. (See Figure 5-12 for a map of stream reaches with high value restoration and preservation reaches labeled).

High priority reaches for winter steelhead in the Skamokawa basin include the middle areas of the mainstem (Skamokawa 7 and 8), McDonald 1, and two middle reaches of Wilson Creek (Wilson 3 and 4) (Figure 5-17). All high priority reaches, except for Wilson 3, show a combined preservation and restoration emphasis. The reach with the highest restoration and preservation emphasis is Skamokawa 8.

For both fall chinook (Figure 5-18) and chum (Figure 5-19), the high priority reaches are generally located in the area between Falk Creek and Standard Creek (Skamokawa 5 and 8 for ChF, and Skamokawa 5 and 6 for chum). All high priority reaches for both species show a preservation emphasis, with Skamokawa 5 possibly having the greatest potential from preservation.

Coho in the Skamokawa have high priority reaches located primarily in the mid to upper areas of the basin (Skamokawa 5 and 6, LF Skamokawa 2, McDonald 3, Wilson 3, and West Valley 2) (Figure 5-20). Each of these reaches, except McDonald 3, show a combined preservation and restoration recovery emphasis. Reach Skamokawa 6 is estimated to have the greatest potential for preservation and restoration.

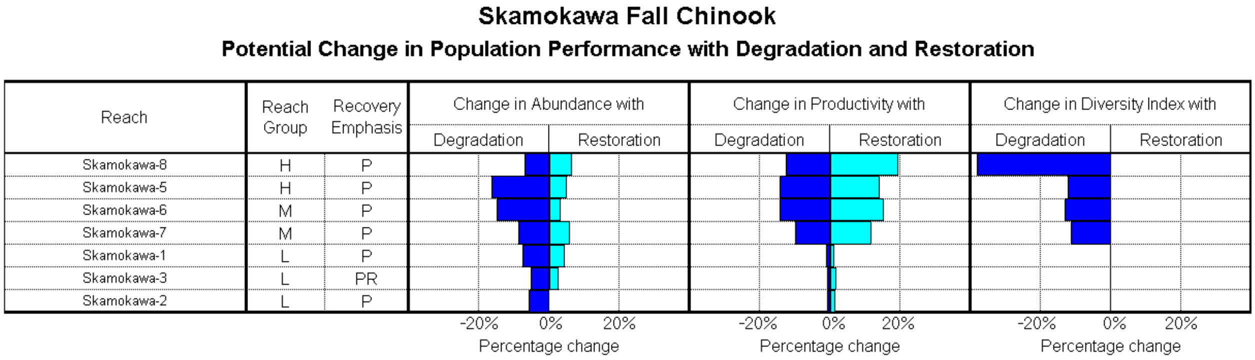


Skamokawa Winter Steelhead

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
Skamokawa-8	H	PR
McDonald-1	H	PR
Wilson-3	H	P
Wilson-4	H	PR
Skamokawa-7	H	PR
McDonald-3	M	P
Skamokawa-6	M	R
Eggman-2	M	P
LF Skamokawa-1	M	PR
Standard-1	M	PR
Quarry-1	M	PR
Falk-2	M	PR
Wilson-2	M	PR
Standard-2	L	PR
Skamokawa-4	L	PR
Wilson-1	L	PR
Falk-1	L	P
Bell Canyon-1	L	PR
LF Skamokawa-4	L	P
Pollard-1	L	PR
LF Skamokawa-3	L	P
McDonald-2	L	P
Skamokawa-5	L	PR
LF Skamokawa-2	L	PR
Skamokawa-3	L	R
Skamokawa-1	L	R
Skamokawa-2	L	R
Eggman-1	L	P
WF Skamokawa-1	L	R
WF Skamokawa-5	L	P
WF Skamokawa-4	L	P
WF Skamokawa-2	L	P
WF Skamokawa-3	L	P
Trib1234547463284-2	L	P
Trib1234547463284-1	L	P
Trib1233686463037	L	P

Figure 5-17. Skamokawa basin winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



Skamokawa Fall Chinook

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
Skamokawa-8	H	P
Skamokawa-5	H	P
Skamokawa-6	M	P
Skamokawa-7	M	P
Skamokawa-1	L	P
Skamokawa-3	L	PR
Skamokawa-2	L	P

Figure 5-18. Skamokawa fall chinook ladder diagram.

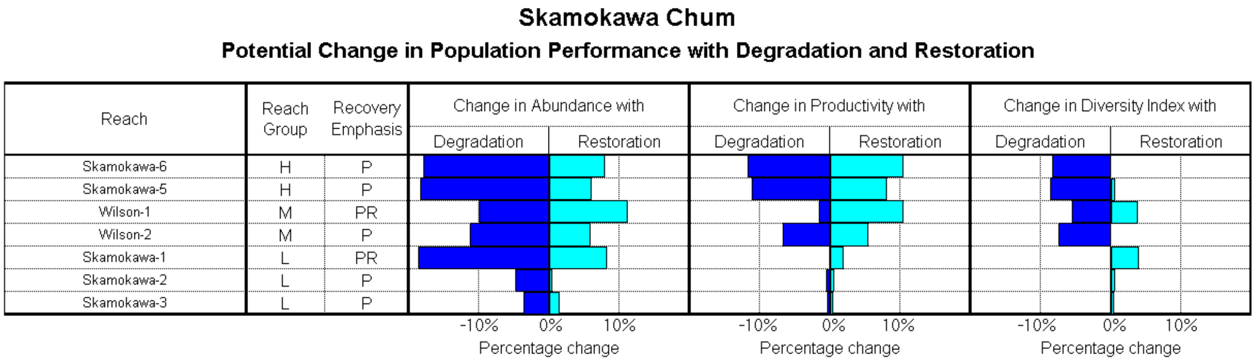


Figure 5-19. Skamokawa chum ladder diagram.

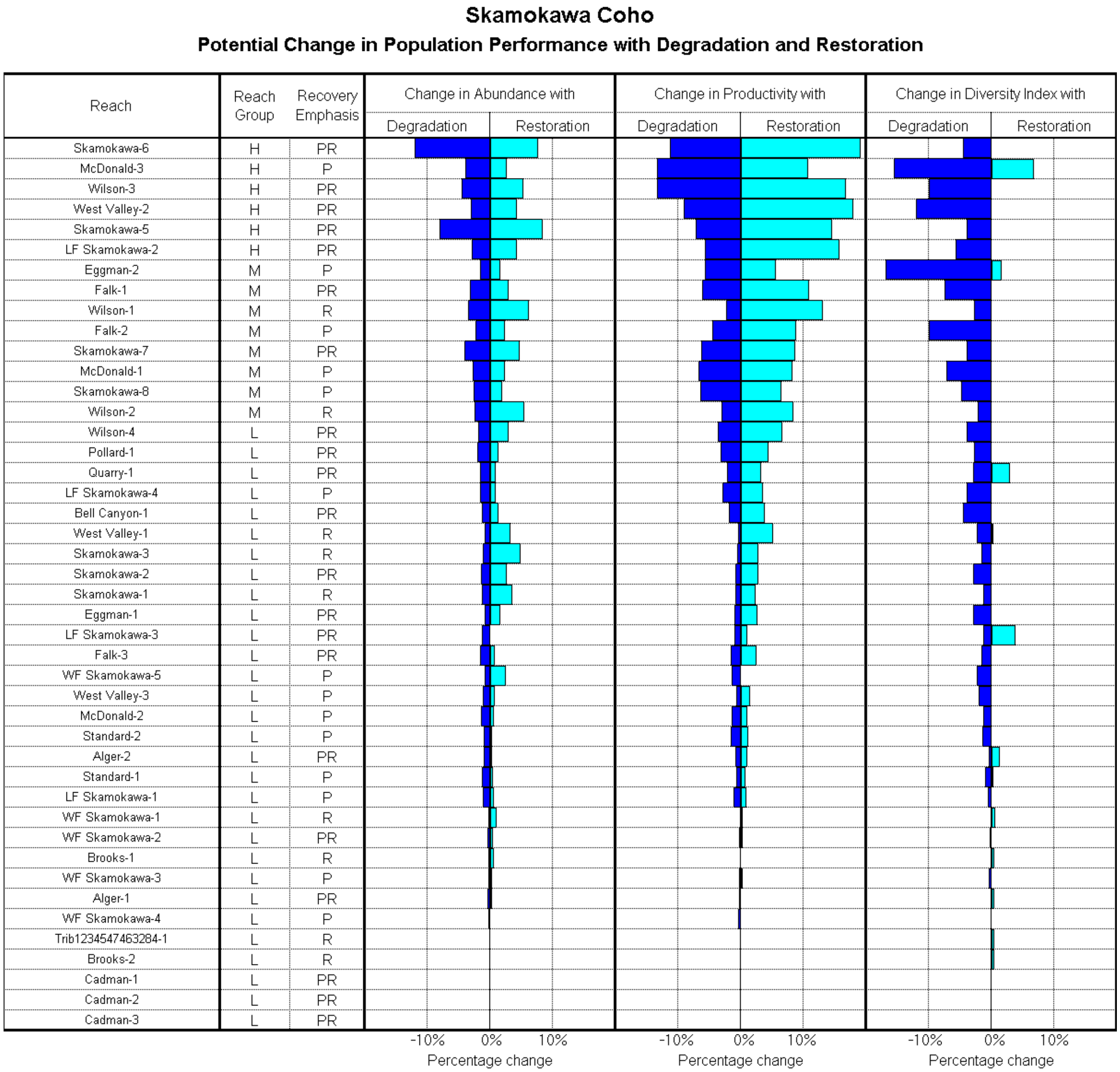


Figure 5-20. Skamokawa coho ladder diagram.

5.6.1.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Key winter steelhead restoration reaches in the Elochoman River are located in both mainstem and tributaries areas between Clear Creek and the North Fork Elochoman. These reaches have degraded sediment, habitat diversity, flow regimes and channel stability (Figure 5-21). Flow impacts are related to upper basin vegetation and road conditions. Over half of the North Elochoman WAU is in early-seral, non-forest, or other cover types, while none of the basin is in the late-seral stage. Riparian vegetation conditions may also be leading to increased temperatures. Entrenchment in the mainstem has altered flow, reduced habitat diversity, and reduced channel stability. Habitat diversity has also been reduced by diking, roads, railroads, and agricultural practices. Lack of LWD has precluded the formation of pools. Road density in the basin is approximately 4 mi/mi^2, which likely contributes to increased fine sediments and altered flow regimes. WDNR (1996) cited road erosion as a primary culprit in delivery of fines to the Elochoman.

Fall chinook restoration reaches in the Elochoman are generally between Beaver Creek and the West Fork Elochoman. These reaches have been degraded by sedimentation, decreased habitat diversity, predation, and decreased channel stability (Figure 5-22). Predation concerns arise because of the presence of the Elochoman hatchery. Hatchery releases can trigger migration of wild fish in the “pied piper” effect while increasing the attraction of predators. The other impacts result from causes described in the winter steelhead discussion.

Important chum restoration reaches are in the lower mainstem below Duck Creek. These reaches have been impacted primarily by sediment, habitat diversity, predation, and harassment/poaching (Figure 5-23). Harvest concerns, related to harassment and poaching, are primarily due to the take of wild fish while fishing for returning hatchery fish. The other impacts result from causes described in the winter steelhead discussion.

Primary coho restoration reaches are scattered throughout the Elochoman, primarily below the West Fork Elochoman. The most important restoration reaches have been negatively affected by reduced habitat diversity, sediment, loss of key habitat, reduced channel stability, altered flow, and predation (Figure 5-24). All of these impacts are related to causes described for the other three species. These causes include land use practices and hatchery impacts.

Elochoman Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Rock-1	●	⬤	●						●	⬤					●	●
Eloch-10	●	⬤							⬤	⬤	•					✚
Eloch-13	●	⬤	•						●	⬤						➕
Eloch-8	●	⬤	●						●	⬤	•			●	•	✚
Beaver-2	●	⬤	●						●	⬤	•				•	➕
WF Eloch-2	●	⬤							⬤	⬤	•					+
WF Eloch-1	●	⬤							⬤	⬤	•					+
Clear-1	●	●							●	⬤					●	•
Clear-3	●	●							•	●						•
Eloch-11	●	⬤							●	⬤						✚
Eloch-12	•	⬤							●	●	•					✚
Eloch-14	●	⬤	•						●	•	•					●
Eloch-9	●	⬤	•						●	●	•				•	✚
Trib1232540463591		●	•						●	⬤						•
Trib1232902463299	•	●							●	•	•					•
NF Eloch-1	•	●	•						●	●						+
Eloch-5	•	●	●	●		•		•	•	●	•			•	•	+
Duck-4	•	●	•						●	⬤						✚
NF Eloch-2	•	●	•						●	●						•
Beaver-1	•	●	•	•					●	●	•					✚
Eloch-6	•	●	•	●		•			•	●	•			•	•	+
Duck-1	•	●	•						●	⬤					•	
Otter-1	•	●	•						●	●						✚
NF Eloch-4	•	●							●	•						●
Duck-6	●	●	•						●	⬤					•	✚
EF Eloch-2	•	●	•						●	●						✚
Trib1232509463400		•							•	•						•
Duck-3	•	•	•						●	⬤						+
Eloch-4	•	●	•	•		•		•	•	●	•			•	•	
NF Eloch-3	•	●							●	●						●
Eloch-7	•	●	•	●		•			•	•	•			•		
Trib1233126462580	•	●							●	●						•
Eloch-3	•	●	●	•		•		•	•	●	•			•	•	+
Trib1232156463572	•	●							●	●						•
Trib1232562463641		●							•	●						•
Eloch-2	•	•	•	●		•			•	•	•			•	•	
Nelson-3	•	•		•		•			•	●						✚
Longtrain-1	•	•	•						•	●						•
Nelson-2		•	•	•					•	•				•		+
Trib1232728463673		•							•							
Nelson-1	•	•	•	•					•	●				•		
Eloch-1		•		•						•					•	
EF Eloch-1		•							•							
WF Eloch-3		•							•							
Otter-2		•							•							
Duck-5 (culvert)																
Duck-2 (culvert)																
Clear-2 (culvert)																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 5-21. Elochoman basin winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Elochoman Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Eloch-10	⬤	⬤							●	⬤						✚
Eloch-4	●	●	•	●					●	⬤	•				●	•
Eloch-7	●	●	•	●					•	⬤	•			•	•	+
Eloch-6	●	●	•	●					•	⬤	•				•	•
Eloch-3	•	●	•	●					●	⬤	•				•	•
Eloch-5	•	●	•	●					•	⬤	•				●	•
Eloch-9	•	●							•	⬤					•	✚
Eloch-2	•	•		●	•				•	•	•				•	
Eloch-8		•														
Eloch-1		•		•					•	•	•				•	

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-22. Elochoman fall chinook habitat factor analysis.

Elochoman Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Eloch-4	•	●		●					•	⬤					●	●
Eloch-3	•	●		●					•	⬤	•				●	●
Eloch-5	•	●		●					•	⬤					●	●
Eloch-6	•	●		●						⬤					●	+
Eloch-2		•		•												•
Eloch-1		•		•												•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-23. Elochoman chum habitat factor analysis.

Elochoman Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Clear-1	⬤	⬤							●	⬤	•				•	⬤
Rock-1	●	⬤							●	●						⬤
Eloch-10	⬤	⬤							●	⬤	•					✚
Clear-3	●	⬤							●	●						⬤
Eloch-5	●	⬤	●	⬤		•		•	●	⬤	●			•	●	●
Eloch-4	●	⬤	●	●		•		•	●	⬤	●			•	•	●
Eloch-13	●	⬤							●	⬤						✛
Duck-1	●	⬤							●	⬤					•	●
Eloch-6	●	⬤	●	●		•			●	●	•			•	•	●
Eloch-3	●	⬤	●	●		•		•	●	⬤	●			•	•	●
Duck-4	•	●	•						●	⬤	•					✛
Duck-6	●	●							●	⬤					•	✛
EF Eloch-1	●	⬤	•						●	⬤	•					✛
Beaver-2	•	●							•	●						✛
Eloch-7	●	⬤	•	●		•			●	●	•			•	•	•
Eloch-8	●	⬤	•						●	●	•			•		✛
Duck-3	•	●							●	⬤						+
Eloch-9	●	⬤	•						●	●	•					✚
Eloch-12	•	●							•	•						+
Trib1232728463673	•	●							•	•						●
Eloch-1	•	●	•	●	•	•			•	•	•			•	•	•
WF Eloch-1	•	●							•	●						•
Eloch-2	•	•	•	●					•	•	•			•		•
Trib1233126462580	•	●							•	•						●
Eloch-11	•	●							•	•						✛
Trib1232540463591	•	●							•	•						●
Longtrain-1	•	•							•	•						•
Nelson-2	•	•	•	●					•	●	•			•		•
Trib1232792463272	•	•														•
Trib1232509463400	•	•								•						•
Beaver-1		•							•	•						
Eloch-14	•	•							•	•	•					●
Nelson-3	•	•							•	•						✛
Otter-1	•	•								•						✛
EF Eloch-2																
NF Eloch-1																
Trib1232562463641		•								•						•
WF Eloch-2	•	•							•	•						•
WF Eloch-3		•								•						•
Trib1232567463186	•	•														•
Trib1232156463572		•								•						•
Nelson-1		•		•												•
NF Eloch-2																
Trib1233036463388-1																
NF Eloch-4																•
NF Eloch-3																
Rock-3																
Duck-5 (culvert)																
Duck-2 (culvert)																
Clear-2 (culvert)																
Rock-2 (culvert)																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-24. Elochoman coho habitat factor analysis.

Key restoration reaches for winter steelhead in the Skamokawa are in the mainstem just upstream and downstream of the LF Skamokawa, as well as in Wilson and McDonald Creeks. These reaches are degraded in numerous ways including sediment, flow, habitat diversity, temperature, food availability, and key habitat (Figure 5-25). None of the vegetative cover in the basin is in the late-seral stage, while 74% is in the early-seral, non-forest or other stage. This vegetation condition combined with a high road density has potentially altered the flow regime, increased sedimentation, and increased summer temperatures. Habitat diversity in the basin is not well quantified, but qualitative reports indicate that important restoration reaches are deficient of side channels. Sedimentation is exacerbated by steep slopes in the basin underlain with sedimentary rock prone to landslides (Ludwig 1992 as cited in Wade 2002). These important restoration reaches lack LWD because of historical land use practices and stream management. The loss of LWD has reduced habitat diversity and key habitat.

Fall chinook restoration reaches are in the mainstem Skamokawa between Falk Creek and Quarry Creek. These reaches have been impacted by decreased habitat diversity, sedimentation, decreased food availability, and loss of key habitat (Figure 5-26). These impacts are the result of the same causes as those described in the winter steelhead discussion.

There are two important chum restoration areas in the Skamokawa Basin. The first is in the mainstem Skamokawa, and the other is in lower Wilson Creek. Both sections are influenced primarily by the loss of habitat diversity and increased sediment (Figure 5-27). These impacts are the result of the same causes as those described in the winter steelhead discussion.

Primary coho restoration reaches are spread throughout the mainstem Skamokawa and in various smaller tributaries. These reaches have been negatively affected by numerous impacts, including sediment, reduced habitat diversity, loss of key habitat, reduced food, altered flow, and temperature regime impairment (Figure 5-28). These impacts are the result of the same causes as those described in the winter steelhead discussion. These causes are generally related to watershed management and land use practices.

Skamokawa Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Skamokawa-8	●	⬤	⬤	●					⬤	⬤	⬤			●		⬤
McDonald-1	•	●	⬤	●					●	⬤	●			•		●
Wilson-3		•	●	●					●	⬤	●			•		●
Wilson-4		⬤	●	●					⬤	⬤	●			•		⬤
Skamokawa-7			⬤	●					●	⬤	●			•		●
McDonald-3	•	●	•	•					●	⬤	•					●
Skamokawa-6	●	⬤	⬤	•	•	•			●	⬤	●			●		+
Eggman-2		●	•						●	⬤	•					●
LF Skamokawa-1	•	●	•	•		•			●	●	•			•		+
Standard-1		●	•	•					●	⬤	●			•		●
Quarry-1	•	●	•	•					●	⬤	•					●
Falk-2	•	●	•						•	●	•					
Wilson-2	•	●	●	•		•			●	⬤	●			•		•
Standard-2	•	●	•	•					●	⬤	●					●
Skamokawa-4		•	⬤	●	•	•			●	•	●			●		
Wilson-1	•	●	●	•	•	•			●	●	•			•		+
Falk-1	•	•	•						•	●	•					
Bell Canyon-1	•	●	•						●	⬤	•					●
LF Skamokawa-4	•	•	•						•	⬤	•					•
Pollard-1		•	●			•			●	⬤	●			•		●
LF Skamokawa-3	•	●	•						•	●	•					•
McDonald-2		•	•						•	⬤	•					•
Skamokawa-5		•	•						•	•	•			•		+
LF Skamokawa-2		•							•	•						+
Skamokawa-3		•	•	•					•	•						•
Skamokawa-1		●		•					•	●	•				•	
Skamokawa-2		•	•	•					•	•						+
Eggman-1		•							•		•					
WF Skamokawa-1		•		•					•	•						
WF Skamokawa-5																
WF Skamokawa-4																
WF Skamokawa-2																
WF Skamokawa-3																
Trib1234547463284-2																
Trib1234547463284-1																
Trib1233686463037																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-25. Skamokawa winter steelhead habitat factor analysis.

Skamokawa Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Skamokawa-8	⬤	●	•						•	⬤	•					⬤
Skamokawa-5	•	●	●	•	•				●	⬤	●					➕
Skamokawa-6	●	●	•		•				•	⬤	●					➕
Skamokawa-7		●	●	•					●	⬤	●					⬤
Skamokawa-1	•	●	•	●	•	•			•	●	●				•	
Skamokawa-3	•	●	•	●	•				•	●	●					●
Skamokawa-2																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 5-26. Skamokawa fall chinook habitat factor analysis.

Skamokawa Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Skamokawa-6	●	⬤	•						•	⬤	•					➕
Skamokawa-5	•	⬤	•						•	⬤	•					➕
Wilson-1	•	⬤							•	⬤	•				•	+
Wilson-2	•	⬤							•	⬤	•					●
Skamokawa-1	•	●		●	•				●	•	●				•	●
Skamokawa-2		•		•							•					+
Skamokawa-3		•		•	•				•	•	•					●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 5-27. Skamokawa chum habitat factor analysis.

Skamokawa Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Skamokawa-6	●	⬤	⬤	•	•	•			●	⬤	⬤			•		✚
McDonald-3	●	⬤							•	⬤	•					⬤
Wilson-3	•	⬤	●	•					●	⬤	⬤					⬤
West Valley-2	●	⬤	•	•		•			●	⬤	●				•	✚
Skamokawa-5	●	⬤	⬤	•	•	•			●	⬤	⬤			•		+
LF Skamokawa-2	●	⬤	•	•		•			●	⬤	●					✚
Eggman-2	●	●							•	⬤	•					●
Falk-1	●	●	•	•	•	•			●	⬤	●					●
Wilson-1	●	⬤	●	•	•	•			●	⬤	●					•
Falk-2	●	●	•	•	•	•			●	⬤	●				•	•
Skamokawa-7	•	⬤	●	•					●	⬤	●					⬤
McDonald-1	•	●	•	•					•	⬤	•					●
Skamokawa-8	●	●	•						•	⬤	•					●
Wilson-2	●	⬤	●	•		•			●	⬤	●					⬤
Wilson-4	•	⬤	•	•					●	⬤	●					⬤
Pollard-1	•	●	•			•			•	⬤	●					●
Quarry-1	•	●							•	●	•					●
LF Skamokawa-4	•	●							•	●	•					●
Bell Canyon-1	•	●							•	●	•					●
West Valley-1	●	●	●	•	•	•			●	●	●				•	+
Skamokawa-3	•	●	●	●	•	•		•	●	●	●			•		⬤
Skamokawa-2		●	●	●	•	•			•	●	•			•		✚
Skamokawa-1	•	●	●	●	•	•			•	●	●			•	•	•
Eggman-1	•	●	•	•					●	●	●					●
LF Skamokawa-3																
Falk-3	•	•							•	●	•					+
WF Skamokawa-5	•	●	•	•					●	•	●					⬤
West Valley-3	•	●							•	●	•					●
McDonald-2	•	•							•	●	•					•
Standard-2	•	•							•	●	•					•
Alger-2		•								•						•
Standard-1	•	•							•	●	•					•
LF Skamokawa-1	•	•							•		•					+
WF Skamokawa-1		●	•	•					•	•	•					•
WF Skamokawa-2		•	•						•	•	•					✛
Brooks-1		•	•	•					•	•	•					•
WF Skamokawa-3		•							•		•					+
Alger-1		•							•							•
WF Skamokawa-4		•														
Trib1234547463284-1																
Brooks-2																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-28. Skamokawa coho habitat factor analysis.

5.6.2 Mill-Abernathy-Germany

5.6.2.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for chum, fall chinook, winter steelhead and coho in the Mill, Germany and Abernathy basins. Model results indicate that adult productivity in Abernathy Creek has declined to approximately 20-30% of historical levels for all four species (Table 5-3), with the decline greatest for chum (to 22% of historical levels) and least for fall chinook (to 31% of historical levels). Similarly, adult abundance shows severe declines for all species, with current numbers at 10% of historical levels for chum, at 27% of historical levels for fall chinook, at 18% of historical levels for coho, and at 41% of historical levels for winter steelhead (Figure 5-29). Diversity (as measured by the diversity index) appears to have remained steady for fall chinook, winter steelhead, and chum, but has declined by 33% for coho (Table 5-3).

In Germany Creek, modeled adult productivity also shows severe declines, with current productivity at approximately 20-30% of historical levels for all species (Table 5-4). Adult abundance appears to have experienced similar declines. Currently, chum abundance is estimated at only one tenth of historical levels, while coho and fall chinook are at 23% and 29% of historical levels, respectively (Figure 5-30). Winter steelhead abundance has declined to 52% of historical levels (Figure 5-30). In Germany Creek, the diversity of all species, except coho, has been maintained (Table 5-4). Model results indicate that coho diversity has declined to 69% of its historical level.

Mill Creek, the furthest downstream of the three Lower Columbia River tributaries, appears to have also experienced declines in productivity in all four species (Table 5-5). Model results indicate a decrease in productivity of 73% for fall chinook, 81% for chum, and 76% for both coho and winter steelhead. Declines in adult abundance from historical levels have been greatest for chum (93%) and coho (82%), followed by fall chinook (73%) and winter steelhead (54%) (Figure 5-31). Diversity appears to have remained unchanged in Abernathy Creek for both fall chinook and winter steelhead. However, model results indicate a decrease in diversity for chum and coho to 57% and 62% of historical levels, respectively (Table 5-5).

Modeled historical-to-current changes in smolt productivity in Abernathy Creek have declined for all four species, with current levels of productivity at 30-60% of historical levels (Table 5-3). Similarly, smolt abundance levels in Abernathy Creek appear to have decreased by 50-83% from historical levels, with losses most significant for chum, and least for fall chinook and winter steelhead (Table 5-3).

Losses in smolt productivity in Germany Creek are similar to those in Mill Creek. Current productivity levels range from one-third of historical levels for steelhead to slightly more than half of historical levels for chum (Table 5-4). Germany Creek has also experienced sharp declines in smolt abundance levels for all species (Table 5-4). Chum smolt abundance is currently estimated at only 16% of historical levels, while coho, fall chinook and winter steelhead are estimated at 42%, 45% and 60% of historical levels, respectively.

As with the other two basins, smolt productivity in Mill Creek has declined for all four species, with estimated losses greatest for winter steelhead and coho (Table 5-5). Smolt abundance levels have also declined for all species (Table 5-5). Current chum and coho smolt abundances are only 13-18% of historical levels, respectively. Fall chinook and winter steelhead abundances are approximately half of historical levels.

Model results indicate that restoration of PFC conditions in each of the three basins would produce substantial benefits (Table 5-3- Table 5-5). Adult returns for chum would benefit the most with runs increasing to 3-5 times current levels. Fall chinook, winter steelhead and coho returns would increase by about 50%. Smolt abundance levels would benefit at similar rates to adults, increasing to 50-80% of historical levels. Significant improvements would also be seen in smolt and adult productivity.

Table 5-3. Abernathy Creek— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]
Fall Chinook	455	709	1,646	3.6	6.1	11.5	1.00	1.00	1.00	101,917	168,583	217,323	557	897	1,125
Chum	182	619	1,878	2.1	5.9	9.3	1.00	1.00	1.00	114,902	374,578	668,348	760	1,054	1,218
Coho	800	1,279	4,302	4.7	8.1	20.0	0.62	0.78	0.92	13,575	28,734	40,595	92	183	286
Winter Steelhead	395	541	962	4.9	9.3	19.9	1.00	1.00	1.00	5,254	8,474	10,558	49	118	161

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

Table 5-4. Germany Creek— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]
Fall Chinook	524	736	1,798	3.3	6.4	11.8	1.00	1.00	1.00	120,843	194,235	271,309	497	944	1,175
Chum	300	886	3,094	1.9	5.6	8.7	0.99	1.00	1.00	169,971	528,781	1,038,737	675	1,016	1,175
Coho	518	850	2,264	4.9	8.9	20.1	0.62	0.70	0.90	11,040	19,941	26,386	111	210	298
Winter Steelhead	347	420	665	5.8	9.2	18.5	1.00	0.97	0.97	5,846	7,689	9,805	73	140	219

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

Table 5-5. Mill Creek— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]
Fall Chinook	386	627	1,411	3.4	6.4	12.4	1.00	1.00	1.00	82,397	141,161	185,456	522	924	1,177
Chum	121	624	1,615	1.7	5.4	8.6	0.57	1.00	1.00	69,066	319,162	531,083	656	972	1,138
Coho	727	881	4,055	4.6	6.9	19.2	0.55	0.77	0.89	4,287	14,942	23,639	71	146	259
Winter Steelhead	155	230	339	4.4	9.5	18.9	0.98	1.00	1.00	2,623	4,048	5,006	75	163	271

[1] Estimate represents historical conditions in the subbasin, and current conditions in the mainstem and estuary.

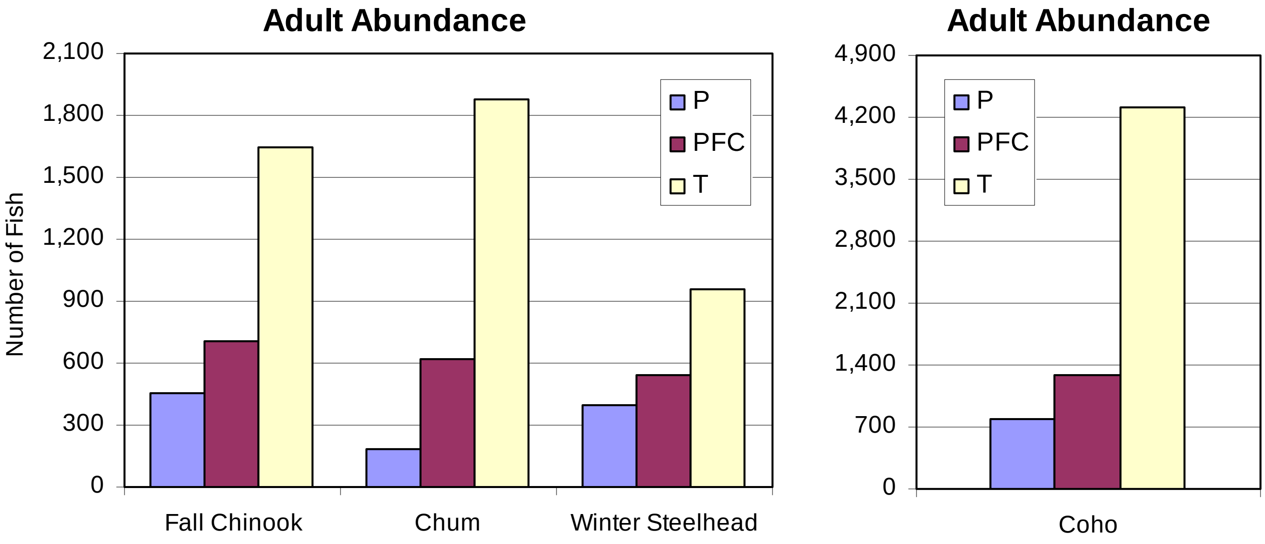


Figure 5-29. Adult abundance of Abernathy Creek fall chinook, chum, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

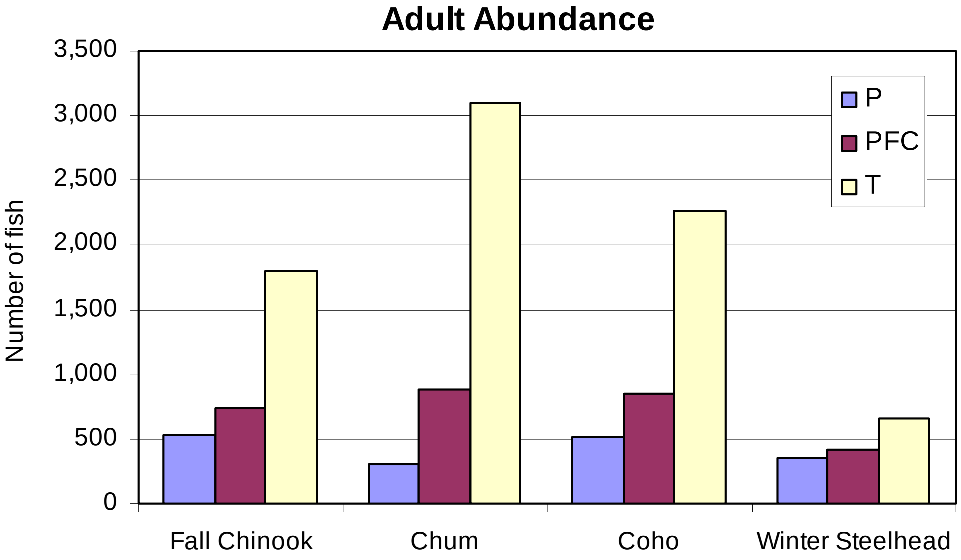


Figure 5-30. Adult abundance of Germany Creek fall chinook, chum, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

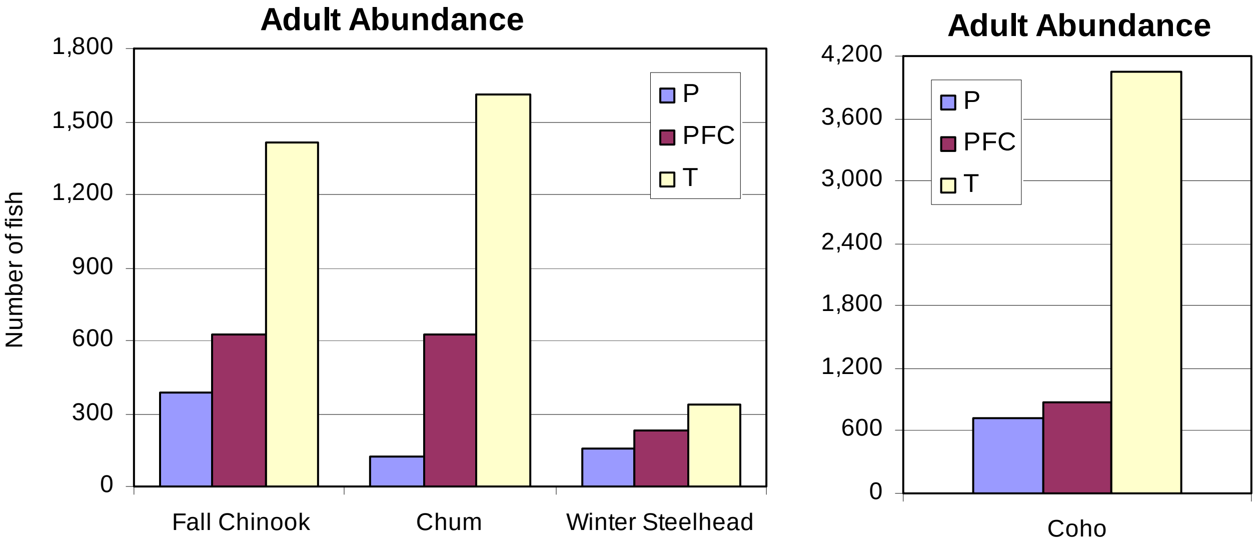


Figure 5-31. Adult abundance of Mill Creek fall chinook, chum, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

5.6.2.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin. Refer to Figure 5-32 for a map of high priority stream reaches within Mill, Abernathy and Germany Creeks.

Winter steelhead production in Mill Creek is primarily in Spruce Creek, North Fork Mill Creek, and South Fork Mill Creek. Fall chinook and chum are found in the lowest reaches of the mainstem Mill Creek. Coho distribution in the basin is not well understood, but it is assumed that they use all areas accessible.

For winter steelhead in Mill Creek, high priority reaches include Mill Creek below North Fork Mill Creek (Mill 2 and Mill 4), portions of South and North Fork Mill Creek (SF Mill 1, NF Mill 2), and the long middle reach of Spruce Creek, downstream of Hunter Creek (Spruce 1 and Spruce 2) (Figure 5-33). These high priority reaches have a mixed preservation and restoration emphasis, with the greatest change in population performance expected in the reach Spruce 1 (Figure 5-33).

A single, though different, high priority reach exists for both fall chinook and chum in Mill Creek. For fall chinook, reach Mill 2, with a combined preservation and restoration emphasis, is the lone high priority reach (Figure 5-34). The single high priority reach for chum is the lowest reach of South Fork Mill Creek, SF Mill 1 (Figure 5-35). SF Mill 1 also shows a combined preservation and restoration emphasis.

High priority reaches for coho include lower, middle and upper sections of Mill Creek (Mill 2, 4, 5 and 8), lower South Fork Mill Creek (SF Mill 1), lower North Fork Mill Creek (NF Mill 2), and the lower sections of Spruce Creek (Spruce 1 and Spruce 2) (Figure 5-36). The majority of these high priority reaches have a mixed preservation and restoration emphasis, with the reach Spruce 1 showing the greatest expected change in population performance (Figure 5-36).

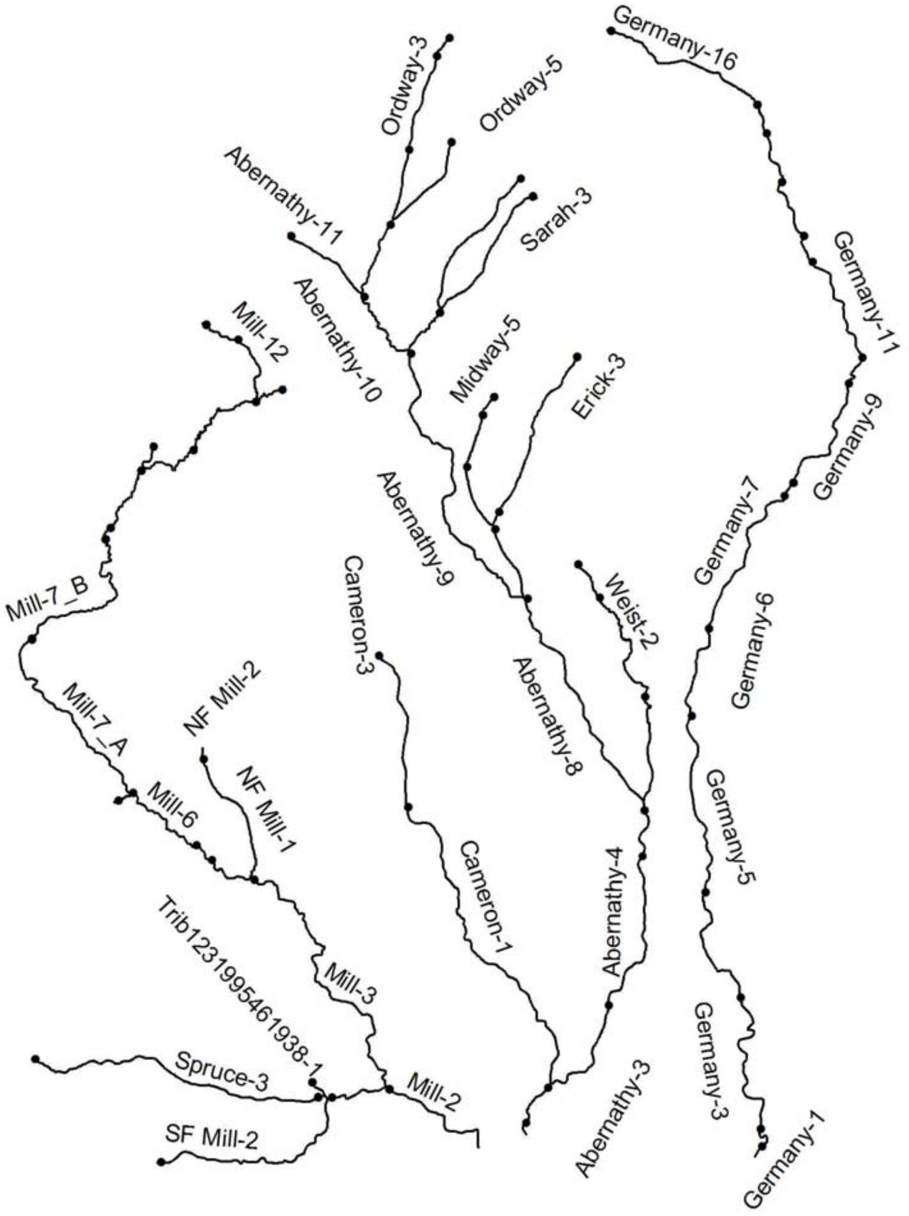


Figure 5-32. Location of EDT reaches in Mill, Germany and Abernathy Creeks. For readability, not all reaches are labeled.

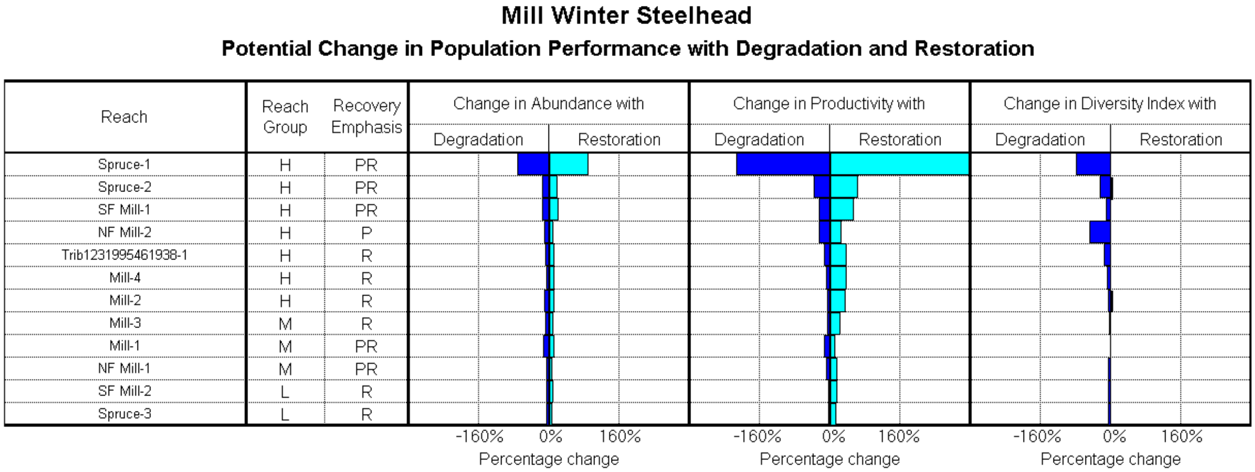


Figure 5-33. Mill Creek winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

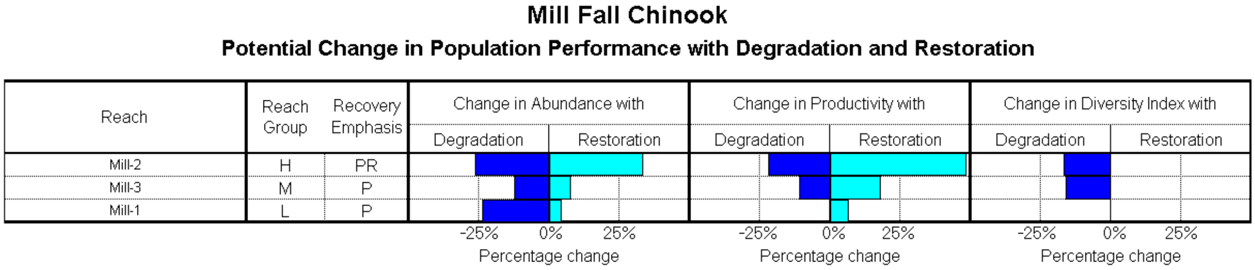


Figure 5-34. Mill Creek fall chinook ladder diagram.

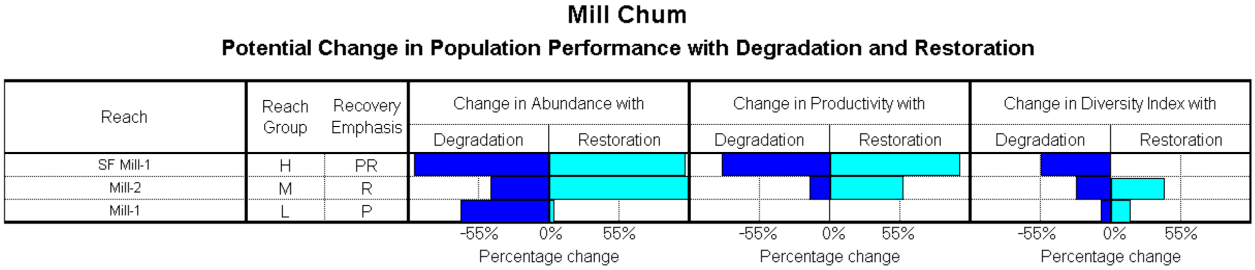


Figure 5-35. Mill Creek chum ladder diagram.

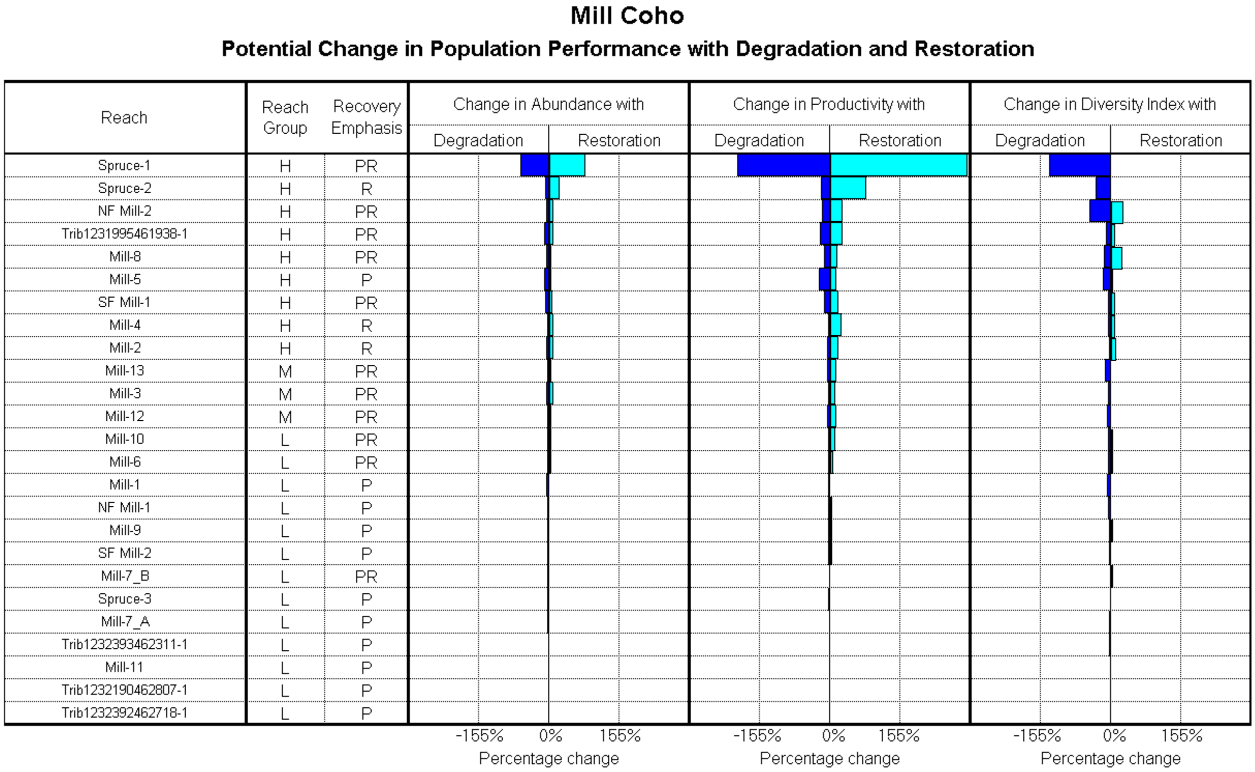


Figure 5-36. Mill Creek coho ladder diagram.

Winter steelhead spawn in the mainstem Germany Creek up to the headwaters, as well as in Loper Creek and John Creek. Fall chinook and chum are found in the lowest reaches of the mainstem Germany Creek. Coho distribution in the basin is not well understood, but it is assumed that they use all areas accessible. Refer to Figure 5-32 for a map of stream reaches within Mill, Abernathy and Germany Creeks.

For winter steelhead in Germany Creek, high priority reaches exist primarily in the middle and upper sections of Germany Creek (Germany 6, 8, 10, and 12-15) and in one unnamed tributary in upper Germany Creek (Figure 5-37). These high priority reaches, with the exception of Germany 8, have mixed preservation and restoration emphasis.

The high potential reaches for both fall chinook and chum exist in lower Germany Creek. For fall chinook the two high priority reaches are Germany 2 and Germany 3, each with a combined preservation and restoration emphasis (Figure 5-38). For chum, the single high priority reach is Germany 2, again with a combined preservation and restoration emphasis (Figure 5-39).

Two of the four high priority reaches identified for coho are in lower Germany Creek (Germany 2 and Germany 3) (Figure 5-40). The other two reaches are located in the middle (Germany 8) and upper (unnamed tributary) sections of the Creek. All high priority reaches for coho had a combined preservation and restoration emphasis.

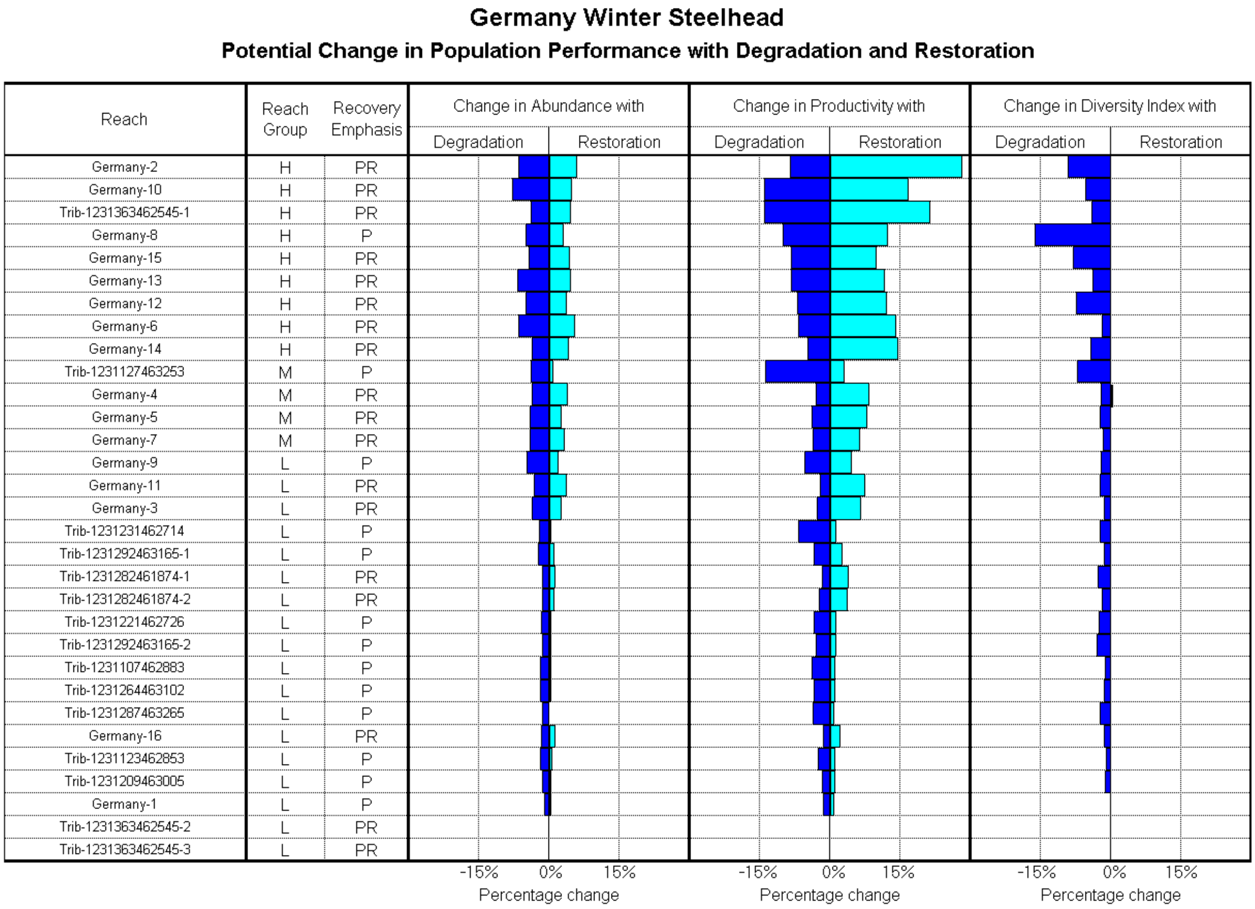


Figure 5-37. Germany Creek winter steelhead ladder diagram

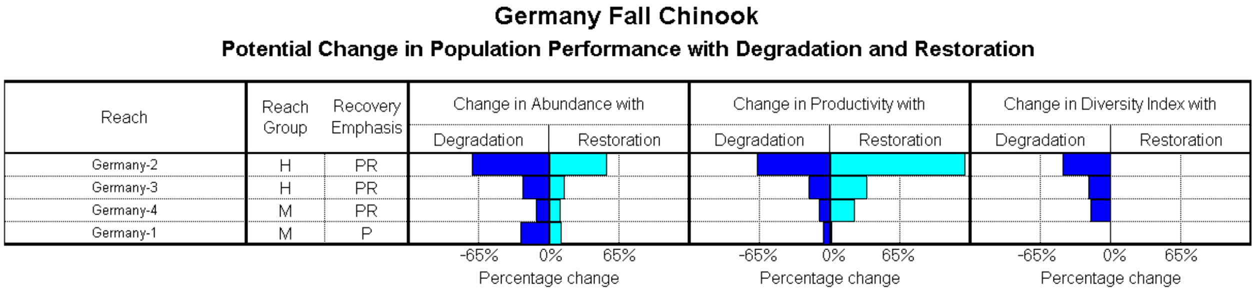


Figure 5-38. Germany Creek fall chinook ladder diagram

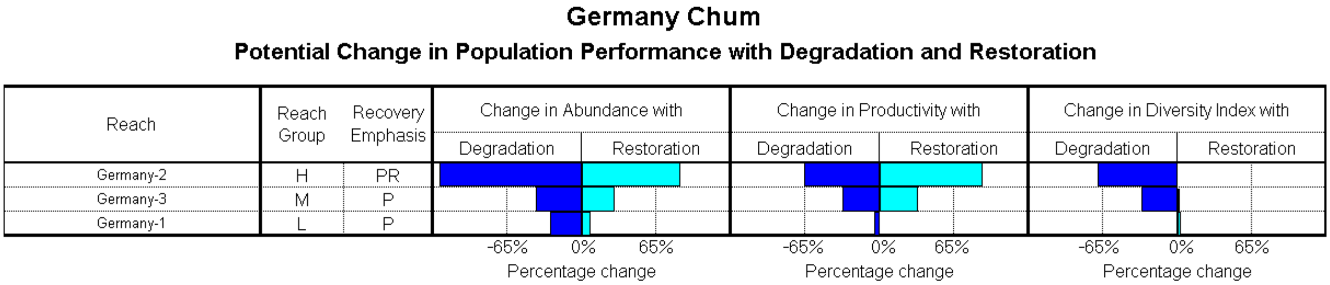


Figure 5-39. Germany Creek chum ladder diagram

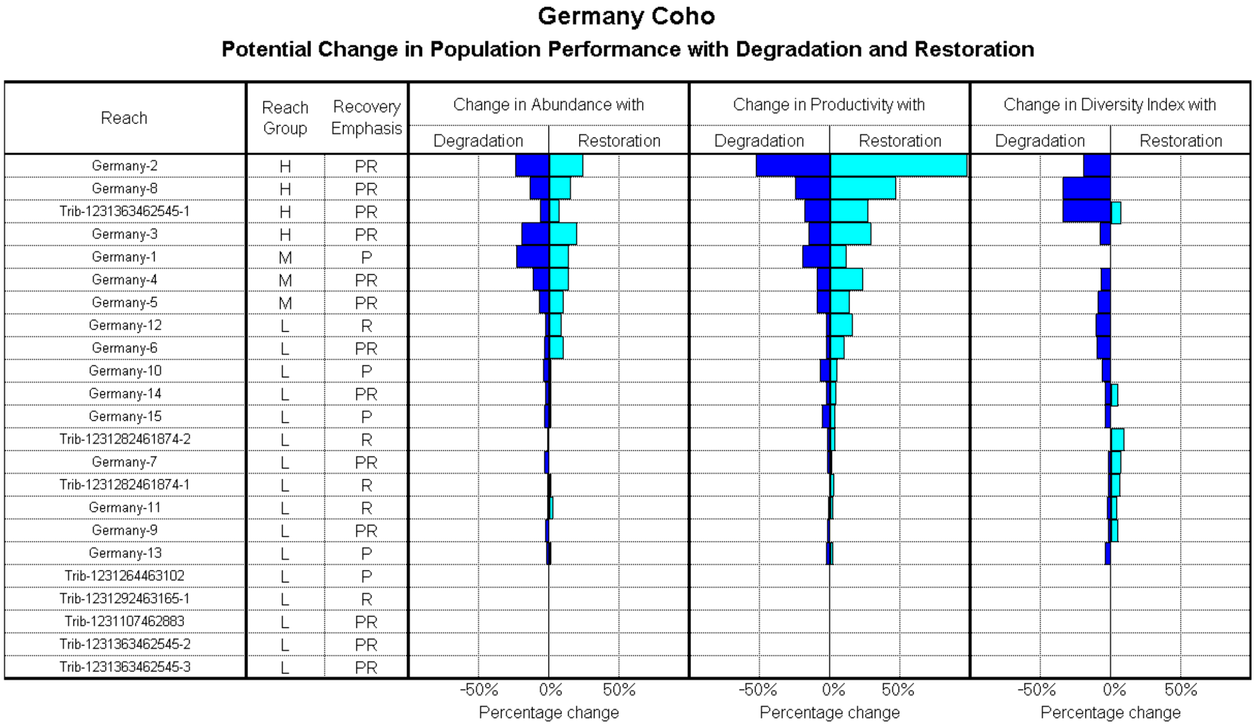


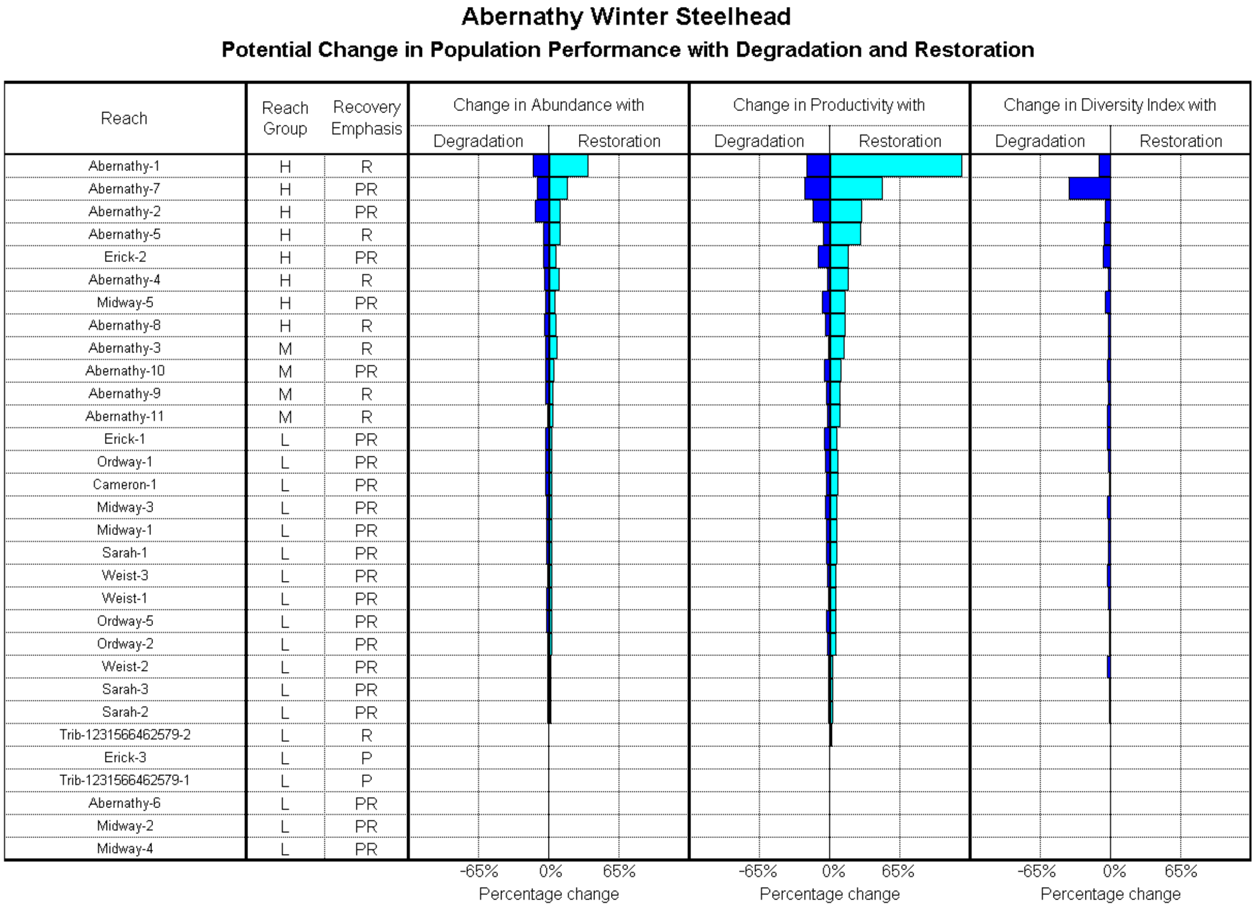
Figure 5-40. Germany Creek coho ladder diagram.

In Abernathy Creek, winter steelhead are found throughout the entire mainstem, Slide Creek and Cameron Creek, while fall chinook and chum are both found in the lower reaches of the mainstem. Coho distribution in the basin is not well understood, but it is assumed that they use all areas accessible. Refer to Figure 5-32 for a map of stream reaches within Mill, Abernathy and Germany Creeks.

High priority reaches for winter steelhead within Abernathy Creek include sections in lower and middle Abernathy Creek (Abernathy 1-2, 4-5, and 7-8), and smaller tributaries entering the middle and upper creek (Erik 2 and Midway 5) (Figure 5-41). These reaches are an even mix of those with a restoration emphasis and those with a combined preservation and restoration emphasis (Figure 5-41).

For both fall chinook and chum, the two high priority reaches, Abernathy 1 and Abernathy 2, are located below Weist Creek (Figure 5-42 and Figure 5-43). For fall chinook, Abernathy 1 has a combined preservation and restoration emphasis, and Abernathy 2 has a preservation emphasis (Figure 5-42). For chum, Abernathy 1 has a restoration emphasis and Abernathy 2 has a combined preservation and restoration emphasis (Figure 5-43).

High priority reaches for Coho in Abernathy Creek occur in select mainstem sections in lower and middle Abernathy Creek (Abernathy 2, 5, and 7) (Figure 5-44). Abernathy 2 and 7 both have a combined preservation and restoration emphasis while Abernathy 5 has only a restoration emphasis.

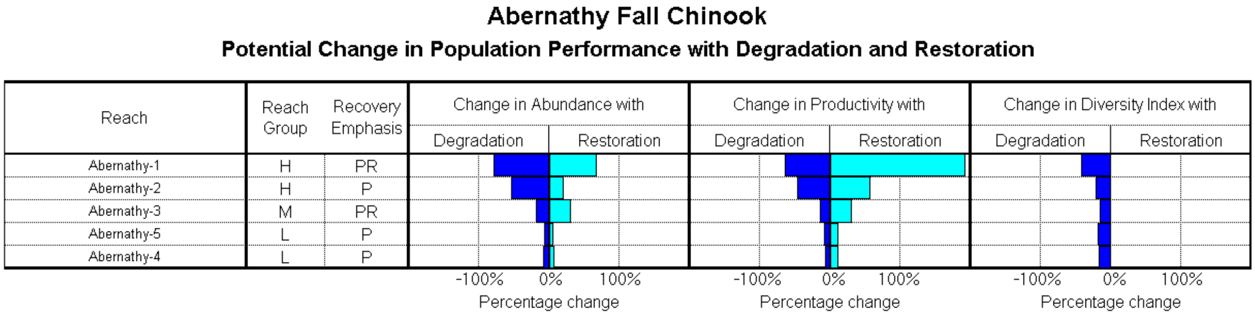


Abernathy Winter Steelhead

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
Abernathy-1	H	R
Abernathy-7	H	PR
Abernathy-2	H	PR
Abernathy-5	H	R
Erick-2	H	PR
Abernathy-4	H	R
Midway-5	H	PR
Abernathy-8	H	R
Abernathy-3	M	R
Abernathy-10	M	PR
Abernathy-9	M	R
Abernathy-11	M	R
Erick-1	L	PR
Ordway-1	L	PR
Cameron-1	L	PR
Midway-3	L	PR
Midway-1	L	PR
Sarah-1	L	PR
Weist-3	L	PR
Weist-1	L	PR
Ordway-5	L	PR
Ordway-2	L	PR
Weist-2	L	PR
Sarah-3	L	PR
Sarah-2	L	PR
Trib-1231566462579-2	L	R
Erick-3	L	P
Trib-1231566462579-1	L	P
Abernathy-6	L	PR
Midway-2	L	PR
Midway-4	L	PR

Figure 5-41. Abernathy Creek winter steelhead ladder diagram.



Abernathy Fall Chinook

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
Abernathy-1	H	PR
Abernathy-2	H	P
Abernathy-3	M	PR
Abernathy-5	L	P
Abernathy-4	L	P

Figure 5-42. Abernathy Creek fall chinook ladder diagram.

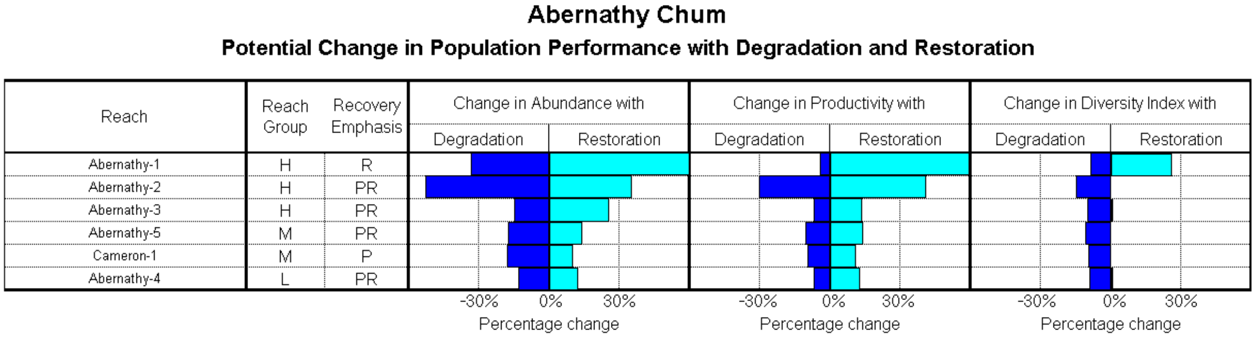


Figure 5-43. Abernathy Creek chum ladder diagram.

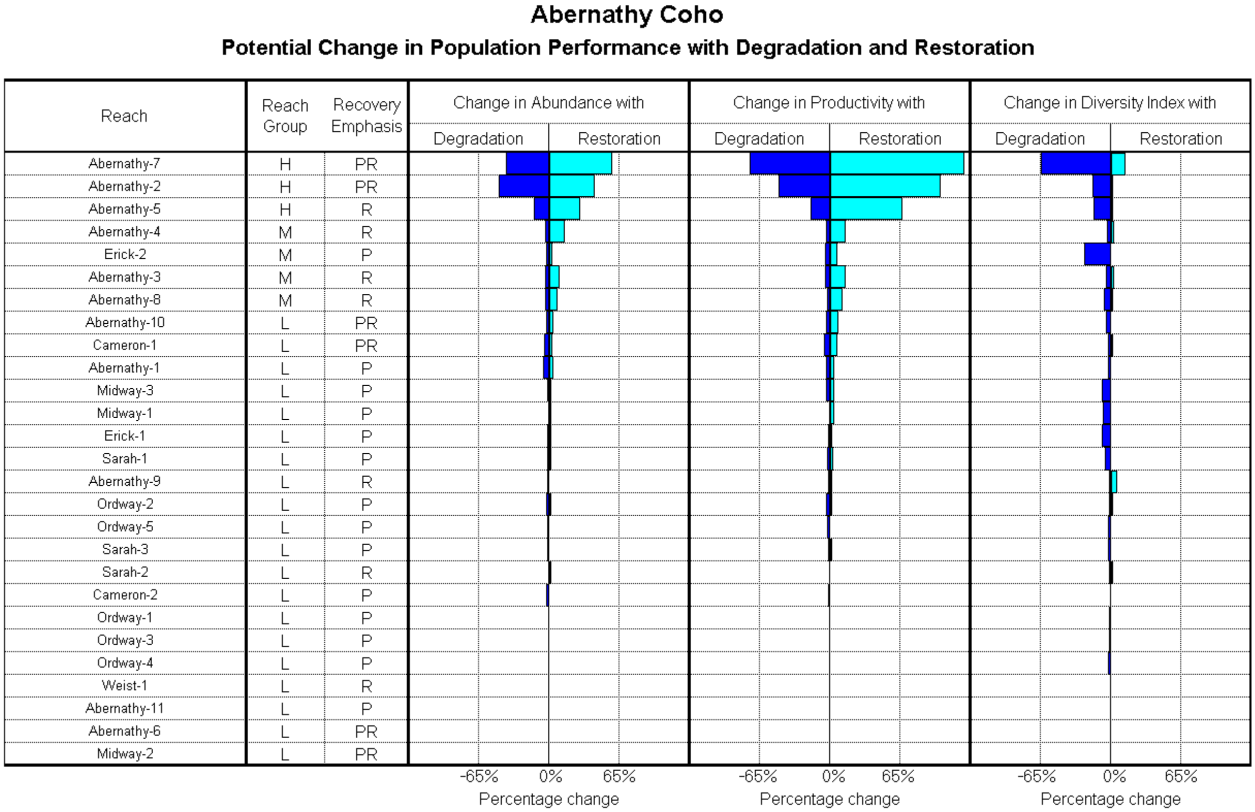


Figure 5-44. Abernathy Creek coho ladder diagram.

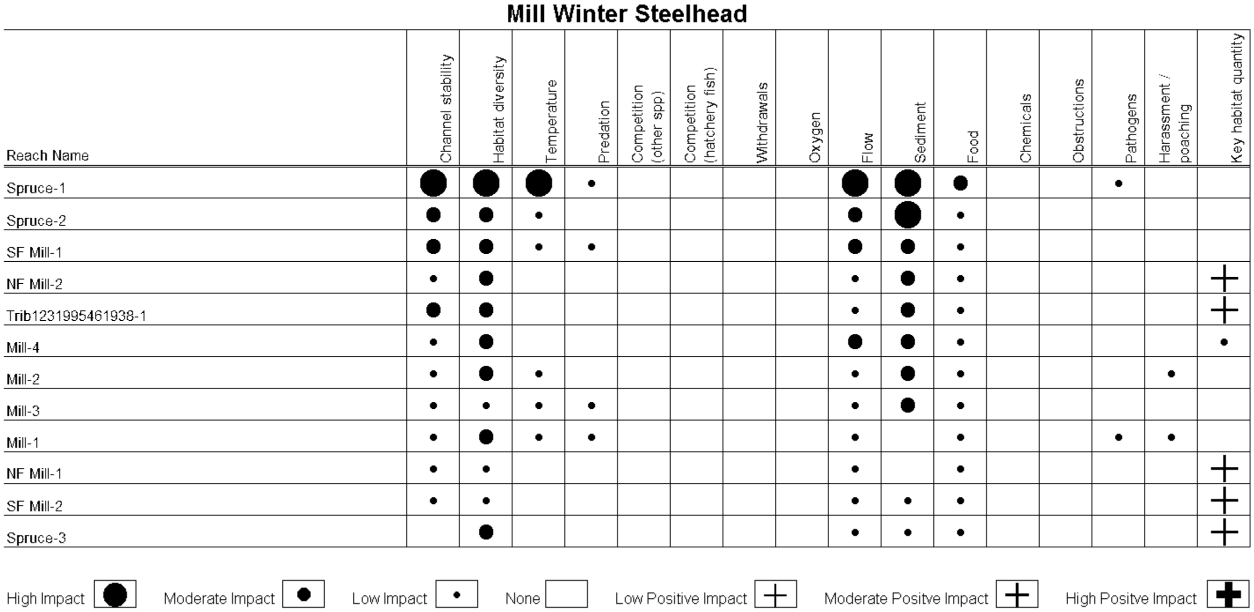
5.6.2.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

In Mill Creek, the highest priority restoration areas for winter steelhead are in Spruce Creek and the lower sections of South Fork and North Fork Mill Creek. Habitat diversity, flow, sediment, and channel stability all have substantial negative impacts in these areas (Figure 5-45). Reduced riparian function and low levels of large woody debris contribute to habitat diversity problems. Riparian function problems result from narrow buffer widths due to residential development and roads adjacent to the streams. Sediment problems result from land use practices and high road densities in the upper basin increasing sediment loads which aggrade in lower basin reaches. Flow alterations are also due to upper basin land use practices. Impairments to channel stability are evident as debris flows and high width-to-depth ratios.

Fall chinook and chum habitat restoration is most important in Mill Creek just below Spruce Creek. Habitat diversity and sediment are the factors most contributing to degradation of this reach (Figure 5-46 and Figure 5-47). The causes of these impacts are similar to those described for winter steelhead.

Key coho restoration reaches are generally located in middle and lower Mill Creek, lower North and South Fork Mill Creek, and Spruce Creek. A loss of habitat diversity, sedimentation, and decreased key habitat quantity are the primary limiting conditions in these reaches (Figure 5-48). The loss of habitat diversity is expressed as a lack of side channel habitat resulting from residential development and roads along the streams.



Mill Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Spruce-1	⬤	⬤	⬤	•					⬤	⬤	●			•		
Spruce-2	●	●	•						●	⬤	•					
SF Mill-1	●	●	•	•					●	●	•					
NF Mill-2	•	●							•	●	•					+
Trib1231995461938-1	●	●							•	●	•					+
Mill-4	•	●							●	●	•					•
Mill-2	•	●	•						•	●	•				•	
Mill-3	•	•	•	•					•	●	•					
Mill-1	•	●	•	•					•		•			•	•	
NF Mill-1	•	•							•		•					+
SF Mill-2	•	•							•	•	•					+
Spruce-3		●							•	•	•					+

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ✚

Figure 5-45. Mill Creek winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat

attributes were restored to template conditions. See section VOLUME VI for more information on habitat factor analysis diagrams.

Mill Fall Chinook

Reac hName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Mill-2	●	⬤							●	⬤	•				●	●
Mill-3	•	●							•	⬤	•					●
Mill-1	•	●		•					•		•					+

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-46. Mill Creek fall chinook habitat factor analysis diagram.

Mill Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
SF Mill-1	•	⬤							•	⬤						●
Mill-2	•	⬤							•	⬤					●	●
Mill-1		•														

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-47. Mill Creek chum habitat factor analysis diagram.

Mill Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Spruce-1	⬤	⬤	●						⬤	⬤	⬤					⬤
Spruce-2	●	⬤	•						●	⬤	●					⬤
NF Mill-2	●	●							•	●	•					●
Trib1231995461938-1	●	●							•	●	•					●
Mill-8	•	●							•	•	•					✚
Mill-5	●	●							•	●	•					•
SF Mill-1	•	●							•	●	•					●
Mill-4	•	⬤							•	●	•					●
Mill-2	•	●							•	•	•				•	●
Mill-13	•	●							•	●	•					●
Mill-3	•	●	•						•	●	•					●
Mill-12	•	●							•	●	•					●
Mill-10	•	●							•	●	•					•
Mill-6	•	●							•	●	•					•
Mill-1		•							•							
NF Mill-1		•														•
Mill-9		•														
SF Mill-2	•	•								•						•
Mill-7_B																
Spruce-3		•								•						•
Mill-7_A																
Trib1232393462311-1																
Mill-11																
Trib1232190462807-1																
Trib1232392462718-1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-48. Mill Creek coho habitat factor analysis diagram.

In Germany Creek, the highest priority restoration areas for winter steelhead are primarily in the middle and upper mainstem. Habitat diversity, sediment, and flow have the largest negative impacts in these reaches (Figure 5-49). High fine sediment loads in the lower basin have resulted from deposition from contributions in upper reaches, and from riparian degradation in agricultural sections. Flow issues are related to high road densities in the basin. Habitat diversity reductions are partially attributable to land use and stream management practices that have channelized and simplified the stream. Removal of LWD has also reduced habitat diversity in these critical reaches. A road along the stream contributed to numerous negative impacts in the key restoration reaches including lost habitat diversity, increased temperature, increased sediment, and lost key habitat.

Important restoration reaches for fall chinook and chum are in lower Germany Creek. These reaches have been most negatively influenced by increased sediment levels and low habitat diversity (Figure 5-50 and Figure 5-51). The causes for these impacts are the same as those cited for winter steelhead restoration reaches.

The highest restoration potential for coho exists throughout the mainstem Germany Creek where reaches have been negatively impacted by increased sediment, decreased habitat diversity, and altered temperatures (Figure 5-52). The cause of these impacts is the same as those cited for winter steelhead restoration reaches.

Germany Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Germany-2		•	⬤	•					●	⬤	•			●	•	+
Germany-10	•	⬤	●						⬤	⬤	●			•		+
Trib-1231363462545-1	●	⬤	•						●	⬤	•					✚
Germany-8		●	•	+					●	⬤	●			•		
Germany-15	●	⬤	•			•			●	•	•					●
Germany-13	•	⬤	•			•			⬤	⬤	●					+
Germany-12		⬤	•	+		•			●	⬤	●					+
Germany-6		●	⬤	●					●	⬤	●			●		•
Germany-14	•	⬤	•						●	⬤	•					●
Trib-1231127463253	•	●							•	•	•					+
Germany-4	•	●	●	•					●	●	•			•		•
Germany-5		•	●	•					●	⬤	•			•		•
Germany-7	•	⬤	•						●	●	•					
Germany-9		●	•	+					●	⬤	•					
Germany-11	•	⬤	•						●	●	•					+
Germany-3	•	•	●	•					●	⬤	•			•		+
Trib-1231231462714		•							•	•						+
Trib-1231292463165-1	•	●							●	•	•					+
Trib-1231282461874-1	•	●							●	●	•					+
Trib-1231282461874-2	•	●							•	●	•					✛
Trib-1231221462726		•							•	•						+
Trib-1231292463165-2		•							•	•						+
Trib-1231107462883		•							•	•						+
Trib-1231264463102		•							•	•						+
Trib-1231287463265		•							•	•						+
Germany-16	•	●							●	•	•					•
Trib-1231123462853	•	•							•	•	•					+
Trib-1231209463005		•							•	•	•					+
Germany-1	•	•	•	•					•							

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-49. Germany Creek winter steelhead habitat factor analysis diagram.

Germany Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Germany-2	●	⬤	●	•					●	⬤	●				●	●
Germany-3	•	●	•						•	⬤	•					+
Germany-4	•	●	•						•	⬤	•					•
Germany-1	•	●	•	•					•	•	•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-50. Germany Creek fall chinook habitat factor analysis diagram.

Germany Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Germany-2	•	⬤	•						•	⬤	•				●	●
Germany-3	•	●							•	⬤						✛
Germany-1	•	•		•					•		•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-51. Germany Creek chum habitat factor analysis diagram.

Germany Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Germany-2	●	⬤	⬤	•					●	⬤	●			•	•	•
Germany-8	●	⬤	•						●	⬤	●					●
Trib-1231363462545-1	●	●							•	●	•					●
Germany-3	●	⬤	⬤	•					●	⬤	●			•		●
Germany-1	●	⬤	●	●					●	•	●			•	•	•
Germany-4	●	⬤	●	•					●	⬤	●			•		●
Germany-5	•	●	●	•					●	⬤	●			•		●
Germany-12	•	⬤				•			●	⬤	•					●
Germany-6	•	⬤	●	•					•	⬤	●					●
Germany-10	•	•							•	●	•					
Germany-14	•	•								•						•
Germany-15	•	•								•						•
Trib-1231282461874-2																
Germany-7		•														
Trib-1231282461874-1	•	•							•	•						•
Germany-11	•	●							•	•						•
Germany-9		•								•						
Germany-13	•	•							•	•						•
Trib-1231264463102																
Trib-1231292463165-1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-52. Germany Creek coho habitat factor analysis diagram.

Winter steelhead restoration reaches in Abernathy Creek are scattered throughout the lower and middle mainstem Abernathy Creek. Impacts to these reaches have resulted from degradation of the following habitat features: sediment, flow, habitat diversity, and temperature (Figure 5-53). Sediment and flow issues are partially attributable to high road densities in the basin. Sediment issues are exacerbated by agricultural practices between RM 1.5 and 3.4. Habitat diversity is limited by the lack of side channels in the lower reaches, lack of LWD for pool formation, and confinement by roads in some sections. Much of the basin is covered by early-seral or non-forest vegetation. This may influence water temperature in the basin, and coupled with high road densities, may be leading to altered flow regimes.

Important restoration reaches for fall chinook and chum are in Abernathy Creek below Weist Creek. These reaches have been most negatively influenced by increased sediment levels, lower habitat diversity, and loss of key habitat (Figure 5-54 and Figure 5-55). Causes of impacts are the same as those described for winter steelhead restoration reaches.

The highest restoration potential for coho is in lower and middle Abernathy Creek, where reaches have been impacted by decreased habitat diversity, increased sediment, disrupted flow regimes, and decreased channel stability (Figure 5-56). Causes for these impacts are the same as those described for winter steelhead, fall chinook and chum restoration reaches.

Abernathy Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Abernathy-1	⬤	⬤	⬤	⬤		•			⬤	⬤	●			●	●	•
Abernathy-7	●	⬤	⬤	•					●	⬤	+			•	•	
Abernathy-2	•	●	●	●		•			●	⬤	•			●	•	
Abernathy-5	•	⬤	●	●		•			●	●	•			●		•
Erick-2		●	•	•					●	⬤	•					●
Abernathy-4	•	●	●	•		•			●	●	•			●		•
Midway-5		●	•			•			●	⬤	•					●
Abernathy-8	•	●	•	•		•			●	●						•
Abernathy-3	•	⬤	●	•		•			●	●	•			•		•
Abernathy-10		●							●	●	+					**+**
Abernathy-9	•	●							●	●						
Abernathy-11	•	●							●	●						•
Erick-1		●	•						●	⬤	•					•
Ordway-1		●	•	•					●	⬤	•					**+**
Cameron-1		●	•	•					•	⬤	•					+
Midway-3		●							●	⬤						•
Midway-1		●							●	●						•
Sarah-1	+	●	•						●	⬤	•					•
Weist-3	•	●	•						•	⬤						●
Weist-1	•	●	•						●	●						•
Ordway-5	**+**	•	•						•	⬤						**+**
Ordway-2	+	●	•						●	⬤						**+**
Weist-2	•	•							•	●						•
Sarah-3	•	•							•	●						•
Sarah-2	•	•							•	●						•
Trib-1231566462579-2		•							•							
Erick-3																
Trib-1231566462579-1																
Abernathy-6																
Midway-2																
Midway-4																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact **+** High Positve Impact ✚

Figure 5-53. Abernathy Creek winter steelhead habitat factor analysis diagram.

Abernathy Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Abernathy-1	●	⬤	•	●					•	⬤	•				●	✛
Abernathy-2	•	●	•	•					•	⬤	•				•	✛
Abernathy-3	●	●	•	•					●	⬤	•					⬤
Abernathy-5	•	•	•						•	⬤						•
Abernathy-4	•	•							•	●						•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-54. Abernathy Creek fall chinook habitat factor analysis diagram.

Abernathy Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Abernathy-1	•	⬤		●					•	⬤	•				●	✛
Abernathy-2	•	⬤		•					•	⬤	•				●	✛
Abernathy-3	•	⬤							•	⬤						⬤
Abernathy-5	•	●							•	⬤						•
Cameron-1	•	●							•	●						•
Abernathy-4	•	●							•	●					•	•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 5-55. Abernathy Creek chum habitat factor analysis diagram.

Abernathy Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Abernathy-7	●	●	•	·					●	●	+				·	•
Abernathy-2	●	●	●	•		·			●	●	•			•	·	+
Abernathy-5	•	●	•	•		·			•	●	•			•		•
Abernathy-4	·	●	·	·		·			•	•	·			·		•
Erick-2	·	•							·	•						•
Abernathy-3	·	●	·	·					·	•	·			·		•
Abernathy-8	·	●	·						·	•						•
Abernathy-10	·	•							·	•						·
Cameron-1	·	•							·	•	·					·
Abernathy-1	·	•		·					·		·					
Midway-3		·							·	·						·
Midway-1		•							·	·						·
Erick-1	·	·							·	·						·
Sarah-1	·	·							·	•						·
Abernathy-9		·								·						·
Ordway-2	·	·							·	•						·
Ordway-5	·	·														·
Sarah-3																
Sarah-2	·	·							·							·
Cameron-2																
Ordway-1		·								·						·
Ordway-3																
Ordway-4																
Weist-1																
Abernathy-11																
Abernathy-6																
Midway-2																

High Impact ● Moderate Impact • Low Impact · None ☐ Low Positive Impact + Moderate Positve Impact ＋ High Positve Impact ✚

Figure 5-56. Abernathy Creek coho habitat factor analysis diagram.

5.7 Integrated Watershed Assessment (IWA)

For the purposes of this analysis, the Elochoman subbasin has been divided into two watersheds: the Skamokawa-Elochoman watershed, and the Mill-Abernathy-Germany watershed. They are treated here in separate sections.

5.7.1 Skamokawa-Elochoman Watershed

The Skamokawa-Elochoman watershed is a composite watershed that incorporates two primary stream drainages, the Skamokawa and Elochoman Rivers. Other important drainages include Jim Crow Creek, Alger Creek, Risk Creek, and Nelson Creek. For the purpose of the IWA analysis, the Skamokawa-Elochoman watershed is divided into 17 LCFRB recovery planning subwatersheds.

5.7.1.1 Results and Discussion

IWA results for the Elochoman - Skamokawa watershed are shown in Table 5-6. As indicated, IWA results are calculated for each subwatershed at the local level (i.e., within a subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A reference map showing the location of each subwatershed in the basin is presented in Figure 5-57. Maps of the distribution of local and watershed level IWA results are displayed in Figure 5-58.

Table 5-6. IWA results for the Skamokawa-Elochomam-watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60101	I	M	M	I	M	none
60102	M	M	M	M	M	60101, 60103
60103	I	M	M	I	M	none
60201	I	M	M	I	M	60101, 60102, 60103, 60202, 60203
60202	M	M	M	M	M	60101, 60102, 60103
60203	M	M	M	M	M	none
60204	I	M	M	I	M	60101, 60102, 60103, 60201, 60202, 60203
60301	M	M	M	M	M	none
60302	I	M	M	I	M	60301
60303	I	M	M	I	M	none
60304	I	M	M	I	M	none
60305	I	M	M	I	M	none
60306	I	F	M	I	M	60301, 60302, 60303, 60307
60307	I	M	M	I	M	none
60308	I	M	M	I	M	60304
60401	I	M	I	I	M	60101, 60102, 60103, 60201, 60202, 60203, 60204
60402	M	F	I	M	F	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

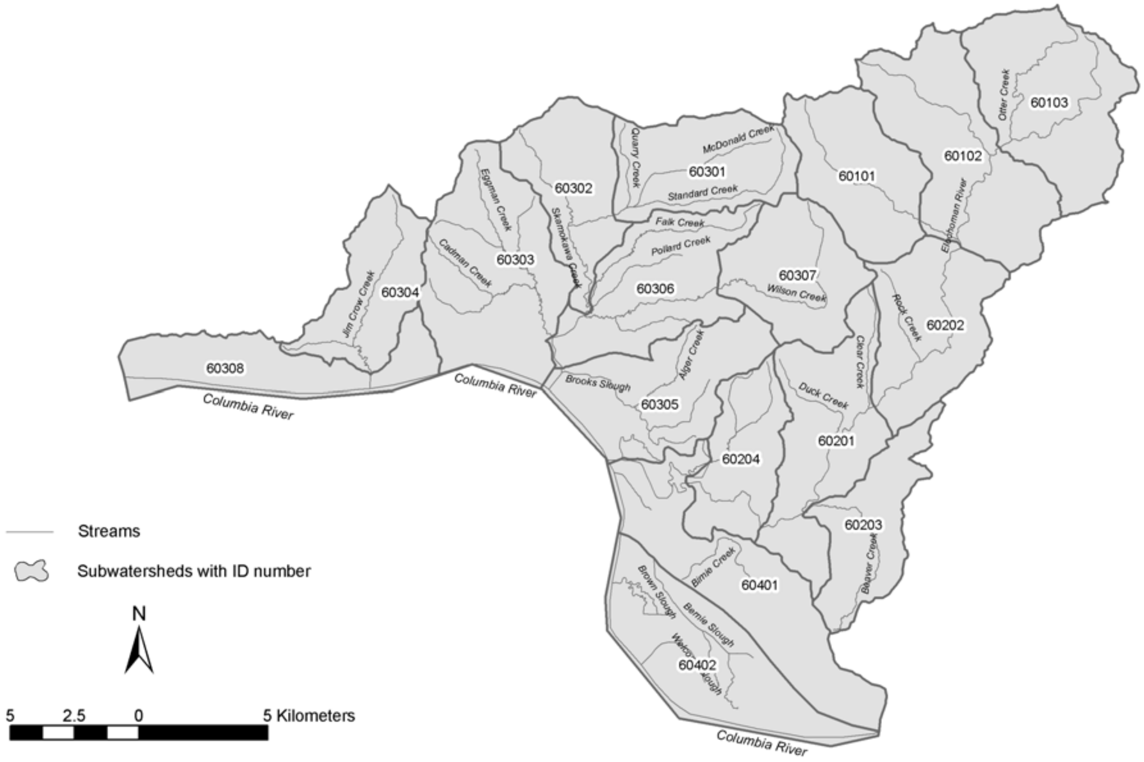


Figure 5-57. Map of the Elochoman-Skamokawa watershed showing the location of the IWA subwatersheds.

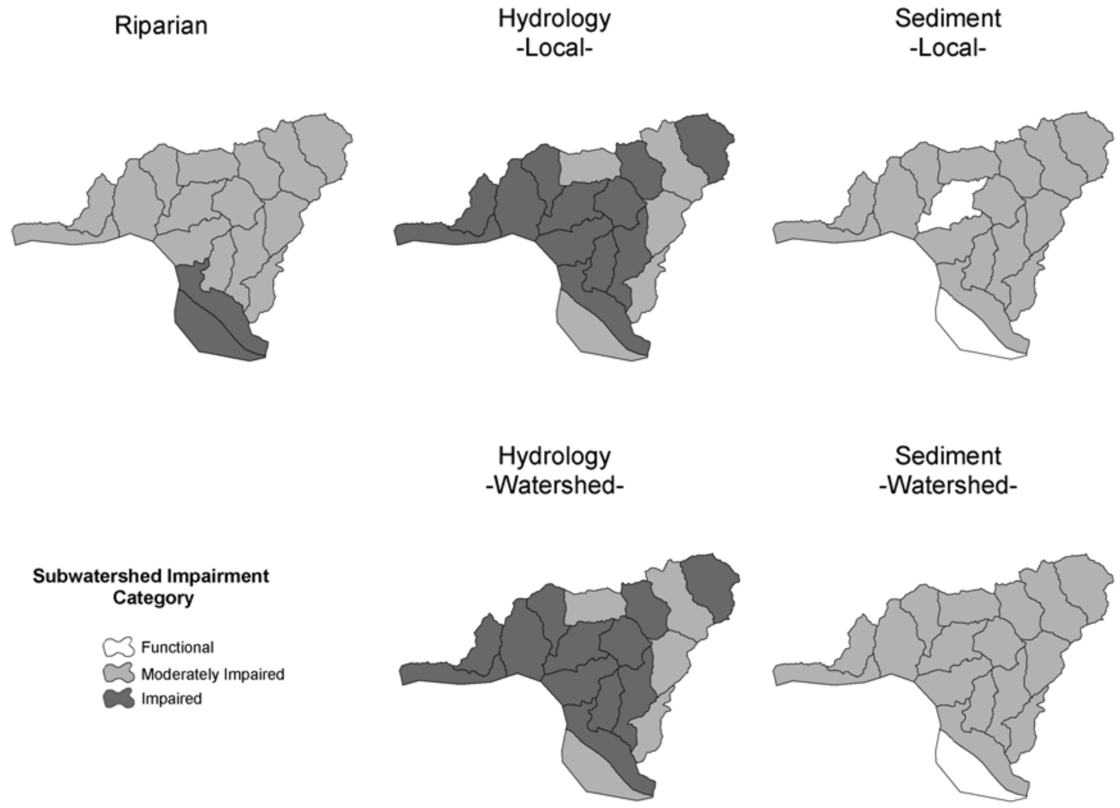


Figure 5-58. IWA subwatershed impairment ratings by category for the Elochoman Skamokawa watershed.

5.7.1.1.1 Hydrology

Local and watershed level hydrologic ratings are identical in the Elochoman-Skamokawa basin. Conditions are rated impaired in the downstream subwatersheds of the Elochoman (60401, 60201 and 60204), the West Fork Elochoman (60101) and in the headwaters Elochoman (60103). The middle and upper Elochoman (60202 and 60102) and Beaver Creek (60203) are rated moderately impaired. Hydrologic conditions in the Skamokawa drainage are rated as impaired in all subwatersheds except the headwaters (60301).

The Elochoman drainage as a whole averages 50% mature forest cover, with Beaver Creek (60203) and the upper mainstem Elochoman (60102 and 60202) collectively approaching 60%. The remaining subwatersheds in the drainage range between 13% and 47% mature forest cover. Road densities in the drainage are generally high, ranging from 3.2 to over 6 mi/mi^2. Of particular concern are impairment ratings in headwaters areas in the East Fork and West Fork (60103 and 60101). These subwatersheds are higher elevation with significant area in the rain-on-snow zone (55% and 17%, respectively). The East Fork headwaters are borderline in terms of road density and forest cover thresholds for hydrology, suggesting that conditions in this watershed are closer to moderately impaired.

The majority of land-use in the Elochoman drainage is timber production on private timber lands. Only two subwatersheds have significant area in public ownership. These are Beaver Creek (60203) and the middle mainstem Elochoman (60202), which are 72% and 48% WDNR lands, respectively. Remaining subwatersheds are predominantly in private timber lands.

Local and watershed level hydrologic conditions in the Skamokawa drainage are rated impaired except in the headwaters of the Skamokawa in McDonald and Standard Creeks (60301), which is rated as moderately impaired. The Skamokawa drainage is the lower elevation large drainage in the watershed, with only the headwaters and upper Wilson Creek (60301 and 60307) having significant area in the rain-on-snow zone (32% and 17%, respectively).

Only limited areas of the Skamokawa drainage have hydrologically mature forest coverage, averaging only 17% across all subwatersheds. Only the McDonald Creek/Standard Creek drainage (60301) has significant mature forest coverage (53%). Road densities are moderately high, with a range of 3.2 to over 5.2 mi/mi^2. Collectively, these factors account for the distribution of impaired ratings in the watershed. The majority of this drainage (70%) is in private lands, primarily timber holdings. The remaining public lands are held by WDNR in the uplands, and in NWR lands at the river mouth.

The generally impaired ratings for hydrology in the watershed are corroborated by acknowledged problems with watershed hydrology. Both the Skamokawa and Elochoman drainages have peak flow and low flow issues characteristic of altered hydrologic patterns. These changes are associated with an increase in the drainage network density due to forest roads, and loss of hydrologically mature forest cover.

Hydrologic conditions in estuarine subwatersheds (60305, 60401 and 60402) are rated moderately impaired to impaired. These ratings are primarily driven by lack of forest cover and higher road densities in these lowland areas, and downstream effects from the remainder of the watershed. However, it is important to note that these areas are more strongly influenced by the hydrology and tidal fluctuations of the Columbia River than by watershed level effects. In addition, the hydrologic condition of these subwatersheds are fundamentally affected by the draining and channelization of floodplain areas for agricultural development. Actual hydrologic conditions in these subwatersheds are less likely to be accurately predicted by the IWA than those in upstream subwatersheds.

5.7.1.1.2 Sediment Supply

Local sediment conditions are uniformly rated moderately impaired in the Elochoman drainage, with the exception of the lower Elochoman/Bernie Creek subwatershed (60402). A similar situation exists in the Skamokawa drainage, where all the subwatersheds are classified as moderately impaired at the local level, with the exception of the lower Skamokawa River (60306), which is rated functional. The watershed level results are nearly identical to the local level results. An exception is the lower Skamokawa subwatershed (60306), which is rated moderately impaired for sediment at the watershed level (versus functional at the local level). In this case, factors potentially affecting sediment conditions in the Wilson Creek headwaters (60307) and the upper Skamokawa (60302) are extensive enough to have potential downstream effects.

In the Elochoman basin, riparian zones are generally degraded due to historical and current land use practices, which in combination with degraded hydrologic conditions is a source of widespread bank and channel erosion (Wade 2002, WDW 1990). High road densities in upland areas are also significant sources of sediment loading, particularly when located on sensitive slopes in areas with extensive timber harvest. The North Elochoman Watershed Analysis identified shallow rapid landslides associated with forest practices and high road densities as major contributors of fine sediment to the stream system (WDNR 1996). The IWA results generally corroborate the findings of the watershed analysis.

Despite the acknowledged problems with sediment in the drainage, the natural erodability rates for these subwatersheds are relatively low in comparison with the remainder of the LCR. Erodability ratings in the Elochoman drainage range from 7-27 (on a scale of 0-126), with only two exceeding a rating of 20. The fact that sediment loading is an ongoing problem in the basin despite the relatively low erodability in the drainage suggests numerous widespread chronic sources of sedimentation. Road densities in the Elochoman are generally high, ranging from 3.2 to over 6 mi/mi^2, with five of seven subwatersheds exceeding 4.5 mi/mi^2. Streamside road densities are generally low (<0.2 miles/stream mile), but stream crossing densities are high. Crossing densities range from 2.0-4.8 crossings/stream mile, with five of seven subwatersheds having over 3 crossings/stream mile. Culvert failures at stream crossings are potentially large sources of sediment delivery.

The causes and sources of sediment problems in the Skamokawa drainage are similar to those for the Elochoman. Sediment loading is an acknowledged problem for fish habitat in the Skamokawa drainage. Bank erosion and numerous mass-wasting problems occur in areas with alluvial deposits where past timber harvest and agricultural activities have removed protective riparian vegetation (Wade 2002). The generally degraded hydrologic conditions present in the watershed exacerbate this effect.

Watershed level ratings for sediment conditions are uniformly rated as moderately impaired throughout the Skamokawa drainage, based on the intersection of roads, steep slopes and erodable geology types. Natural erodability rates in the drainage are low to moderate (11-29 on a scale of 0-126), with the least erodable areas in bedrock zones in the headwaters. The remainder of the drainage is in the moderately erodable range. This natural instability, combined with extensive road construction and timber management, has led to substantial sediment loads and unstable, aggrading stream channels. Much of the sediment originated from past forest practices, including indiscriminate logging around and through streams, the use of splash dams to transport logs, and poor road construction (WDW 1990).

Forest road densities in the Skamokawa drainage are relatively high, ranging from 3.2 to 6.1 mi/mi^2. In contrast, streamside road densities are low (0.03-0.13 miles/mile of stream). Stream crossing densities range from low to moderate (1.3-3.6 crossings/stream mile). In combination, these factors suggest that the current high road densities and history of land use are primary drivers of sediment problems. Local bank and channel erosion caused by degraded hydrologic conditions is also likely to contribute to sediment delivery.

Sediment conditions in estuary subwatersheds (60305, 60401 and 60402) are affected by sediment delivery from the upper watershed. However, sediment conditions in these tidally influenced areas of the watershed are more strongly influenced by tidal fluctuations and the hydrology of the mainstem Columbia. Due to this dominant influence, IWA results are not expected to predict actual sediment conditions in these subwatersheds as accurately as for upstream subwatersheds.

5.7.1.1.3 Riparian Condition

Riparian conditions are rated moderately impaired to impaired throughout the majority of the Skamokawa-Elochoman watershed. Impaired ratings are concentrated in the lowland estuary subwatersheds (60401, 60402) where extensive floodplain and side channel habitat has been disconnected from most of the lower river mainstems and tributaries by diking and agricultural conversion. The riparian rating for these subwatersheds also reflects a natural tendency towards less coniferous vegetation. Information is lacking on the quantity and quality of floodplain, side channel, estuary, or wetland habitats in the watershed, and the loss of these habitats due to various land use activities (Wade 2002).

5.7.1.2 Predicted Future Trends

5.7.1.2.1 Hydrology

Given the high proportion of watershed area in active forest lands, high road densities, and young forest, and given the likelihood of continuing harvest rotations, hydrologic conditions in the Elochoman and Skamokawa drainages are predicted to trend stable (i.e., moderately impaired to impaired) over the next 20 years.

The estuarine portion of the watershed (60305, 60401 and 60402) is expected to trend stable with respect to hydrologic conditions due to the extent of development and the presence of extensive NWR lands.

5.7.1.2.2 Sediment Supply

In the Elochoman and Skamokawa basins, timber harvests on private forest lands are likely to continue for the foreseeable future. Because the forest road network will be maintained to support these activities, road related indicators (road density, streamside road density, and stream crossing density) are expected to remain relatively constant. Based on this information, the trend in sediment conditions is expected to remain relatively constant over the next 20 years, with the potential for some improvement if old roads are replaced using improved road design and management.

Given the extent of development and the presence of extensive NWR lands in the estuarine portion of the watershed, hydrologic conditions are expected to trend stable, following general trends for the remainder of the watershed.

5.7.1.2.3 Riparian Condition

Riparian conditions throughout most of the basin are expected to improve over time due to improved forest practices that aim to protect riparian areas. In the lower mainstem and estuarine areas of the watershed, the potential for riparian recovery is relatively limited due to the extent of channelization. Therefore, riparian conditions are generally predicted to trend stable. Tidal water areas at the mouth of the Skamokawa and Jim Crow Creek (60304 and 60405) are being managed as wildlife refuges. Actual conditions in these areas are not accurately reflected by the riparian ratings which average conditions over the entire subwatershed. Riparian conditions in these subwatersheds should trend towards improvement over the next 20 years.

5.7.2 Mill-Abernathy-Germany Watershed

The Mill-Abernathy-Germany watershed is primarily a low elevation system, comprised primarily of volcanic (85%) and sedimentary and metamorphic rocks (13%). Twelve of the fourteen subwatersheds are comprised of low elevation, headwater and tributary subwatersheds; mostly in areas of low natural erodability (average rating is 11 on a scale of 0-126). Moderate-sized, low elevation stream reaches drain the other two subwatersheds.

5.7.2.1 Results and Discussion

IWA results for the Mill-Abernathy-Germany watershed are shown in Table 5-7. As indicated, IWA results are calculated for each subwatershed at the local level (i.e., within a subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A reference map showing the location of each subwatershed in the basin is presented in Figure 5-59. Maps of the distribution of local and watershed level IWA results are displayed in Figure 5-60.

Table 5-7. IWA results for the Mill-Abernathy-Germany basin.

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
50101	I	I	I	I	I	50104
50102	I	I	I	I	I	50104
50103	I	M	I	I	I	50201, 50202
50104	I	I	I	I	I	none
50201	I	M	M	I	M	50202
50202	I	M	M	I	M	none
50301	I	M	M	I	M	50302
50302	I	M	M	I	M	none
50401	M	M	M	M	M	none
50402	I	M	M	M	M	50401, 50403
50403	I	M	M	I	M	50401
50501	I	M	M	I	M	none
50502	M	F	M	M	M	50501, 50503
50503	M	M	F	M	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] WA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] WA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed

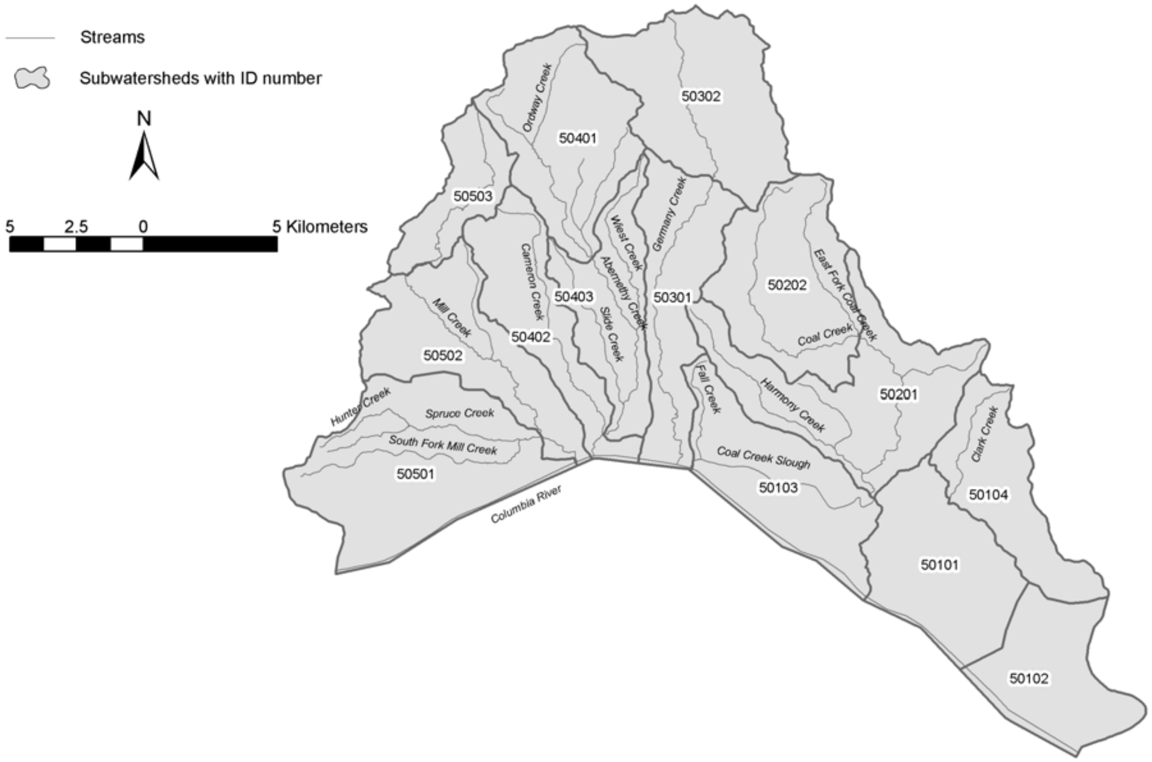


Figure 5-59. Map of the Mill-Abernathy-Germany watershed showing the location of the IWA subwatersheds.

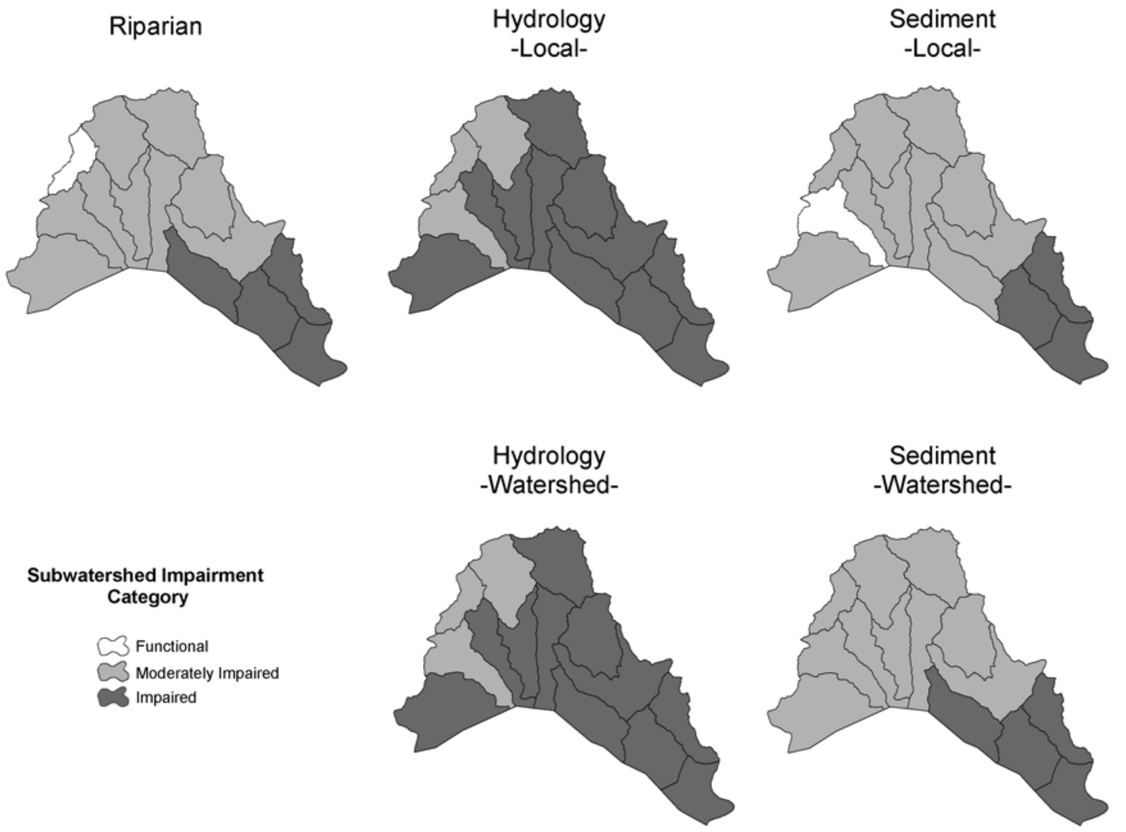


Figure 5-60. IWA subwatershed impairment ratings by category for the Mill-Abernathy-Germany watershed.

5.7.2.1.1 Hydrology

Of the fourteen subwatersheds in the basin, eleven are rated as hydrologically impaired at the local level, and three are rated as moderately impaired. Watershed level hydrology conditions are the same as those for local conditions. The only moderately impaired subwatersheds are located in headwater areas of the Abernathy Creek drainage (50401), and along Mill Creek (50502, 50503).

In the Mill Creek drainage, the mainstem subwatershed 50502 encompasses the most important reaches for anadromous fish. This subwatershed appears to be driven by local subwatershed problems, although some upstream conditions likely play a role as well. Road densities throughout the Mill Creek drainage are moderately high (4.1-4.7 mi/mi^2), but there is almost no rain-on-snow area, and mature vegetation cover is greater than 50% in the Mill Creek subwatersheds. Moderately impaired conditions in 50502 and 50503 likely buffer against the inputs from the impaired SF Mill subwatershed (50501).

In the Abernathy Creek drainage (50401-50403), the upper watershed (50401) is rated moderately impaired by IWA with respect to hydrologic process conditions, whereas the lower Abernathy (50402) and Cameron Creek (50403) subwatersheds are rated as moderately impaired. The Cameron and upper Abernathy watersheds are primarily under public ownership, the lower Abernathy subwatershed is mostly privately owned, and all are subject to active timber production. Rain-on-snow is not uncommon in subwatersheds 50401 and 50402. Immature forests cover most of these subwatersheds, with the average mature forest coverage at 28%. Road densities are moderately high, with an average of 5.1 mi/mi^2.

The hydrologic conditions in the Germany Creek subwatersheds (50301-50302) are impaired, which probably impacts the fish-bearing reaches in the lower Germany subwatershed (50301). Impairment in subwatersheds 50301 and 50302 is driven by a lack of mature forest coverage (11% and 28%, respectively), moderately high road densities (6.0 mi/mi^2 and 6.2 mi/mi^2), and some impacts due to rain-on-snow events in the upper watershed (rain-on-snow zone covers 43%). Splash dams and culverts are reported to occur in the area as well. Most of the land is in private holdings, with large amounts in timber production.

5.7.2.1.2 Sediment Supply

The majority of the subwatersheds in the Mill-Abernathy-Germany watershed are rated by IWA as moderately impaired. The exceptions include the impaired tideland areas in the lower Coal Creek drainage (50101-50104), and lower Mill Creek (50502), which is classified as functional for local conditions but moderately impaired at the watershed level. A comparison of Figure #-3 and Figure #-4 reveals that the impaired sediment conditions in the upper subwatersheds of Mill and Coal Creeks appear to contribute to the degradation of conditions within the lower subwatersheds.

Based on geology type and slope classification, most of the subwatersheds, not including the southeastern Coal Creek drainage, possess low natural erodability ratings. The erodability ratings in these subwatersheds are less than 12 on a scale of 0-126. This suggests that these subwatersheds would not be large sources of sediment impacts under undisturbed conditions. However, road densities, streamside roads, and stream crossings in these subwatersheds are relatively high, leading to erosion concerns.

Within the Mill Creek drainage, the locally functional sediment condition rating in subwatershed 50502 becomes moderately impaired at the watershed level. Moderately impaired conditions in the upper Mill Creek subwatershed (50503) and South Fork Mill Creek subwatershed (50501) are mostly driven by high road densities, and a lack of mature vegetation cover in subwatershed 50501.

Sediment conditions throughout the Abernathy Creek drainage (50401-50403) are rated as moderately impaired. These conditions are probably caused by moderate to high road densities (4.8–5.8 mi/mi^2) and stream crossing densities (2.1-5 crossings/stream mile) throughout the basin, and low mature vegetation coverage (averaging 30%) in the two lower subwatersheds (50402, 50403).

Both subwatersheds in the Germany Creek drainage are rated moderately impaired with respect to sediment supply. As with the other subwatersheds within the Germany-Abernathy watershed, high road densities (average is 6.1 mi/mi^2) in sensitive areas are primary contributing factors. In addition, poor mature forest cover (average is 20%) and high stream crossing densities (average is 5.9 crossings/stream mile) are factors that have the potential to increase sediment supply.

5.7.2.1.3 Riparian Condition

The riparian conditions are similar to the sediment ratings, with 1 functional, 9 moderately impaired, and 4 impaired. Moderately impaired IWA riparian conditions exist throughout the watershed, with the exception of upper Mill Creek, which possesses a functional rating, and the subwatersheds southwest of Coal Creek (50101-50104), which are rated as impaired. These southwestern subwatersheds are largely degraded due to development around Longview, Washington.

5.7.2.2 Predicted Future Trends

5.7.2.2.1 Hydrology

The land area in the Mill Creek subwatersheds is primarily publicly owned, although there is a substantial amount of private ownership (43%) in the lower subwatershed (50502). Forest cover on public land in these subwatersheds is predicted to generally mature and improve. Based on this information, hydrologic conditions are predicted to trend stable or improve gradually over the next 20 years in subwatershed 50502.

In the Abernathy Creek drainage, the high percentage of active timber lands, the high road densities, and the young forests suggest a stable (i.e., impaired, and moderately impaired) overall trend with respect to hydrologic conditions over the next 20 years.

Hydrologic conditions in the Germany Creek subwatersheds are predicted to trend stable (i.e., impaired, and moderately impaired) over the next 20 years due to ownership issues, high road densities, and young forests.

5.7.2.2.2 Sediment Supply

Because most of the land in the Mill Creek subwatersheds is publicly owned, the outlook for stable or improving conditions above SF Mill Creek is good. A large percentage of private ownership and relatively low mature forest cover in the SF Mill Creek subwatershed (50501) indicates that sediment conditions in Mill Creek below SF Mill Creek may remain stable. The overall outlook for the lower Mill Creek subwatershed is stable.

With the amount of timber production and private land ownership within the Abernathy Creek drainage, sediment conditions are expected to remain stable. In the Germany Creek subwatersheds, most of the land is in private timber holdings and conditions are expected to remain stable or slowly decline.

5.7.2.2.3 Riparian Condition

Based on the assumption that the trend for hydrologic recovery will also benefit riparian conditions, the predicted trend is for conditions in the western third of the watershed to remain relatively unchanged and to continue to degrade in the subwatersheds around Longview. The exception is the lower Mill Creek subwatershed (50502), which, due to its public ownership and relatively low streamside road impacts could improve gradually over the next 20 years.

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Volume II, Chapter 6
Cowlitz Subbasin—Coweeman

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6.0 Cowlitz Subbasin—Coweeman River

6.1 Subbasin Description

6.1.1 Topography & Geology

The Coweeman basin encompasses approximately 200 mi^2 in Cowlitz County and lies within WRIA 26 of Washington State. The Coweeman River joins the mainstem Cowlitz at RM 17. Principal tributaries include Goble, Mulholland, Baird, O'Neill, and Butler Creeks. Elevations range from just above sea level at the mouth to over 3,000 feet. The basin is comprised of Eocene basalt flows and flow breccia. Glacial activity has influenced valley morphology and soils.

6.1.2 Climate

The basin has a typical northwest maritime climate. Summers are dry and warm and winters are cool, wet, and cloudy. Mean monthly precipitation ranges from 1.1 inches (July) to 8.8 inches (November) at Mayfield Dam. Mean annual precipitation is 46 inches near Kelso (WRCC 2003). Most precipitation occurs between October and March. The basin is rain-dominated, with winter snow in the higher elevations.

6.1.3 Land Use/Land Cover

Forestry is the dominant land use in the subbasin. Commercial forestland makes up over 90% of the Coweeman basin. Much of the lower river valleys are in agricultural and residential uses, with substantial impacts to riparian and floodplain areas in places. The largest population center is Kelso, WA, located near the river mouth. Projected population change from 2000 to 2020 for unincorporated areas in WRIA 26 is 22%. The town of Kelso has a projected change of 42% by 2020 (LCFRB 2001). A breakdown of land ownership and land cover in the Coweeman basin is presented in Figure 6-1 and Figure 6-2. Figure 6-3 displays the pattern of landownership for the basin. Figure 6-4 displays the pattern of land cover / land-use.

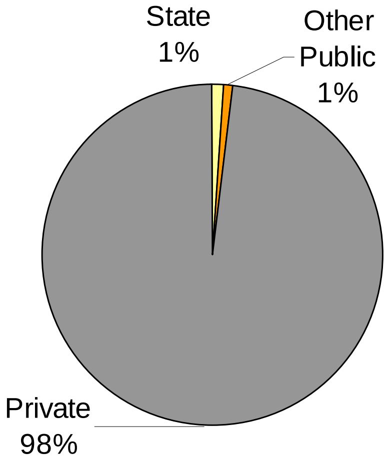


Figure 6-1. Coweeman River subbasin land ownership

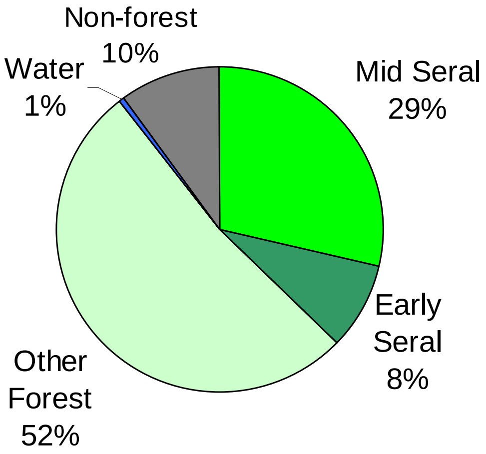


Figure 6-2. Coweeman River subbasin land cover

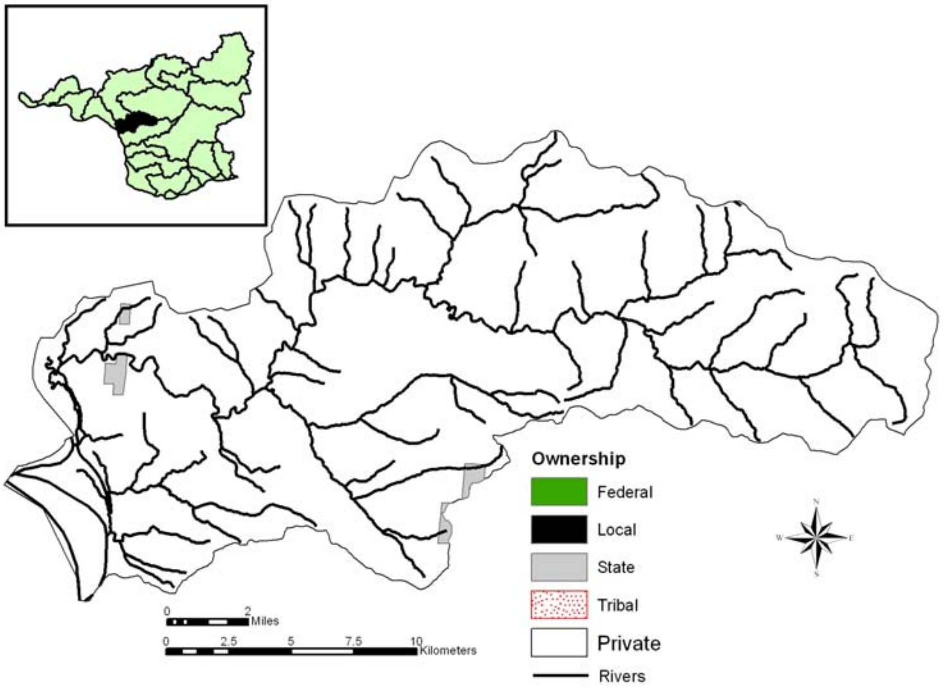


Figure 6-3. Landownership within the Coweeman basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

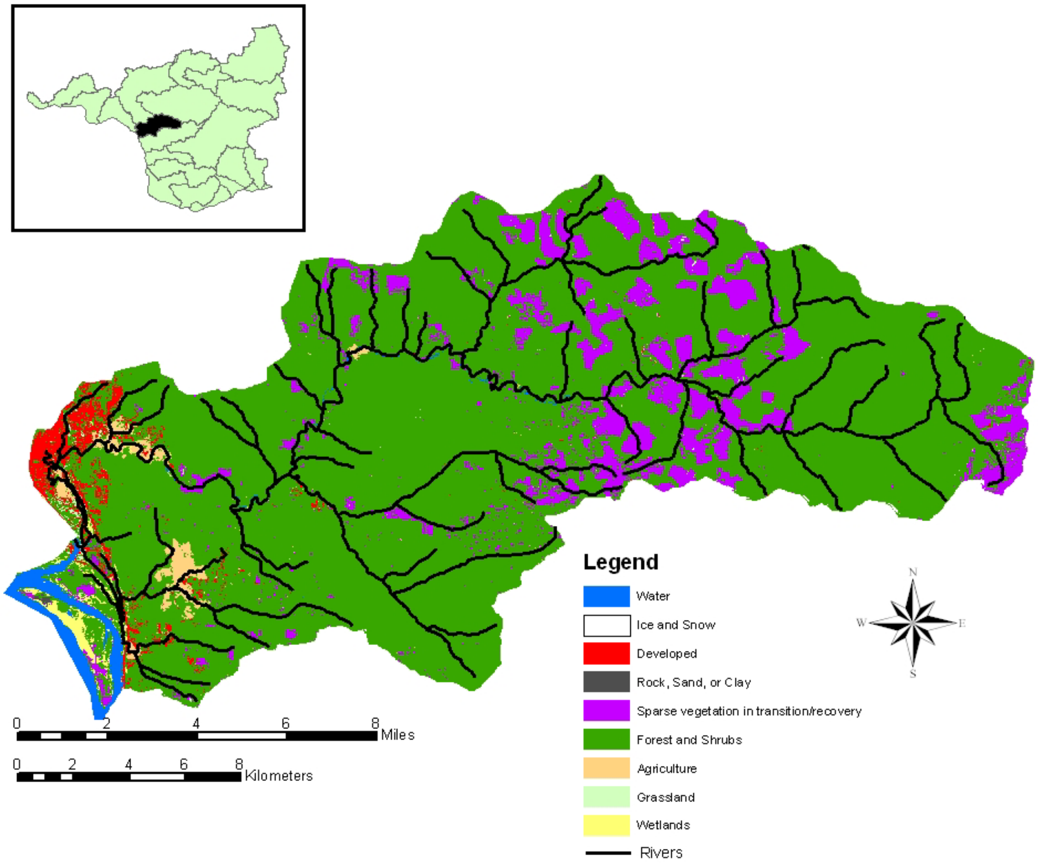
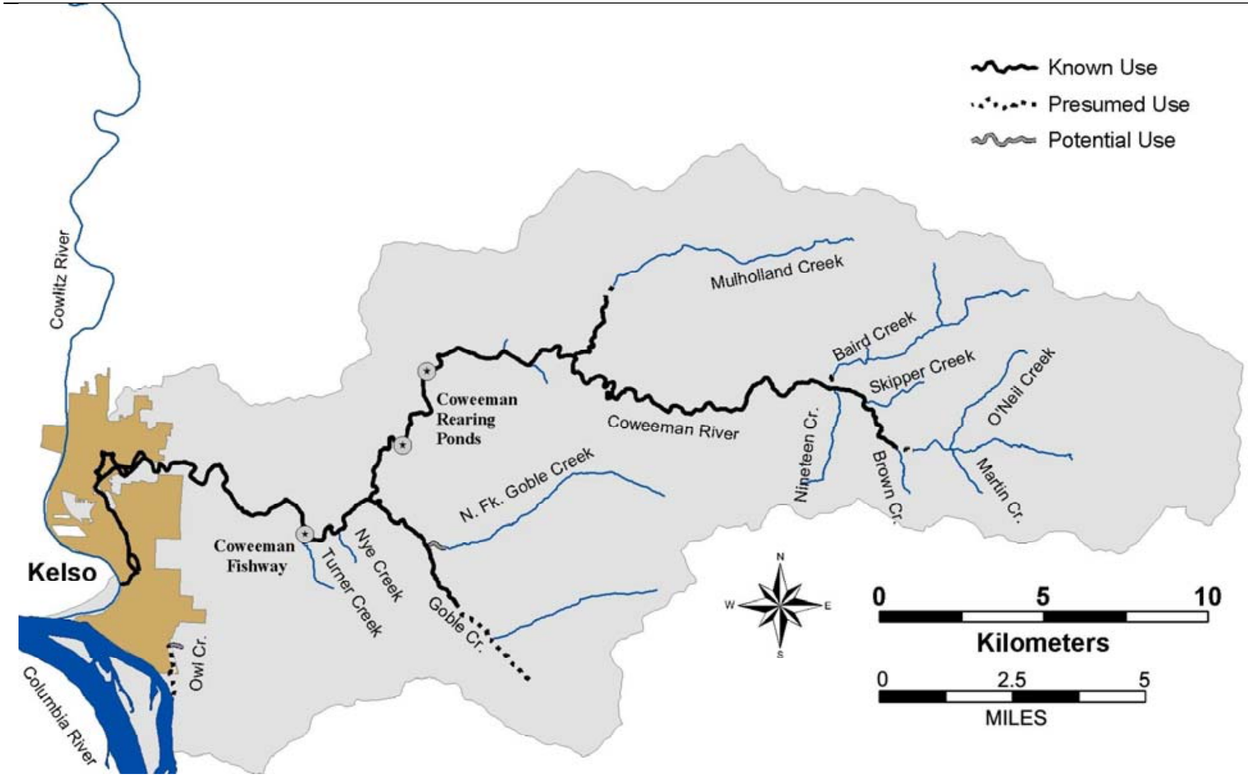


Figure 6-4. Land cover within the Coweeman basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

6.2 Focal Fish Species

6.2.1 Fall Chinook—Cowlitz Subbasin (Coweeman)

ESA: Threatened 1999 **SASSI: Depressed 2002**

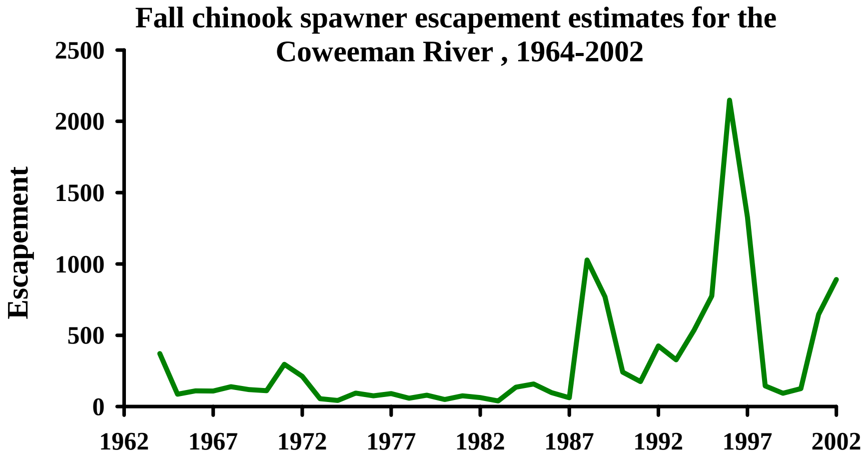


Distribution

- Spawning occurs in the mainstem primarily from Mulholland Creek to the Jeep Club Bridge (~6 mi)

Life History

- Columbia River fall chinook migration occurs from mid August to mid September, depending partly on early fall rain
- Natural spawning occurs between late September and mid November, usually peaking in mid October
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult age of 4
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the late spring/summer as sub-yearlings



Diversity

- Considered a component of the tule fall chinook population within the lower Columbia River Evolutionarily Significant Unit (ESU)
- Tule stock designated based on distinct spawning distribution and life history characteristics
- Allozyme analyses from 1996 and 1997 indicate Coweeman River fall chinook are significantly different from all other Columbia River basin chinook stocks, including lower Columbia River hatchery fall chinook (most distinct Washington lower Columbia tule fall chinook)
- Considered wild production with minimum hatchery influence
- Focal species for Endangered Species Act (ESA) monitoring because of minimum hatchery influence

Abundance

- An escapement survey in the late 1930s observed 1,746 chinook in the Coweeman River
- In 1951, WDF estimated fall chinook escapement to the Coweeman River was 5,000 fish
- Coweeman River spawning escapements from 1964-2001 ranged from 40 to 2,148 (average 302)
- Coweeman River current WDFW escapement goal is 1,000 fish; the goal has been met three times since 1986

Productivity & Persistence

- NMFS Status Assessment for the Coweeman River indicated zero risk of 90% decline in 25 years, 90% decline in 50 years, or extinction in 50 years
- Smolt density model predicted natural production potential for the Coweeman River of 602,000 smolts
- One of two self sustaining natural runs in the lower Columbia River; the recent year natural run has been stable at low levels without hatchery influence

Hatchery

- Hatchery releases of fall chinook in the Coweeman River occurred between 1951-1979; releases were from Spring Creek, Washougal, and Toutle Hatcheries; releases were discontinued in 1980

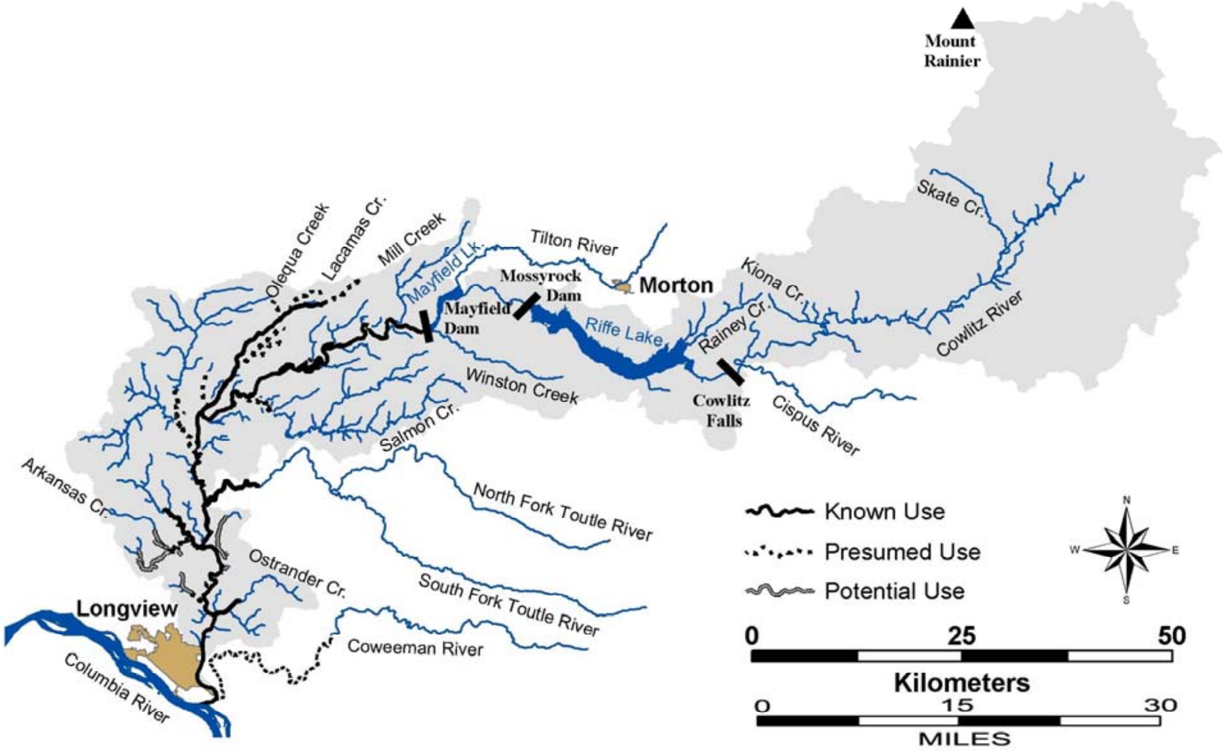
- No hatchery tags have been recovered in Coweeman River natural spawning fall chinook in surveys conducted since 1980, indicating the population is not currently influenced by stray hatchery fish from outside the system

Harvest

- Columbia River fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are an important contributor to Washington Ocean troll and sport fisheries and to the Columbia River estuary sport (Buoy 10) fishery
- Columbia River commercial harvest occurs primarily in September, but tule flesh quality is low once the fish move from salt water; price is low compared to higher quality Upriver Bright chinook
- Tule fall chinook are also important to lower Columbia tributary sport fisheries
- The magnitude of harvest is variable depending on management response to annual abundance
- Coweeman River wild fall chinook are not tagged but likely display an ocean and Columbia River harvest distribution similar to lower Columbia hatchery tule fall chinook
- Coded-wire tag (CWT) analysis of 1989-94 brood North Toutle Hatchery fall chinook (the closest tule population to Coweeman River; adjusted for zero harvest of fall chinook in the Coweeman basin) indicates an ocean and Columbia River combined harvest rate of 28% and a terminal escapement of 72%
- The majority of ocean and Columbia River fishery CWT recoveries of 1992-94 brood North Toutle Hatchery fall chinook (adjusted for zero harvest of Toutle Hatchery fall chinook in the Coweeman basin) were distributed between British Columbia (43%), Alaska (21%), Columbia River (18%), and Washington ocean (15%) sampling areas
- Coweeman River is closed to sport harvest of chinook
- Ocean and Columbia River harvest of Coweeman fall chinook limited to 49% or less by ESA requirements

6.2.2 *Chum—Cowlitz Subbasin*

ESA: Threatened 1999	**SASSI: NA**



Distribution

- Chum were reported to historically utilize the lower Cowlitz River and tributaries downstream of the Mayfield Dam site

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts generally from March to May

Diversity

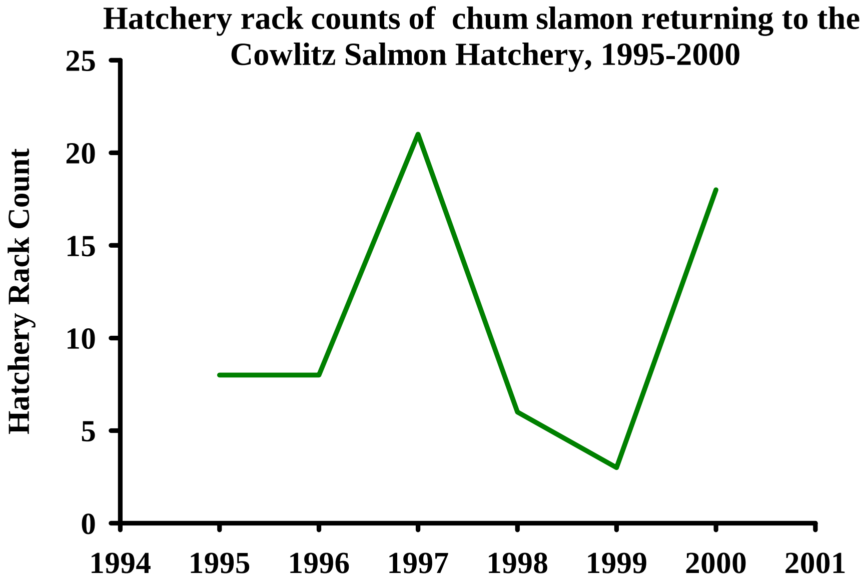
- No hatchery releases of chum have occurred in the Cowlitz basin

Abundance

- Estimated escapement of approximately 1,000 chum in early 1950's
- Between 1961 and 1966, the Mayfield Dam fish passage facility counted 58 chum
- Typically less than 20 adults are collected annually at the Cowlitz Salmon Hatchery

Productivity & Persistence

- Anadromous chum production primarily in lower watershed
- Harvest, habitat degradation, and to some degree construction of Mayfield and Mossyrock Dams contributed to decreased productivity



Hatchery

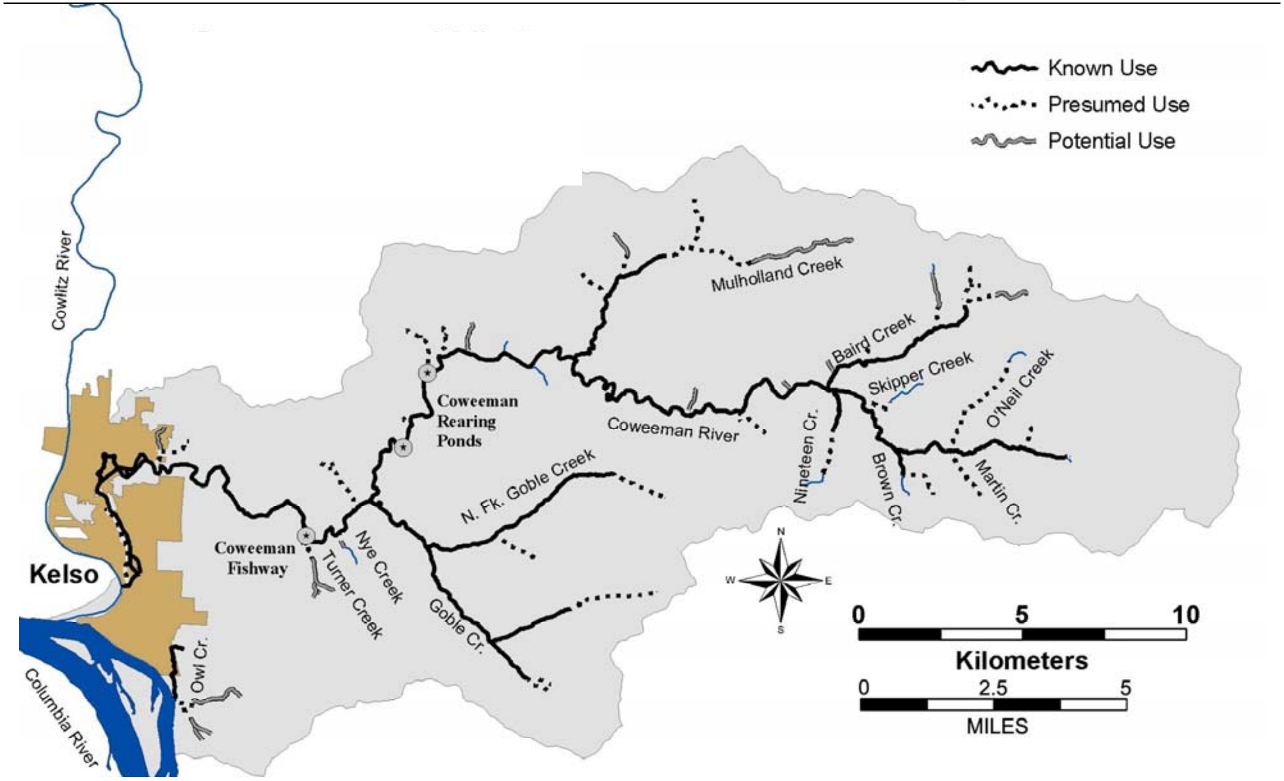
- Cowlitz Salmon Hatchery does not produce/release chum salmon
- Chum salmon are captured annually in the hatchery rack

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

6.2.3 Winter Steelhead—Cowlitz Subbasin (Coweeman)

ESA: Threatened 1998 **SASSI: Depressed 2002**



Distribution

- Winter steelhead are distributed throughout the mainstem Coweeman, Goble Creek, and the lower reaches of Mulholland and Baird Creeks
- The 1980 eruption of Mt. St. Helens had little impact on Coweeman River habitat

Life History

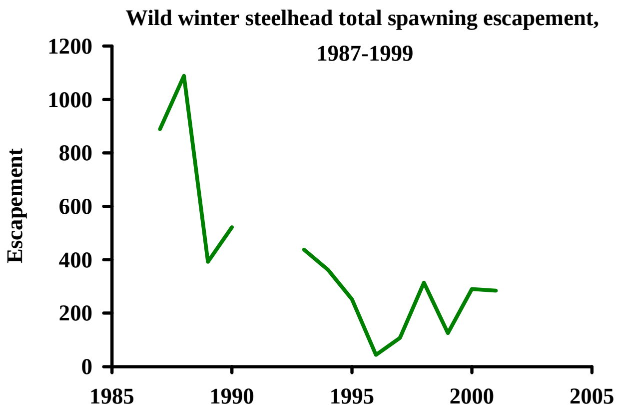
- Adult migration timing for Coweeman winter steelhead is from December through April
- Spawning timing on the Coweeman is generally from early March to early June
- Age composition data for Coweeman River winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

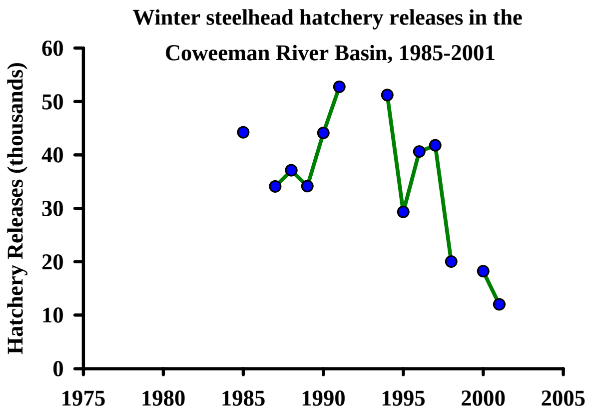
Diversity

- Coweeman winter steelhead stock designated based on distinct spawning distribution
- Hybridization of wild stock with Chambers Creek hatchery brood stock is unlikely because of about a three month separation in peak spawn timing

Abundance

- In 1936, steelhead were reported in the Coweeman River during escapement surveys
- Coweeman River total escapement counts from 1987-2001 ranged from 44-1,008 (average 393); escapement goal for the Coweeman is 1,064 fish; escapements have been low since 1989





Productivity & Persistence

- Estimated potential winter steelhead smolt production for the Coweeman River is 38,229

Hatchery

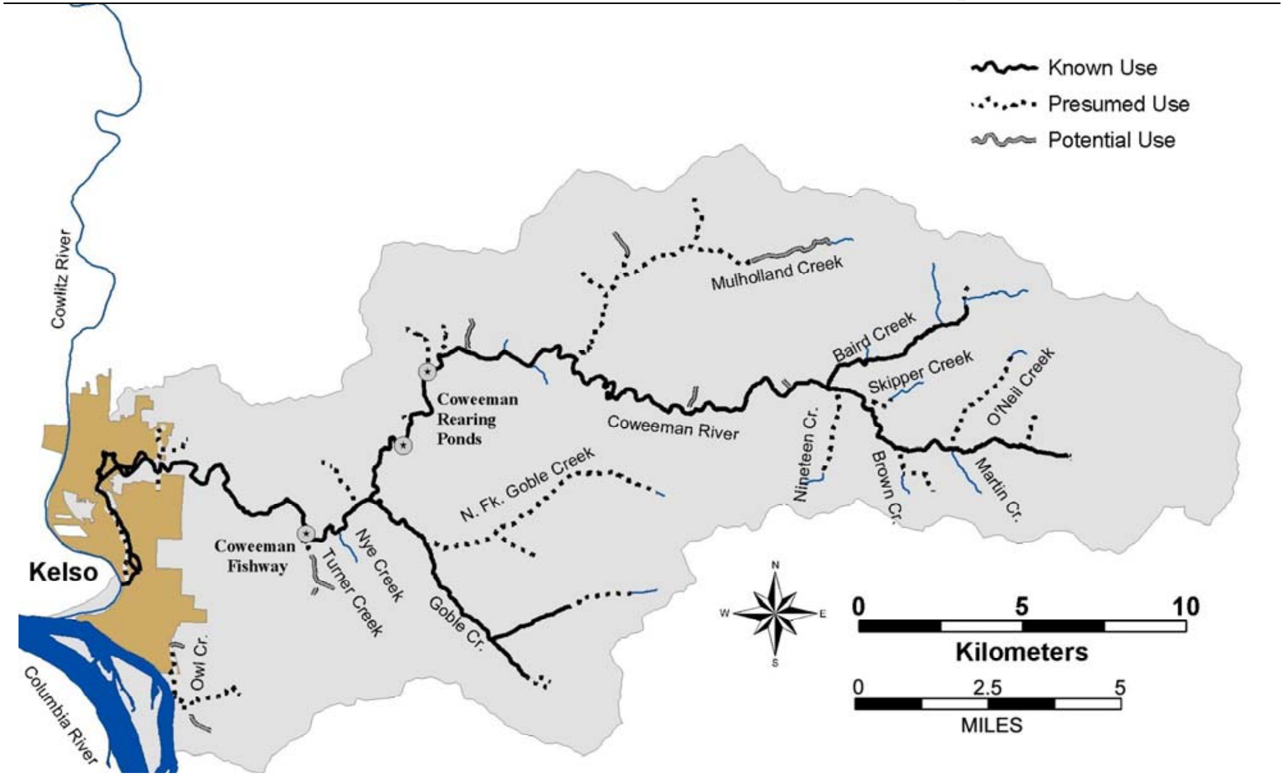
- The Cowlitz Trout Hatchery, located on the mainstem Cowlitz at RM 42, is the only hatchery in the basin producing winter steelhead
- Hatchery winter steelhead have been planted in the Coweeman River basin since 1957; broodstock from the Elochoman and Cowlitz Rivers and Chambers Creek have been used, but most releases have been from Chambers Creek; release data are displayed from 1985-2001
- Hatchery fish comprise most of the winter steelhead run in the Coweeman River basin; hatchery fish escapements from 1986-1990 ranged from 1,795 to 2,427; however, hatchery fish contribute little to natural production

Harvest

- No directed commercial or tribal fisheries target Coweeman winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Coweeman River
- Approximately 6.2% of returning Cowlitz River hatchery steelhead are harvested in the Columbia River sport fishery
- Winter steelhead sport harvest (hatchery and wild) in the Coweeman River from 1986-1989 ranged averaged 241 fish; since 1990, regulations limit harvest to hatchery fish only
- ESA limits fishery impact of wild winter steelhead in the mainstem Columbia River and in the Coweeman River

6.2.4 Cutthroat Trout—Cowlitz River Subbasin (Coweeman)

ESA: Not Listed **SASSI: Depressed 2000**



Distribution

- Anadromous forms have access to most of the watershed except above Washboard Falls (RM 31)

Life History

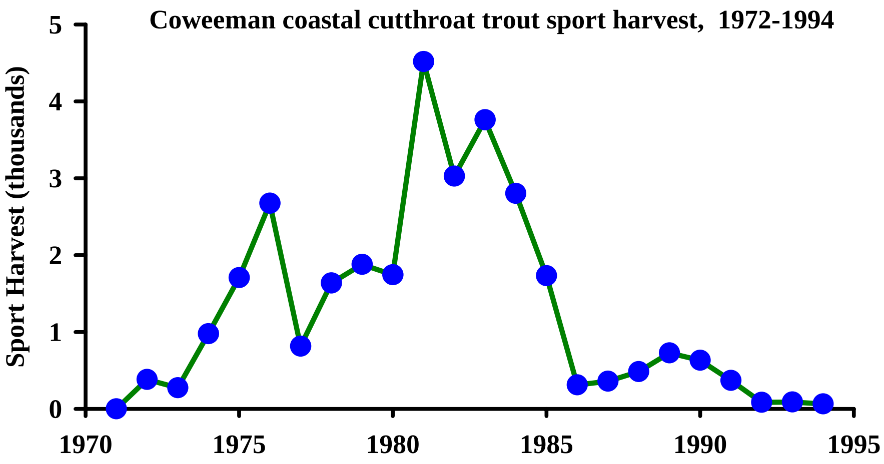
- Anadromous, fluvial and resident forms are present
- Anadromous river entry is from August through March, with peak entry in the fall
- Anadromous spawning occurs from January through mid-April
- Fluvial and resident spawn timing is not documented but is believed to be similar to anadromous timing

Diversity

- Distinct stock based on geographic distribution of spawning areas
- No genetic sampling has been conducted

Abundance

- No abundance information exists for resident and fluvial forms
- Anadromous forms are considered depressed due to long term negative decline in the lower Columbia River cutthroat catch
- The early 1990s harvest data are less than 5% of peak harvest counts in the early 1980s



Hatchery

- No hatcheries exist on the Coweeman River
- From 1989 to 1993 12,000 anadromous cutthroat from Beaver Creek Hatchery were released into the Coweeman River annually
- Hatchery cutthroat releases into the Coweeman River were discontinued
- Hatchery steelhead smolts are released into the Coweeman River

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia River summer fisheries downstream of the Cowlitz River
- Wild Coweeman River cutthroat (unmarked fish) are released in mainstem Columbia River and Coweeman River sport fisheries

6.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quantity and quality has significant impacts on winter steelhead coho and chum populations. For fall chinook, loss of tributary habitat is of moderate importance. Loss of estuary habitat is moderately important to fall chinook and chum, but is of minor importance to both winter steelhead and coho.
- Harvest impacts are of high importance to both fall chinook and coho, but is of relatively minor importance to winter steelhead and chum.
- Predation is moderately important to all three populations in the Coweeman.
- Impacts from hatcheries and the hydrosystem are relatively minor for each population.

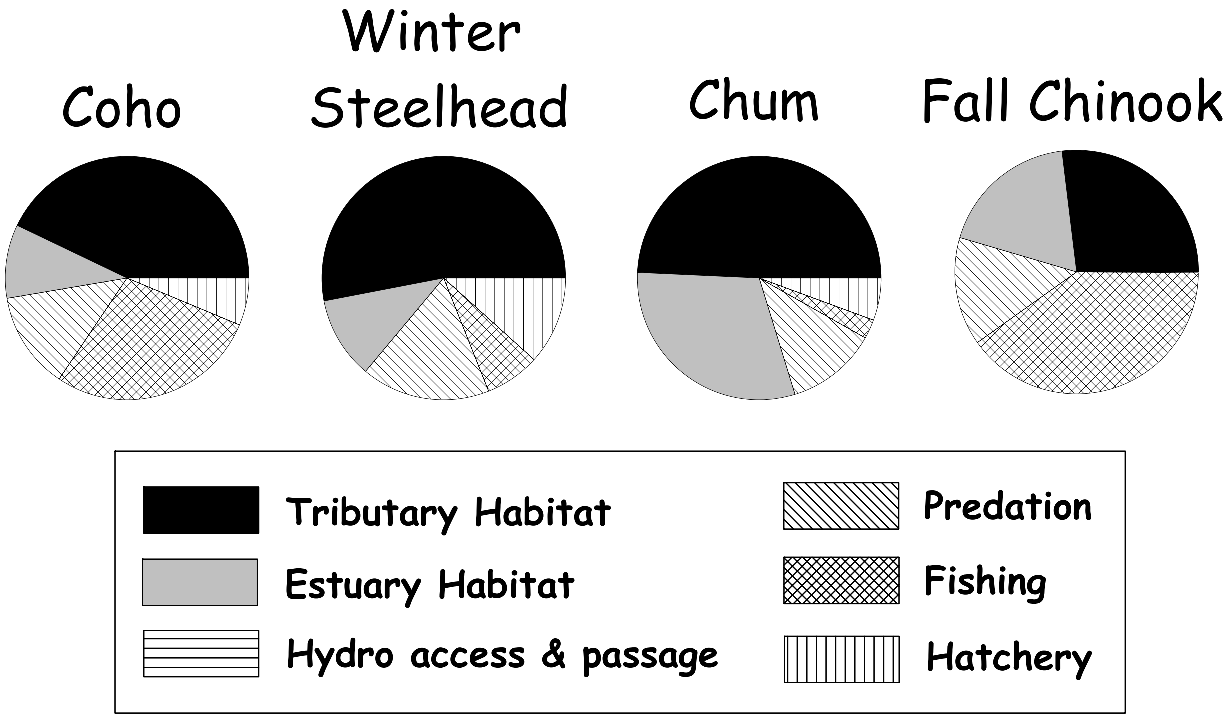


Figure 6-5. Relative index of potentially manageable mortality factors for each species in the Coweeman subbasin.

6.4 Hatchery Programs

Vol II, Chapter 8.4 contains a discussion of the hatcheries in the Cowlitz basin.

6.5 Fish Habitat Conditions

6.5.1 Passage Obstructions

Numerous culverts present full or partial barriers to anadromous fish passage in the watershed. A detailed description of the type and location of natural and artificial passage barriers is given in the Washington Conservaton Commission's WRIA 26 Limiting Factors Analysis (Wade 2000).

6.5.2 Stream Flow

Runoff is predominantly generated by rainfall, with a portion of spring flows coming from snowmelt in the upper elevations and occasional winter peaks related to rain-on-snow events. Streamflows are primarily the result of winter rainfall.

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that runoff properties are 'impaired' throughout most of the basin, with 'moderately impaired' hydrologic conditions only in the headwaters subwatersheds. High road densities and young forest stands are the primary causes of hydrologic impairment. These conditions create a risk of increased peak flow volumes.

Low flows in the Coweeman have been responsible for impeding chinook and coho migrations as well as limiting juvenile rearing habitat. Using the Toe-Width method to assess flow suitability in 1998, it was determined that flows for fall spawning were less than optimal until November, and flows for juvenile rearing were less than optimal from mid-July through September (Caldwell et al. 1999).

Watershed Planning Assessments conducted by the Lower Columbia Fish Recovery Board (LCFRB) indicate that the current and future projected groundwater withdrawal appears to be much less than the groundwater available in the subbasin. The extent of impact of groundwater pumping on stream flow rates appears to be minimal on a subbasin scale (LCFRB 2001).

6.5.3 Water Quality

The lower Coweeman was listed on the 1998 303(d) list for exceedance of temperature standards (WDOE 1998). Temperatures measured in the Coweeman near Kelso from 1950 to 1967 consistently exceeded 18ºC (64°F) June through September and often exceeded 25ºC (77°F) in July and August (Wade 2000). The Coweeman has been listed as "temperature sensitive" due to logging (WDW 1990). The tributaries Baird, Mulholland, and Goble Creeks were also listed on the 1998 303(d) list due to temperature problems. Nutrient deficits are an assumed problem due to low escapement levels of winter steelhead, coho, and chum (Wade 2000). A TMDL for fecal coliform was initiated in 1999 on Gibbons Creek.

6.5.4 Key Habitat

The upper Coweeman has low pool frequencies and depths that are considered a concern for fish (Weyerhaeuser 1996). Information on pool habitat elsewhere in the Coweeman is lacking.

6.5.5 Substrate & Sediment

WDFW noted in 1990 that substrate conditions limit production of coastal cutthroat, winter steelhead, fall chinook, and coho. The low gradient between RM 17-26 on the Coweeman contributes a large amount of persistent sediment due to the underlying parent material containing a high fraction of fines. For this reason, the area also experiences frequent mass failures and bank erosion. Sediment production in this reach is apparent as chocolate brown stormflow and as fine sediment accumulation on channel margins, backwater areas, and in side-channels. Historical splash dams throughout the Coweeman basin accumulated sediments, which the channels incised; these continue to deliver fines to downstream areas (Weyerhaeuser 1996).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The model indicates that sediment supply conditions are ‘moderately impaired’ throughout most of the basin, with ‘impaired’ conditions in the lower basin near the town of Kelso. The only ‘functional’ subwatersheds are located in the headwaters of Baird and Mulholland Creeks.

Sediment supply impairments are mostly the result of the forest road network within the basin. With an average road density of 6.54 mi/mi2 and over 69 miles of stream-adjacent roads, roads in the Coweeman basin are believed to increase sediment production. Several roads contributing fine sediment to streams were identified in the upper Coweeman basin as part of the watershed analysis (Weyerhaeuser 1996).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

6.5.6 Woody Debris

As part of the Upper Coweeman Watershed Analysis conducted by Weyerhaeser in 1996, approximately half of the surveyed streams had high near-term LWD recruitment potential and about one-third had low near-term recruitment potential.

6.5.7 Channel Stability

The Coweeman River between RM 4 – 7.5 has bank stability problems associated with adjacent agricultural uses. From RM 17 – 26, lateral bank stability is a problem. The upper Coweeman has experienced mass wasting related to roads. Pin Creek and Goble Creek (Coweeman tributaries) have some stability problems in their upper reaches (Weyerhaeuser 1996).

6.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, the Coweeman basin suffers from ‘moderately impiared’ riparian conditions throughout the basin. The only exceptions are the mainstem headwaters, which is rated as ‘functional’, and the lowermost portion of the basin, which is rated as ‘impaired’. This pattern of riparian impairment is supported by an assessment by Lewis County GIS (2000), which identified poor riparian conditions on over 40% of stream miles in the lower Coweeman basin compared to less than 15% in the upper basin. A contributing factor to riparian impairment is the large amount of valley bottom roads (over 69 miles) that reduce or eliminate riparian function. Cattle grazing between RM 4 – 7.5 is also a concern (Wade 2000).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

6.5.9 Floodplain Function

The lower four miles has been diked as part of industrial and commercial development in the Kelso area, limiting access to over-wintering habitat for juveniles. RM 4 – 7.5 provides some decent off-channel habitats, as does a small portion of floodplain habitat below RM 1. Above RM 17 are a few unconfined reaches that historically may have provided off-channel habitats but are now incised to the point that accessible off-channel areas no longer exist (Wade 2000).

6.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Coweeman River steelhead, chum, coho and fall chinook. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

6.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Coweeman basin for fall chinook, chum, coho and winter steelhead. Model results indicate an estimated 60- 86% decline in adult productivity for all species compared to historical estimates (Table 6-1). Modeled historical adult abundance of coho and winter steelhead was nearly three times greater than current estimates (Figure 6-6). Current abundance of adult fall chinook is estimated at 56% of historical levels, while the current abundance of chum is estimated at only 8% of historical levels (Figure 6-6). Diversity (as measured by the diversity index) is estimated to have remained relatively constant for fall chinook, chum, and winter steelhead. However, diversity has declined by approximately 40% for coho (Table 6-1).

Smolt productivity has also declined from historical levels for each species in the Coweeman basin (Table 6-1). For fall chinook and chum, smolt productivity has decreased by 57% and 42%, respectively. For both coho and winter steelhead the decrease was estimated as approximately 74%. Smolt abundance in the Coweeman clearly declines most dramatically for chum and coho, with respective 79% and 81% changes from historical levels. Current fall chinook and steelhead smolt abundance levels are modeled at approximately half of historical numbers.

Model results indicate that restoration of properly functioning habitat conditions (PFC) would achieve significant benefits for all species (Table 6-1). Adult returns of both chum and coho would increase by greater than 230%. Adult returns of both fall chinook and winter steelhead would increase by greater than 50%. Smolt numbers are also estimated to increase dramatically for all species, especially for coho, which shows a 288% increase in smolt abundance with restoration of PFC.

Table 6-1. Coweeman River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	1,839	2,877	3,270	4.3	8.6	11.0	1.00	1.00	1.00	218,075	324,661	374,482	480	879	1,115
Chum	277	932	3,217	2.1	7.0	10.0	0.97	1.00	1.00	132,516	340,763	636,146	667	1,023	1,152
Coho	1,873	6,225	8,434	3.4	8.1	12.5	0.51	0.82	0.87	33,578	130,350	178,656	65	165	253
Winter Steelhead	653	1,017	2,423	3.9	9.0	28.2	0.86	0.98	1.00	11,599	18,040	22,929	73	165	275

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

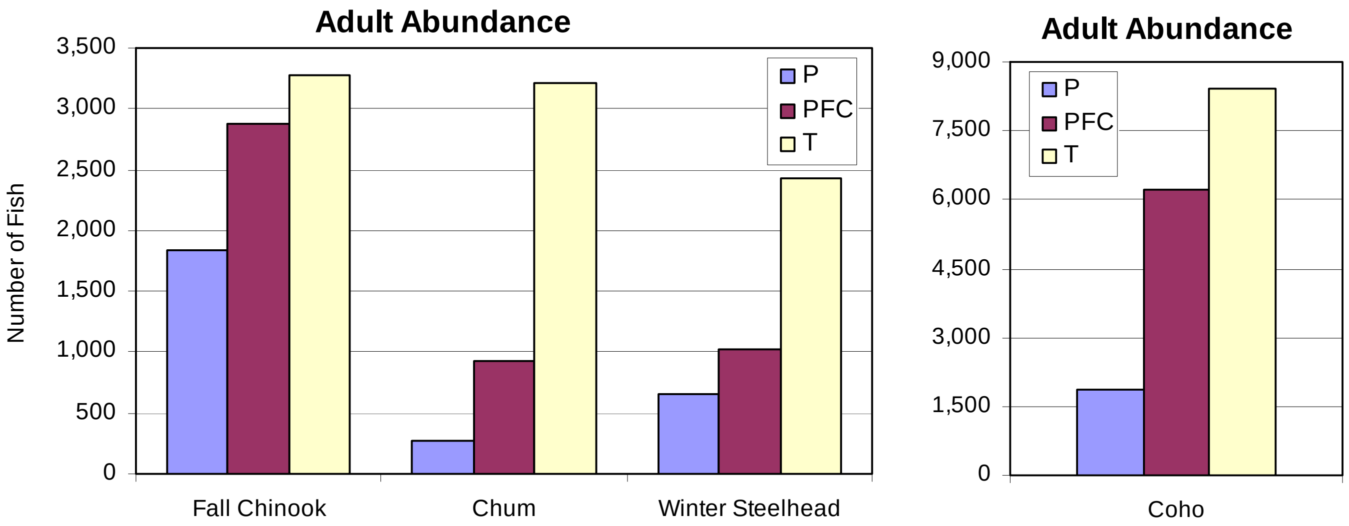


Figure 6-6. Adult abundance of Coweeman fall chinook, chum, winter steelhead and coho based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

6.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

For the purposes of the EDT model, the Coweeman basin was divided into approximately 40 reaches that are used by salmon and steelhead (Figure 6-7). Winter steelhead utilize all of these reaches, whereas fall chinook and coho use primarily just the mainstem reaches, and chum use only the first few mainstem reaches. Reaches 1-4 are low gradient reaches that course through Kelso and the agricultural land upstream of town. In general, reaches 5 and up are moderately confined, with forestry, and in some cases residential development, as the primary impacts.

Winter steelhead reaches with a high priority ranking include those in the upper basin (Coweeman 15-16), and headwaters (Coweeman 17-22) (Figure 6-8). The upper sections, including the headwaters and the headwater tributaries, represent primary steelhead spawning and rearing areas, while the middle tributaries have rearing but limited spawning potential. Therefore, almost all of these reaches have a combined preservation and restoration emphasis (Figure 6-8). For fall chinook, high priority reaches include the middle mainstem (Canyon 2 and 3, Coweeman 5, 8, 10 and 11) and the upper Coweeman (Coweeman 16) (Figure 6-9). Both the canyon and upper reaches show a preservation only emphasis while the other middle reaches show a combined preservation and restoration emphasis (Figure 6-9). Current conditions are poor for chum in the lower mainstem, however, the one high priority reach for chum, Coweeman 4, shows a preservation emphasis (Figure 6-10). High priority reaches for coho include Coweeman 4-5, 8-11, 16-18, and Canyon 3 (Figure 6-11). With the exception of Coweeman 16, which has a combined preservation and restoration emphasis, all other high priority reaches for coho show a restoration emphasis.

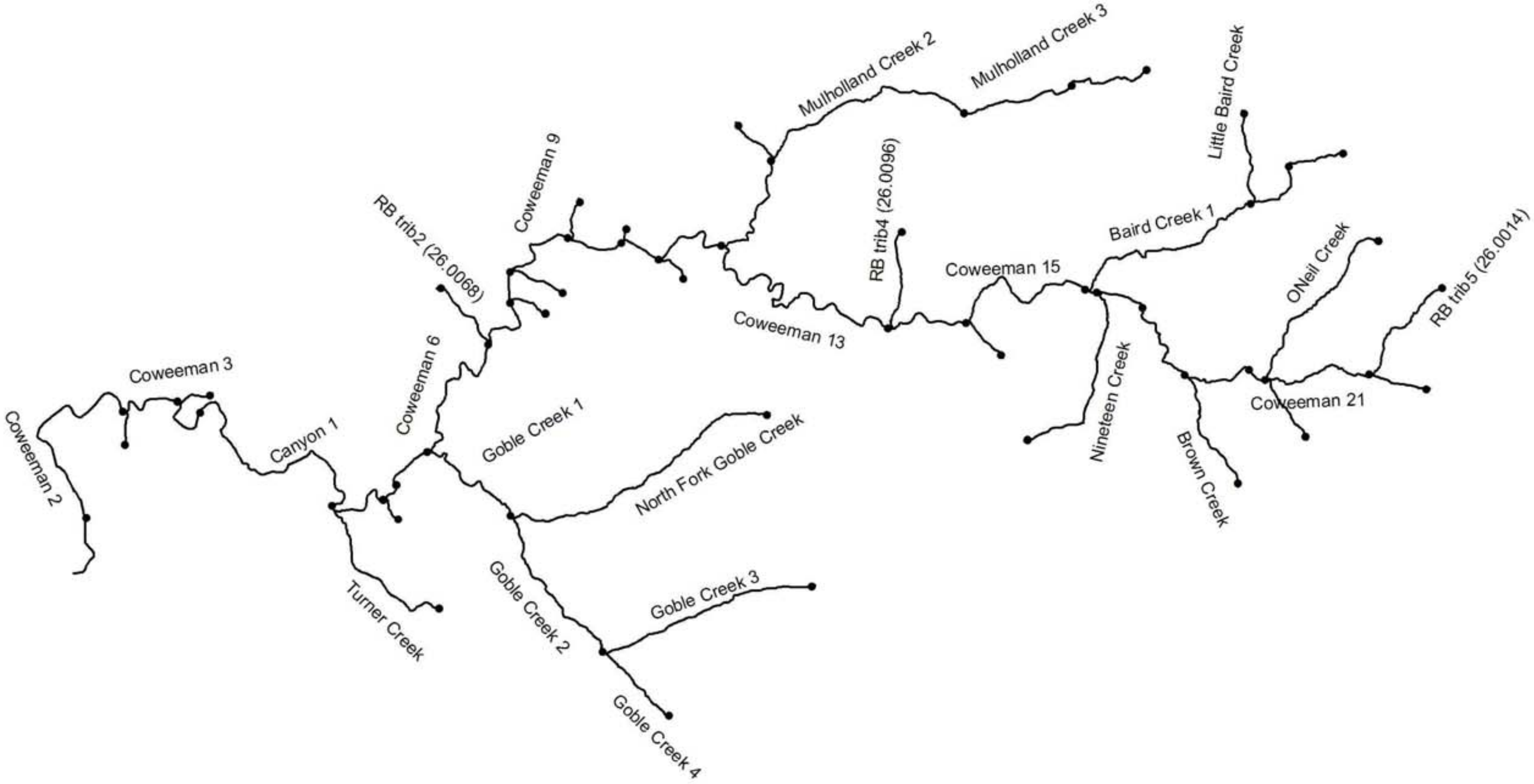
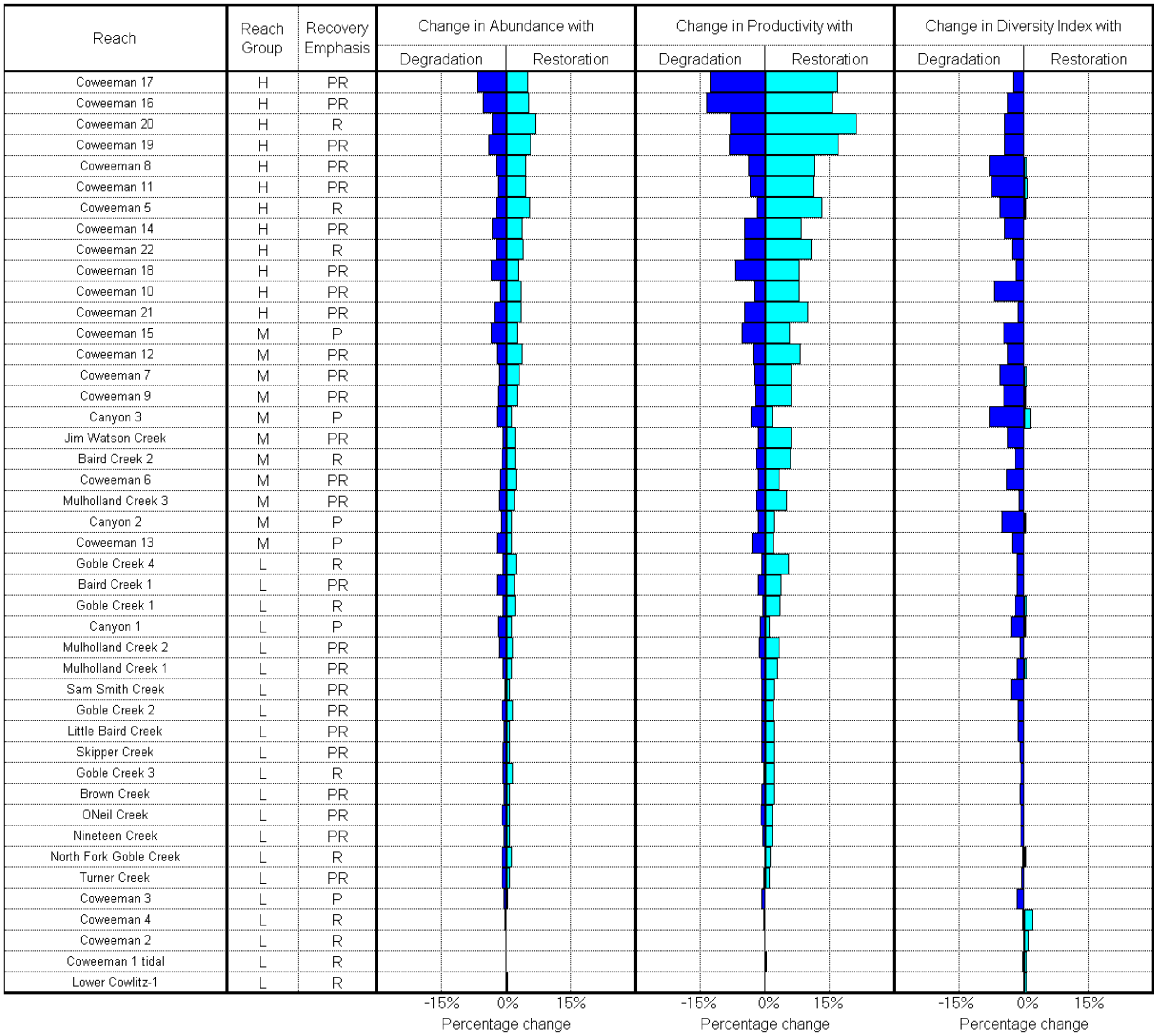


Figure 6-7. Coweeman basin with EDT reaches identified. For readability, not all reaches are labeled.

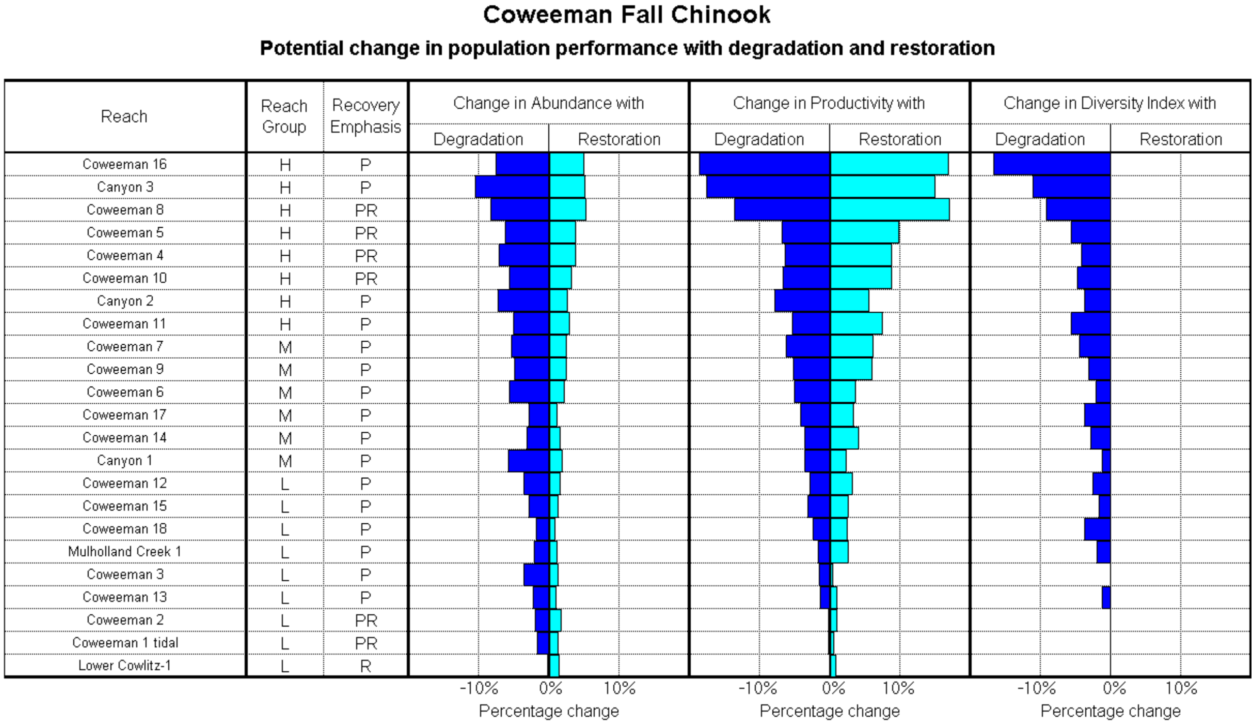
Coweeman Winter Steelhead

Potential change in population performance with degradation and restoration



Reach	Reach Group	Recovery Emphasis
Coweeman 17	H	PR
Coweeman 16	H	PR
Coweeman 20	H	R
Coweeman 19	H	PR
Coweeman 8	H	PR
Coweeman 11	H	PR
Coweeman 5	H	R
Coweeman 14	H	PR
Coweeman 22	H	R
Coweeman 18	H	PR
Coweeman 10	H	PR
Coweeman 21	H	PR
Coweeman 15	M	P
Coweeman 12	M	PR
Coweeman 7	M	PR
Coweeman 9	M	PR
Canyon 3	M	P
Jim Watson Creek	M	PR
Baird Creek 2	M	R
Coweeman 6	M	PR
Mulholland Creek 3	M	PR
Canyon 2	M	P
Coweeman 13	M	P
Goble Creek 4	L	R
Baird Creek 1	L	PR
Goble Creek 1	L	R
Canyon 1	L	P
Mulholland Creek 2	L	PR
Mulholland Creek 1	L	PR
Sam Smith Creek	L	PR
Goble Creek 2	L	PR
Little Baird Creek	L	PR
Skipper Creek	L	PR
Goble Creek 3	L	R
Brown Creek	L	PR
ONeil Creek	L	PR
Nineteen Creek	L	PR
North Fork Goble Creek	L	R
Turner Creek	L	PR
Coweeman 3	L	P
Coweeman 4	L	R
Coweeman 2	L	R
Coweeman 1 tidal	L	R
Lower Cowlitz-1	L	R

Figure 6-8. Coweeman basin winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. See Volume VI for more information on EDT ladder diagrams.

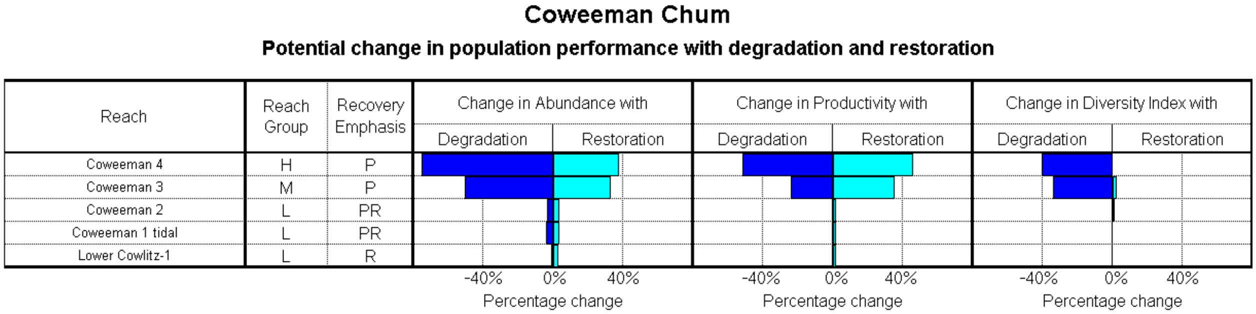


Coweeman Fall Chinook

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Coweeman 16	H	P
Canyon 3	H	P
Coweeman 8	H	PR
Coweeman 5	H	PR
Coweeman 4	H	PR
Coweeman 10	H	PR
Canyon 2	H	P
Coweeman 11	H	P
Coweeman 7	M	P
Coweeman 9	M	P
Coweeman 6	M	P
Coweeman 17	M	P
Coweeman 14	M	P
Canyon 1	M	P
Coweeman 12	L	P
Coweeman 15	L	P
Coweeman 18	L	P
Mulholland Creek 1	L	P
Coweeman 3	L	P
Coweeman 13	L	P
Coweeman 2	L	PR
Coweeman 1 tidal	L	PR
Lower Cowlitz-1	L	R

Figure 6-9. Coweeman basin fall chinook ladder diagram.

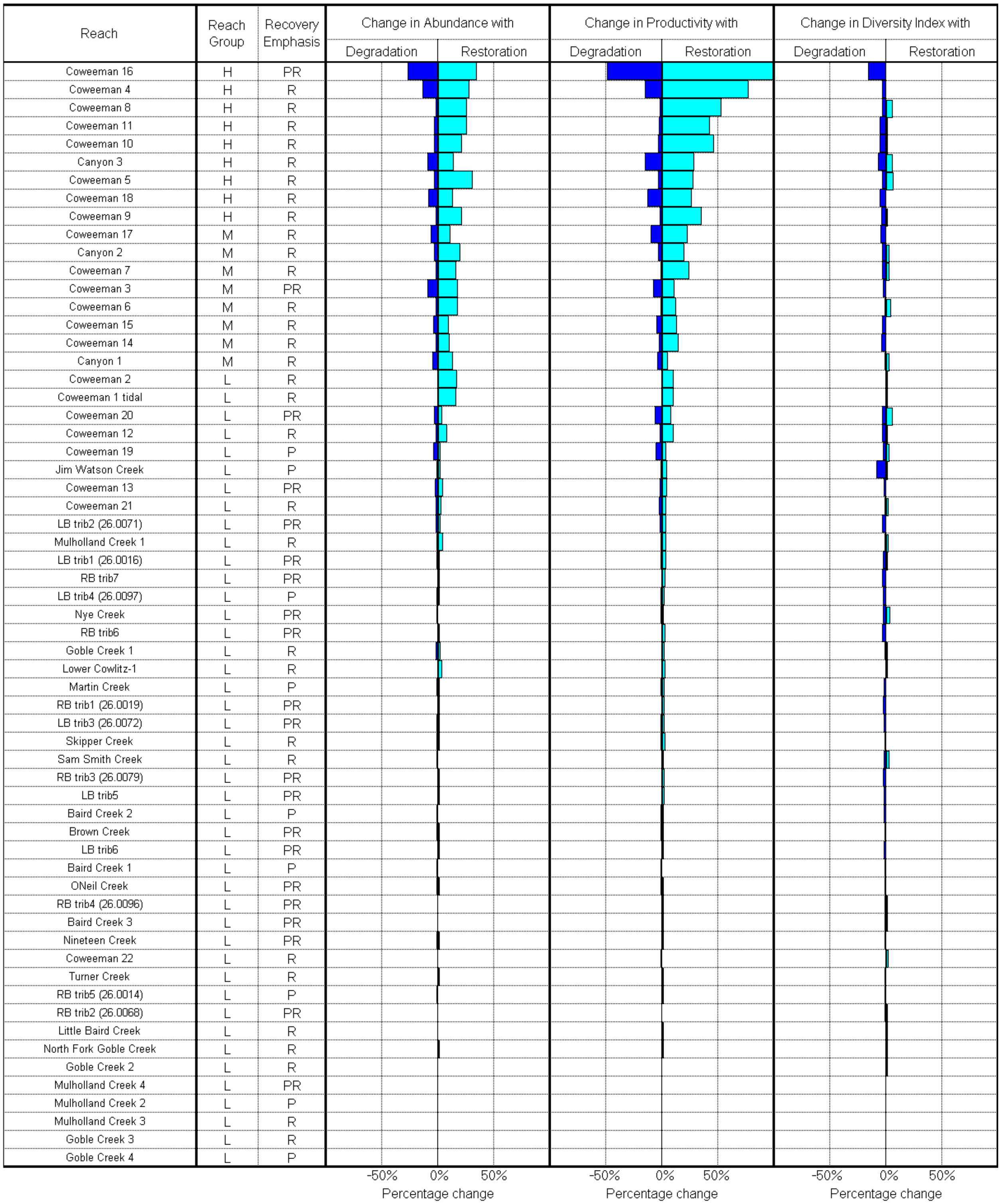


Coweeman Chum

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Coweeman 4	H	P
Coweeman 3	M	P
Coweeman 2	L	PR
Coweeman 1 tidal	L	PR
Lower Cowlitz-1	L	R

Figure 6-10. Coweeman basin chum ladder diagram.



Coweeman Coho

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Coweeman 16	H	PR
Coweeman 4	H	R
Coweeman 8	H	R
Coweeman 11	H	R
Coweeman 10	H	R
Canyon 3	H	R
Coweeman 5	H	R
Coweeman 18	H	R
Coweeman 9	H	R
Coweeman 17	M	R
Canyon 2	M	R
Coweeman 7	M	R
Coweeman 3	M	PR
Coweeman 6	M	R
Coweeman 15	M	R
Coweeman 14	M	R
Canyon 1	M	R
Coweeman 2	L	R
Coweeman 1 tidal	L	R
Coweeman 20	L	PR
Coweeman 12	L	R
Coweeman 19	L	P
Jim Watson Creek	L	P
Coweeman 13	L	PR
Coweeman 21	L	R
LB trib2 (26.0071)	L	PR
Mulholland Creek 1	L	R
LB trib1 (26.0016)	L	PR
RB trib7	L	PR
LB trib4 (26.0097)	L	P
Nye Creek	L	PR
RB trib6	L	PR
Goble Creek 1	L	R
Lower Cowlitz-1	L	R
Martin Creek	L	P
RB trib1 (26.0019)	L	PR
LB trib3 (26.0072)	L	PR
Skipper Creek	L	R
Sam Smith Creek	L	R
RB trib3 (26.0079)	L	PR
LB trib5	L	PR
Baird Creek 2	L	P
Brown Creek	L	PR
LB trib6	L	PR
Baird Creek 1	L	P
ONeil Creek	L	PR
RB trib4 (26.0096)	L	PR
Baird Creek 3	L	PR
Nineteen Creek	L	PR
Coweeman 22	L	R
Turner Creek	L	R
RB trib5 (26.0014)	L	P
RB trib2 (26.0068)	L	PR
Little Baird Creek	L	R
North Fork Goble Creek	L	R
Goble Creek 2	L	R
Mulholland Creek 4	L	PR
Mulholland Creek 2	L	P
Mulholland Creek 3	L	R
Goble Creek 3	L	R
Goble Creek 4	L	P

Figure 6-11. Coweeman basin coho ladder diagram.

6.6.3 Habitat Factor Analysis

The habitat factor analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the habitat factor analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis is based on a comparison of current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration rank, which factors in their relative restoration benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to PFC.

The top priority restoration area for winter steelhead is the upper mainstem (Figure 6-12). These reaches suffer from high impacts related to habitat diversity, sediment, and flow, with moderate impacts from temperature and channel stability. These impacts are mostly the result of forestry operations throughout the basin. Sediment and flow problems are related to high road densities and early seral vegetation. Road densities in upper basin subwatersheds range from 4.5 to 6.4 mi/mi^2. Habitat diversity is due to loss of instream LWD. Temperature and channel stability problems are related to loss of riparian forest structure. Over 30% of riparian buffer cover along the upper mainstem is in ‘other forest’ conditions, which implies shrub-like or grass conditions. Minor predation and pathogen impacts are due to the hatchery steelhead program. A few middle mainstem reaches (Coweeman 5, 8, 10, and 11) are also ranked as high priority. These reaches have high impacts related to temperature, sediment, flow, and habitat diversity. Riparian conditions in the middle mainstem are poor, with over 75% of riparian cover in early seral or ‘other forest’ vegetation conditions. The highway, which parallels the river in the upstream portion of this segment, contributes to riparian degradation. In addition, the road network in the middle mainstem subwatershed is extensive, with over 7.5 mi/mi^2. This is one of the most densely roaded forested subwatersheds in the region. Influence from hatchery operations is represented in the pathogen and predation impacts.

Restoration priorities for fall chinook in the middle mainstem include sediment, habitat diversity, temperature, channel stability, and key habitat (Figure 6-13). Sediment in spawning gravels is a major concern and is mostly related to basin forestry activities as described above for steelhead. Modification of historical channel morphologies as a result of flow, sediment, and riparian changes is reflected in the channel stability attribute and also contributes to loss of key habitat. The lower reaches also have high restoration priority for fall chinook and are impacted by sediment and temperature, with lesser habitat diversity, channel stability, and key habitat impacts.

Attributes with a high impact to chum (Figure 6-14) are found in the lower reaches and include habitat diversity, key habitat, and sediment, with moderate channel stability, flow, and food effects. Habitat diversity is reduced by a loss of instream LWD and an increase in channel confinement. Sediment accumulates readily in the lower reaches, especially in reaches 3 and 4 as the gradient drops considerably once exiting the canyon. Reaches 1 and 2 have experienced extensive diking in this urban area (Kelso), whereas reaches 3 and 4 are bordered by agricultural lands. Reaches 3 and 4 are fairly unconstrained reaches that have adjacent abandoned oxbows and wetland habitat that may provide good restoration opportunities. Restoration efforts focused on the unconfined reaches 3 and 4 may increase the quality of spawning habitats.

Coho in the Coweeman basin are affected by adverse habitat conditions primarily in the middle and upper mainstem reaches (Figure 6-15). In these locations, habitat diversity and sediment appear to be the habitat factors with the highest impacts on coho. Other contributing factors include channel stability, temperature, flow, and key habitat. Causes for the observed impacts are similar to those discussed above for winter steelhead.

Coweeman Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Coweeman 17	•	⬤	•	•					⬤	⬤	●			•		+
Coweeman 16	•	⬤	●	•					⬤	⬤	●			•		+
Coweeman 20	●	⬤	●	•					⬤	⬤	●					+
Coweeman 19	●	⬤	•	•					⬤	⬤	●					+
Coweeman 8	•	⬤	●	•					●	⬤	•			•		+
Coweeman 11	•	⬤	●	•					●	●	•			•		+
Coweeman 5	●	⬤	●	•		•			●	●	•			•		+
Coweeman 14	•	⬤	●	•					●	●	•			•		+
Coweeman 22	•	⬤	•	•					●	⬤	•					✚
Coweeman 18	•	●	•	•					●	⬤	•					+
Coweeman 10	•	⬤	●	•					●	●	•			•		
Coweeman 21	•	●	•	•					●	⬤	•					+
Coweeman 15	•	●	•	•					●	●	•					
Coweeman 12	•	⬤	●	•					●	●	•			•		
Coweeman 7	•	●	●	•					●	●	•			•		
Coweeman 9	•	●	●	•					●	●	•			•		
Canyon 3	•	●	●	•					•	●				•		
Jim Watson Creek		•	●	•					•	⬤	•			•		+
Baird Creek 2	•	●	●	•		•			●	⬤	•			•		+
Coweeman 6	•	●	●	•					●	●	•			•		
Mulholland Creek 3	•	•	●	•					•	⬤	•			•		✚
Canyon 2	•	●	•	•					•	•				•		
Coweeman 13	•	●	•						•	●	•			•		
Goble Creek 4	•	●	•						●	●	•			•		+
Baird Creek 1	•	●	●	•					●	●	•			•		+
Goble Creek 1	•	●	•						●	●	•			•		+
Canyon 1	•	●	•	•					•	•				•		
Mulholland Creek 2		•	●	•					•	●	•			•		+
Mulholland Creek 1	•	●	●						•	●	•			•		+
Sam Smith Creek	•	•	•						•	⬤	•					+
Goble Creek 2	•	●	•						●	●	•			•		+
Little Baird Creek	•	•	•						•	●	•					+
Skipper Creek	•	●	•						•	●	•					+

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 6-12. Coweeman basin winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes

Coweeman Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Coweeman 16	●	⬤	●						●	⬤	•					●
Canyon 3	●	●	⬤	•					•	⬤	•					●
Coweeman 8	●	●	⬤						●	⬤	•					●
Coweeman 5	●	●	●						•	⬤	•					●
Coweeman 4	●	●	⬤						•	⬤	•					●
Coweeman 10	●	●	●						●	⬤	•					●
Canyon 2	●	●	●						•	⬤	•					●
Coweeman 11	●	●	●						•	⬤	•					●
Coweeman 7	●	●	●						•	⬤	•					●
Coweeman 9	•	●	●						•	⬤	•					●
Coweeman 6	●	●	•						•	●	•					●
Coweeman 17	•	●	•						•	⬤	•					•
Coweeman 14	•	●	•						•	⬤	•					•
Canyon 1	•	●	•						•	●	•					●
Coweeman 12	•	●	•						•	⬤	•					●
Coweeman 15	•	●	•						•	●	•					●
Coweeman 18	•	●	•						•	⬤	•					•
Mulholland Creek 1	•	●	•						•	⬤	•					•
Coweeman 3	•	●	•			•			•	•	•					●
Coweeman 13	•	●	•						•	●	•					•
Coweeman 2	•	●	•	•	•	•			•	•	•			•	•	●
Coweeman 1 tidal	•	●	•	•					•	•	•			•	•	●
Lower Cowlitz-1	•	●	•	•		•			•	•	•			•	•	•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ✚

Figure 6-13. Coweeman basin fall chinook habitat factor analysis diagram.

Coweeman Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Coweeman 4	●	⬤							●	⬤	●					⬤
Coweeman 3	●	⬤							●	⬤	●					⬤
Coweeman 2	•	•		•					•		•				•	•
Coweeman 1 tidal	•	•		•					•		•				•	•
Lower Cowlitz-1	•	•							•		•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ✚

Figure 6-14. Coweeman basin chum habitat factor analysis diagram.

Coweeman Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Coweeman 16	●	⬤	●	•					⬤	⬤	●					●
Coweeman 4	⬤	⬤	⬤	•		•		•	●	⬤	●			•		●
Coweeman 8	●	⬤	●						●	⬤	•					●
Coweeman 11	●	⬤	●	•					●	⬤	•					●
Coweeman 10	●	⬤	●	•					●	⬤	•					●
Canyon 3	●	⬤	●	•					•	⬤	•					•
Coweeman 5	⬤	⬤	●	•		•			●	●	•			•		●
Coweeman 18	•	⬤	•						●	⬤	•					●
Coweeman 9	●	⬤	●	•					●	●	•					●
Coweeman 17	•	⬤	•						●	⬤	•					●
Canyon 2	●	⬤	●	•		•			•	●	•			•		●
Coweeman 7	●	⬤	●						●	●	•					●
Coweeman 3	●	⬤	●	•		•		•	●	•	●			•		•
Coweeman 6	•	⬤	●	•		•			●	●	•			•		●
Coweeman 15	•	⬤	•						●	●	•					●
Coweeman 14	•	⬤	•						●	●	•					●
Canyon 1	•	⬤	●	•		•			•	●	•			•		●
Coweeman 2	•	⬤	●	●	•	•			●	•	•			•		⬤
Coweeman 1 tidal	•	⬤	●	●	•	•			•	•	•			•		⬤
Coweeman 20	•	●							•	●	•					•
Coweeman 12	•	⬤	•						•	●	•					•
Coweeman 19	•	●							•	•	•					•
Jim Watson Creek	•	•	•						•	●	•					✛
Coweeman 13	•	●	•						•	●	•					•
Coweeman 21	•	●							•	•	•					•
LB trib2 (26.0071)	•	•							•	●						✛
Mulholland Creek 1	•	●	•						•	•	•					●
LB trib1 (26.0016)	•	•							•	●	•					•
RB trib7	•	•							•	•	•					✛
LB trib4 (26.0097)	•	•							•	●	•					✛
Nye Creek	•	•								•						+
RB trib6	•	•							•	•	•					✛
Goble Creek 1	•	●	•						•	•						•
Lower Cowlitz-1	•	●		•		•			•	•	•			•		•
Martin Creek	•	•							•	•	•					✛
RB trib1 (26.0019)	•	•							•	•						✛
LB trib3 (26.0072)	•	•							•	•						✛
Skipper Creek	•	•							•	•						•
Sam Smith Creek		•								•						+
RB trib3 (26.0079)	•	•							•	•						✛
LB trib5	•	•							•	•						✛
Baird Creek 2	•	•								•						
Brown Creek		•							•	•						✛
LB trib6	•	•							•	•						✛
Baird Creek 1		•								•						
ONeil Creek		•							•	•	•					✛

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 6-15. Coweeman basin coho habitat factor analysis diagram. Some low priority reaches are not included for display purposes

6.7 Integrated Watershed Assessment (IWA)

For the purpose of recovery planning, the Coweeman River watershed has been divided into 18 subwatersheds totaling 129,544 acres. Principal tributaries to the Coweeman River include Goble, Mulholland, Baird, O'Neil, and Butler creeks. Note that three subwatersheds within the watershed, one encompassing Stratton Creek (80201) and the other two Ostrander Creek (80101 and 80102), do not drain to the Coweeman River, but are tributary to the lower mainstem Cowlitz.

Based on their physiographic and hydrologic characteristics, subwatersheds in the Coweeman River drainage are primarily small to medium sized lowland areas composed of sedimentary/metamorphic geology and rain-dominated runoff characteristics. A significant portion (26%) of the Coweeman watershed consists of small, high elevation drainages where precipitation falls mainly as snow and the potential for erosion is low.

6.7.1 Results and Discussion

IWA metrics were calculated for all 18 subwatersheds in the Coweeman River watershed. Subwatershed, or local, level IWA metrics reflect the effects of local conditions on hydrologic, sediment, and riparian processes within individual subwatersheds. They do not consider the influence of subwatersheds located upstream. Watershed-level IWA metrics, determined separately for each subwatershed, reflect the combined effect of local conditions and upstream subwatersheds. IWA results for each subwatershed are presented in Table 6-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 6-16. Maps of the distribution of local and watershed level IWA results are displayed in Figure 6-17.

Table 6-2. IWA results for the Coweeman River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
80401	I	M	M	I	M	80301,80302, 80303, 80304, 80305, 80306, 80307, 80404, 80405
80102	I	M	M	I	M	80101, Coweeman
80301	I	M	M	I	M	80302, 80303, 80304, 80305, 80306, 80307
80302	I	M	M	I	M	80306
80303	I	M	M	I	M	80304, 80305, 80307
80304	M	F	M	M	F	none
80305	M	M	M	M	M	none
80307	M	M	M	M	M	80305
80401	I	M	M	I	M	80301,80302, 80303, 80304, 80305, 80306, 80307, 80404, 80405
80402	I	I	I	I	M	80301,80302, 80303, 80304, 80305, 80306, 80307, 80401,80403, 80404, 80405
80403	I	M	M	I	M	80301,80302, 80303, 80304, 80305, 80306, 80307, 80401, 80404, 80405
80405	I	M	M	I	M	80404
80407	I	M	I	I	M	80301,80302, 80303, 80304, 80305, 80306, 80307, 80401,80403, 80404, 80405
80101	I	M	M	I	M	none
80102	I	M	M	I	M	none
80306	M	F	M	M	F	none
80404	I	M	M	I	M	none
80406	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

d Subwatersheds upstream from this subwatershed.

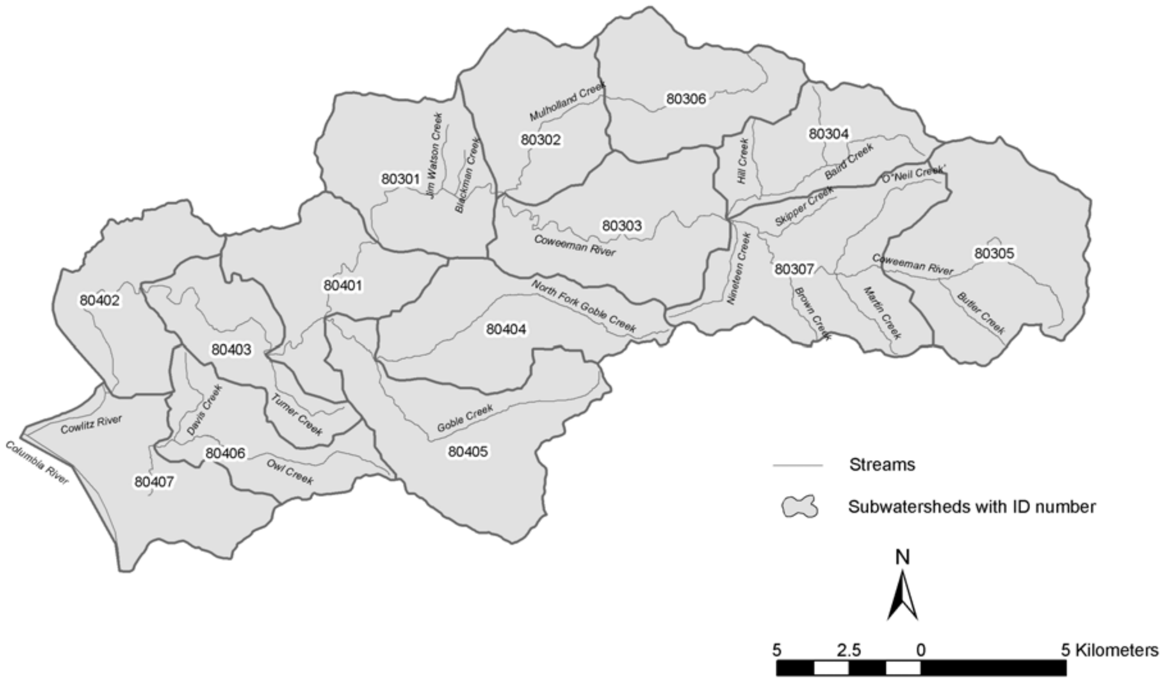


Figure 6-16. Map of the Coweeman basin showing the location of the IWA subwatersheds.

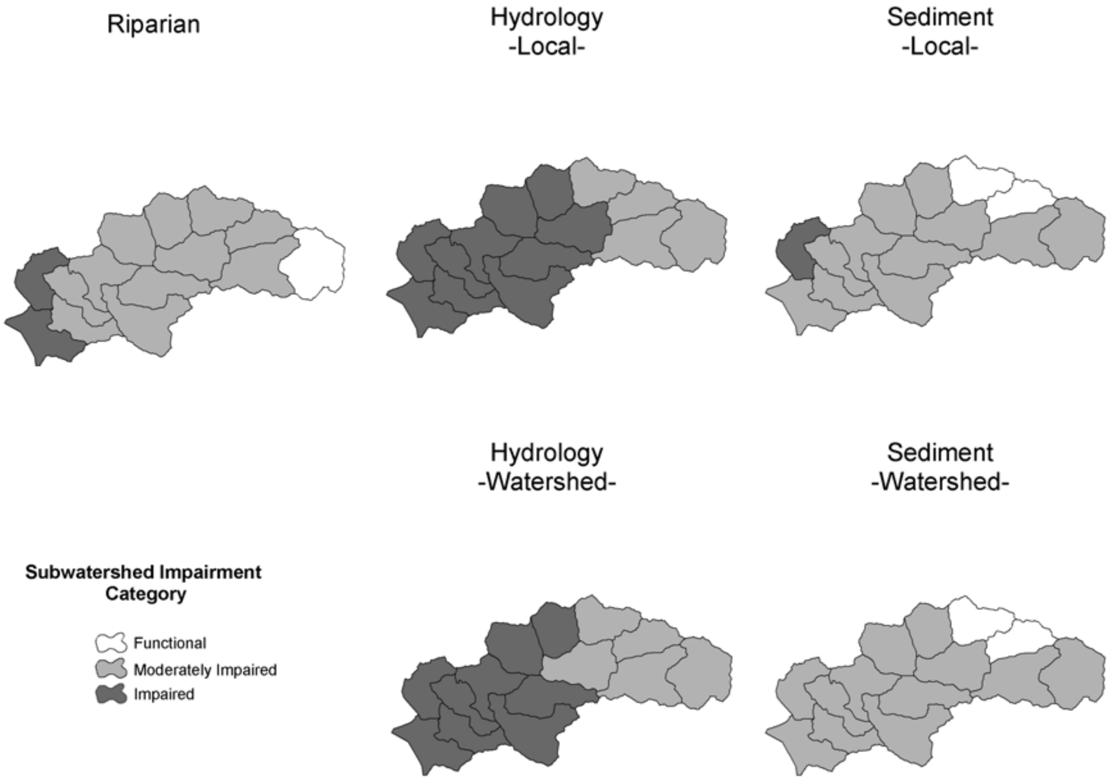


Figure 6-17. IWA subwatershed impairment ratings by category for the Coweeman basin

Based on their geologic, topographic and hydrologic characteristics, subwatersheds in the Coweeman can be stratified into two primary groups:

1. Small, higher elevation drainages where precipitation falls mainly as snow and the potential for erosion is low.
2. Small-to-medium size lower elevation drainages characterized by moderate aspects, erodable terrain and rain-dominated seasonal runoff patterns.

The overall impression afforded by the results of the IWA is one of moderate to severe disturbance of processes within subwatersheds in the Coweeman watershed. The preponderance of fully and moderately impaired hydrologic conditions suggests that hydrology may be a primary factor limiting habitat quality and fish population performance. Less-than-desirable sediment and riparian conditions are observed over most of the watershed. Degraded hydrologic and riparian conditions increase the probability that sediment processes will be adversely affected in drainages having highly erodable rock and soil types. These problems are ameliorated in low elevation, low-relief subwatersheds lying outside the rain-on-snow zone. The results of the IWA analysis for each process condition are described in more detail below.

6.7.1.1 Hydrology

Viewed at the local scale, most (78%) of the subwatersheds are hydrologically impaired; the rest are moderately impaired. One subwatershed (80303) shifts from impaired to moderately impaired when upstream (i.e., watershed-level) effects are taken into account. This subwatershed is located on the upper Coweeman River mainstem immediately downstream of a cluster of four (hydrologically) moderately impaired subwatersheds. Hydrologic conditions worsen progressively on a downstream gradient. The least impaired subwatersheds (note that none receive a “functional” rating) are situated in the upper Coweeman, Baird Creek, and Mulholland Creek drainages. All of the subwatersheds downstream of the junction of the Coweeman River and Baird Creek are hydrologically impaired.

Most of the upper basin subwatersheds have been extensively logged. Furthermore, several subwatersheds in the upper basin fall within the rain-on-snow zone and present steep aspects, making them more susceptible to hydrologic disturbance.

The lower elevation subwatersheds have been heavily logged and roaded, and in some cases developed for agriculture and residential purposes, resulting in degraded hydrologic (as well as sediment and riparian conditions) throughout. These subwatersheds are also influenced by hydrologic impairments from upstream areas, which further impacts watershed conditions.

Wetlands are an uncommon feature of the Coweeman watershed other than in the lower floodplain areas. Most of the wetlands are found at lower elevations and may be classified as “riverine”, that is, in close proximity and hydraulically linked to the active river channel. Subwatershed 80407, located at the mouth of the Coweeman River, contains 67% of the known wetland area delineated in the Coweeman watershed. The frequency and degree of inundation of riverine wetlands is directly linked to water table levels and seepage, channel-floodplain configuration, and streambank heights.

The effects of reduced hydrologic buffering by headwater subwatersheds are apparent. Lower than normal seasonal flows have been recorded in recent years in the lower Coweeman mainstem. Low streamflow conditions during the summer through October period are thought to limit the physical space for juvenile rearing and to reduce travel speeds of migrating chinook and coho salmon, reducing their growth and survival (WDW 1990). Caldwell et al. (1999) reported suboptimal flows during the fall spawning period.

6.7.1.2 Sediment

Sediment conditions throughout the Coweeman watershed are generally rated as moderately impaired. Functional conditions (local and watershed level) are found only in the upper subwatersheds of Baird and Mulholland Creeks (80304 and 80306). The one subwatershed found to be locally impaired was 80402, located near the mouth of the Coweeman River.

The underlying geologic material of the upper Coweeman watershed consists primarily of resistant volcanic rocks with local deposits of erodable alluvium. The geology in lower elevation areas of the Coweeman watershed consists of sedimentary/metamorphic rock overlain in many places by a mixture of gravel, sand, and silt alluvial deposits. These materials are highly erodable, particularly in steep terrain. The subwatersheds in this watershed are densely forested, with relatively high proportions of mature coniferous vegetation under natural conditions. Commercial forestry and road building on unstable slopes is the primary cause of human-induced sediment supply impairments.

There is evidence of sediment contribution to the mainstem Coweeman between RMs 17 and 26 (Wade 2000). Sediment delivery to this reach is apparent as turbidity during flood flows and as sediment deposits in slackwater areas after flows recede. Fine sediment accumulations in this reach are thought to limit production of coastal cutthroat, winter steelhead, fall chinook, and coho.

6.7.1.3 Riparian

fewer than 12% of the subwatersheds, at most, are functional in terms of their riparian conditions.

The index of riparian condition is based on the proportion of streamside vegetation within different vegetation classes. The riparian condition analysis was applied only at the subwatershed level. Dense forests, some of old growth, cover the steep topography of the upper Coweeman drainage. Commercial forestland makes up over 90% of the watershed. Much of the harvestable timber has been cut at some point in the past, resulting in a patchwork of logged and unlogged areas intersected by logging roads. Areas logged in the past currently comprise immature stands of young coniferous and/or deciduous vegetation.

Riparian conditions in the Coweeman River watershed are generally rated as moderately impaired, although two of the 18 subwatersheds are rated as fully impaired. Both are the most downstream areas of the watershed and encompass development around the cities of Kelso and Longview. The lower four miles of the Coweeman (80407) are tidally influenced and contain riparian habitats of low quality due to extensive channelization and bank modifications. The Coweeman headwaters (80305) is the only subwatershed rated as functional for riparian conditions.

6.7.2 Predicted Future Trends

6.7.2.1 Hydrology

Headwaters subwatersheds with a high percentage of mature forest cover and lower road densities are less likely to be degraded hydrologically than are areas downstream. Nevertheless, timber harvest is likely to occur on these lands over the next 20 years. Roads, already fairly extensive in portions of the upper watershed, will likely increase concomitant with timber extraction. The effect of future forest practices will be mitigated to some degree by road construction and maintenance requirements under the new Forest Practices regulations. Considering these factors, hydrologic conditions in high elevation subwatersheds are expected to remain stable over the next 20 years.

In lower and mid elevation subwatersheds, it is expected that some of the current forestland will be converted to private and commercially developed land. Despite these land-use changes, timber harvest is expected to remain the predominant land use and hydrologic conditions are expected to remain relatively stable.

In the lower, floodplain areas of the lower Coweeman River, development is increasing and the development trend is likely to continue. Hydrologic condition is expected to decline in these newly developed areas.

6.7.2.2 Sediment

Because the majority of the Coweeman watershed is owned and managed by large industrial timber companies, high levels of timber harvests are likely to continue under typical harvest rotation schedules for the foreseeable future. The widespread implementation of improved forestry and road management practices is expected to mitigate timber harvest impacts on sediment supply to stream channels. Given these factors, sediment conditions are predicted to trend stable over the next 20 years.

6.7.2.3 Riparian

Riparian systems are considered highly vulnerable to human-caused disturbance (Naiman et al. 1993). Land uses alter riparian systems and associated processes in ways that can profoundly alter aquatic and riparian habitat (Montgomery and Buffington 1993). Because riparian systems influence the structure and function of small streams more than large streams, their condition in headwater areas is critical to watershed health.

Riparian conditions were assessed using the subwatershed-level IWA metrics in conjunction with additional landscape scale data. As noted previously, the majority of Coweeman subwatersheds were rated as moderately impaired, with two subwatersheds in the developed areas of the lower watershed rated as fully impaired. There is only one subwatershed rated as functional, located in the Coweeman headwaters.

Based on future trend data, riparian conditions are likely to remain stable with a trend towards gradual improvment in the upper watershed. However, the re-establishment of native vegetation in the middle and upper watershed may be hampered by degraded hydrologic conditions. In contrast, conditions are likely to degrade further in more downstream subwatersheds as development pressures expand. In these low-lying areas, encroachment and riparian degradation resulting from construction of roads, stream crossings, and buildings is expected to increase over time.

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Volume II, Chapter 7
Cowlitz Subbasin—Toutle

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7.0 Cowlitz Subbasin—Toutle

7.1 Subbasin Description

7.1.1 Topography & Geology

The Toutle basin encompasses approximately 513 mi^2 in portions of Lewis, Cowlitz, and Skamania Counties. The basin is within WRIA 26 of Washington State. The Toutle enters the Cowlitz at RM 20, just north of the town of Castle Rock. Elevations range from near sea level at the mouth to over 8,000 feet at the summit of Mount St. Helens. The Toutle drains the north and west sides of Mount St. Helens and flows generally westward towards the Cowlitz. The watershed contains three main drainages: the North Fork Toutle, the South Fork Toutle, and the Green River. Most of the North and South Fork were impacted severely by the 1980 eruption of Mount St. Helens and the resulting massive debris torrents and mudflows.

7.1.2 Climate

The basin has a typical northwest maritime climate. Summers are dry and warm and winters are cool, wet, and cloudy. Mean annual precipitation is 61 inches at Kid Valley (North Fork Toutle). Most precipitation occurs between October and March. Snowfall predominates in the higher elevations around Mount St. Helens and rainfall predominates in most of the remaining, lower elevation portion of the basin.

7.1.3 Land Use/Land Cover

Forestry is the dominant land use in the basin. Commercial forestland makes up over 90% of the Toutle basin. Much of the upper basin around Mount St. Helens is within the Mount St. Helens National Volcanic Monument and is managed by the US Forest Service. A significant proportion of the forests to the north and west of Mount St. Helens were decimated in the 1980 eruption and are now in early seral or 'other forest' (bare soil, shrubs) vegetation conditions. Population centers in the basin consist primarily of small rural towns. Projected population change from 2000-2020 for unincorporated areas in WRIA 26 is 22% (LCFRB 2001). A breakdown of land ownership and land cover is presented in Figure 7-1 and Figure 7-2. Figure 7-3 displays the pattern of landownership for the basin. Figure 7-4 displays the pattern of land cover / land-use.

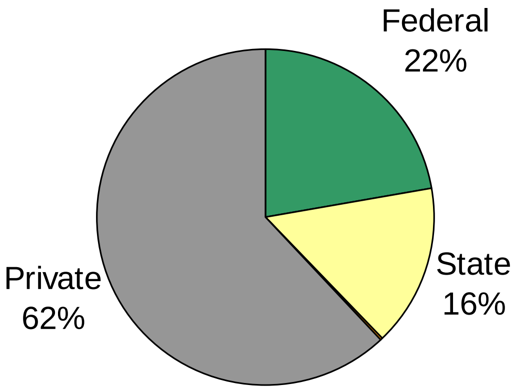


Figure 7-1. Toutle River basin land ownership

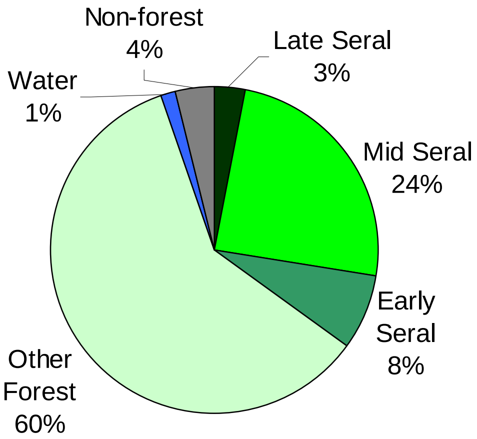


Figure 7-2. Toutle River basin land cover

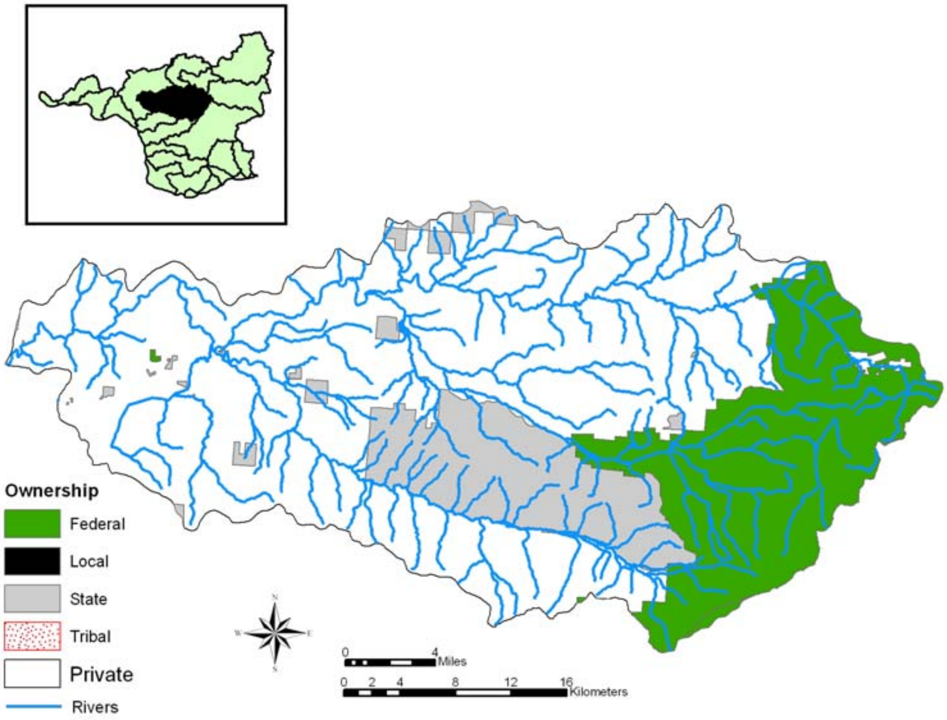


Figure 7-3. Landownership within the Toutle basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

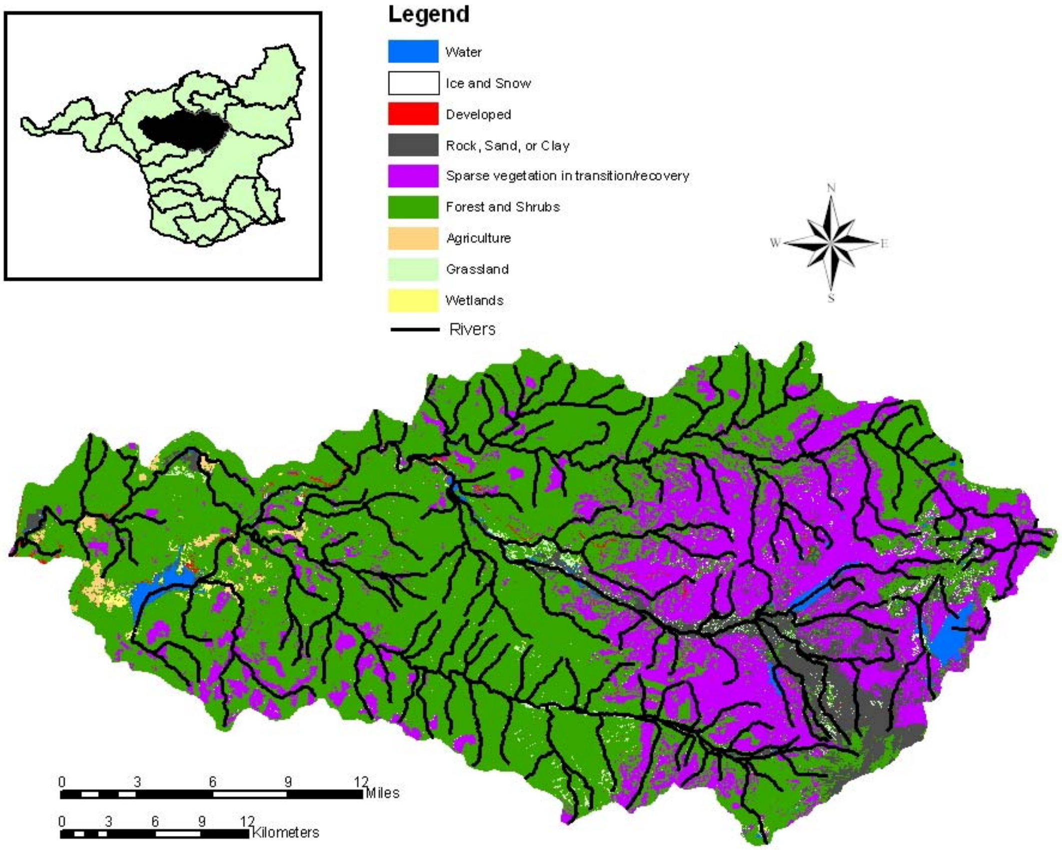
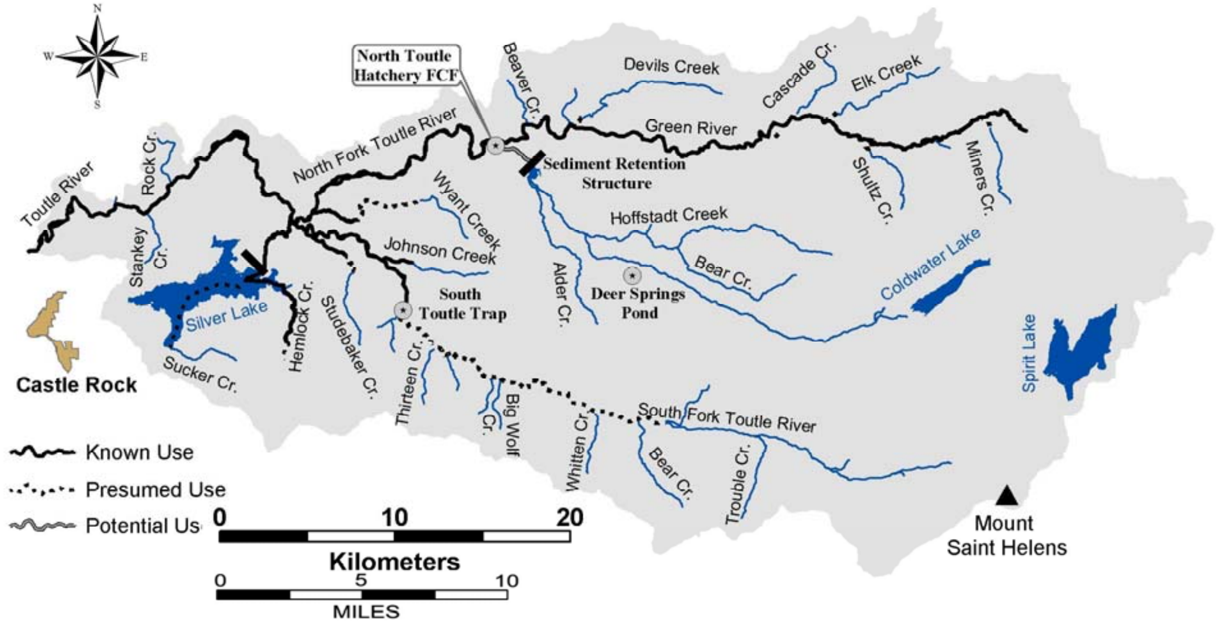


Figure 7-4. Land cover within the Toutle basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

7.2 Focal Fish Species

7.2.1 Fall Chinook—Cowlitz Subbasin (Toutle/Green River)

ESA: Threatened 1999 **SASSI: South Fork—Depressed 2002, Green—Healthy 2002**

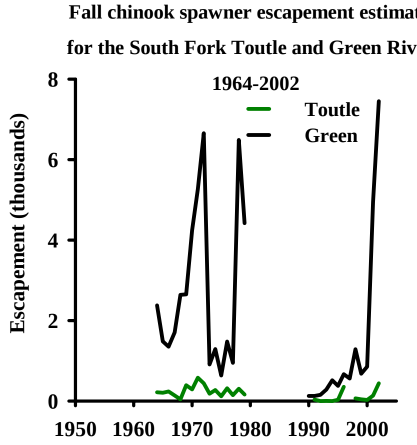


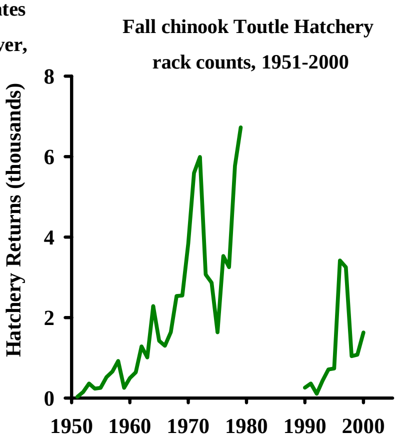
Distribution

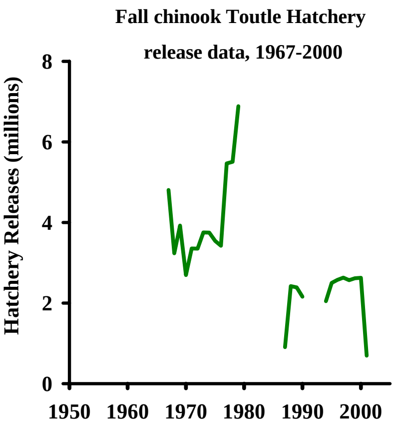
- Toutle River fall chinook spawning distribution from 1964 to 1979 was estimated as 4.8% mainstem Toutle, 3.8% SF Toutle, 49.4% NF Toutle, and 42% Green River
- Historical spawning areas in the mainstem Toutle, NF Toutle, and lower Green River were devastated by the 1980 eruption of Mt. St. Helens
- Records indicate most historical fall chinook spawning occurred in the lower 5 miles of the mainstem Toutle River, but spawning spread as far upstream as Coldwater Creek on the NF Toutle River (46 mi from the river mouth)
- In the SF Toutle River, spawning primarily occurs from the 4700 Bridge to the confluence with the mainstem Toutle River (~2.6 mi)
- In the Green River, spawning primarily occurs from the North Toutle Hatchery to the river mouth (~0.6 mi)

Life History

- Columbia River fall chinook migration occurs from mid August to early September, depending partly on early fall rain
- Natural spawning occurs between late September and early-November, usually peaking in mid-October
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult ages of 3 and 4
- Fry emerge around early May, depending on time of egg deposition and water temperature; fall chinook fry spend the summer in fresh water, and emigrate in the late summer/fall as sub-yearlings


Fall chinook spawner escapement estimates for the South Fork Toutle and Green River, 1964-2002


Fall chinook Toutle Hatchery rack counts, 1951-2000


Fall chinook Toutle Hatchery release data, 1967-2000

Diversity

- Considered a tule population within the lower Columbia River Evolutionary Significant Unit (ESU)
- NF and SF Toutle River stocks designated based on distinct spawning distribution

Abundance

- In 1951, WDF estimated fall chinook escapement to the Toutle River was 6,500 fish
- SF Toutle River spawning escapements from 1964-2001 ranged from 0-578 (average 177)
- Green River spawning escapements from 1964-2001 ranged from 10-6,654 (average 1,900)
- Hatchery production accounts for most fall chinook returning to the Toutle River Basin; chinook are re-establishing a population in the basin after the 1980 Mt. St. Helens eruption
- Hatchery produced adults comprise the majority of natural spawners in the Green and NF Toutle Rivers

Productivity & Persistence

- Smolt density model predicted natural production potential for the Toutle River of 2,799,000 smolts
- Juvenile production from natural spawning is presumed to be low

Hatchery

- The North Toutle Hatchery (formerly called the Green River Hatchery) is located on the lower Green River near the confluence with the NF Toutle River; operations began in 1956, but the hatchery was destroyed in the 1980 eruption of Mt. St. Helens
- The North Toutle Hatchery was renovated and began collecting brood stock again in 1990
- Rearing ponds near the original hatchery site were developed after the eruption and began operation in 1985
- Releases of fall chinook in the Toutle River basin has occurred since 1951; current program releases 2.5 million sub-yearling fall chinook annually; release data are displayed from 1967-2002

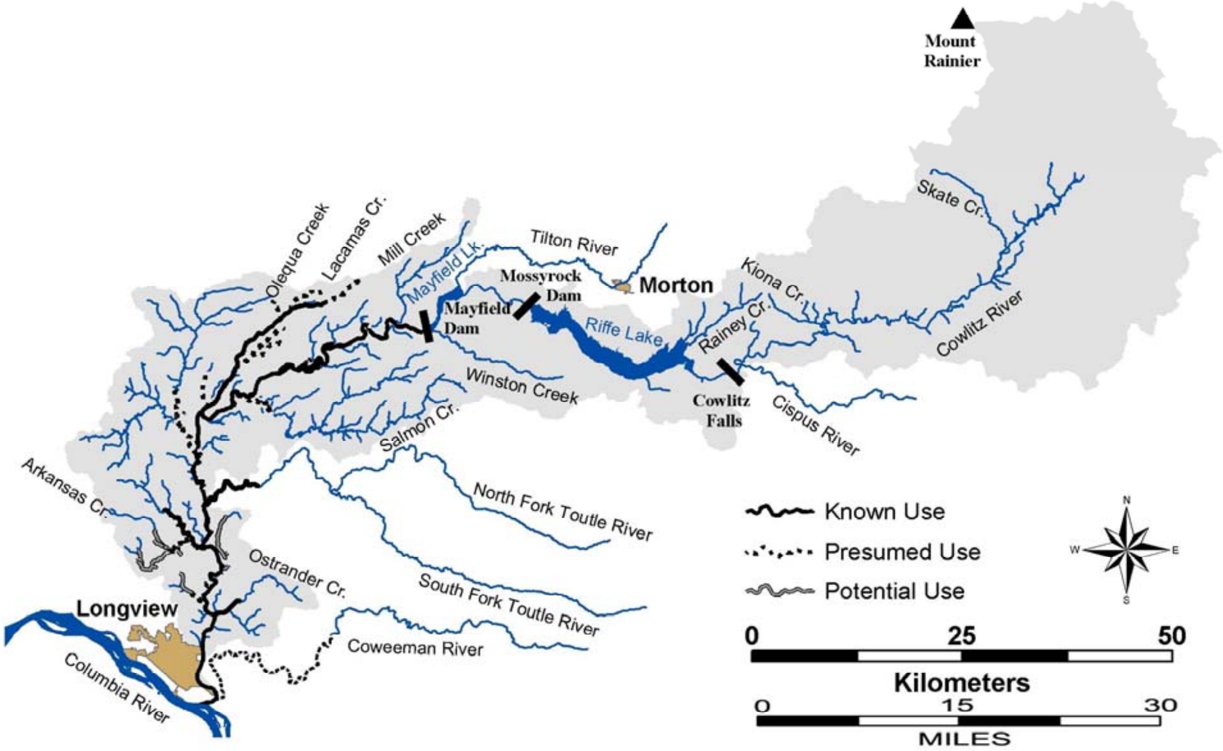
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and freshwater sport fisheries

- Lower Columbia tule fall chinook are an important contributor to Washington ocean troll and sport fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; the price is low compared to higher quality bright stock chinook
- Annual harvest is dependent on management response to annual abundance in Pacific Salmon Commission (PSC)(US/Canada), Pacific Fisheries Management Council (PFMC) (US ocean), and Columbia River Compact forums
- outle River and Green River chinook harvest in ocean and mainstem Columbia River limited by an ESA constraint of 49% or less on Coweeman River fall chinook
- Coded-wire tag (CWT) data analysis of the 1989-94 brood North Toutle Hatchery fall chinook indicates a total Toutle River fall chinook harvest rate of 41%
- The majority of the North Toutle Hatchery fall chinook stock harvest occurred in Toutle tributary sport (31%), British Columbia (30%), Columbia River (13%), Alaska (14%), and Washington ocean (10%) fisheries
- Sport fishing in the SF Toutle River has been closed since the 1980 eruption of Mt. St. Helens

7.2.2 Chum—Cowlitz Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Chum were reported to historically utilize the lower Cowlitz River and tributaries downstream of the Mayfield Dam site

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts generally from March to May

Diversity

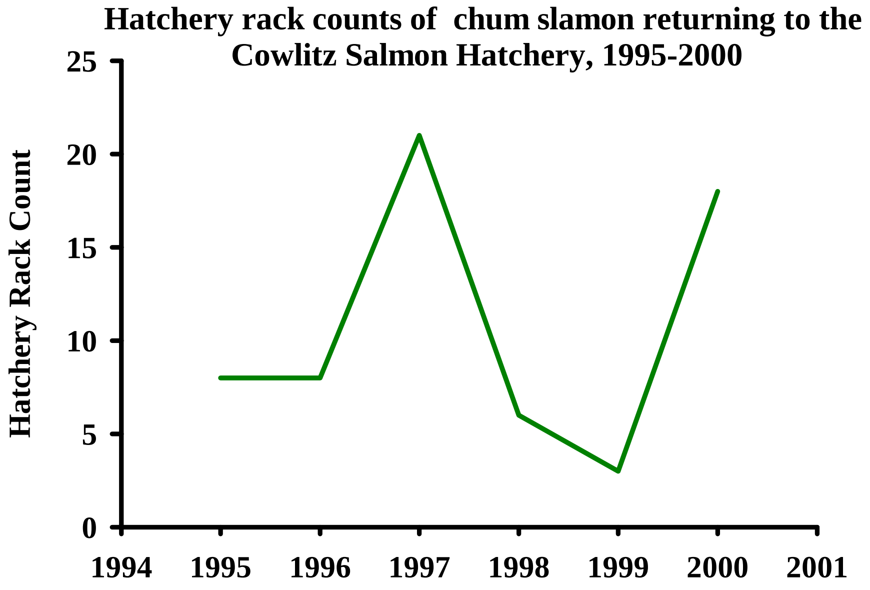
- No hatchery releases of chum have occurred in the Cowlitz basin

Abundance

- Estimated escapement of approximately 1,000 chum in early 1950's
- Between 1961 and 1966, the Mayfield Dam fish passage facility counted 58 chum
- Typically less than 20 adults are collected annually at the Cowlitz Salmon Hatchery

Productivity & Persistence

- Anadromous chum production primarily in lower watershed
- Harvest, habitat degradation, and to some degree construction of Mayfield and Mossyrock Dams contributed to decreased productivity



Hatchery

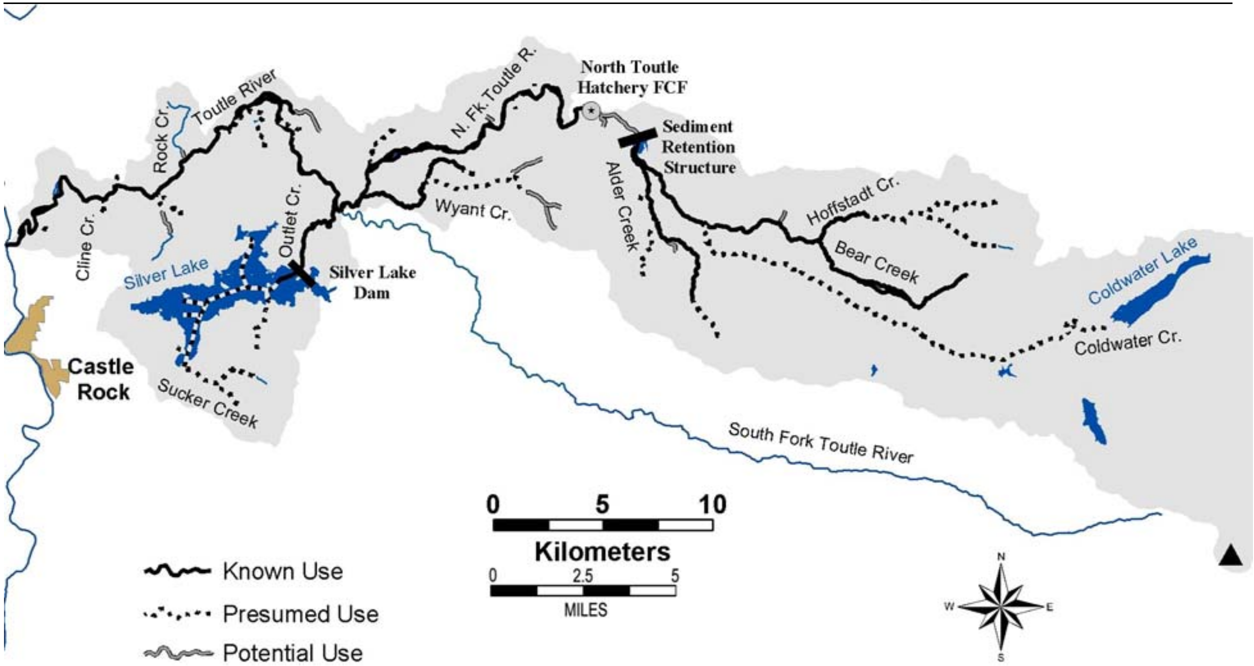
- Cowlitz Salmon Hatchery does not produce/release chum salmon
- Chum salmon are captured annually in the hatchery rack

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

7.2.3 Winter Steelhead—Cowlitz Subbasin (Mainstem & NF Toutle/Green)

ESA: Threatened 1998 **SASSI: Depressed 2002**



Distribution

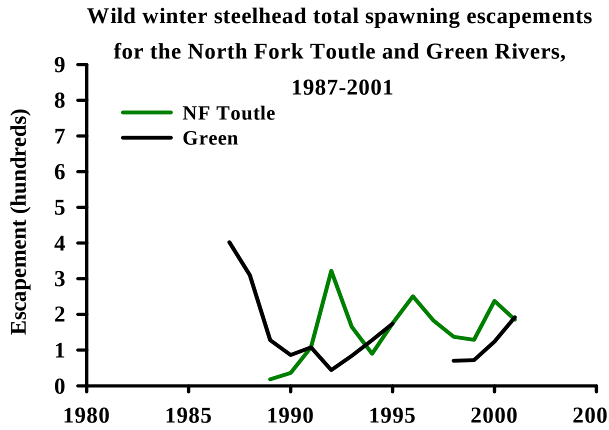
- Historically, steelhead were distributed throughout the mainstem Toutle, NF Toutle and Green Rivers
- In the mainstem/NF Toutle, spawning occurs in the mainstem and Alder and Deer Creeks
- In the Green River, spawning occurs in the mainstem and Devil, Elk, and Shultz Creeks
- The 1980 eruption of Mt. St. Helens greatly altered the habitat within the Toutle River Basin; the NF Toutle sustained the most significant habitat degradation

Life History

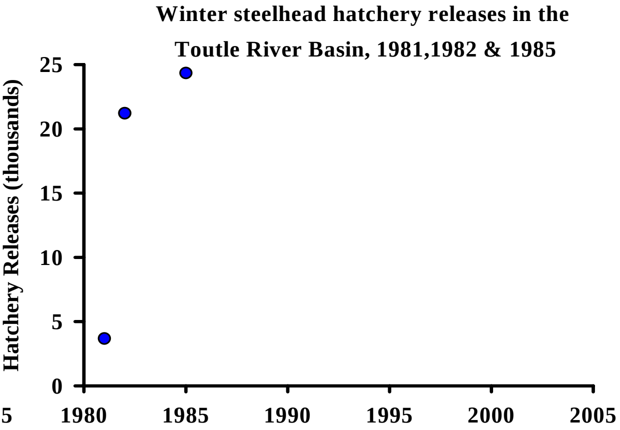
- Adult migration timing for mainstem/NF Toutle and Green River winter steelhead is from December through April
- Spawning timing on the mainstem/NF Toutle and Green River is generally from March to early June
- Limited age composition data for Toutle River winter steelhead indicate that the dominant age class is 2.2 (58.6%)
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Mainstem/NF Toutle and Green River winter steelhead stocks designated based on distinct spawning distribution
- Wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River is a concern
- Allele frequency analysis of Green River winter steelhead in 1995 was unable to determine the distinctiveness of the stock compared to other lower Columbia steelhead stocks



Wild winter steelhead total spawning escapements for the North Fork Toutle and Green Rivers, 1987-2001



Winter steelhead hatchery releases in the Toutle River Basin, 1981,1982 & 1985

Abundance

- In 1936, steelhead were observed in the Toutle River during escapement surveys
- Between 1985-1989, an average of 2,743 winter steelhead escaped to the Toutle River annually to spawn
- North Fork Toutle total escapement counts from 1989-2001 ranged from 18-322 (average 157)
- Green River total escapement counts from 1985-2001 ranged from 44-775 (average 193)
- From 1991-1996, the winter steelhead run was believed to be completely from naturally produced fish

Productivity & Persistence

- Live-spawning of Toutle River winter steelhead in 1982 and 1988 resulted in mean fecundity estimates of 2,251 and 3,900 eggs per female, respectively
- Estimated potential winter steelhead smolt production for the Toutle River is 135,573
- The NMFS Status Assessment estimated that the risk of 90% decline in 25 years was 0.71, the risk of 90% decline in 50 years was 0.93, and the risk of extinction in 50 years was 0.73 for the Green River winter steelhead

Hatchery

- The Cowlitz Trout Hatchery, located on the mainstem Cowlitz at RM 42, is the only hatchery in the basin producing winter steelhead
- Hatchery winter steelhead have been planted in the NF Toutle River basin from 1953-1985; broodstock from the Elochoman and Cowlitz Rivers and Chambers Creek have been used
- Aside from small releases of winter steelhead fry after the 1980 Mt. St. Helens eruption, no hatchery winter steelhead have been released in the Green River
- Hatchery fish contribute little to natural production of winter steelhead

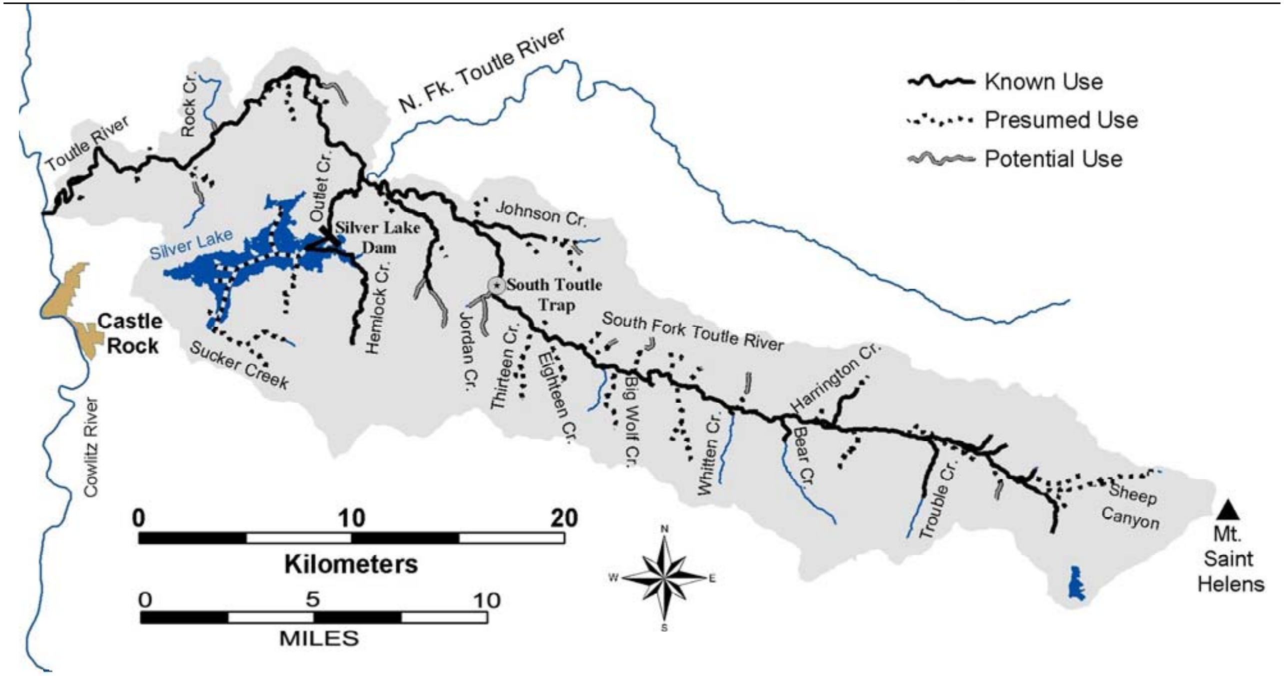
Harvest

- No directed commercial or tribal fisheries target NF Toutle winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Approximately 6.2% of returning Cowlitz River hatchery steelhead are harvested in the Columbia River sport fishery

- Winter steelhead sport harvest (hatchery and wild) in the mainstem Toutle River from 1987-1990 averaged 223; the NF Toutle River has been closed to sport fishery harvest since 1980; the Green River has been closed since 1981
- ESA limits fishery impact of wild winter steelhead to 2% per year

7.2.4 *Winter Steelhead—Cowlitz Subbasin (SF Toutle)*

ESA: Threatened 1998 **SASSI: Depressed 2002**



Distribution

- Spawning occurs in the mainstem SF Toutle and Studebaker, Johnson, and Bear Creeks
- The 1980 eruption of Mt. St. Helens greatly altered the habitat within the Toutle River

Life History

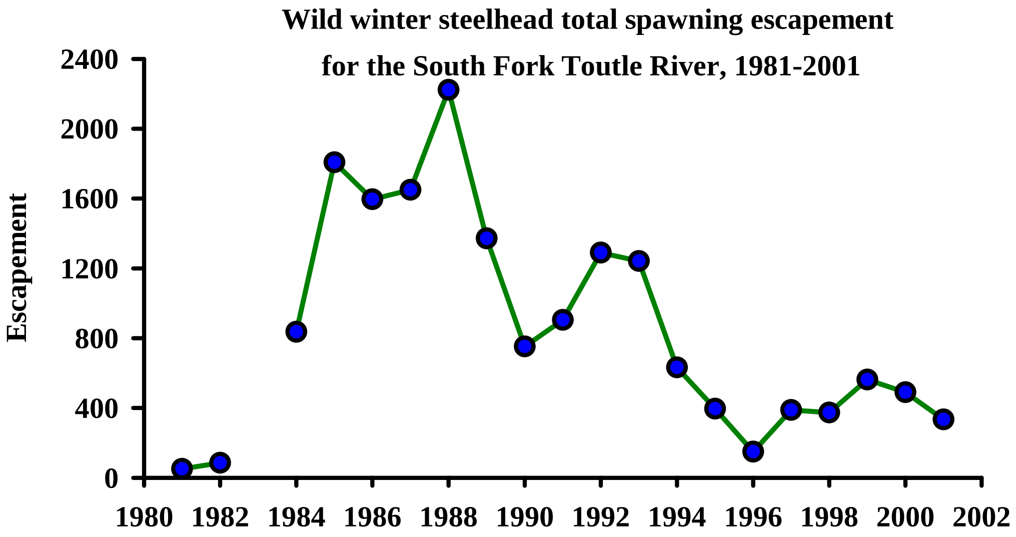
- Adult migration timing for SF Toutle winter steelhead is from December through April
- Spawning timing on the SF Toutle is generally from early March to early June
- Limited age composition data for Toutle River winter steelhead indicate that the dominant age class is 2.2 (58.6%)
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- SF Toutle winter steelhead stock designated based on distinct spawning distribution
- Allele frequency analysis of SF Toutle winter steelhead in 1996 was unable to determine the distinctiveness of this stock compared to other lower Columbia steelhead stock

Abundance

- In 1936, steelhead were observed in the Toutle River during escapement surveys
- Between 1985-1989, an average of 2,743 winter steelhead escaped to the Toutle River annually to spawn
- SF Toutle total escapement counts from 1981-2001 ranged from 51-2,222 (average 857); escapements have been low since 1994
- Escapement goal for the SF Toutle River is 1,058 wild adult steelhead



Productivity & Persistence

- The NMFS Status Assessment estimated that the risk of 90% decline in both 25 years and 50 years was 1.0 for the SF Toutle River winter steelhead
- Estimated potential winter steelhead smolt production for the Toutle River is 135,573

Hatchery

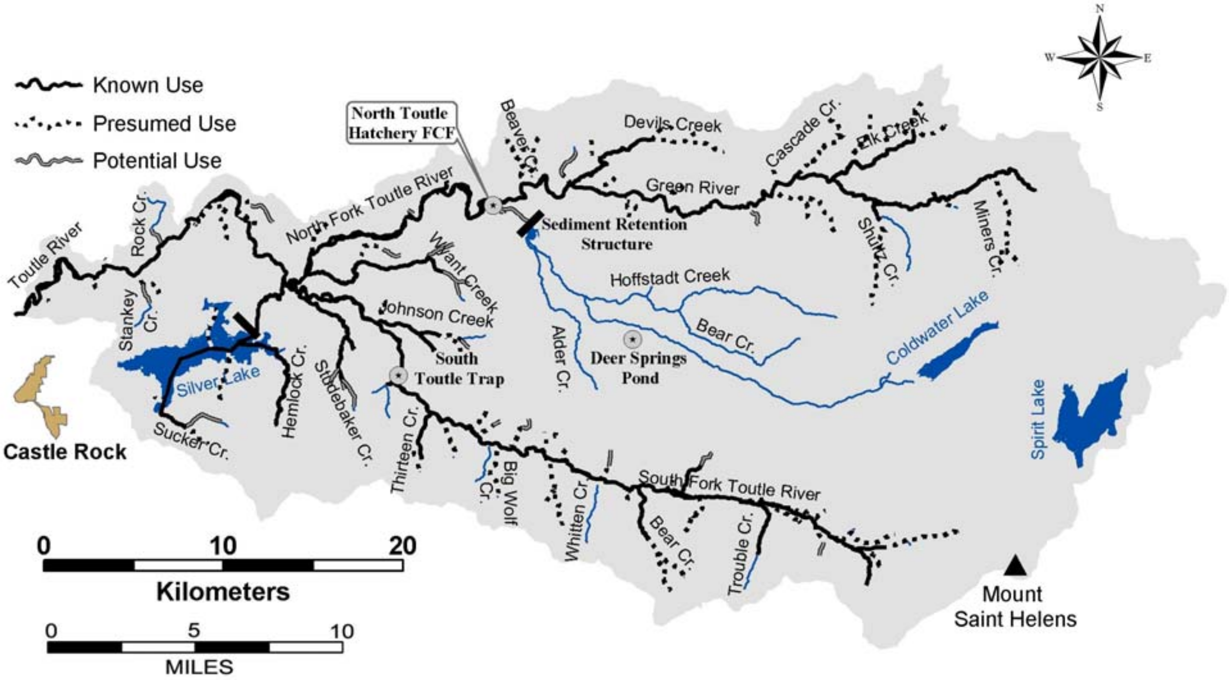
- The Cowlitz Trout Hatchery, located on the mainstem Cowlitz at RM 42, is the only hatchery in the basin producing winter steelhead
- Aside from small releases of winter steelhead fry after the 1980 Mt. St. Helens eruption, no hatchery winter steelhead have been released in the SF Toutle River; total winter steelhead hatchery releases are estimated as 58,079 from 1968-1985

Harvest

- No directed commercial or tribal fisheries target South Fork Toutle winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur on the South Fork Toutle River
- Approximately 6.2% of returning Cowlitz River steelhead are harvested in the Columbia River sport fishery
- Winter steelhead sport harvest (hatchery and wild) in the Toutle River from 1987-1990 averaged 223; the SF Toutle River was closed to sport fish harvest in 1981 and reopened to limited harvest in 1987
- ESA fishery impact on wild winter steelhead to 2% per year

7.2.5 Cutthroat Trout—Cowlitz River Subbasin (Toutle)

ESA: Not Listed **SASSI: Depressed 2000**



Distribution

- Anadromous forms have access to most of the watershed except upper tributary, high gradient reaches
- Adfluvial forms are documented in Silver Lake
- Resident and fluvial forms are observed throughout the subbasin

Life History

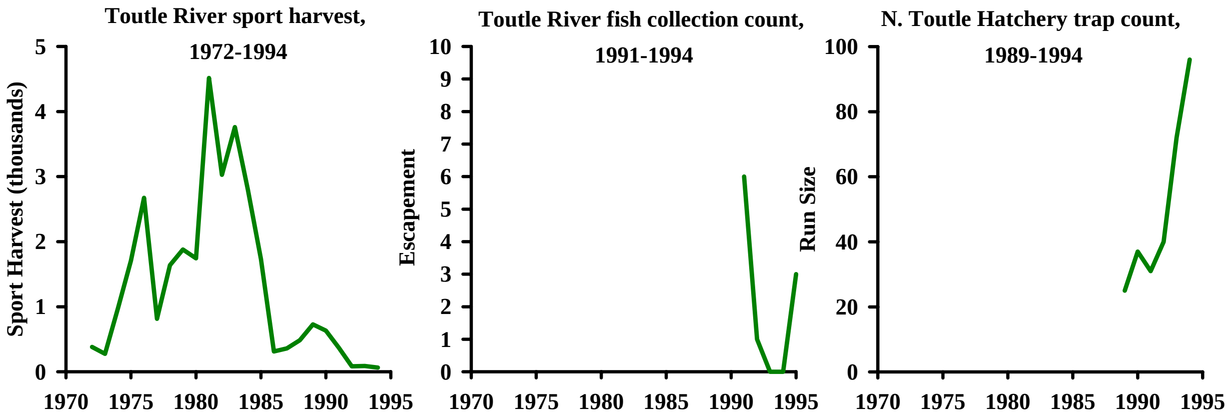
- Anadromous, adfluvial, fluvial and resident forms are present
- Anadromous river entry peaks from September through November
- Anadromous spawning occurs from January through June
- Fluvial and resident spawn timing is not documented but is believed to be similar to anadromous timing

Diversity

- Distinct stock based on geographic distribution of spawning areas
- No genetic sampling has been conducted

Abundance

- No abundance information exists for resident and fluvial forms
- Long term negative decline in the lower Columbia River cutthroat catch
- North Toutle Hatchery counts have shown a steady increase since the eruption of Mt. St. Helens in 1980, but escapement remains low
- Chronically low escapement at Toutle River Fish Collection Facility (0 to 6 fish annually since 1991)


Toutle River sport harvest, 1972-1994

Toutle River fish collection count, 1991-1994

N. Toutle Hatchery trap count, 1989-1994

Hatchery

- North Toutle Hatchery raises chinook and coho
- Summer steelhead smolts from Elochoman or Kalama Hatchery are released into the SF and NF Toutle and Green Rivers annually
- Silver Lake was stocked with rainbow trout prior to 1980

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia River summer fisheries downstream of the Cowlitz River
- Toutle River wild cutthroat (unmarked fish) must be released in mainstem Columbia River and Toutle basin sport fisheries

7.3 Potentially Mangeable 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quantity and quality is highly important to all five populations, and is extremely important to winter steelhead. Effects from losses to estuary habitat are relatively minor for spring chinook, steelhead and coho, but are moderately imporant to both fall chinook and chum.
- Harvest is important to spring and fall chinook and coho, but is of lesser importance to winter steelhead and chum.
- Hatchery impacts are moderately important to coho, spring and fall chinook, and are of minor importance to chum. For winter steelhead, hatchery impacts are non-existent.
- Predation impacts are moderately important to all five populations within the Toutle.

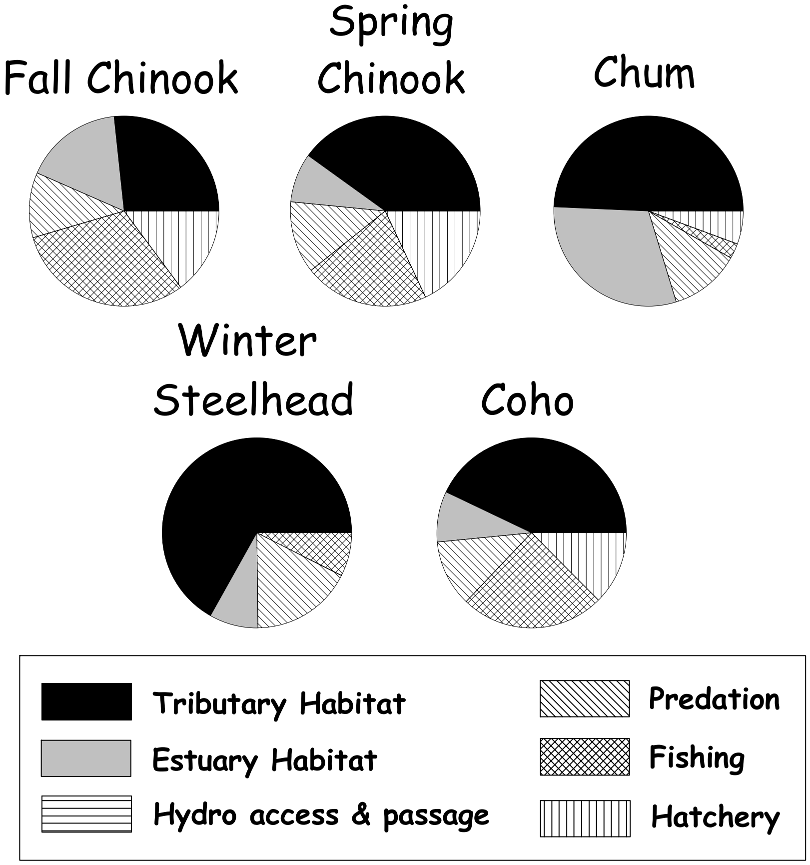


Figure 7-5. Relative index of potentially manageable mortality factors for each species in the Toutle subbasin.

7.4 Hatchery Programs

Vol II, Chapter 7 discusses hatcheries in the Cowlitz basin.

7.5 Fish Habitat Conditions

7.5.1 Passage Obstructions

The two major passage barriers in the Toutle basin are the Sediment Retention Structure (SRS) on the North Fork Toutle and the Silver Lake Dam on Outlet Creek. Problems at Silver Lake Dam are associated with lack of sufficient flows in the fishway and low flows and high temperatures in Outlet Creek. These problems may limit fish access into the Silver Lake basin. Other passage problems in the Toutle basin are associated with culverts, road crossings, trash racks, beaver dams, and fish weirs. A thorough description is provided in the WRIA 26 Limiting Factors Analysis (Wade 2000).

7.5.2 Stream Flow

Runoff is predominantly generated by fall, winter, and spring rainfall, with a portion of spring flows coming from snowmelt in the upper elevations and occasional winter peaks related to rain-on-snow events. Combined surface water and groundwater demand in the Toutle basin, which totaled 389 acre-feet per year in 2000, is expected to increase 21.9% by 2020

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that the majority of the basin suffers from'impaired' runoff conditions as a result of immature forest stands and high road densities. Several headwater subwatersheds around Mount St. Helens were modeled to only have 'moderately impaired' conditions. Only 1 subwatershed, located in the upper Green River basin, was identified as hydrologically 'functional'.

The Upper Toutle Watershed Analysis found that 55% of the upper basins have the potential for an increase in peak flow volumes of over 10% due to a lack of mature coniferous stand structures. The USFS also noted that stream lengths have been increased by as much as 63% due to roads, with an addition of approximately 370 miles to the stream network as a result of roads and road ditches (USFS 1997). Increasing the stream network can accelerate the delivery of streamflow to downstream channels, thereby increasing stormflow peaks.

Low summer flows in Outlet Creek were identified in the Silver Creek Watershed Analysis as a problem for juvenile rearing (Weyerhaeuser 1994).

7.5.3 Water Quality

Water temperatures in the upper Toutle basin are thought to be high due to channel widening and loss of riparian cover associated with mud and debris flows. Temperatures near the mouth of the Green River at the Toutle River Hatchery often exceed state standards. The Green River and Harrington Creek (South Fork Toutle tributary) were listed on the State's 1998 303(d) list for elevated water temperatures (WDOE 1998). High suspended sediment and turbidity are considered major limiting factors in the North Fork and mainstem Toutle, restricting suitable fish habitat to tributary streams. Nutrient problems may exist in the Toutle basin as a result of low steelhead, chinook, and coho escapement (Wade 2000).

Silver Lake was identified as being in an advanced state of eutrophication in the 1994 watershed analysis. This is likely due to natural rates of phosphorous delivery as well as anthropogenic nutrient sources including forest fertilizers and residential septic systems (Weyerhaeuser 1994). Water temperatures are also a concern in the Silver Lake basin.

7.5.4 Key Habitat

Following the eruption of Mount St. Helens, some channels in the NF and SF Toutle basins re-developed pool habitats to near pre-eruption levels, however, pool quality was generally low (Jones and Salo 1986). Large sediment loads will likely continue to reduce the quality of pools throughout the Toutle system. Side channel habitat may be created in the upper Toutle channels that experienced debris flows, though adequate LWD and riparian cover necessary for good side channel habitat will take a long time to develop (Wade 2000). Side channel habitat in the Silver Lake basin is lacking (Weyerhaeuser 1994).

7.5.5 Substrate & Sediment

Massive debris torrents and mud flows in the NF and SF Toutle buried, scoured, or filled spawning gravels with sediment. Conditions have improved quicker in the South Fork and Green River than in the North Fork (USFWS 1984). Annual sediment yields in the North Fork had not changed appreciably 5 years following the eruption (Lucas 1986) and sediment delivery is still considered a major liming factor in the system. The SRS is considered a major source of sediment in the mainstem North Fork and its existence is believed to be preventing the recovery of the system (Wade 2000).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented in greater detail later in this chapter. The results indicate that sediment supply conditions are ‘moderately impaired’ throughout the basin, with a few ‘impaired’ subwatersheds scattered throughout and a few ‘functional’ subwatersheds in headwater areas around Mount St. Helens. Risk of increased sediment supply is related to the 1980 eruption as well as intensive road building in the 1980s and 1990s. There is an average road density of 4.63 mi/mi^2. Furthermore, the eruption prevented access to many private roads that may now have elevated erosion potential due to lack of maintenance. The Silver Lake Watershed Analysis concluded that road erosion contributed to fine sediment production in the Silver Lake basin. A lack of spawning gravels was attributed to a lack of coarse material delivery and low LWD levels (Weyerhaeuser 1996).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

7.5.6 Woody Debris

Low levels of LWD likely existed prior to 1980 due to extensive logging. Mud and debris flows associated with the eruption of Mount St. Helens further reduced LWD through channel scouring, destruction of riparian forests, and burying of in-stream wood (Jones and Salo 1986). Salvage operations removed much of the remaining LWD in areas outside the National Monument (USFS 1997). LWD concentrations are considered poor in nearly all of the tributary basins. Wood accumulations have formed pools in the upper Green River, but they are of low quality (Wade 2000). Recruitment potential is also regarded as poor. 80-100% of riparian areas in the upper basin (National Forest portion) contain grass/forb vegetation structures (USFS 1997).

7.5.7 Channel Stability

The eruption of Mount St. Helens, combined with years of logging impacts, has increased the potential for elevated peak flows, exacerbating channel erosion and channel shifting. Eruption-related mud and debris flows in the North Fork, South Fork, and many tributaries altered channel form and location. Channel adjustments frequently occur during high flow events (USFWS 1984). Dredging and the placement of dredge spoils along channel margins are believed to have increased bank instability on portions of the lower river. Channel stability is improving in some areas, as the systems are slowly recovering from the effects of the eruption.

7.5.8 Riparian Function

The eruption of Mount St. Helens, timber harvest, timber salvage, and fire have drastically altered the quality of riparian forests; most of the riparian areas in the basin are in early- to mid-successional stages (USFS 1997). Only 11.6% of the basin has >70% mature coniferous cover. Low canopy cover in the upper basin is believed to contribute to elevated stream temperatures. The Silver Lake and Outlet Creek basins have degraded riparian areas that are dominated by deciduous species (Wade 2000).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, nearly the entire watershed has ‘moderately impaired’ riparian function. This rating was based on the amount of mature forest stands along stream channels. Riparian function is expected to improve as forests continue to recover from the eruption and timber harvest impacts.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

7.5.9 Floodplain Function

Following the eruption of Mount St. Helens, significant floodplain loss occurred due to the dredging and placement of sediment in the floodplain and near-stream wetlands, essentially creating levees along the channel. Floodplain disconnection has occurred on several Toutle River tributaries as well, also as a result of diking, channel incision, and dredging (Wade 2000).

7.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Toutle River fall chinook, spring chinook, chum and winter steelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in section XX.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

7.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes. Habitat-based assessments were completed in the Toutle basin for winter steelhead, fall chinook, spring chinook and chum. It is important to note that spring chinook have become functionally extinct in the Toutle subbasin. As such, all current estimates for spring chinook in the population analysis are approximately zero (Table 7-1). Therefore, there will be no discussion of relative change among model variables for spring chinook.

Model results indicate a decline in adult productivity for all species in the Toutle basin (Table 7-1). Declines in adult productivity from historical levels range from 70% for fall chinook to greater than 90% for winter steelhead. Similarly, adult abundance levels have declined for all species (Figure 7-6). Current estimates of abundance are 44% of historical levels for fall chinook, 13% of historical levels for winter steelhead, 11% of historical levels for coho and only 5% of historical levels for chum.

Estimated diversity has also decreased significantly for all species in the Toutle basin (Table 7-1). Declines in species diversity range from 34% for fall chinook, to greater than 70% for coho. This sharp decline in diversity may be due to a dramatic loss of available habitats compared to pre-Mount St. Helens eruption conditions. The 1980 eruption may also contribute to the observed trends in productivity and abundance. Timber harvest and road building in the post-eruption years has further depressed the stocks and has limited the rate of recovery.

As with adult productivity, model results indicate that current smolt productivity is sharply reduced compared to historical levels. Current smolt productivity estimates are between 17% and 52% of historical productivity, depending on species (Table 7-1). Smolt abundance numbers are similarly low, especially for chum and coho (Table 7-1). Current smolt abundance estimates for chum and coho are at 13% and 10% of historical levels, respectively.

Model results indicate that restoration of PFC conditions would have large benefits in all performance parameters for all species (Table 7-1). For adult abundance, restoration of PFC conditions would increase current returns by 107% for fall chinook, by 255% for winter steelhead, by 496% for chum and by 600% for coho. Similarly, smolt abundance numbers would increase for all species (Table 7-1). Coho would see the greatest increase in smolt numbers with a modeled 709% increase.

Table 7-1. Toutle subbasin — Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	4,370	9,066	10,046	3.2	8.3	10.7	0.66	1.00	1.00	499,147	919,467	1,022,259	306	738	937
Spring Chinook	0	2,703	3,083	0.0	10.9	15.8	0.00	1.00	1.00	0	85,801	96,292	0	319	454
Chum	1,376	8,196	25,984	1.9	7.1	10.5	0.39	1.00	1.00	595,692	2,731,905	4,495,859	548	901	1,057
Winter Steelhead	1,343	4,766	10,330	3.1	13.0	36.1	0.45	0.94	0.99	29,188	86,779	100,718	64	233	345

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

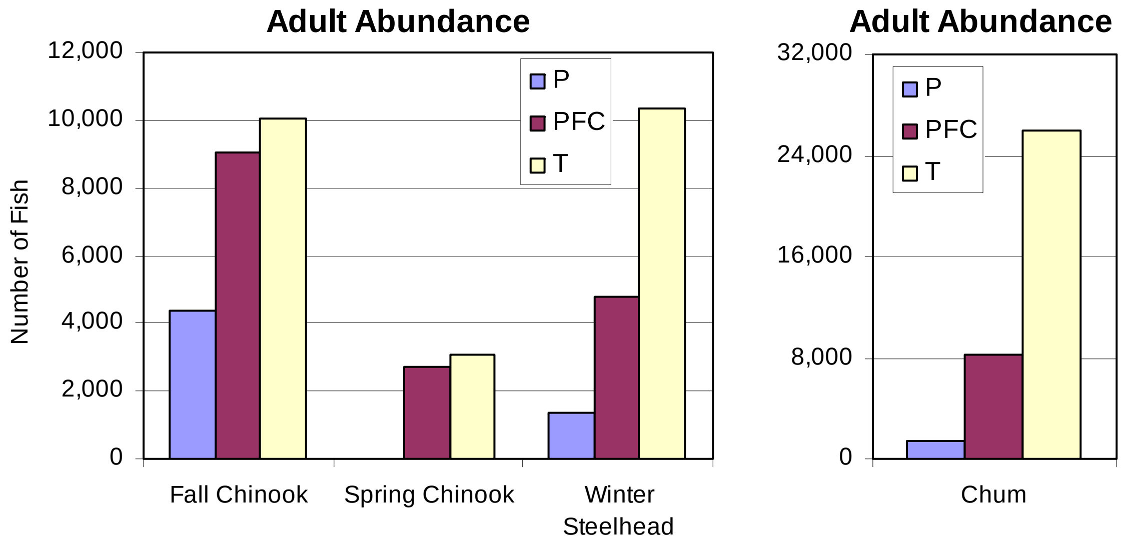


Figure 7-6. Adult abundance of Toutle subbasin fall chinook, spring chinook, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

7.6.2 Reach Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

The Toutle basin is one of the largest basins in the region analyzed with the EDT model. It consists of nearly 100 EDT reaches in the Toutle, South Fork, North Fork, and Green River basins. Spawning and rearing for winter steelhead occurs throughout the mainstems and tributaries of these basins. Fall chinook use is constrained primarily to the mainstems, and chum use is limited to just the first several lower Toutle River reaches. Each major stream system within the Toutle basin is characterized by a variety of channel and valley types, from steep and confined sections—like Hollywood Gorge—to broad alluvial floodplain valleys—like those found in the lower South Fork and upper North Fork. See Figure 7-7 for a map of reaches in the Toutle River subbasin.

Reaches with a high priority ranking for winter steelhead are located in the South Fork Toutle (SF Toutle 12-20), the Green River (Green 6), and the North Fork Toutle (NF Toutle 7 and 12-13) (Figure 7-8). All high priority reaches in the NF Toutle show a strong habitat restoration emphasis, while reaches in the SF Toutle have either a restoration emphasis or a combined preservation and restoration emphasis. The one high priority reach in the Green River shows a combined habitat preservation and restoration emphasis (Figure 7-8). The Green River was spared the worst of the eruption impacts and therefore has some good preservation value.

High priority reaches for fall chinook include those in the lower Green River (Green River 3 and 4), the mainstem Toutle (Toutle 4 and 9), and the South Fork Toutle (SF Toutle 1-4, 7-9, 11-13 and 16) (Figure 7-9). The lower and middle South Fork reaches are widely used by chinook, especially since the North Fork and lower Toutle channels have been slower to recover from eruption impacts. Reach Green River 4 has the highest habitat preservation potential and highest habitat restoration potential of any fall chinook reach modeled in the Toutle basin.

For spring chinook, the high priority reaches are located in the middle and upper NF Toutle (NF Toutle 10-12) (Figure 7-10). Due to the fact that spring-run chinook are functionally extinct from the basin, these reaches all show a huge habitat restoration potential, with reach NF Toutle 10 having the highest restorative potential of any spring chinook reach in the system.

High priority reaches for chum are located in the lower mainstem Toutle River (Toutle 1 and 3-6) (Figure 7-11). These reaches are important for chum spawning and rearing and have significantly degraded habitat. As such, all of the high priority reaches modeled for chum show a strong habitat restoration emphasis. Reach Toutle 4 has the highest restorative potential of any reach modeled for chum.

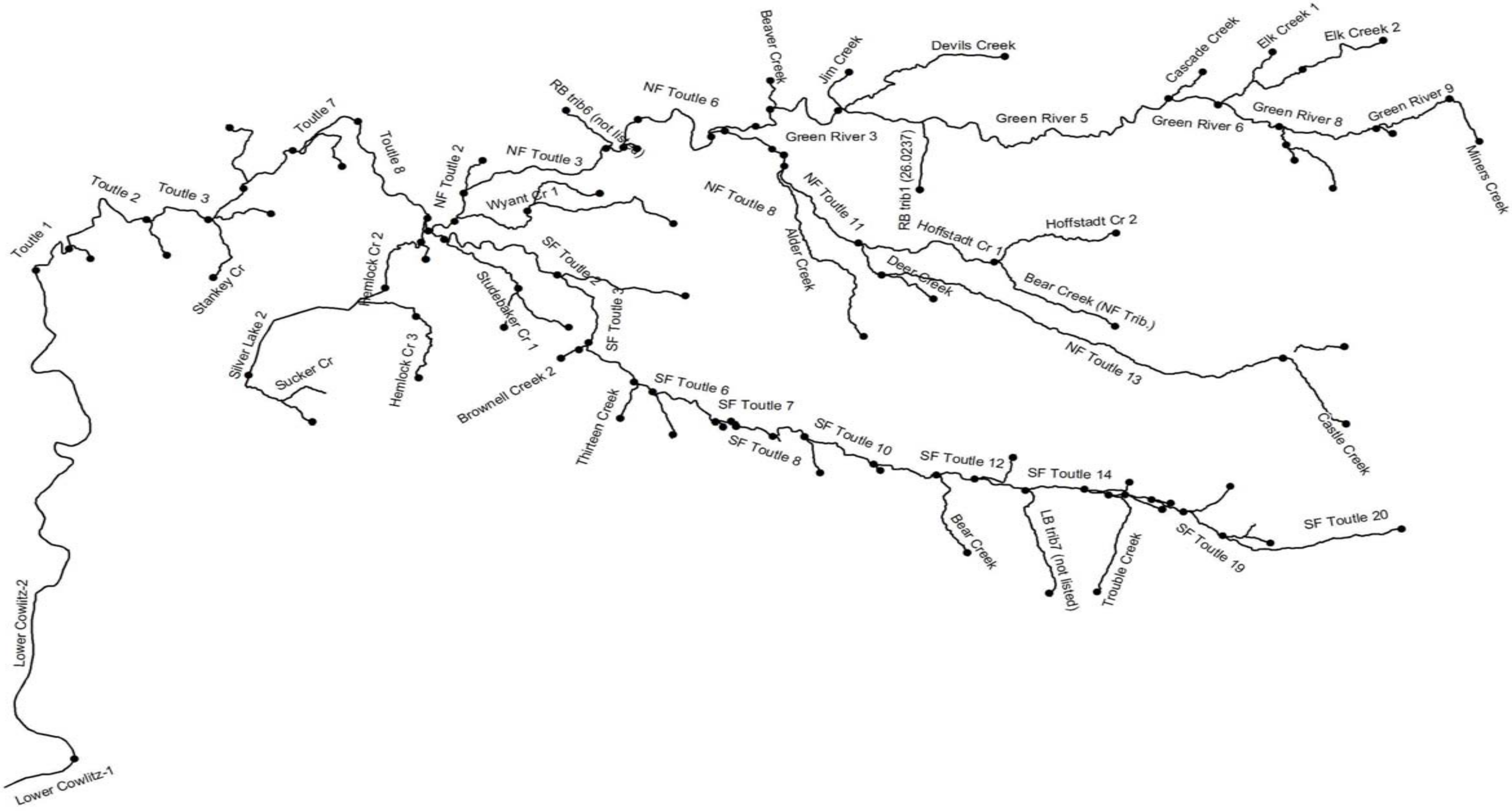
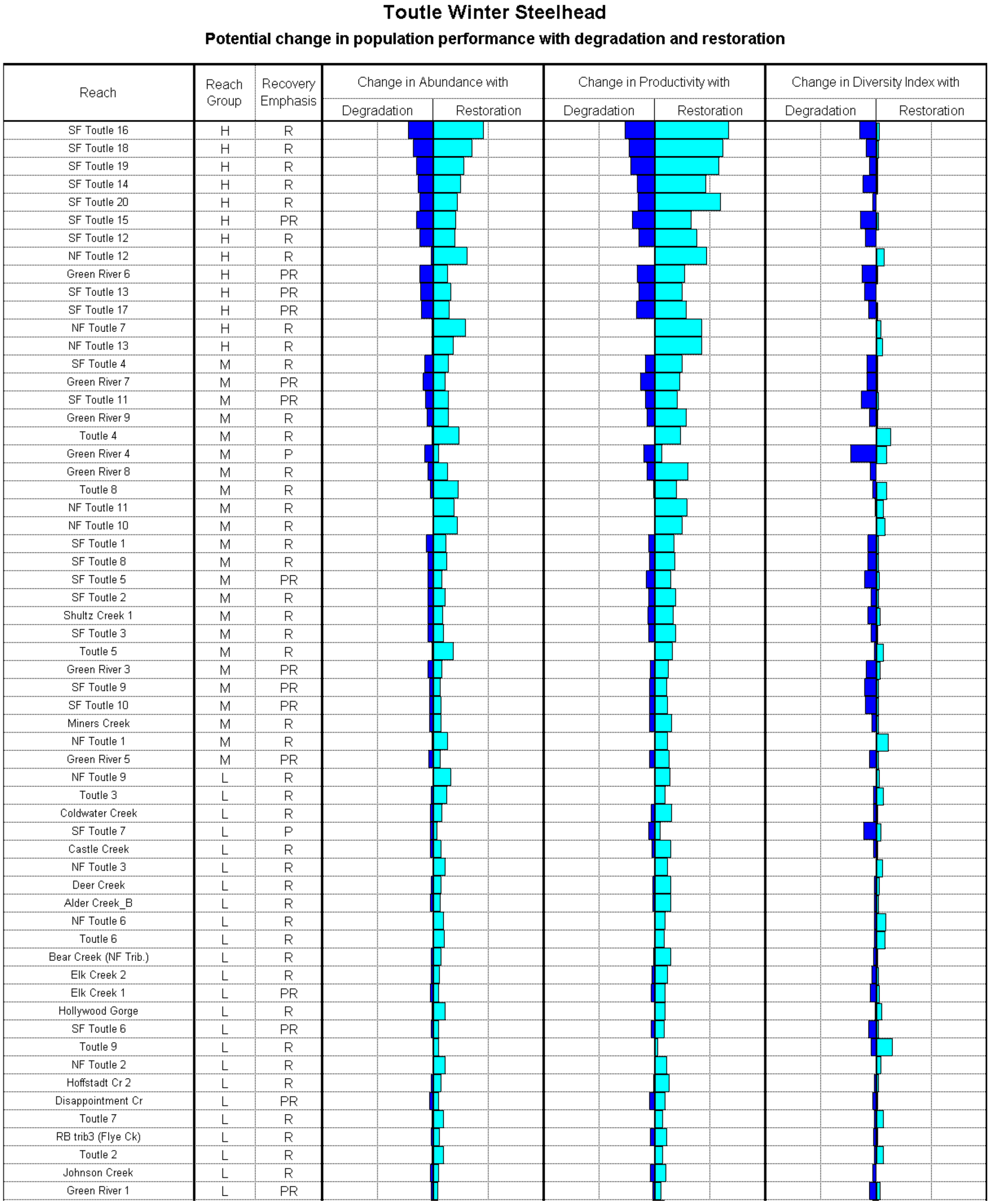


Figure 7-7. Toutle basin EDT reaches. Some reaches not labeled for clarity.

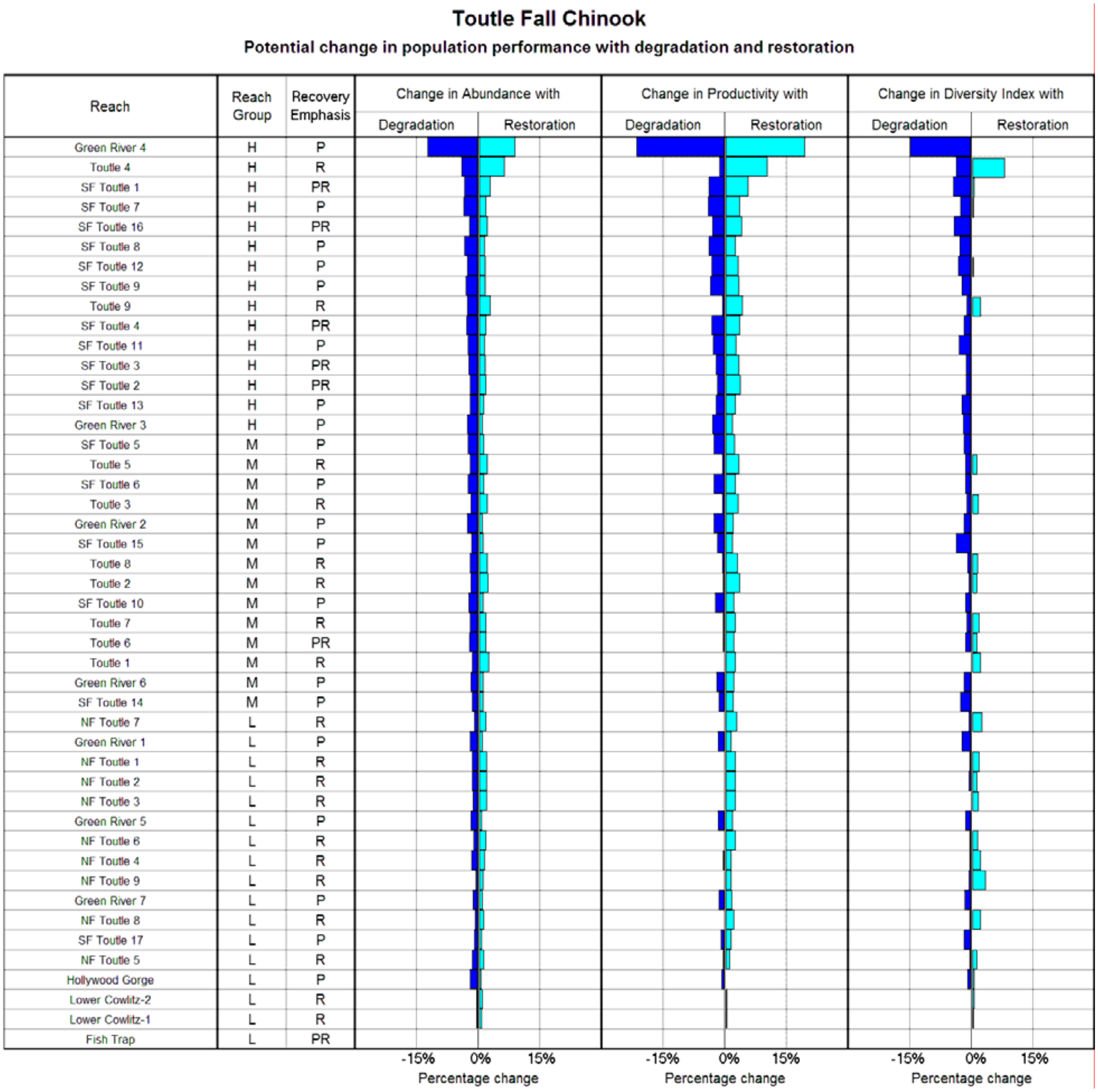


Toutle Winter Steelhead

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
SF Toutle 16	H	R
SF Toutle 18	H	R
SF Toutle 19	H	R
SF Toutle 14	H	R
SF Toutle 20	H	R
SF Toutle 15	H	PR
SF Toutle 12	H	R
NF Toutle 12	H	R
Green River 6	H	PR
SF Toutle 13	H	PR
SF Toutle 17	H	PR
NF Toutle 7	H	R
NF Toutle 13	H	R
SF Toutle 4	M	R
Green River 7	M	PR
SF Toutle 11	M	PR
Green River 9	M	R
Toutle 4	M	R
Green River 4	M	P
Green River 8	M	R
Toutle 8	M	R
NF Toutle 11	M	R
NF Toutle 10	M	R
SF Toutle 1	M	R
SF Toutle 8	M	R
SF Toutle 5	M	PR
SF Toutle 2	M	R
Shultz Creek 1	M	R
SF Toutle 3	M	R
Toutle 5	M	R
Green River 3	M	PR
SF Toutle 9	M	PR
SF Toutle 10	M	PR
Miners Creek	M	R
NF Toutle 1	M	R
Green River 5	M	PR
NF Toutle 9	L	R
Toutle 3	L	R
Coldwater Creek	L	R
SF Toutle 7	L	P
Castle Creek	L	R
NF Toutle 3	L	R
Deer Creek	L	R
Alder Creek_B	L	R
NF Toutle 6	L	R
Toutle 6	L	R
Bear Creek (NF Trib.)	L	R
Elk Creek 2	L	R
Elk Creek 1	L	PR
Hollywood Gorge	L	R
SF Toutle 6	L	PR
Toutle 9	L	R
NF Toutle 2	L	R
Hoffstadt Cr 2	L	R
Disappointment Cr	L	PR
Toutle 7	L	R
RB trib3 (Flye Ck)	L	R
Toutle 2	L	R
Johnson Creek	L	R
Green River 1	L	PR

Figure 7-8. Toutle River winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams. Some low priority reaches are not included for display purposes.

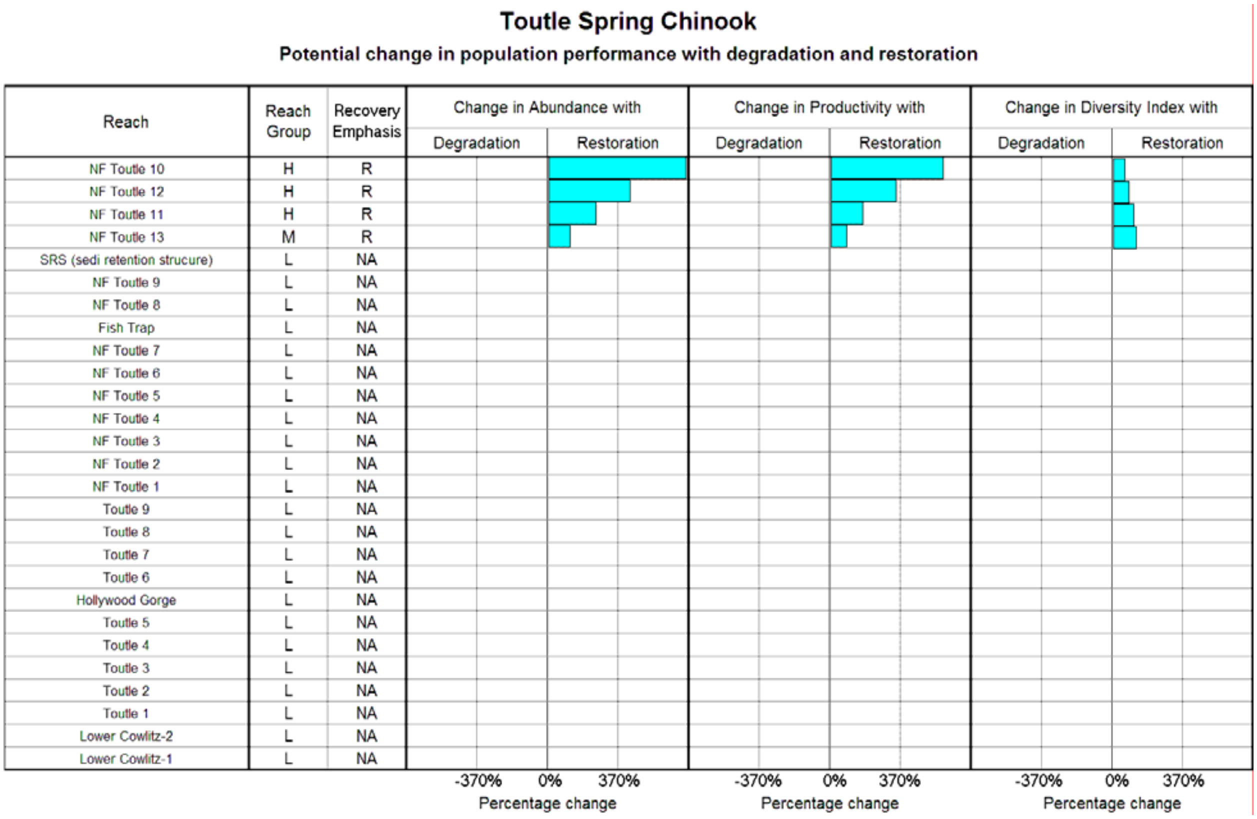


Toutle Fall Chinook

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Green River 4	H	P
Toutle 4	H	R
SF Toutle 1	H	PR
SF Toutle 7	H	P
SF Toutle 16	H	PR
SF Toutle 8	H	P
SF Toutle 12	H	P
SF Toutle 9	H	P
Toutle 9	H	R
SF Toutle 4	H	PR
SF Toutle 11	H	P
SF Toutle 3	H	PR
SF Toutle 2	H	PR
SF Toutle 13	H	P
Green River 3	H	P
SF Toutle 5	M	P
Toutle 5	M	R
SF Toutle 6	M	P
Toutle 3	M	R
Green River 2	M	P
SF Toutle 15	M	P
Toutle 8	M	R
Toutle 2	M	R
SF Toutle 10	M	P
Toutle 7	M	R
Toutle 6	M	PR
Toutle 1	M	R
Green River 6	M	P
SF Toutle 14	M	P
NF Toutle 7	L	R
Green River 1	L	P
NF Toutle 1	L	R
NF Toutle 2	L	R
NF Toutle 3	L	R
Green River 5	L	P
NF Toutle 6	L	R
NF Toutle 4	L	R
NF Toutle 9	L	R
Green River 7	L	P
NF Toutle 8	L	R
SF Toutle 17	L	P
NF Toutle 5	L	R
Hollywood Gorge	L	P
Lower Cowlitz-2	L	R
Lower Cowlitz-1	L	R
Fish Trap	L	PR

Figure 7-9. Toutle fall chinook ladder diagram.

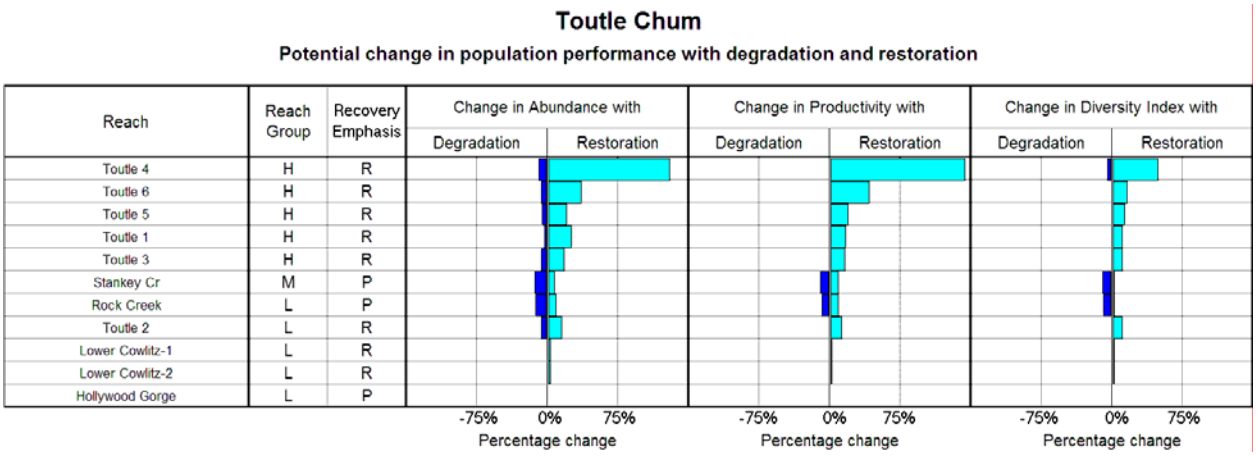


Toutle Spring Chinook

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
NF Toutle 10	H	R
NF Toutle 12	H	R
NF Toutle 11	H	R
NF Toutle 13	M	R
SRS (sedi retention strucure)	L	NA
NF Toutle 9	L	NA
NF Toutle 8	L	NA
Fish Trap	L	NA
NF Toutle 7	L	NA
NF Toutle 6	L	NA
NF Toutle 5	L	NA
NF Toutle 4	L	NA
NF Toutle 3	L	NA
NF Toutle 2	L	NA
NF Toutle 1	L	NA
Toutle 9	L	NA
Toutle 8	L	NA
Toutle 7	L	NA
Toutle 6	L	NA
Hollywood Gorge	L	NA
Toutle 5	L	NA
Toutle 4	L	NA
Toutle 3	L	NA
Toutle 2	L	NA
Toutle 1	L	NA
Lower Cowlitz-2	L	NA
Lower Cowlitz-1	L	NA

Figure 7-10. Toutle spring chinook ladder diagram.



Toutle Chum

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Toutle 4	H	R
Toutle 6	H	R
Toutle 5	H	R
Toutle 1	H	R
Toutle 3	H	R
Stankey Cr	M	P
Rock Creek	L	P
Toutle 2	L	R
Lower Cowlitz-1	L	R
Lower Cowlitz-2	L	R
Hollywood Gorge	L	P

Figure 7-11. Toutle chum ladder diagram.

7.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Key reaches for winter steelhead in the Toutle basin are located primarily in the South Fork and North Fork Toutle. These reaches are negatively impacted by sediment, habitat diversity, flow, channel stability, and temperature (Figure 7-12). Sediment remains in the system from the eruption and continues to be delivered as a result of unstable upslope soils and high road densities. Much of the North Fork basin was heavily roaded and harvested following the 1980 eruption, further increasing sediment and flow problems and slowing recovery rates. Except for the subwatersheds on the flanks of Mount St. Helens, the entire North Fork basin has road densities of over 5 mi/mi^2. Habitat diversity is low due to a lack of LWD. Mudflows from the eruption either scoured wood from channels or buried it with sediment. Recruitment of LWD is very low due to a lack of mature riparian forest cover. Reduced riparian cover and increased channel widths due to sediment aggradation have increased summer stream temperatures. Peak flows are believed to have increased due to the low hydrologic maturity of basin forests. Many of the upper North Fork subwatersheds have over 90% ‘other forest’ conditions, indicating severely degraded vegetation conditions.

For fall chinook, many of the important reaches and the habitat factors affecting them are similar to those for winter steelhead but with a greater emphasis on reaches lower in the system. Sediment has had the greatest impact, followed by channel stability, habitat diversity and temperature. Sediment is a significant problem for chinook as it impacts important spawning areas in the mainstem and SF Toutle. Sediment originates from channel as well as upslope sources. Severe sediment aggradation from upstream sources has initiated bank cutting that increases sedimentation from channel sources. Habitat diversity has been reduced by scour or burial of large wood pieces. Loss of channel stability and wood recruitment potential is related to the poor condition of riparian forests.

Important spring chinook reaches in the Toutle basin are located in the North Fork. Habitat factors affecting these reaches include sediment, temperature, channel stability and habitat diversity (Figure 7-14). The causes of these impacts are similar to those discussed above.

In the lower Toutle mainstem, where the majority of important reaches for chum are located, habitat has been negatively impacted by sediment, habitat diversity, and channel stability (Figure 7-15). Reaches 1-2 and 6-8 have nearly 80% of riparian forests in ‘other forest’ condition, which consists of brush, grass, or bare soil. Reach 3 up to Hollywood Gorge has over 60% of riparian forests in ‘other forest’ conditions. These poor riparian conditions contribute to impaired habitat diversity and channel stability.

Toutle Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
SF Toutle 16	⬤	⬤	●	•		•			⬤	⬤	●			•		+
SF Toutle 18	⬤	⬤	●	•		•			⬤	⬤	●			•		+
SF Toutle 19	●	⬤	●	•		•			⬤	⬤	●			•		✚
SF Toutle 14	●	⬤	●	•		•			⬤	●	●			•		+
SF Toutle 20	●	●	●	•		•			⬤	⬤	●			•		⬤
SF Toutle 15	●	⬤	●			•			●	●	•			•		+
SF Toutle 12	●	⬤	●	•					●	●	•			•		+
NF Toutle 12	●	●	⬤	•		•			⬤	⬤	●			•		+
Green River 6	●	●	●	•					●	●	•			•		+
SF Toutle 13	●	⬤	●			•			●	●	•					+
SF Toutle 17	●	●	•	•		•			●	●	●			•		+
NF Toutle 7	●	●	⬤	●		●			●	⬤	•			•		
NF Toutle 13	●	●	●	•		•			●	⬤	•			•		⬤
SF Toutle 4	●	●	●	•		•			●	●	•			•		+
Green River 7	●	●	•	•					●	●	•			•		+
SF Toutle 11	●	⬤	•						●	●	•					+
Green River 9	●	●	•	•					●	●						✚
Toutle 4	●	⬤	●	●		•			●	⬤	•			•		
Green River 4	•	●	●						•	●						
Green River 8	●	●	•	•					●	●	•					+
Toutle 8	●	⬤	●	●		●			●	⬤	•			•		+
NF Toutle 11	●	●	●	•	•	•			●	⬤	●			•		+
NF Toutle 10	●	●	⬤	•	•	•			●	⬤	●			•		+
SF Toutle 1	●	●	●	•		•			●	●	•			•		
SF Toutle 8	•	●	●						●	●	•			•		
SF Toutle 5	•	●	•						•	●	•					
SF Toutle 2	●	●	●	•		•			●	●	•			•		
Shultz Creek 1	•	•	●	•					•	●				•		+
SF Toutle 3	●	●	●	•		•			●	●	•			•		
Toutle 5	●	⬤	●	●		•			●	⬤	•			•		
Green River 3	•	●	●						●	•				•		
SF Toutle 9	•	●	•						•	•	•					
SF Toutle 10	•	●	•						•	●	•					
Miners Creek	•	•	●	•					•	●				•		•
NF Toutle 1	●	●	●	●		•			●	⬤	•			•		
Green River 5	•	●	•						•	●						●
NF Toutle 9	●	●	●	•		•			●	⬤	•			•		
Toutle 3	•	●	●	●		•			●	⬤	•			•		
Coldwater Creek	•	•	●	•					●	●	•			•		•
SF Toutle 7	•	●	•						•	•						
Castle Creek	•	•	●	•					●	●	•			•		●
NF Toutle 3	•	●	●	•		•			●	⬤	•			•		

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 7-12. Toutle winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Toutle Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Green River 4	⬤	⬤	⬤						●	⬤	•					●
Toutle 4	⬤	●	⬤	•		•			●	⬤	•					●
SF Toutle 1	●	●	⬤	•					•	⬤	•				•	•
SF Toutle 7	●	●	•						•	⬤	•				•	•
SF Toutle 16	●	●	•						•	⬤	•					+
SF Toutle 8	●	●	•						•	●	•					•
SF Toutle 12	●	●	•						•	⬤	•					+
SF Toutle 9	●	●	•						•	⬤	•					•
Toutle 9	●	●	●	•		•			•	⬤	•					●
SF Toutle 4	●	●	•						•	⬤	•				•	•
SF Toutle 11	●	●	•						•	●	•					+
SF Toutle 3	●	●	●						•	●	•				•	
SF Toutle 2	●	●	●						•	●	•				•	+
SF Toutle 13	●	●	•						•	●	•					+
Green River 3	●	●	•						•	●						•
SF Toutle 5	●	●	•						•	●	•				•	•
Toutle 5	●	●	●	•		•			•	⬤	•					•
SF Toutle 6	●	●	•						•	●	•				•	•
Toutle 3	●	●	●	•		•			•	⬤	•					•
Green River 2	•	•	●						•	●					•	
SF Toutle 15	●	●							•	●	•					+
Toutle 8	●	●	●	•		•			•	⬤	•					•
Toutle 2	●	●	●	•		•			•	⬤	•					•
SF Toutle 10	●	●	•						•	●	•					
Toutle 7	●	●	●	•		•			•	⬤	•					•
Toutle 6	●	●	●	•		•			•	⬤	•					•
Toutle 1	●	●	●	•		•			•	⬤	•				•	●
Green River 6	●	●	•						•	⬤						+
SF Toutle 14	●	●							•	●	•					+
NF Toutle 7	●	●	●						•	⬤	•					+
Green River 1	•	•	●						•	●						•
NF Toutle 1	●	●	●	•		•			•	⬤	•					•
NF Toutle 2	●	●	●	•		•			•	⬤	•				•	•
NF Toutle 3	●	●	●	•		•			•	⬤	•				•	
Green River 5	•	●	•						•	●						+
NF Toutle 6	●	●	●	•		•			•	⬤	•					
NF Toutle 4	●	●	•			•			•	⬤	•					•
NF Toutle 9	●	•	●						•	●						+
Green River 7	●	•	•						•	●						+
NF Toutle 8	●	•	●						•	⬤						+
SF Toutle 17	●	•	•						•	●	•					+
NF Toutle 5	●	●	•			•			•	⬤	•					•
Hollywood Gorge	•	●	•	•		•			•	●	•					•
Lower Cowlitz-2	•	●	•	•		•					•			•	•	•
Lower Cowlitz-1	•	●	•	•		•					•			•	•	•
Fish Trap																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 7-13. Toutle fall chinook habitat factor analysis diagram.

Toutle Spring Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
NF Toutle 10	⬤	⬤	⬤		•	•			●	⬤	●					●
NF Toutle 12	⬤	⬤	⬤			•			●	⬤	●					✚
NF Toutle 11	●	●	⬤		•	•			●	⬤	●					•
NF Toutle 13	●	●	⬤						•	⬤	•					✛
SRS (sedi retention strucure)																
NF Toutle 9																
NF Toutle 8																
Fish Trap																
NF Toutle 7																
NF Toutle 6																
NF Toutle 5																
NF Toutle 4																
NF Toutle 3																
NF Toutle 2																
NF Toutle 1																
Toutle 9																
Toutle 8																
Toutle 7																
Toutle 6																
Hollywood Gorge																
Toutle 5																
Toutle 4																
Toutle 3																
Toutle 2																
Toutle 1																
Lower Cowlitz-2																
Lower Cowlitz-1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 7-14. Toutle spring chinook habitat factor analysis diagram.

Toutle Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Toutle 4	⬤	⬤		•					●	⬤	●				●	✛
Toutle 6	●	⬤		•					●	⬤	•					✛
Toutle 5	•	●		•					•	⬤	•				•	✛
Toutle 1	•	●							•	●	•				•	●
Toutle 3	•	●		•					•	⬤	•				•	✛
Stankey Cr	•	●							•	•	•				•	✛
Rock Creek	•	●							•	•	•				•	✛
Toutle 2	•	●		•					•	⬤	•				•	✛
Lower Cowlitz-1		•														•
Lower Cowlitz-2		•							•							•
Hollywood Gorge																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 7-15. Toutle chum habitat factor analysis diagram.

7.7 Integrated Watershed Assessment (IWA)

The Toutle River watershed contains 46 planning subwatersheds, ranging from approximately 3,000 to 12,000 acres. The Toutle River watershed is primarily a high elevation system, comprised of Cascade granitic and volcanic rocks with low to moderate natural erodability. Nineteen of the subwatersheds are high elevation, headwaters subwatersheds. Another 17 subwatersheds are characterized by moderate-size, mainstem reaches situated at high elevations. Three subwatersheds include the large mainstem reaches of the Toutle River—below the confluence of the North and South Forks. In addition, some of the smaller tributaries in the western part of the watershed, such as Hemlock (70403), Studebaker (50402), and Wyant (70302) Creeks drain lowland subwatersheds consisting of erodable metamorphic and sedimentary materials.

7.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Toutle River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 7-2. Almost all of the subwatersheds are rated as moderately impaired with respect to riparian and sediment supply conditions, and the majority of the subwatersheds are impaired with respect to hydrology. At the watershed level, the number of subwatersheds in each impairment category remains similar to the local level results. A reference map showing the location of each subwatershed in the basin is presented in Figure 7-16. Maps of the distribution of local and watershed level IWA results are displayed in Figure 7-17.

Table 7-2. IWA results for the Toutle River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30101	M	M	M	M	M	none
30102	M	F	M	M	F	none
30103	I	M	M	I	M	none
30104	M	F	M	M	F	none
30201	I	F	M	M	F	30101, 30102, 30103, 30104, 30203, 30204, 30205, 30301, 30302
30202	I	M	M	M	F	30101, 30102, 30103, 30104, 30201, 30203, 30204, 30205, 30301, 30302
30203	M	M	M	M	F	30204
30204	M	F	M	M	F	none
30205	M	M	M	M	M	none
30301	I	M	M	I	M	30302, 30305
30302	I	M	M	I	M	none
30303	M	M	M	M	M	none
30304	I	M	M	I	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205, 30301, 30302, 30303, 30305, 30306
30305	I	M	M	I	M	30302
30306	I	M	M	M	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205
40101	F	M	F	M	M	40102
40102	M	M	M	M	M	none
40201	I	M	M	I	M	40101, 40102, 40202
40202	I	M	M	I	M	none
40203	I	I	M	I	I	none
40301	I	M	I	I	M	40101, 40102, 40201, 40202, 40203, 40302
40302	I	I	M	I	I	none
40401	M	M	M	I	M	40101, 40102, 40201, 40202, 40203, 40301, 40302
40402	I	M	M	I	M	40101, 40102, 40201, 40202, 40203, 40301, 40302, 40401, 40403, 40404
40403	M	M	M	M	M	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
40404						40101, 40102, 40201, 40202, 40203, 40301, 40302, 40401
50101	M	M	M	M	M	none
50102	M	M	M	M	M	none
50201	I	M	M	I	M	50101, 50102
50202	I	I	M	I	I	none
50301	M	M	M	I	M	50101, 50102, 50201, 50202, 50302
50302	I	M	M	I	M	50101, 50102, 50201, 50202
50401	I	M	M	I	M	50101, 50102, 50201, 50202, 50301, 50302, 50404, 50405
50402	I	M	M	I	M	none
50403	I	I	M	I	M	50101, 50102, 50201, 50202, 50301, 50302, 50401, 50404, 50405
50404	M	M	M	I	M	50101, 50102, 50201, 50202, 50301, 50302, 50405
50405	M	M	M	I	M	50101, 50102, 50201, 50202, 50301, 50302, 50401, 50402, 50403
70301	I	M	M	I	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205, 30301, 30302, 30303, 30304, 30305, 30306, 40101, 40102, 40201, 40202, 40203, 40301, 40302, 40401, 40402, 40403, 40404
70302	I	M	M	I	M	none
70401	I	M	M	I	M	70402, 70403
70402	I	M	M	I	M	none
70403	I	M	M	I	M	none
70602	M	M	M	M	M	none
70603	I	M	M	I	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205, 30301, 30302, 30303, 30304, 30305, 30306, 40101, 40102, 40201, 40202, 40203, 40301, 40302, 40401, 40402, 40403, 40404, 50101, 50102, 50201, 50202, 50301, 50302, 50401, 50402, 50403, 50404, 50405, 70301, 70302, 70401, 70402, 70403
70604	I	M	M	I	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205, 30301, 30302, 30303, 30304, 30305, 30306, 40101, 40102, 40201, 40202, 40203, 40301, 40302, 40401, 40402, 40403, 40404, 50101, 50102, 50201, 50202, 50301, 50302, 50401, 50402, 50403, 50404, 50405, 70301, 70302, 70401, 70402, 70403, 70602, 70603
70607	I	M	M	I	M	30101, 30102, 30103, 30104, 30201, 30202, 30203, 30204, 30205, 30301, 30302, 30303, 30304, 30305, 30306, 40101, 40102, 40201,

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
						40202, 40203, 40301, 40302, 40401, 40402, 40403, 40404, 50101, 50102, 50201, 50202, 50301, 50302, 50401, 50402, 50403, 50404, 50405, 70301, 70302, 70401, 70402, 70403, 70602, 70603, 70604

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800050#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional

M: Moderately impaired

I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed

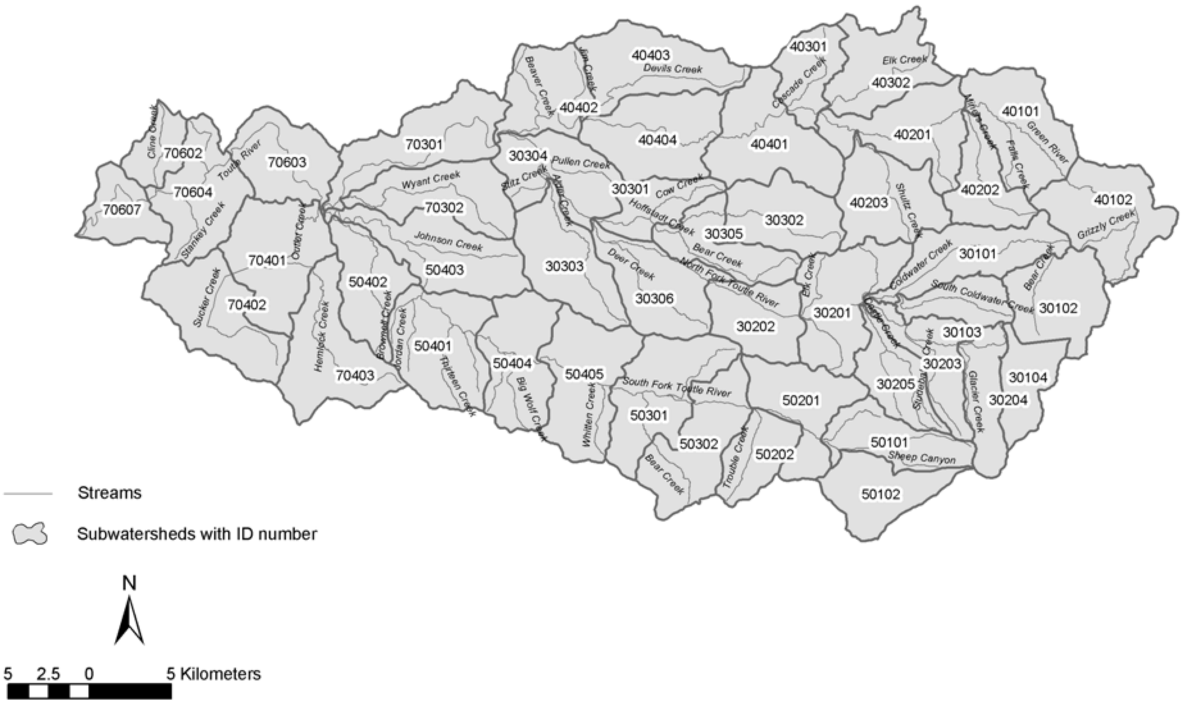


Figure 7-16. Map of the Toutle basin showing the location of the IWA subwatersheds.

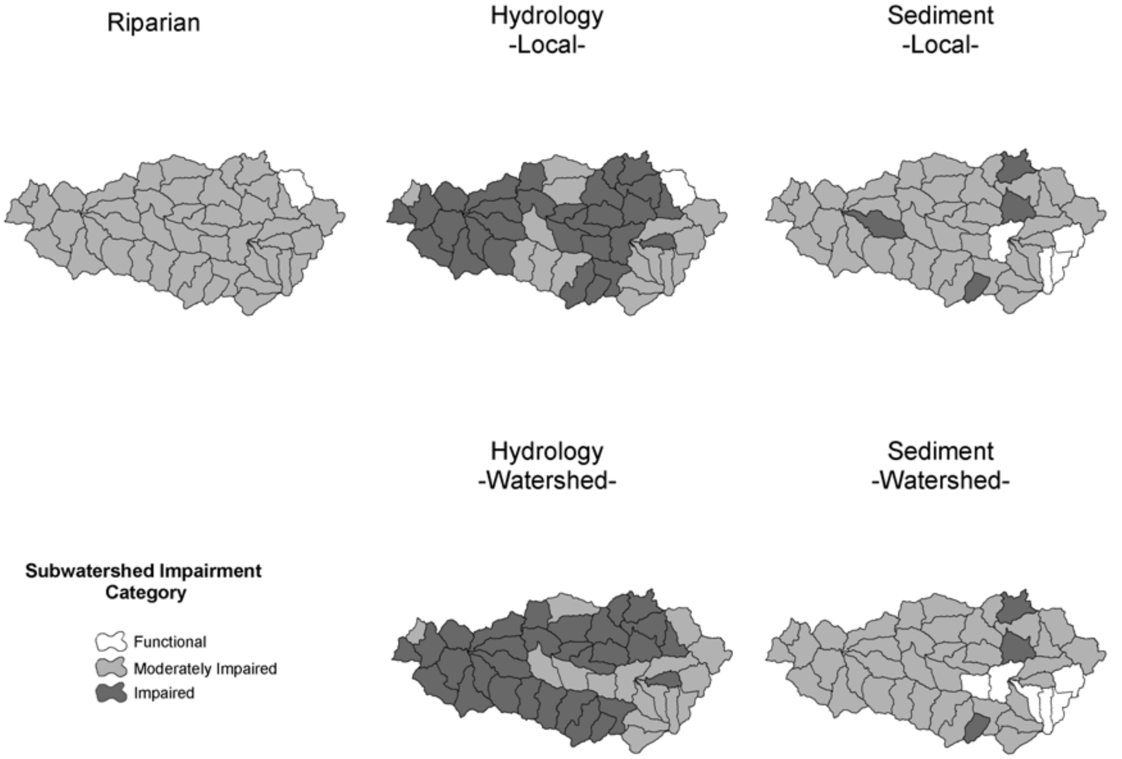


Figure 7-17. IWA subwatershed impairment ratings by category for the Toutle basin.

7.7.1.1 Hydrology

Local level hydrologic conditions across the Toutle River watershed range from moderately impaired to impaired. The only functional hydrologic rating is in the upper Green River-Falls Creek subwatershed (40101). Moderately impaired subwatersheds are located in headwater areas, along the lower Green River, and along the middle mainstem of the SF Toutle. Impaired conditions make up the remainder of the basin. Watershed level conditions have a slightly different pattern across the basin. Impaired subwatersheds are concentrated in the entire lower porton of the basin, along the mainstem SF Toutle, throughout the Green River basin, and in the Hoffstadt basin (tributary to the middle NF Toutle). Less impaired hydrologic conditions in headwater subwatersheds buffer downstream conditions in the upper NF, but this is not the case in the Green and SF basins, which contain impaired subwatersheds. Except for the moderately impaired subwatersheds in the upper NF basin (30306, 30202, 30201), all major anadromous fish bearing subwatersheds are impaired at the watershed level.

Subwatersheds in the NF drainage are susceptible to hydrologic impacts due to vegetation destruction caused by the 1980 eruption. This risk is mitigated by low road densities (0-2.7 mi/sq mi) and large amounts of wetland area (>10%). The exception is the South Coldwater Creek subwatershed (30103) and the NF Toutle below Maratta Creek (30306, 30302), which have high road and stream crossing densities.

Hydrologic impairments along the lower NF subwatersheds are caused by locally high road densities, young forest vegetation, and upstream inputs. The mainstem NF Toutle above the Green River confluence (30304) supports important winter steelhead habitat and suffers from high road densities (6.6 mi/sq mi) and low mature forest vegetation coverage (33%). It is also impacted by the Hoffstadt Creek drainage (30301, 30302, 30305), which is rated as impaired across all subwatersheds. The lower NF Toutle (70301) has even worse values for road density (7.1 mi/sq mi) and mature forest cover (23%). It also receives inputs from hydrologically impaired upstream subwatersheds (Green River and North Fork drainages).

IWA impairment ratings for the SF Toutle basin (50201-50302, 50402-50405) are strongly influenced by local hydrologic conditions, including high road densities (average 6.3 mi/sq mi) and moderate rain-on-snow zone coverage (avg. 37%). Similar conditions exist in subwatersheds drained by the Green River (40201-40402), with IWA results showing impaired local and watershed level conditions driven by high road densities (average 6.1 mi/sq mi) and moderate rain-on-snow area (average is 47% and maximum is 84%). Current land cover conditions in the Green River subwatersheds are poor, with only 27% of subwatershed area in hydrologically mature forest. Impaired hydrologic conditions in subwatersheds along the upper Green and the SF Toutle contribute to impaired ratings for downstream subwatersheds.

Subwatersheds along the mainstem Toutle River that encompass important anadromous fish habitat (70603, 70604, and 70607) are rated as hydrologically impaired at the local and watershed levels. The impairments are due to upstream inputs, high local road densities (5.3-6.1 mi/sq mi), and locally young forest vegetation (22-34% hydrologically mature).

7.7.1.2 Sediment

Local and watershed level sediment supply ratings are nearly identical, with only a few exceptions. The majority of subwatersheds (80%) have moderately impaired sediment supply ratings. The few impaired subwatersheds are scattered throughout the basin. Functional conditions occur in the upper NF Toutle basin. These functional conditions improve the watershed level ratings of downstream subwatersheds. Impaired subwatersheds (40302, 40203, 50202, and 50403) suffer from young forests and high road densities on erodable geology types. Streamside road densites and stream crossing densities are also high in these areas.

Fish bearing subwatersheds along the mainstem NF Toutle are rated as moderately impaired for sediment. The impairments are due to young forests and high road densities. Inputs from upstream subwatersheds in the lower and middle part of the drainage, such as Hoffstadt Creek (30301, 30302, 30305) and the Green River, also affect sediment condition.

Most of the mainstem Toutle subwatersheds (70603, 70604, and 70607) are moderately impaired with respect to sediment supply conditions. Again, most of the problems arise from young forest vegetation, high road densities, and high stream crossing densities. Upstream sediment conditions play a major role in the watershed level sediment ratings for these lower basin subwatersheds.

7.7.1.3 Riparian

Riparian conditions are rated moderately impaired throughout the Toutle River watershed, with the exception of one subwatershed in the Green River headwaters (40101). These conditions are due to historical logging practices and the impacts of the Mount St. Helens eruption. Riparian conditions in all important anadromous subwatersheds are uniformly rated as moderately impaired.

7.7.2 Predicted Future Trends

7.7.2.1 Hydrology

Hydrologic conditions in the Toutle River watershed are generally predicted to trend towards gradual improvement over the next 20 years as a result of improved forestry practices and vegetation recovery from the Mount St. Helens eruption.

Hydrologic conditions in the NF Toutle basin are predicted to trend stable or improve gradually over the next 20 years. Much of the land in the NF Toutle drainage is publicly owned, managed by either the USFS or WDNR. Forest cover within these subwatersheds is predicted to generally mature and improve. These improvements are expected to benefit downstream mainstem reaches.

Similar conditions are prevalent throughout the SF Toutle and Green River basins, however, there is more degradation in headwaters areas of these drainages. The limited extent of hydrologically mature vegetation and high road densities limit the extent to which hydrologic conditions recover over the next 20 years. Because the majority of the area in these subwatersheds is in private holdings, forestry activities and development are expected to continue at the same level, albeit mitigated by improved forestry and road management practices. These factors are predicted to result in stable trends in hydrologic condition.

Conditions in lower mainstem reaches are dependent on the future trends in upstream areas. Based on likely trends in upstream areas, hydrologic conditions in these lower mainstem subwatersheds are predicted to trend towards gradual improvement over the next 20 years.

7.7.2.2 Sediment

In general, Toutle River basin subwatersheds have low to moderate natural erodability ratings, based on geology type and slope class, averaging less than 20, with a maximum of 40, on a scale of 0-126. This suggests that these subwatersheds would not be major sources of sediment impacts under undisturbed conditions. However, road densities, streamside road densities, and stream crossings in these subwatersheds are relatively high, leading to a risk of elevated sediment supply. Given the large amount of private and public timber holdings, and the protected areas around Mount St. Helens, the overall sediment condition is expected to remain stable over the next 20 years.

The outlook is good for improving conditions in the NF Toutle above Hoffstadt Creek because of the high degree of public ownership. In the lower NF Toutle, the large percentage of industrial timber lands and high road densities suggests that trends are likely to remain stable. However, some gradual improvement may occur as improved forestry and road management practices are implemented. Sediment conditions in the SF Toutle and Green River basins are likely to follow a similar trend, as forestry and road management practices on private timberlands improve.

Trends in sediment conditions in mainstem subwatersheds are expected to remain relatively constant due to the likelihood of ongoing timber harvest, high road densities, moderately high streamside road densities (ranging from 0.4-0.6 miles/stream mile), and the potential for increased development.

7.7.2.3 Riparian Condition

In general, riparian conditions are likely to improve over time with improved forestry practices and recovery of vegetation destroyed by the Mount St. Helens eruption.

Mainstem subwatersheds on the upper NF Toutle (30201, 30202, 30306), which contain important anadromous fish habitat, have large areas of public and private lands managed for timber harvest and low to moderate streamside road densities (12 miles/stream mile). The predicted trend in these subwatersheds is for riparian conditions to remain the same or to slightly improve. Some riparian recovery is expected on timber lands where streamside roads are not present, however, these gains may be offset by streamside development in some areas.

Riparian conditions along the lower mainstem Toutle, the SF Toutle, and the Green River are expected to remain stable or trend towards further degradation over the next 20 years, as development pressure and timber production continue in the lower basin.

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Volume II, Chapter 8
Cowlitz Subbasin—Lower Cowlitz

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8.0 Cowlitz Subbasin—Lower Cowlitz

8.1 Subbasin Description

8.1.1 Topography & Geology

For the purposes of this assessment, the Lower Cowlitz basin is the Cowlitz watershed below Mayfield Dam, not including the Toutle and Coweeman basins. The basin encompasses approximately 440 square miles in portions of Lewis and Cowlitz Counties and lies within WRIA 26 of Washington State. The Cowlitz enters the Columbia at RM 68, approximately 3.5 miles southeast of Longview, WA. The Coweeman and Toutle are the two largest tributaries. These basins are covered in separate chapters. Other significant tributaries include Salmon Creek, Lacamas Creek, Olequa Creek, Delameter Creek, and Ostrander Creek.

Mayfield Dam (RM 52), constructed in 1962, blocks all natural passage of anadromous fish to the upper basin. The Cowlitz Salmon Hatchery Barrier Dam (RM 49.5), located below Mayfield Dam, is a collection facility for trapping and hauling fish into the upper basin, a practice that has been in effect since 1969. Below the Barrier Dam, the river flows south through a broad valley. Much of the lower mainstem Cowlitz suffers from channelization features related to industrial, agricultural, and urban development.

The Toutle River, which enters the Cowlitz at RM 20, is a major lower tributary that drains the north and west sides of Mount St. Helens. The Toutle River was impacted severely by the 1980 eruption of Mount St. Helens and the resulting massive debris torrents and mudflows, which also impacted the Cowlitz mainstem downstream of the Toutle confluence. Following the eruption, the lower mainstem Cowlitz was dredged and dredge spoils were placed in the floodplain.

The lower valley is comprised of Eocene basalt flows and flow breccia. Alpine glaciation and subsequent fluvial working of glacially derived sediments have heavily influenced valley morphology and soils. The most common forest soils are Haplohumults (reddish brown lateritic soils) and the most common grassland soils are Argixerolls (prairie soils) (WDW 1990).

8.1.2 Climate

The subbasin has a typical northwest maritime climate. Summers are dry and warm and winters are cool, wet, and cloudy. Mean monthly precipitation ranges from 1.1 inches (July) to 8.8 inches (November) at Mayfield Dam. Annual precipitation averages 46 inches near Kelso, WA (WRCC 2003). Most precipitation occurs between October and March. Snow and freezing temperatures are common in the upper elevations while rain predominates in the middle and lower elevations.

8.1.3 Land Use/Land Cover

Forestry is the dominant land use in the subbasin. Commercial forestland makes up over 80% of the Cowlitz basin below Mayfield Dam. Much of the private land in the lower river valleys is agricultural and residential, with substantial impacts to riparian and floodplain areas in places. Population centers in the subbasin consist primarily of small rural towns, with the larger towns of Castle Rock and Longview/Kelso along the lower river. Projected population change from 2000 to 2020 for unincorporated areas in WRIA 26 is 22%. The following towns in the lower Cowlitz basin are listed with their estimated population change between 2000 and 2020: Longview 21%, Kelso 42%, Castle Rock 2%, Vader 64%, Toledo 64%, and Winlock 49% (LCFRB 2001). A breakdown of land ownership is presented in Figure 8-1. In most areas, climax species are western hemlock, Douglas fir, and western red cedar. Alder, cottonwood, maple, and willow dominate the larger stream riparian areas (WDW 1990). A breakdown of land cover is presented in Figure 8-2. Figure 8-3 displays the pattern of landownership for the basin. Figure 8-4 displays the pattern of land cover / land-use.

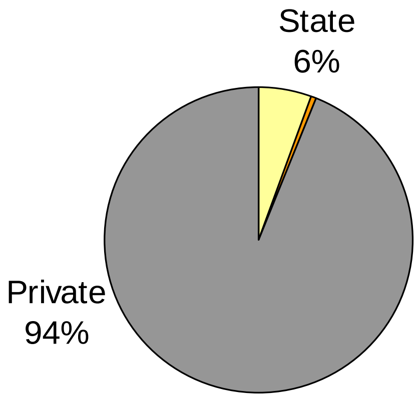


Figure 8-1. Lower Cowlitz River basin land ownership

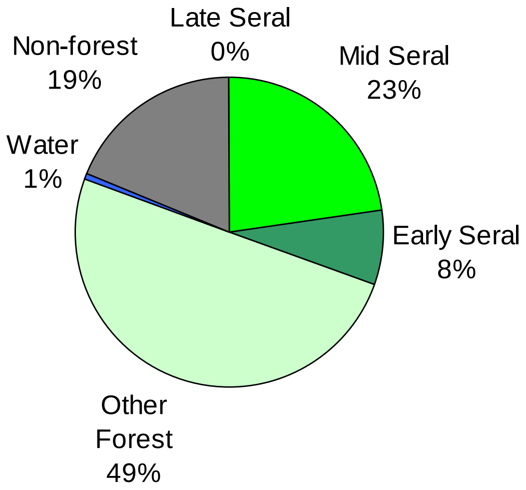


Figure 8-2. Lower Cowlitz River basin land cover

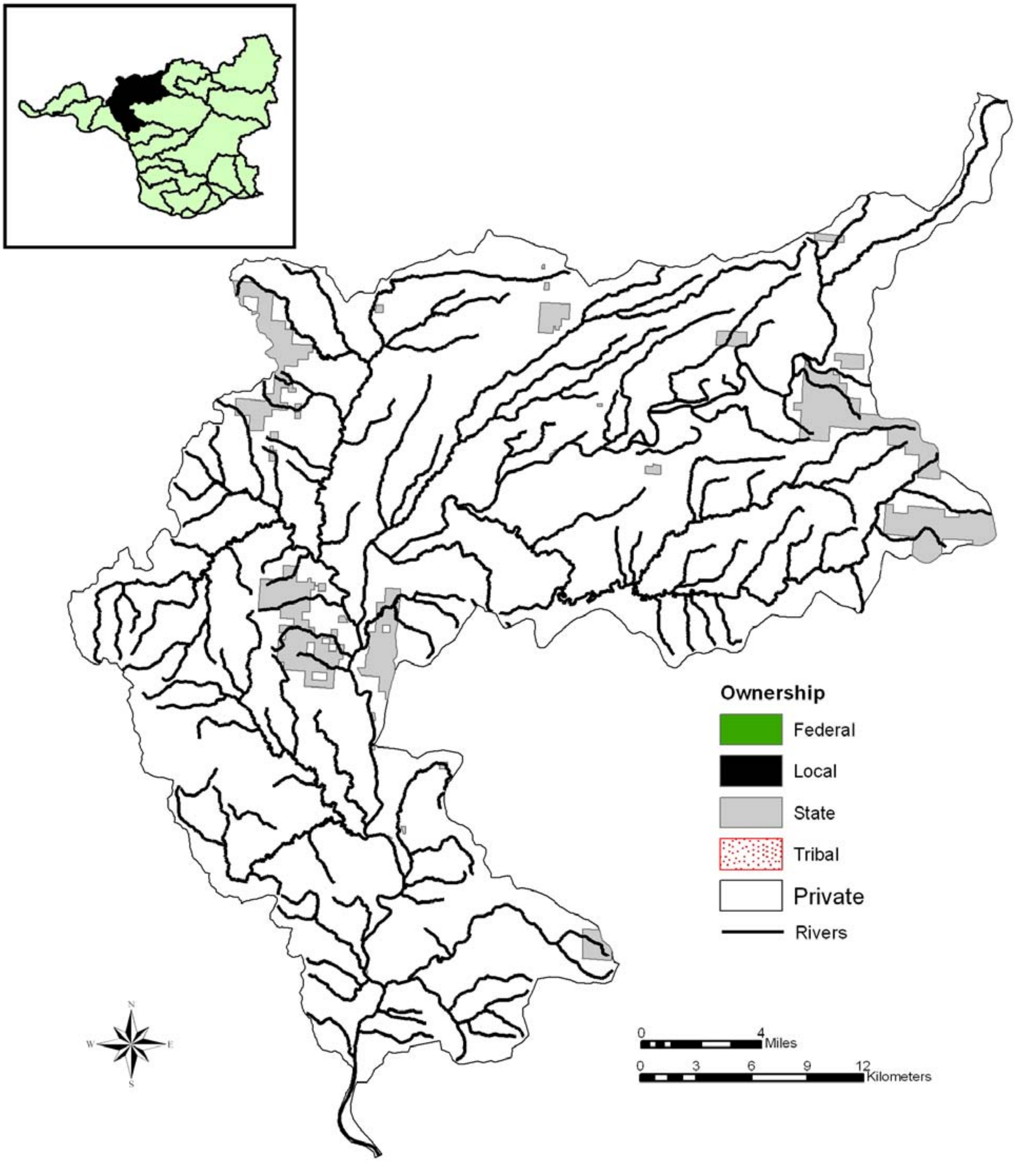


Figure 8-3. Landownership within the Lower Cowlitz basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

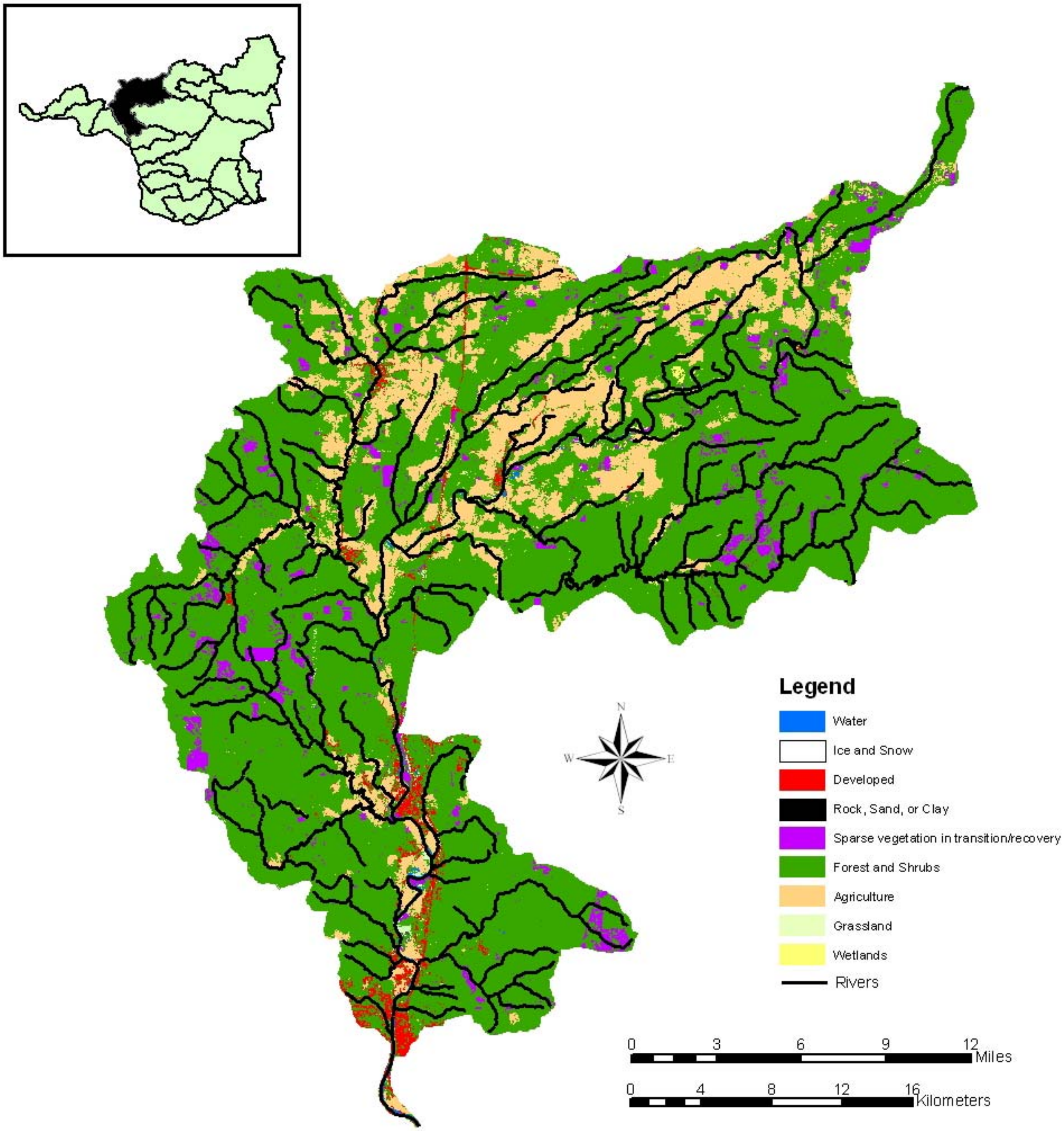
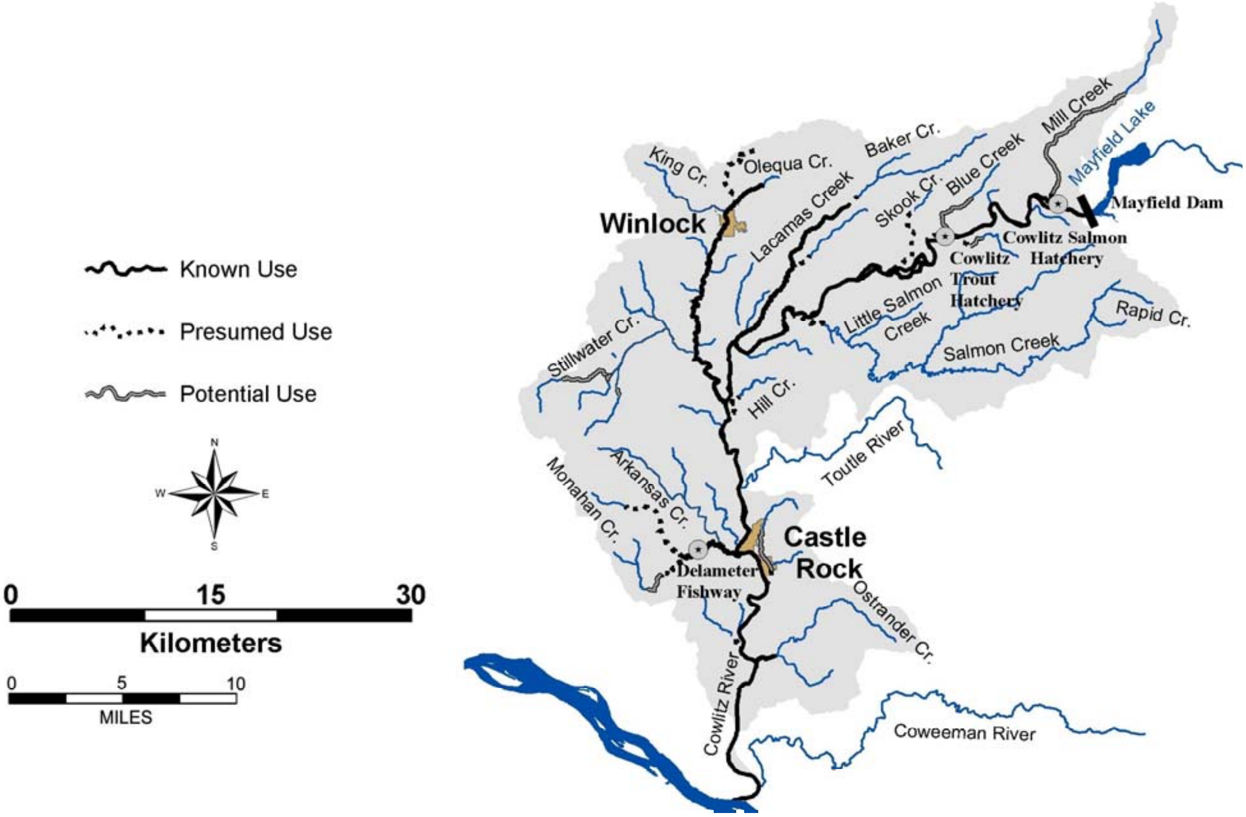


Figure 8-4. Land cover within the Lower Cowlitz basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

8.2 Focal Fish Species

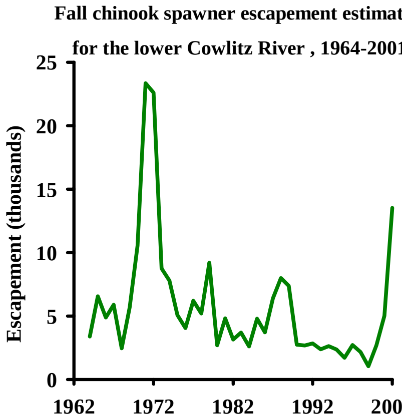
8.2.1 *Fall Chinook—Cowlitz Subbasin (Lower Cowlitz)*

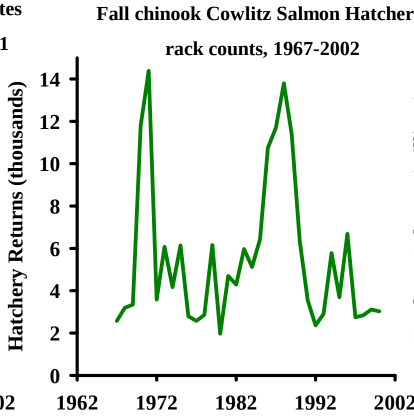
ESA: Threatened 1999 **SASSI: Depressed 2002**

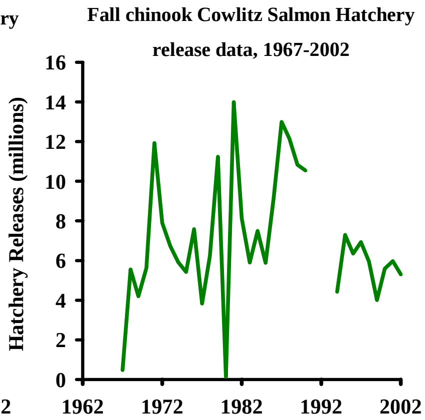


Distribution

- Spawning occurs in the mainstem Cowlitz River between the Cowlitz River Salmon Hatchery and the Kelso Bridge (~45 miles), but is concentrated in the area between the Cowlitz Salmon and Trout Hatcheries (RM 52 and 41.3)
- Historically, Cowlitz River fall chinook were distributed from the mouth to upper tributaries such as the Ohanapecosh and Tilton Rivers and throughout the upper basin
- Completion of Mayfield Dam in 1962 blocked access above the dam (RM 52); all fish were passed over the dam from 1962-66; from 1967-80, small numbers of fall chinook were hauled to the Tilton and upper Cowlitz
- An adult trap and haul program began again in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam


Fall chinook spawner escapement estimates for the lower Cowlitz River , 1964-2001


Fall chinook Cowlitz Salmon Hatchery rack counts, 1967-2002


Fall chinook Cowlitz Salmon Hatchery release data, 1967-2002

Life History

- Fall chinook enter the Cowlitz River from early September to late November
- Natural spawning in the Cowlitz River occurs between October and November, over a broader time period than most lower Columbia fall chinook; the peak is usually occurs during first week of November
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult age of 3, 4, and 5 (averages are 16.49%, 58.05%, and 19.31%, respectively)
- Fry emerge around March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings
- Cowlitz fall chinook display life history characteristics (spawn timing, migration patterns) that fall between tules and Lewis River late spawning wild fall chinook

Diversity

- The Cowlitz River fall chinook stock is designated based on distinct spawning timing and distribution
- Genetic analysis of Cowlitz River Hatchery fall chinook from 1981, 1982, and 1988 determined they were similar to, but distinct from, Kalama Hatchery fall chinook and distinct from other Washington chinook stocks

Abundance

- Historical abundance of natural spawning fall chinook in the Cowlitz River is estimated to have once been 100,000 adults, declining to about 18,000 adults in the 1950s, 12,000 in the 1960s, and recently to less than 2,000
- In 1948, WDF and WDG estimated that the Cowlitz River produced 63,612 adult fall chinook; escapement above the Mayfield Dam site was at least 14,000 fish
- Fall chinook escapement estimates in 1951 were 10,900 in the Cowlitz River and minor tributaries, 8,100 in the Cispus, and 500 in the Tilton
- From 1961-1966, an average of 8,535 fall chinook were counted annually at Mayfield Dam
- Lower Cowlitz River spawning escapement from 1964-2002 ranged from 1,045 to 23,345 (average 5,522)
- Currently hatchery production accounts for most fall chinook returning to the Cowlitz River
- WDFW interim natural spawning escapement goal is 3,000 fish; the goal was not met from 1990-2000

Productivity & Persistence

- NMFS Status Assessment for the Cowlitz River indicated a 0.15 risk of 90% decline in 25 years and a 0.33 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- Two adult production potential estimates have been reported for the upper Cowlitz: 63,818 and 93,015
- Smolt density model predicted natural production potential for the Cowlitz River below Mayfield Dam of 2,183,000 smolts; above Mayfield Dam the model predicts production potential of 357,000 smolts from the Tilton River and 4,058,000 smolts above Cowlitz Falls
- Current juvenile production from natural spawning is presumed to be low

Hatchery

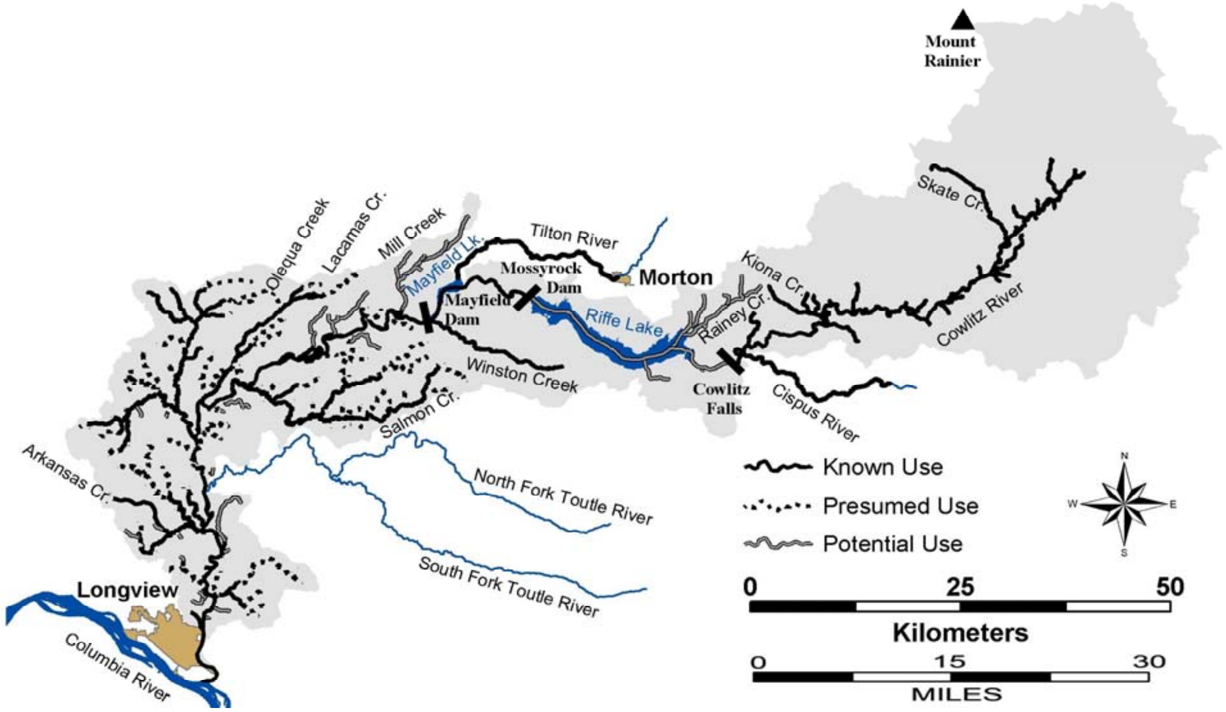
- Cowlitz River Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; hatchery was completed in 1967; broodstock is primarily derivered from native Cowlitz fall chinook
- Hatchery releases of fall chinook in the Cowlitz River began in 1952; hatchery release data are displayed for 1967-2002
- The current hatchery program goal is 5 million fall chinook juveniles released annually
- Cowlitz hatchery fall chinook are not currently being reintroduced above Cowlitz Falls Dam

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial and sport fisheries
- Ocean and mainstem Columbia River fisheries are managed for Snake River and Coweeman River wild fall chinook Endangered Species Act (ESA) harvest rate limits which limits the harvest of Cowlitz fall chinook
- Cowlitz River fall chinook are important contributors to Washington ocean sport and troll fisheries and to the Columbia River estuary sport (Buoy 10) fishery
- CWT data analysis of the 1989-94 brood years indicates a total Cowlitz Hatchery fall chinook harvest rate of 33% with 67% accounted for in escapement
- The majority of fishery CWT recoveries of 1989-94 brood Cowlitz Hatchery fall chinook were distributed between Washington ocean (30%), British Columbia (21%), Alaska (15%), Cowlitz River (11%), and Columbia River (8%) sampling areas
- Annual harvest is variable depending on management response to annual abundance in Pacific Salmon Commission (PSC)(US/Canada), Pacific Fisheries Management Council (PFMC) (US ocean), and Columbia River Compact Forums
- Sport harvest in the Cowlitz River averaged 2,672 fall chinook annually from 1977-1986
- Freshwater sport fisheries in the Cowlitz River are managed to achieve adult fall chinook hatchery escapement goals

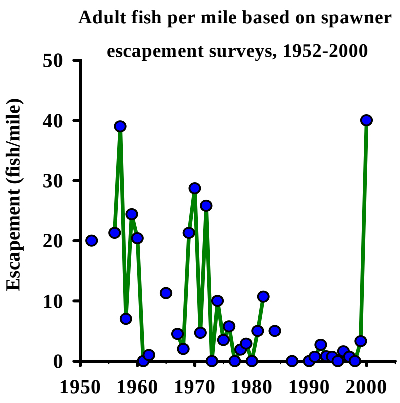
8.2.2 Coho—Cowlitz Subbasin

ESA: Candidate 1995 **SASSI: Cowlitz—Depressed 2002;**

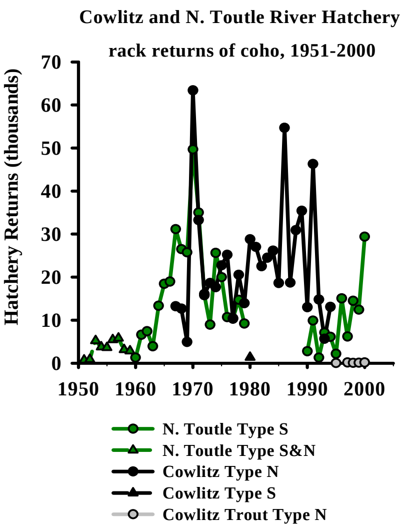


Distribution

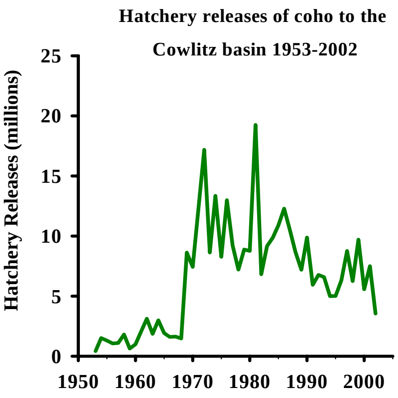
- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River and late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho, including the Toutle, SF Toutle, Coweeman, and Green Rivers and all accessible tributaries
- Natural spawning in lower Cowlitz tributaries occurs primarily in Olequa, Lacamas, Brights, Ostrander, Blue, Otter, Mill, Arkansas, Foster, Stillwater, Campbell, and Hill Creeks
- Natural spawning in the Coweeman River basin is primarily in tributaries downstream of the confluence of Mulholland Creek
- The post Mt. St. Helens eruption Toutle River system includes tributaries at various stages of recovery and some tributaries (primarily on the Green and South Toutle) with minor effects of the eruption. Bear, Hoffstadt, Johnson, Alder, Devils, and Herrington Creeks are examples of tributaries important to coho; coho adults are collected and passed to tributaries above the North Toutle Sediment Retention Dam
- Completion of Mayfield Dam in 1962 blocked access above the dam; a returning adult trap and haul program began in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam, restoring some access to the upper watershed.



Adult fish per mile based on spawner escapement surveys, 1952-2000



Cowlitz and N. Toutle River Hatchery rack returns of coho, 1951-2000



Hatchery releases of coho to the Cowlitz basin 1953-2002

Life History

- Adults enter the Columbia River from August through January (early stock primarily from mid-August through September and late stock primarily from late September to October)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge from January through April on the Cowlitz, depending on water temperature
- Coho spend one year in fresh water, and emigrate as age-1 smolts in the spring

Diversity

- Late stock (or Type-N) coho are informally considered synonymous with Cowlitz River stock
- Early stock(or Type-S) coho are informally considered synonymous with Toutle River stock
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Cowlitz River wild coho run is a fraction of its historical size
- In 1948, WDF estimated coho escapement to the basin was 77,000; in the early 1950s, escapement to the basin was estimated as 32,500 coho
- Escapement surveys on Olequa Creek from 1952-1990 established a range of 0-40 fish/mile
- Average total escapement of natural coho to the Toutle River was estimated as 1,743 for the years 1972-1979, prior to the 1980 eruption of Mt. St. Helens
- In 1985, an estimated 5,229 coho naturally spawned in lower Cowlitz River tributaries (excluding the Coweeman and Toutle systems), but the majority of spawners were fish originating from the Cowlitz Hatchery
- Hatchery production accounts for most coho returning to the Cowlitz River

Productivity & Persistence

- Natural coho production is presumed to be very low in the lower Cowlitz basin with Olequa Creek the most productive

- The Toutle River system likely provided the most productive habitat in the basin in the 1960s and 1970s, but was greatly reduced after the 1980 Mt. St. Helens eruption
- Reintroduction efforts in the upper Cowlitz River basin have demonstrated good production capabilities in tributaries above the dams, but efforts are challenged in passing juvenile production through the system
- Smolt density model natural production potential estimates were made on various sections of the Cowlitz River basin: 123,123 smolts for the lower Cowlitz River, 131,318 smolts for the Tilton River and Winston Creek, 155,018 smolts above Cowlitz Falls, 142,234 smolts for the Toutle River, and 37,797 smolts for the Coweeman River

Hatchery

- The Tilton River Hatchery released coho in the Cowlitz basin from 1915-1921
- A salmon hatchery operated in the upper Cowlitz River near the mouth of the Clear Fork until 1949
- The Cowlitz Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; hatchery was completed in 1967; the hatchery is programmed for an annual release of 4.2 million late coho smolts
- Cowlitz Hatchery coho are important to the reintroduction effort in the upper basin
- The North Toutle Hatchery is located on the Green River less than a mile upstream of the confluence with the North Fork Toutle River; the hatchery is programmed for an annual release of 1 million early coho smolts

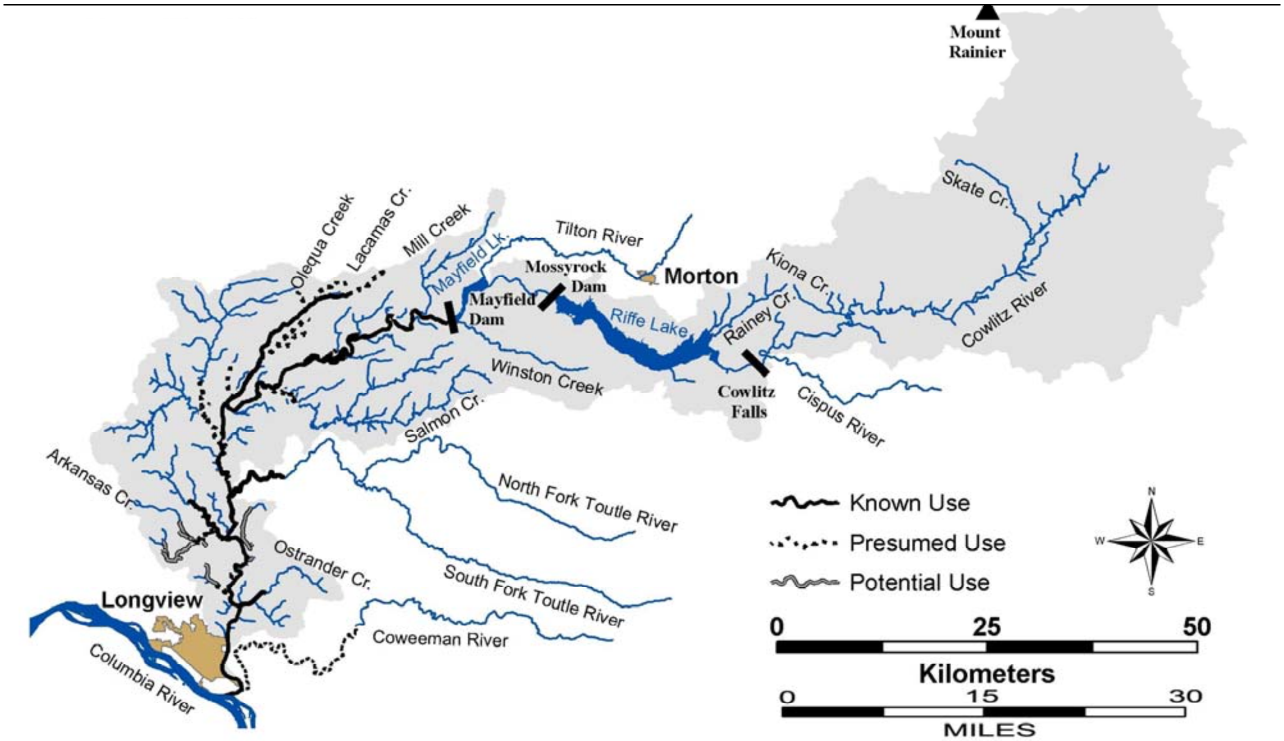
Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest of Columbia produced coho ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho stocks
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, Columbia River hatchery fish have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late coho harvest can also be substantial
- An average of 1,494 coho (1986-1990) were harvested annually in the Cowlitz River sport fishery

- The Toutle River sport fishery was closed in 1982 after the eruption of Mt. St. Helens; the Green River sport fishery was closed from 1981 to 1988 after the eruption of Mt. St. Helens and was reopened in 1989
- CWT data analysis of the 1995-97 North Toutle Hatchery early coho indicates 34% were captured in fisheries and 66% were accounted for in escapement
- CWT data analysis of the 1994 and 1997 brood Cowlitz Hatchery late coho indicates 64% were captured in fisheries and 36% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 Toutle coho were distributed between Columbia River (47%), Washington ocean (37%), and Oregon ocean (15%) sampling areas
- Fishery CWT recoveries of 1994 and 1997 brood Cowlitz coho were distributed between Columbia River (55%), Washington ocean (30%), and Oregon ocean (15%) sampling areas

8.2.3 Chum—Cowlitz Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Chum were reported to historically utilize the lower Cowlitz River and tributaries downstream of the Mayfield Dam site

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts generally from March to May

Diversity

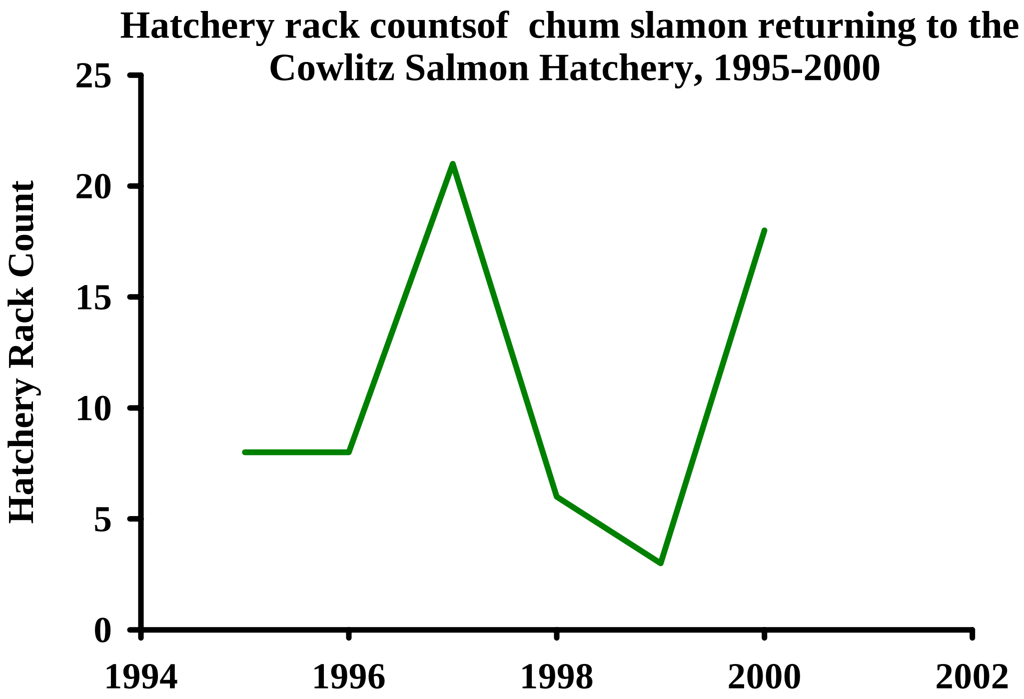
- No hatchery releases of chum have occurred in the Cowlitz basin

Abundance

- Estimated escapement of approximately 1,000 chum in early 1950's
- Between 1961 and 1966, the Mayfield Dam fish passage facility counted 58 chum
- Typically less than 20 adults are collected annually at the Cowlitz Salmon Hatchery

Productivity & Persistence

- Anadromous chum production primarily in lower watershed
- Harvest, habitat degradation, and to some degree construction of Mayfield and Mossyrock Dams contributed to decreased productivity



Hatchery

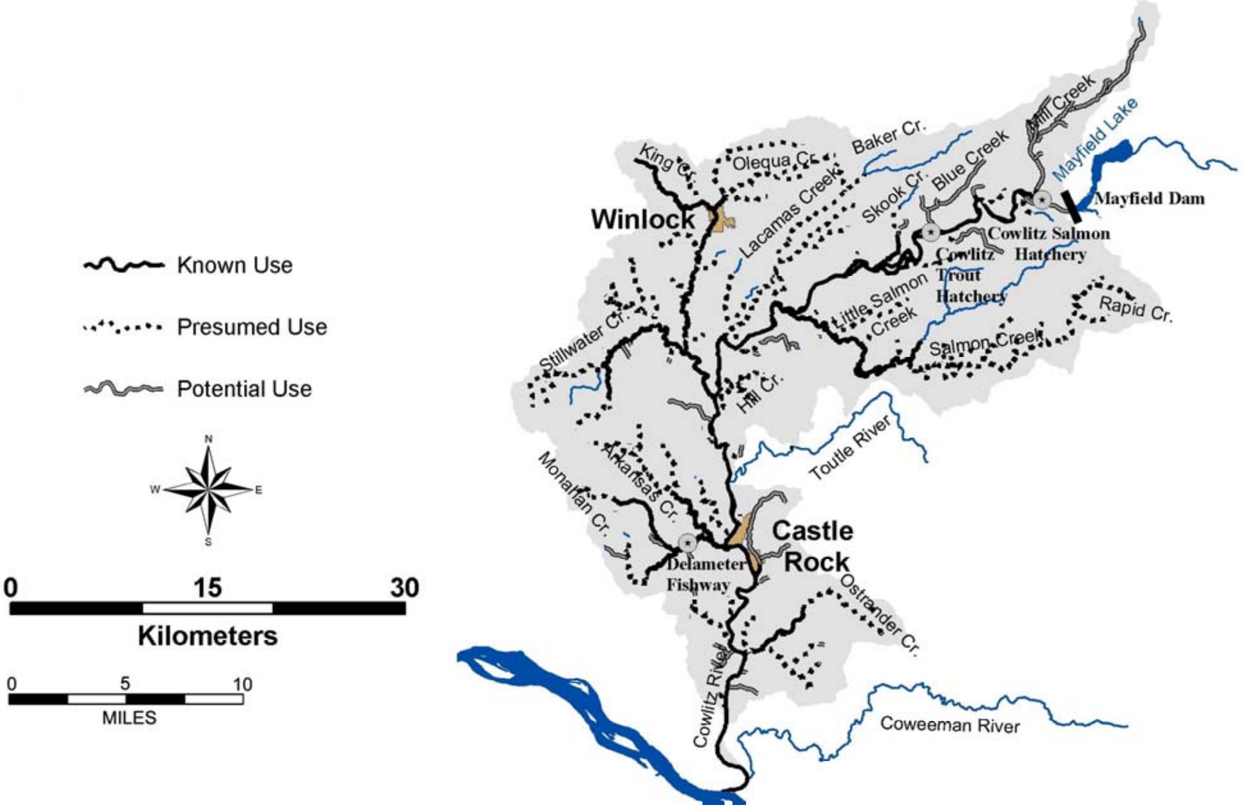
- Cowlitz Salmon Hatchery does not produce/release chum salmon
- Chum salmon are captured annually in the hatchery rack

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

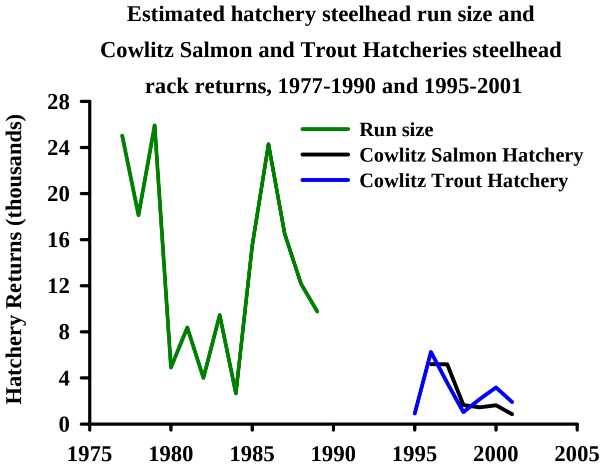
8.2.4 Winter Steelhead—Cowlitz Subbasin (Cowlitz)

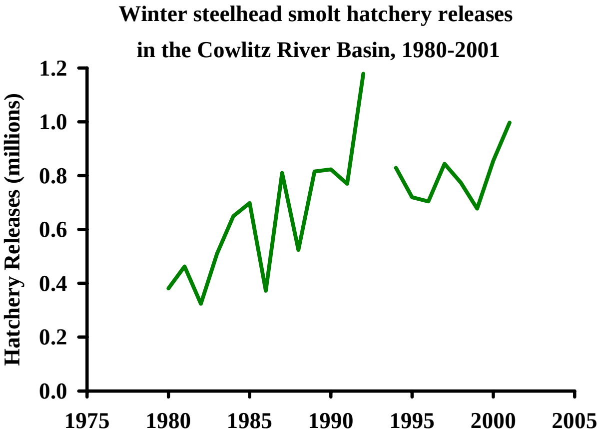
ESA: Threatened 1998	SASSI: Unknown 2002



Distribution

- Winter steelhead are distributed throughout the mainstem Cowlitz below Mayfield Dam; natural spawning occurs in Olequa, Ostrander, Salmon, Arkansas, Delameter, Stillwater and Whittle Creeks
- Historically, winter steelhead were distributed throughout the upper Cowlitz, Cispus, and Tilton Rivers; known spawning areas include the mainstem Cowlitz near Riffle and the reach between the Muddy Fork and the Clear Fork and the lower Ohanapecosh River
- Construction of Mayfield Dam in 1963 blocked winter steelhead access to the upper watershed; approximately 80% of the spawning and rearing habitat are not accessible
- In 1994, a trap and haul program began to reintroduce anadromous salmonids to the watershed above Cowlitz Falls Dam; adult winter steelhead are collected at the Cowlitz hatcheries and released in the Upper Cowlitz, Cispus, and Tilton basins; smolts resulting from natural production in the upper watershed are collected at the Cowlitz Falls Fish Collection Facility, acclimated at the Cowlitz Salmon Hatchery, and released in the mainstem Cowlitz


Estimated hatchery steelhead run size and Cowlitz Salmon and Trout Hatcheries steelhead rack returns, 1977-1990 and 1995-2001


Winter steelhead smolt hatchery releases in the Cowlitz River Basin, 1980-2001

Life History

- Adult migration timing for Cowlitz winter steelhead is from December through April
- Spawning timing on the Cowlitz is generally from early March to early June
- Limited age composition data for Cowlitz River winter steelhead indicate that the dominant age classes are 2.2 and 2.3 (54.2% and 32.2 %, respectively)
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Cowlitz winter steelhead stock designated based on distinct spawning distribution
- Concern with wild stock interbreeding with hatchery brood stock from Chambers Creek and the Cowlitz River (Cowlitz and late Cowlitz stock)
- Allele frequency analysis of Cowlitz Hatchery late winter steelhead in 1996 was unable to determine the distinctiveness of the stock compared to other lower Columbia steelhead stocks

Abundance

- Historically, annual wild winter steelhead runs to the Cowlitz River were estimated at 20,000 fish; escapement was estimated as 11,000 fish
- In 1936, steelhead were observed in the Cispus River and reported in the Tilton River during escapement surveys
- Between 1961 and 1966, an average of 11,081 adult steelhead were collected annually at the Mayfield Dam Fish Passage Facility
- In the late 1970s and 1980s, wild winter steelhead annual average run size in the Cowlitz River was estimated to be 309 fish
- From 1983-1995, the annual escapement of Cowlitz River (hatchery and wild)winter steelhead ranged from 4,067 to 30,200 (average 16,240)

Productivity & Persistence

- In the late 1970s and 1980s, wild winter steelhead contribution to the annual winter steelhead return was estimated to be 1.7%
- Estimated potential winter steelhead smolt production for the Cowlitz River is 63,399

Hatchery

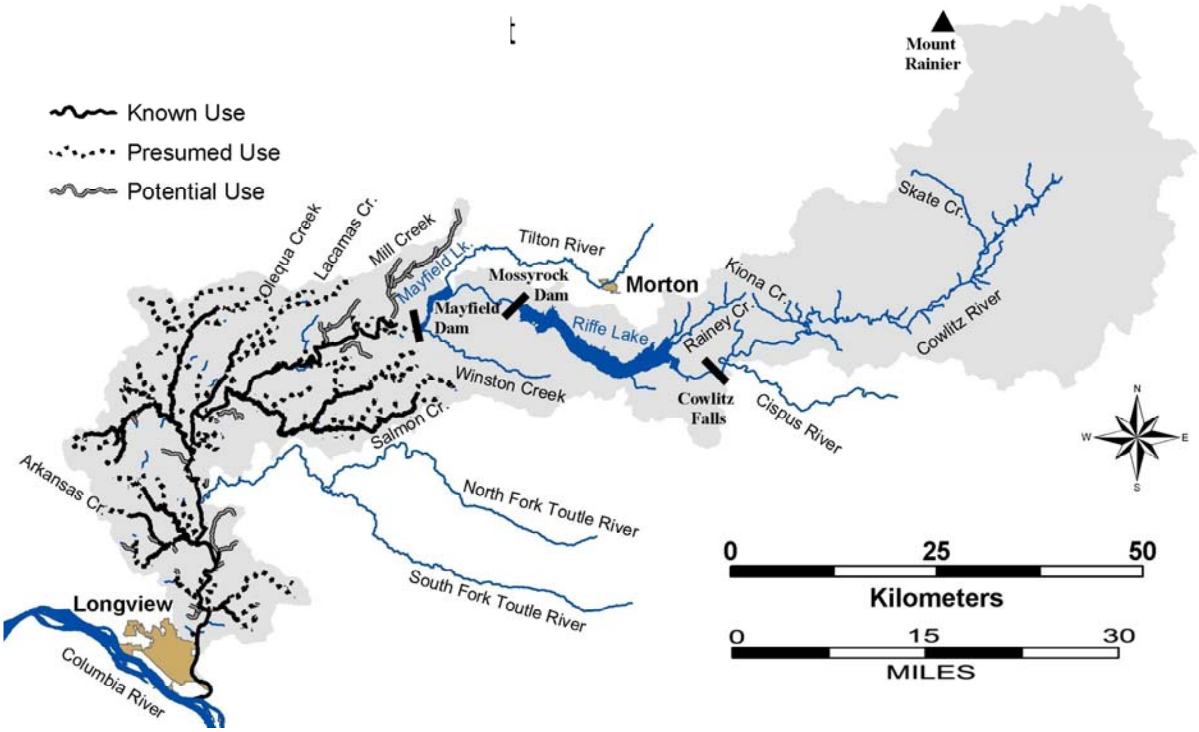
- The Cowlitz Trout Hatchery, located on the mainstem Cowlitz at RM 42, is the only hatchery in the Cowlitz basin producing winter steelhead
- Hatchery winter steelhead have been planted in the Cowlitz River basin since 1957; broodstock from the Cowlitz River and Chambers Creek have been used; an annual average of 180,000 hatchery winter steelhead smolts were released in the Cowlitz River from 1967-1994; smolt release data are displayed from 1980-2001
- Hatchery fish account for the majority of the winter steelhead run to the Cowlitz River basin

Harvest

- No directed commercial or tribal fisheries target Cowlitz winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Steelhead sport fisheries in the Columbia must release wild winter steelhead which are not marked with an adipose fin clip
- ESA limits fishery impact of Cowlitz wild winter steelhead in the mainstem Columbia and in the Cowlitz River
- Approximately 6.2% of returning Cowlitz River steelhead are harvested in the Columbia River sport fishery
- Wild winter steelhead sport harvest in the Cowlitz River from in the late 1970s and early 1980s ranged from 102-336; wild winter steelhead contribution to the total annual sport harvest was less than 2%
- The Cowlitz River may be the most intensely-fished basin in the Washington sport fisheries; the Cowlitz has been the top winter steelhead river in Washington

8.2.5 Cutthroat Trout—Cowlitz River Subbasin

ESA: Not Listed **SASSI: Depressed 2000**

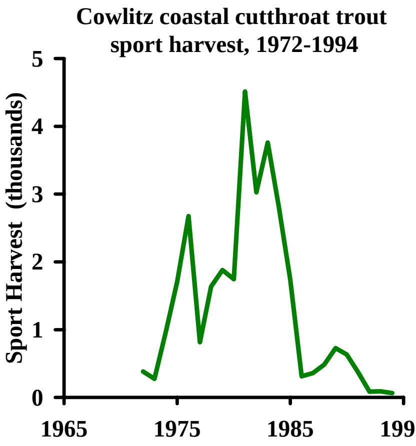


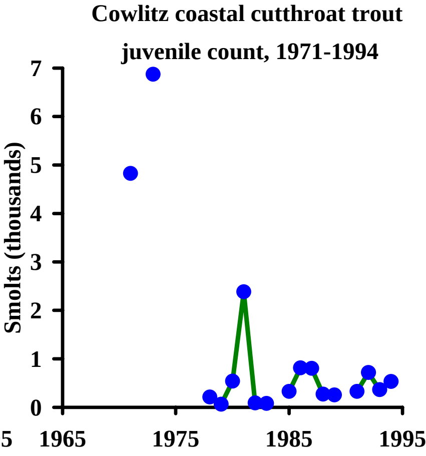
Distribution

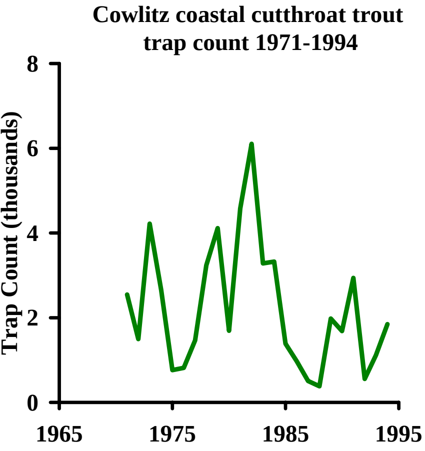
- Anadromous forms were historically present throughout the watershed, but are now limited to the area downstream of Mayfield Dam, which block passage
- Adfluvial forms are present in Mayfield, Riffe, and Scanewa Reservoirs
- Resident forms are documented throughout the system and are the only form present upstream of Mayfield Dam

Life History

- Anadromous, adfluvial, fluvial and resident forms are present
- Anadromous river entry is from July through October, with peak entry in August and September
- Anadromous spawning occurs from January through mid-April
- Fluvial and resident spawn timing is not documented but is believed to be similar to anadromous timing
- Spawn timing at higher elevations is likely later, and may occur as late as June
- Hatchery cutthroat spawn from November to February, due to artificial selection for early spawn timing
- Smolt migration occurs in the spring after juveniles have spend 2 to 3 years in fresh water


Cowlitz coastal cutthroat trout sport harvest, 1972-1994


Cowlitz coastal cutthroat trout juvenile count, 1971-1994


Cowlitz coastal cutthroat trout trap count 1971-1994

Diversity

- Distinct stock based on geographic distribution of spawning areas
- Genetic sampling of ten groups within the Cowlitz system showed little difference among the groups
- Cowlitz collections were significantly different from other lower Columbia samples, except for Elochoman/Skamakowa Creek.

Abundance

- Anadromous counts at Mayfield Dam from 1962 to 1996 ranged from 5458 to 12,324 fish, and averaged 8698
- Outmigrant trapping at Mayfield migrant trap shows a long term declining trend
- Recent years' counts average about 10% of outmigrant counts when sampling began in the early 60s
- Smolt counts have been under 1000 every year since 1978, with the exception of 1982
- No population size data for resident forms

Hatchery

- Cowlitz Trout Hatchery began producing anadromous cutthroat in 1968
- The goal is 115,000 smolts larger than 210 mm to produce a return to the hatchery of 5000 adults

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia River summer fisheries downstream of the Cowlitz River
- Cowlitz River sport harvest for hatchery cutthroat can be significant in year of large adult returns.
- Wild cutthroat (unmarked fish) must be released

8.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat has significant impacts on fall chinook, chum, winter steelhead and coho in the lower Cowlitz.
- Loss of estuary habitat is moderately important for fall chinook and chum, but is not of great importance for spring chinook, winter steelhead or coho.
- Harvest has moderately high impacts for fall chinook and coho, but has minor impacts on winter steelhead and chum.
- Hatchery impacts are moderately important to all four populations.
- Predation is of moderate to minor importance for each of the lower Cowlitz populations.

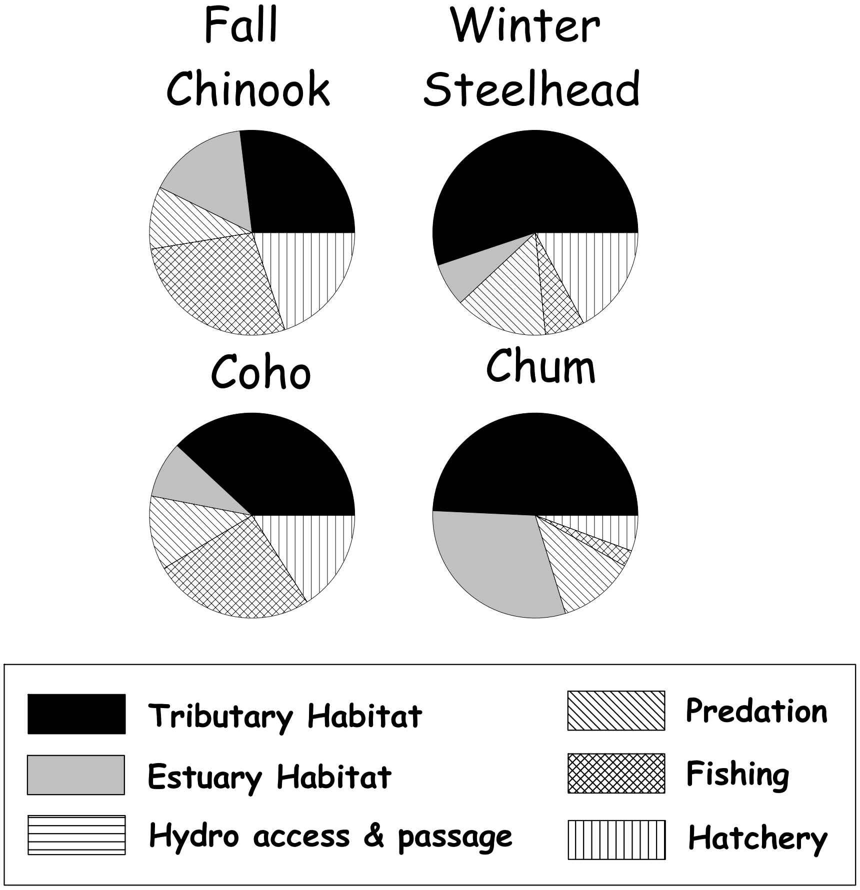


Figure 8-5. Relative index of potentially manageable mortality factors for each species in the Lower Cowlitz subbasin.

8.4 Hatchery Programs

Hatcheries have operated in the Cowlitz River basin since the early 1900s. For example, the Tilton River Hatchery released coho salmon in the Cowlitz River from 1915–21 and a salmon hatchery operated in the upper Cowlitz near the mouth of the Clear Fork until 1949. Three hatcheries currently operate in the basin: the Cowlitz Salmon Hatchery, the Cowlitz Trout Hatchery, and the North Toutle Hatchery (formerly the Green River Hatchery). The three hatcheries coordinate annual production efforts and are collectively referred to as the Cowlitz River Hatchery Complex.

- The Cowlitz Salmon Hatchery, completed in 1967, is approximately two miles downstream of Mayfield Dam. Current production goals are 5 million fall chinook juveniles released in the Cowlitz River, approximately 1.2 million spring chinook smolts (967,000 into the lower Cowlitz, and 100,000 to the Deep River net pens), 300,000 spring chinook fry for release into the upper Cowlitz above Cowlitz Falls Dam, and 3.2 million late-stock coho smolts (Figure 8-6).
- The Cowlitz Trout Hatchery is located on the mainstem Cowlitz at RM 42. Current production goals include 300,000 early run winter steelhead smolts released to the lower Cowlitz River; 352,500 late-run winter steelhead smolts to the lower Cowlitz River; 250,000 fingerlings and 37,500 late-run winter steelhead smolts to the upper Cowlitz and Cispus rivers, and 100,000 late-run winter steelhead fingerlings to the Tilton River; 500,000 summer steelhead smolts in the lower Cowlitz River; 100,000 sea run cutthroat trout fingerlings in the Tilton River; and 160,000 sea-run cutthroat trout fingerlings in the Cowlitz River and Blue Creek (Figure 8-6).

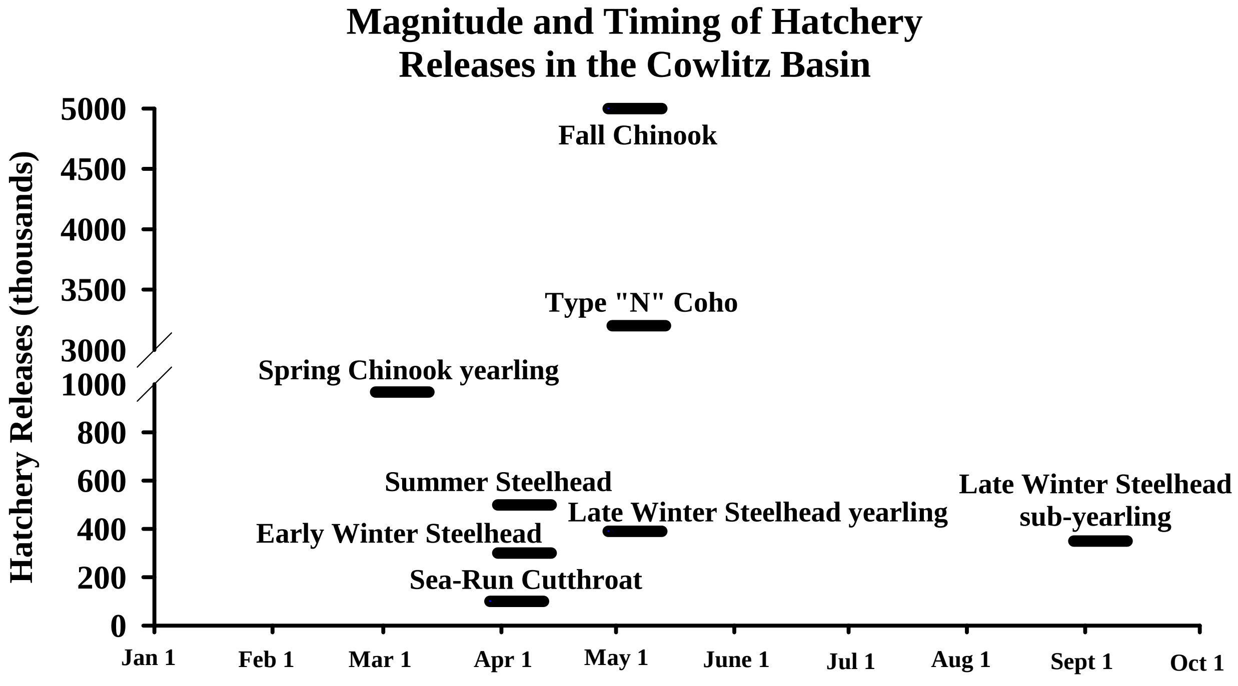


Figure 8-6. Magnitude and timing of hatchery releases in the Cowlitz River basin by species, based 2003 brood production goals.

- The North Toutle Hatchery, on the Green River less than a mile upstream of the confluence with the NF Toutle River, began operations in 1956 and was destroyed in the 1980 Mt. St.

Helens eruption. Rearing ponds near the hatchery site were developed after the eruption and operations were restored in 1985. The rebuilt hatchery resumed collecting broodstock in 1990. Current hatchery release goals are 2.5 million sub-yearling fall chinook, 800,000 early-stock coho smolts, and 50,000 summer steelhead (from Skamania Hatchery) smolts (Figure 8-7). Rearing ponds located at RM 8 on the Coweeman River are used to acclimate winter steelhead for release in the basin. Annual production goals are 14,000 smolts; an additional 6,000 smolts are released directly to the Coweeman River without acclimation at the ponds (Figure 8-7).

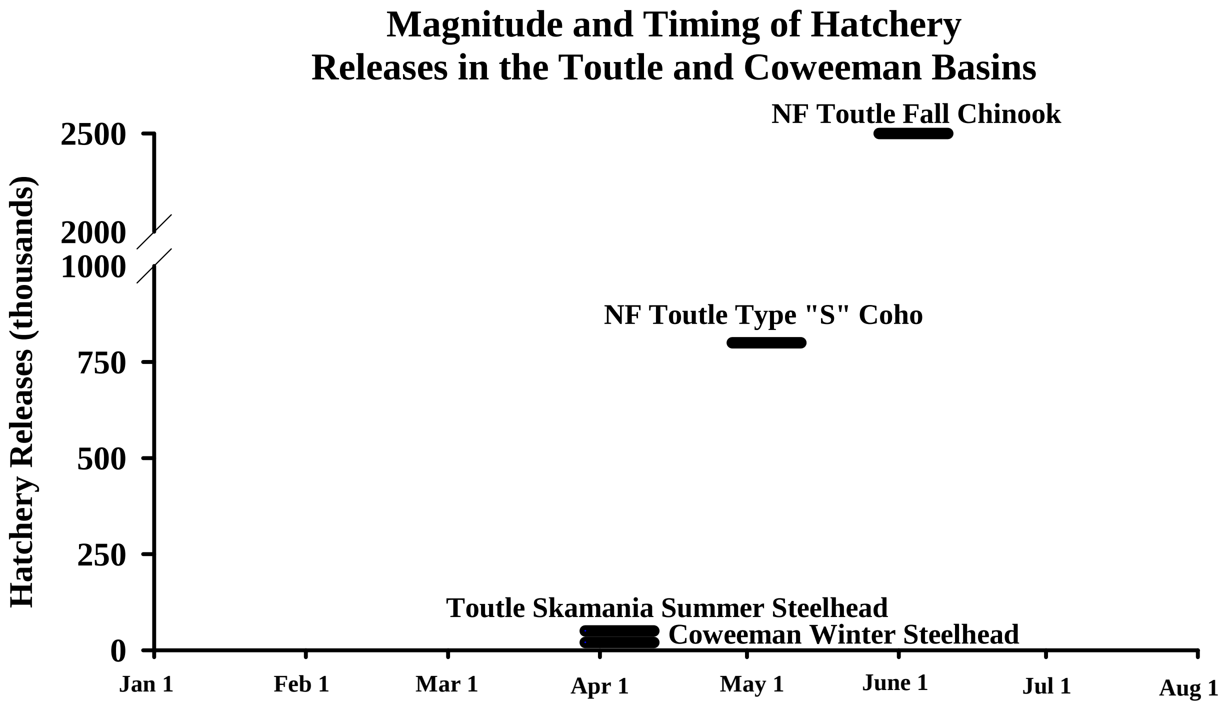


Figure 8-7. Magnitude and timing of hatchery releases in the Toutle and Coweeman River basins by species, based on 2003 brood production goals.

Genetics—Broodstock for fall chinook at the Cowlitz Salmon Hatchery have come almost entirely from native Cowlitz fall chinook, with hatchery fall chinook transfers into the Cowlitz in a few years. There have been no transfers of fall chinook into the Cowlitz since 1990, and past transfers have all come from hatcheries within the Lower Columbia ESU. Genetic analysis from the 1980s indicated that Cowlitz Salmon Hatchery fall chinook were similar to, but distinct from, Kalama Hatchery fall chinook and distinct from other Washington fall chinook stocks in the lower Columbia River.

Fall chinook broodstock at the North Toutle Hatchery have been primarily collected from the Toutle River although there have been been significant transfers made from lower Columbia ESU hatchery stocks, most significantly Spring Creek Hatchery and Kalama Hatchery fall chinook. Specific genetic data is not available for Toutle Fall chinook.

Fall chinook in the Coweeman River basin are considered wild fish with little hatchery influence. Hatchery fall chinook from the Spring Creek, Washougal, and Toutle Hatcheries were released periodically in the Coweeman during 1951–1979, but releases were discontinued in 1980. Since the early 1980s, hatchery-tagged fall chinook have not been recovered in the

Coweeman basin during spawning surveys, indicating the population is not influenced by stray hatchery fish.

Spring chinook broodstock for the Cowlitz Salmon Hatchery has been almost exclusively collected from Cowlitz River native spring chinook (In the late 1960s there were fewer then a million Willamette spring chinook released into the Cowlitz). Genetic analysis in the 1980s indicated that Cowlitz Salmon Hatchery spring chinook were genetically similar to, but distinct from, Kalama Hatchery and Lewis River wild spring chinook and significantly different from other lower Columbia River spring chinook stocks.

Broodstock for the coho salmon hatchery programs has come from native Cowlitz River (Cowlitz Salmon Hatchery) and Toutle River (North Toutle Hatchery) stocks. These stocks also have been used as broodstock for other lower Columbia River coho hatchery programs. Late stock coho salmon (Type N) and early coho salmon (Type S) are informally considered synonymous with Cowlitz River and Toutle River coho stocks, respectively. Columbia River early and late stock coho salmon produced from Washington hatcheries have not been found to be genetically different.

Both early and late winter steelhead hatchery programs exist at the Cowlitz Trout Hatchery. Broodstock for the early winter steelhead has come from a combination of Chambers Creek, Elochoman River, and Cowlitz River winter steelhead. Broodstock for the late-run winter steelhead program has come only from the Cowlitz River late winter steelhead stock. Genetic analysis in the mid-1990s was unable to determine the distinctiveness of Cowlitz basin winter steelhead from other lower Columbia winter steelhead stocks. Broodstock for the summer steelhead hatchery program at the Cowlitz Trout Hatchery and the North Toutle Hatchery originated from Skamania stock. The North Toutle Hatchery continues to receive broodstock from the Skamania Hatchery, while summer steelhead broodstock for the Cowlitz program is collected at the Cowlitz Trout and Salmon hatcheries. Winter steelhead broodstock for smolts acclimated and released from the Coweeman rearing ponds comes from hatchery returns to the Elochoman River Hatchery.

Broodstock for the cutthroat trout program at the Cowlitz Trout Hatchery originated from native Cowlitz River sea-run cutthroat trout with some limited influence from Beaver Creek stocks. Current broodstock collection comes from adults returning to the hatchery.

Interactions—Hatchery fall chinook account for most adults returning to the Cowlitz, Toutle, and Green rivers. Hatchery returns are approximately double the natural escapement in the Cowlitz basin (Figure 8-8 and Figure 8-9). Many natural spawners are expected to be first generation hatchery fish; wild fish abundance is likely low. The Toutle and Green River fall chinook populations are being re-established after the 1980 Mt. St. Helens eruption. Depending on the rebuilding success of these populations, the potential for wild/hatchery fish interactions may increase. The lower Cowlitz River downstream of the Cowlitz Salmon Hatchery barrier dam is an important rearing area for naturally produced fall chinook. Hatchery-origin fall chinook released in the lower Cowlitz may compete with natural-origin fall chinook for food and space; research to study this potential interaction is in progress. Hatchery-origin fall chinook fingerlings released in the lower Cowlitz also may be preyed upon by wild steelhead and cutthroat trout smolts.

Hatchery spring chinook account for most adults returning to the Cowlitz River (Figure 8-8). Hatchery spring chinook are released downstream of the Hatchery Barrier Dam as smolts for the harvest mitigation program and into the upper Cowlitz (upstream of Cowlitz Falls Dam) as subyearlings to supplement the natural reintroduction program. Some predation by hatchery-origin smolts may occur on naturally produced fall chinook, coho, or chum fry. However, the potential for these interactions is minimized by timing the release of hatchery smolts (March) to when the fish are smolted and prepared to quickly emigrate from the river to the Columbia estuary.

Hatchery coho salmon, account for most adults returning to the Cowlitz and Toutle rivers (Figure 8-8 and Figure 8-9). Significant coho production can occur in the upper Cowlitz basin from adults transplanted from the lower river; these fish are usually first generation hatchery fish. The smolt-to-adult survival of naturally produced coho juveniles in the upper Cowlitz has been low in the initial years of the program, so few naturally produced coho adults have been available for transplanting to the upper Cowlitz. Hatchery smolts released in the lower Cowlitz River potentially compete with wild fall chinook, steelhead, and chum salmon for food and space, but competition is limited to smolt migration time through the basin. Migration time is minimized by releasing smolts (in May) when they are prepared to move towards the Columbia estuary.

Hatchery fish account for most winter steelhead adults returning to the Cowlitz and Coweeman rivers (Figure 8-8). In the Toutle River system, the winter steelhead annual return is thought to be primarily comprised of naturally produced fish (Figure 8-9). Potential for interaction between wild and hatchery adults is expected to be low because of relative numbers of natural and hatchery fish and temporal and spatial segregation. Summer steelhead are not expected to reproduce naturally in the Cowlitz River (Figure 8-8) because they are introduced to the basin and there is no intention for a naturally reproducing population. Hatchery summer and winter steelhead smolts are released from the Cowlitz Trout Hatchery and Coweeman rearing ponds in May at a size and stage of smoltification intended to minimize travel time during emigration. Preliminary data suggests that steelhead smolts move downstream rapidly at approximately 20 miles per day so competition with native and non-native species in the lower Cowlitz is considered low. However, steelhead smolts that residualize may actively prey upon spring and fall chinook, coho, and chum fry that are present in the lower Cowlitz River basin. Large releases of hatchery smolts may attract additional predators causing increased predation on wild fish, but conversely, wild fish may benefit from the presence of large numbers of hatchery fish because wild fish usually have better predator avoidance capabilities.

Hatchery sea-run cutthroat trout account for most adults returning to the Cowlitz River (Figure 8-8). A natural population (anadromous and resident below the dams and resident above the dams) exists but is assumed to be relatively small. Hatchery sea run cutthroat trout smolts are released from the Cowlitz Trout Hatchery in April at a target size of 8.3 in (210 mm) FL; trout at this size generally exhibit smolt characteristics and rapidly emigrate. Hatchery cutthroat smolts have the potential to compete for food and space or to prey on juvenile fish in the system, however, competition with native and non-native species in the lower Cowlitz is considered low. Competition with, and predation on, other salmonids is likely greater when cutthroat trout smolts residualize.

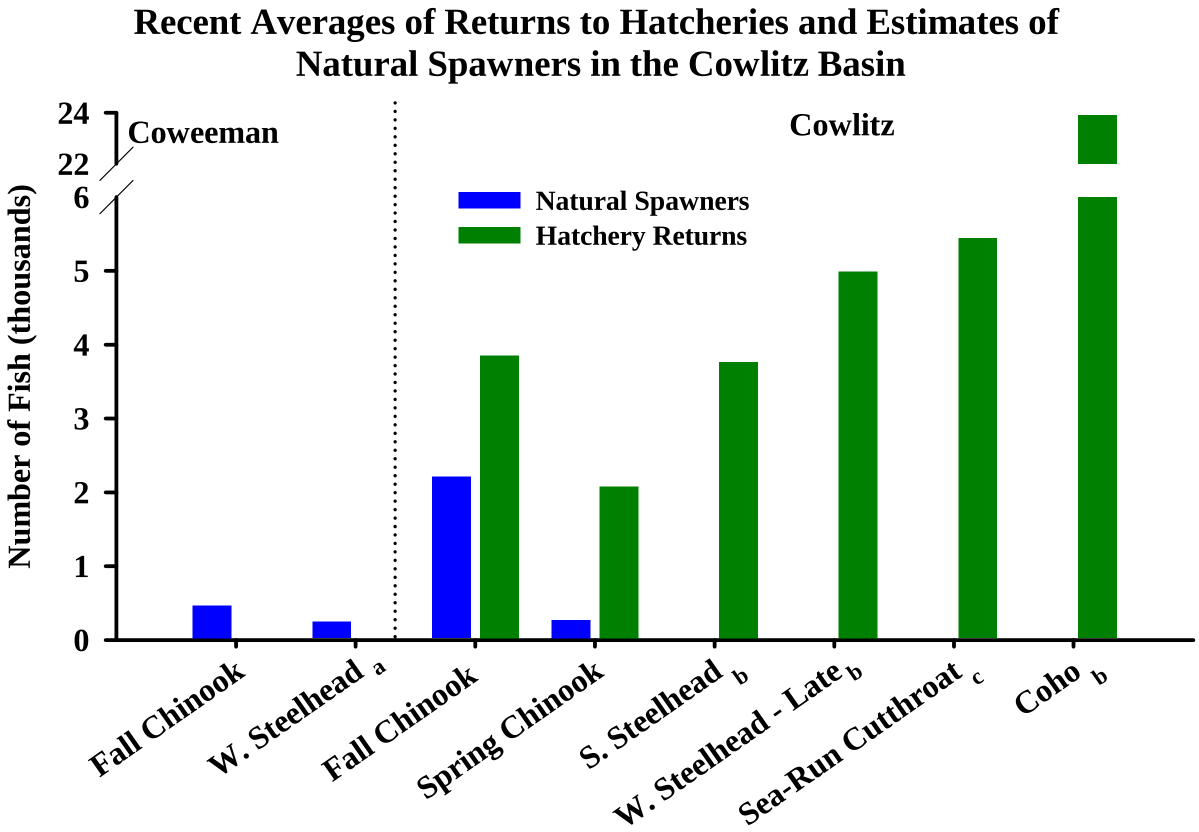


Figure 8-8. Recent average hatchery returns and estimates of natural spawning escapement in the Cowlitz River basin by species.

The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present. Calculation of each average utilized a minimum of 5 years of data.

[a] There is no hatchery facility in the basin to enumerate and collect returning adult hatchery fish. All hatchery fish released in the basin are intended to provide harvest opportunity.

[b] A natural stock for this species and basin has not been identified based on populations in WDFW's 2002 SASSI report; to date, escapement data are not available.

[c] Although a natural population of this species exists in the basin based on populations identified in WDFW's 2002 SASSI report, escapement surveys have not been conducted and the stock status is unknown.

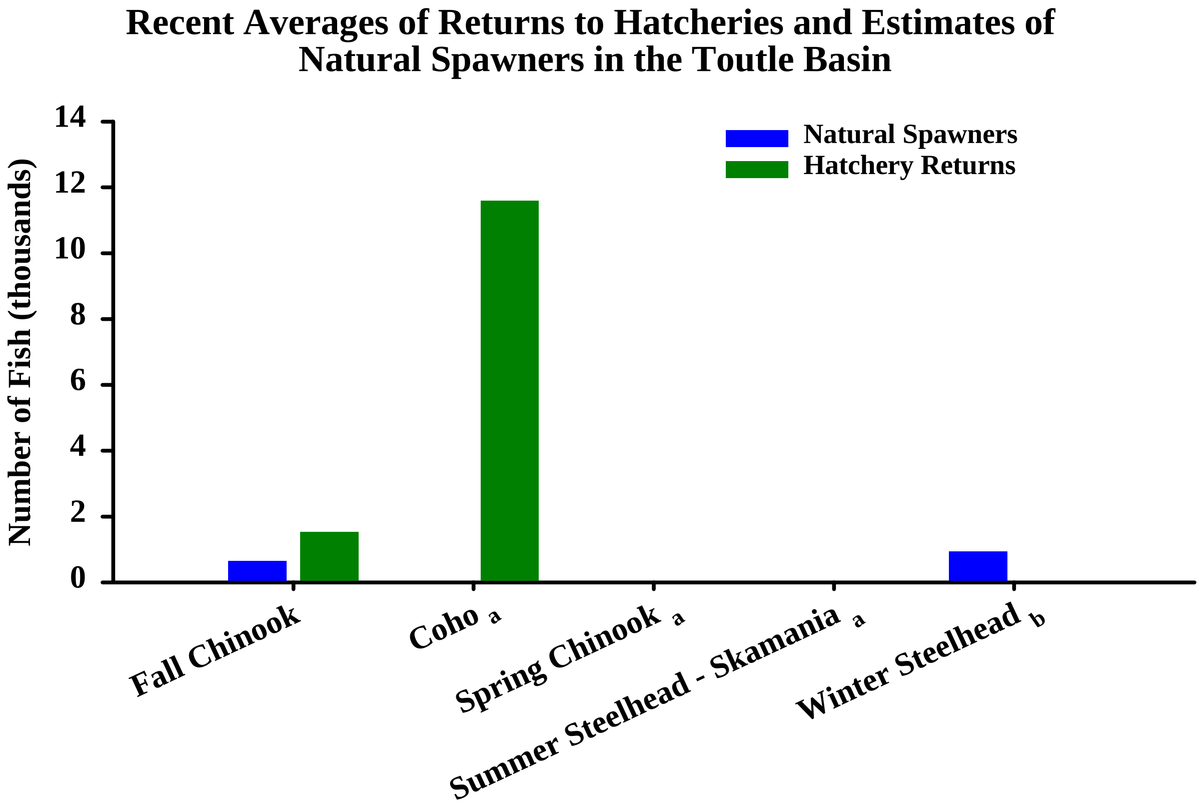


Figure 8-9. Recent average hatchery returns and estimates of natural spawning escapement in the Toutle River basin by species.

The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present. Calculation of each average utilized a minimum of 5 years of data.

[a] A natural stock for this species and basin has not been identified based on populations in WDFWs 2002 SASSI report; to date, escapement data are not available.

[b] Data may exist but was not obtained by the time of publication of this report.

Water Quality/Disease—Water for the Cowlitz Salmon Hatchery comes from three sources. The majority of water is supplied from the Cowlitz River, with an average 75,000 gpm available to the rearing ponds and 15,000 gpm available for the fish separator and ladder. Two separate well systems provide 1,000 and 700 gpm, respectively, between August and April and generally are used for egg incubation and early fry rearing. During incubation, salmon *Saprolegniasis* (fungus) is the primary concern and requires daily formalin treatments at 1:600 for 15 minutes. Excessive gas in the incubation effluent is variable and may be associated with periodic increases in yolk coagulation in eggs and fry. Water flow to fry is kept below 6 gpm to reduce or eliminate Bacterial Cold Water Disease (BCWD). A fish pathologist routinely checks for Infectious Hematopoeitic Necrosis Virus (IHNV) and Bacterial Kidney Disease (BKD). All equipment in the rearing ponds is sanitized with an iodine solution after each use.

Water for the Cowlitz Trout Hatchery also comes from three sources. Nine shallow wells on either side of the river provide up to 5 cfs. The well water is generally used for initial rearing and for water temperature regulation throughout the facility. The north well has had some bacteria and gas problems, is not used, and may be abandoned. An ozone plant operates from

May to December to disinfect up to 20 cfs of Cowlitz River water; the ozone plant removes pathogens (primarily *Ceratomyxa shasta*) present in the river water. Untreated river water up to 50 cfs is available when the ozone plant is not in operation. All water entering the facility is stored in basins, where it flows to the fish rearing ponds via gravity. Because of a limited water supply, all water is reused in the lower rearing ponds and some may be used three times without treating. Hatchery staff follows protocols in the Fish Health Manual to reduce the occurrence of disease. During incubation, diseases that occur include BCWD and *Trichodina*. Rearing fish are routinely examined by hatchery staff and a fish health specialist; treatments are prescribed accordingly.

Water for the North Toutle Hatchery comes from the Green River; the hatchery has a water right totaling 26,031 gpm. A rearing site associated on the South Fork Toutle River utilizes 3-4 cfs directly from the river. Rearing ponds at the facility are sanitized with chlorine at 20 parts per million before being stocked with fry. Equipment used at the rearing ponds is routinely disinfected with an iodine solution. Fish are monitored throughout the rearing phase by WDFW pathologists.

Water for the Coweeman rearing ponds comes directly from tributary creeks of the Coweeman River. Operations of the acclimation ponds are not subject to NPDES requirements, thus discharge water quality parameters are not monitored. Fish health is monitored daily and the area fish health specialist conducts monthly visits and advises disease treatment. Sanitizing rearing pond equipment is done according to the Fish Health Manual.

Mixed Harvest—The purpose of the fall chinook hatchery program at the Cowlitz Salmon Hatchery is to mitigate for losses resulting from hydroelectric development in the basin. Historically, exploitation rates of hatchery and wild fall chinook likely were similar. Fall chinook are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as in Cowlitz River recreational fisheries. CWT data analysis of the fall chinook 1989–1994 brood years from the Cowlitz Salmon and North Toutle hatcheries indicate a 33% and 41% exploitation rate, respectively, leaving 67% and 59% of the respective adult return for escapement. Exploitation of wild fish during the same period likely was similar. Hatchery and wild fall chinook harvest rates remain similar and are now constrained by ESA harvest limitations.

At the Cowlitz Salmon Hatchery, the spring chinook program mitigates for salmon lost as a result of hydroelectric development in the basin. The program provides fish for harvest while minimizing adverse effects on ESA-listed fish. Historically, exploitation rates of hatchery and wild spring chinook were likely similar. Spring chinook are an important target species in Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years from the Cowlitz Salmon Hatchery indicate a 40% exploitation rate on spring chinook; 60% of the adult return was accounted for in escapement. Most of the harvest occurred in the Cowlitz River sport fishery. Exploitation of wild fish during the same period likely was similar. Selective fisheries targeting hatchery spring chinook have been implemented in recent years in the mainstem Columbia sport and commercial fisheries and in the Cowlitz River sport fishery. Regulations allowing retention of hatchery fish and requiring release of wild fish increase opportunity to catch hatchery fish and significantly decrease impacts to wild fish. The selective fishery program enables the spring chinook reintroduced into the upper Cowlitz to pass through the fisheries.

Mitigating for late run coho salmon lost as a result of hydroelectric development is a goal of the Cowlitz Salmon Hatchery coho salmon program. The program provides fish for harvest while minimizing adverse effects on ESA-listed fish. All hatchery smolts are adipose fin-clipped to allow for selective harvest. Ocean and Columbia River sport and commercial fisheries and Cowlitz River sport fisheries benefit from this program. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. Ocean and Columbia River combined harvest of Columbia River-produced coho ranged from 70% to over 90% during 1970–1983. To protect several wild coho stocks, ocean fisheries were limited beginning in the mid-1980s and Columbia River commercial fisheries were temporally adjusted in the early 1990s. With the advent of selective fisheries for marked hatchery fish, exploitation of wild coho has been reduced, while hatchery fish can be harvested at higher rates. Currently, Cowlitz wild coho benefit from ESA harvest restrictions placed on Oregon Coastal natural coho (federal listing) in ocean fisheries and Oregon Lower Columbia natural coho (state listing) in Columbia River fisheries.

At the Cowlitz Trout Hatchery, the early and late winter steelhead hatchery programs mitigate for winter steelhead lost as a result of hydroelectric development in the basin; the program provides fish for harvest while minimizing adverse effects on ESA-listed fish. Fisheries that benefit include lower Columbia and Cowlitz River sport fisheries; approximately 6.2% of the returning Cowlitz Trout Hatchery steelhead are harvested in the lower Columbia River sport fishery and about 70% are harvested in the Cowlitz River sport fishery. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead likely were similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and Washington tributaries became selective during 1986–1992 (except the Toutle in 1994). Current selective harvest regulations in the lower Columbia and tributary sport fisheries have targeted hatchery steelhead and limited harvest of wild winter steelhead to less than 10% (estimated at 6% for the Cowlitz tributary sport fishery). In the Cowlitz River, winter steelhead originating from the upper Cowlitz are marked with a right ventral fin clip and are protected from harvest in the lower Cowlitz fishery. Ventral fin-clipped fish that return to either of the Cowlitz River hatcheries are transported to the upper Cowlitz River to provide harvest opportunity for anglers and spawners for the reintroduction program.

The Coweeman rearing ponds provide winter steelhead for tributary sport harvest opportunity. Sport fisheries in the Coweeman, lower Cowlitz, and lower Columbia rivers benefit from this program. Selective fishery regulations allow for protection of wild winter steelhead while maximizing harvest rates on Coweeman hatchery winter steelhead. The Coweeman tributary fishery harvest rate for hatchery winter steelhead is estimated to be 30% with a 4% mortality impact estimated for wild winter steelhead.

At the Cowlitz Trout Hatchery and the North Toutle Hatchery, the summer steelhead hatchery programs mitigate for steelhead lost as a result of hydroelectric development in the basin and provide harvest opportunity. Summer steelhead are introduced to the basin; there is no intention of trying to develop a self-sustaining population of summer steelhead. Fisheries that benefit include tributary and lower Columbia River recreational fisheries. Selective fishing regulations and the differences in the timing of runs focus harvest on hatchery summer steelhead and minimize effects to wild steelhead.

The Cowlitz Trout Hatchery's sea-run cutthroat trout program mitigates for losses resulting from hydroelectric development in the basin and provides harvest opportunity. These fish contribute to the tributary sport fishery; harvest effects on wild fish should be minimal because of the differences in the timing of runs of cutthroat trout and regulations about minimum size, bag limit, and wild cutthroat trout release.

Passage—At the Cowlitz Salmon Hatchery, the adult collection facility is a barrier dam across the entire width of the river that prevents upstream migration of all returning salmonids. Returning adults enter through a fish ladder into a sorting, transfer, and holding facility. Fish to be retained for broodstock are directed to the holding facilities, while fish to be transported and released in the upper watershed are directed toward transfer facilities. If fish are able to bypass collection, Mayfield Dam—with no fish passage facilities—is approximately two miles upstream.

At the Cowlitz Trout Hatchery, the adult collection facility consists of a weir and fish ladder in Blue Creek and upstream migration in the mainstem Cowlitz River is unimpeded. Fish are hand-sorted and retained in adult holding ponds if they are needed for broodstock. Fish exceeding broodstock needs are transferred back to the river, or to the Cowlitz Salmon Hatchery, via specialized fish tanker trucks.

At the North Toutle Hatchery, the adult collection facility is a temporary weir for collecting coho salmon and fall chinook. The weir is installed and removed annually and only effects fish passage during the time of adult coho and fall chinook collection.

There are no adult collection facilities at the Coweeman rearing ponds. Hatchery programs at this facility obtain broodstock from other hatchery facilities.

Supplementation—The Cowlitz Salmon Hatchery spring chinook program is partly intended to restore natural spawning populations of spring chinook in the upper Cowlitz River basin. Current production goals are 300,000 fingerling spring chinook for annual release. As well, hatchery-origin adult returns in excess of annual broodstock needs are transported above Cowlitz Falls Dam as part of the reintroduction program. Reintroduction efforts have been challenged by low success in collecting emigrating juveniles to pass through the hydro system.

This hatchery’s late stock coho salmon (Type-N) program also provides for restocking of the upper Cowlitz basin. Annual production goals depend on the availability of adults for natural spawning in the upper basin. If insufficient adults are available, the release goal is 1 million fry annually in the upper Cowlitz. Reintroduction efforts indicate good production capabilities in tributaries above the dams. Although coho smolt collection at the hydroelectric facility has been more successful then chinook, reintroduction efforts are also challenged in passing juveniles through the system.

The Cowlitz Trout Hatchery has an annual goal of restoring natural spawning late-run winter steelhead populations in the upper Cowlitz and Tilton River basins. Current annual release goals are 350,000 fingerlings and 37,500 smolts in the upper watershed. Juvenile downstream migrant passage is better at the hydro-facility then for chinook, and similar to coho.

8.5 Fish Habitat Conditions

8.5.1 Passage Obstructions

The hydropower system blocks upstream passage and has flooded many miles of stream habitat. Now, 100 percent of fall chinook and 60 percent of steelhead spawning in the Cowlitz River mainstem occurs in the lower basin (Mobrand Biometrics 1999). The Cowlitz River Barrier Dam (RM 49.5) blocks most anadromous fish and the Mayfield Dam presents a complete barrier. Some stocks are collected at the Barrier Dam and passed into upper basin streams. A notable passage barrier is a hydroelectric dam on Mill Creek (confluence near the Barrier Dam) that blocks approximately 5.2 miles of anadromous habitat. Culverts, floodgates, inadequate fish ladders, and dams present passage barriers to anadromous fish in many of the smaller tributaries to the lower mainstem Cowlitz. A full description can be found in the limiting factors analysis (Wade 2000).

8.5.2 Stream Flow

Runoff is predominantly generated by rainfall, with a portion of spring flows coming from snowmelt in the upper elevations and occasional winter peaks from rain-on-snow events. Flow in the mainstem is regulated in large part by the hydropower system. Mayfield Dam (RM 52) is operated by Tacoma Power and has a relatively small (133,764 acre-foot) capacity. Behind Mayfield Dam, Mayfield Lake provides little flood storage capacity and flows from Mayfield Dam are largely in response to the regulation of flows through Mossyrock Dam upstream.

Flood flows in the lower mainstem have been substantially reduced due to flow regulation at the dams. Low summer flows have increased due to flow releases designed to protect the fishery resource in the lower river. In general, average summer, fall, and winter flows have increased and average spring flows have decreased since Mayfield Dam came online in 1956 (Figure 8-10). This altered streamflow regime is believed to have improved conditions for some anadromous fish that spawn in the lower river but it is also believed to improve conditions for the intermediate host of the salmonid parasite, Ceratomyxa Shasta (Mobrand Biometrics 1999).

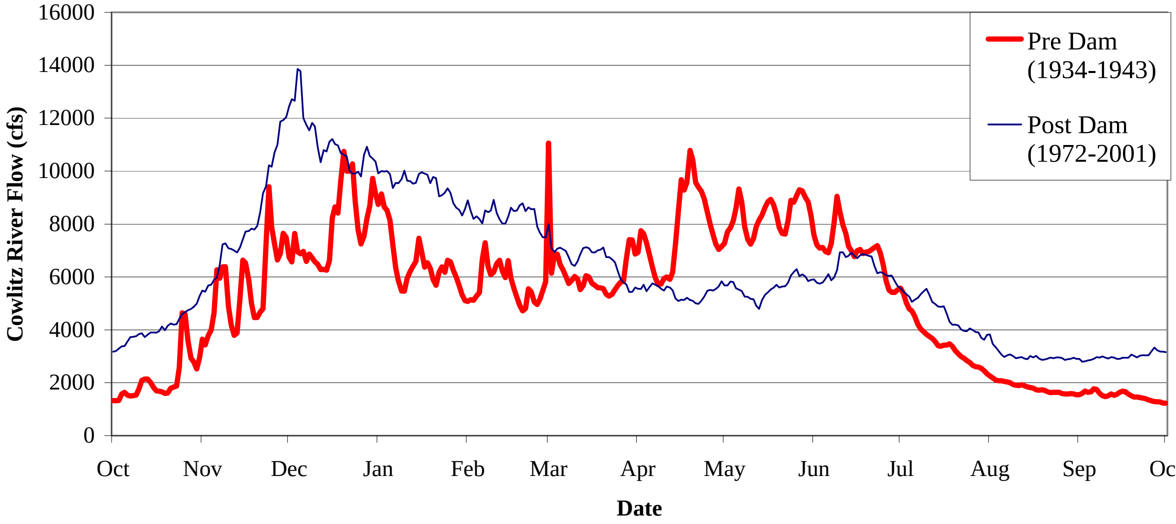


Figure 8-10. Lower Cowlitz River flow pre and post Mayfield Dam (1956). Values are average daily flows. Hydropower operations have altered the annual streamflow regime. Data are from USGS Stream Gage #14238000; Cowlitz River Below Mayfield Dam, Wash.

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that runoff conditions are ‘impaired’ throughout the basin, with only a couple of exceptions where conditions are ‘moderatly impaired’. These ratings are consistent with a peak flow assessment conducted by Lewis County GIS (2000) that identified the entire lower Cowlitz basin as ‘impaired’ with regards to an elevated risk of peak flow volumes. Hydrologic impairment is related to a number of factors. Much of the developed land in the lower basin has high watershed imperviousness, which contributes to degraded runoff conditions. Other areas have immature forest stands and high forest road densities, which creates a risk of increased peak flow volumes.

Analysis of low flows in Ostrander Creek and several other smaller tributaries to the Cowlitz using the Toe-Width method indicated that flows were below optimal levels in the fall for spawning and rearing (Caldwell et al. 1999). It is believed that low flows are responsible for low production in these streams (Wade 2000).

Based on the population projections and the estimated total groundwater use in the subbasin, the current and future projected groundwater withdrawal appears to be much less than the groundwater available in the basin (LCFRB 2001).

8.5.3 Water Quality

The lower Cowlitz (RM 4.9) was placed on Washington State's 303(d) list for impaired water bodies in 1996 for exceedances of pH, water temperature, and fecal coliform standards. The 1998 list only included this reach as having an exceedance of arsenic levels (WDOE 1998). Elevated dissolved gas levels in the mainstem below the dams have been measured during high flow events (Harza 1999a as cited in Wade 2000). The lead standard was exceeded in one sample collected at Cowlitz River at Toledo (USEPA, STORET database). Several exceedances of temperature and fecal coliform have occurred on Cowlitz tributaries. Pesticide and herbicide chemicals have been detected on Olequa Creek (Wade 2000). A TMDL study was initiated on Salmon Creek in 1999 for fecal coliform, temperature, and turbitity.

8.5.4 Key Habitat

Most of the lower mainstem Cowlitz (up to RM 17) and the lower 4 miles of the Coweeman are tidally influenced and contain pool habitat of low quality due to channelization. Diking, placement of dredge spoils, and transportation corridors have eliminated the bulk of the side-channel habitat on the lower Cowlitz and the lower reaches of tributaries (Wade 2000). Gravel mining has eliminated historical side channel habitat at various sites along the mainstem from RM 20 – 50. Exposed gravel bars along the channel have decreased since 1939. Measures of pool habitat in the mainstem below the Barrier Dam ranged from 3% (10,000 cfs) to 17% (2,140 cfs) (Harza 2000). Stream surveys conducted by the Cowlitz Conservation District in the 1990s identified low pool frequencies in 7 tributaries between RM 20 and 50 (Wade 2000).

8.5.5 Substrate & Sediment

The eruption of Mount St. Helens added an enormous amount of fine sediments to the lower mainstem Cowlitz channel and floodplain. Spawning size gravel is limited in the mainstem from Mayfield Dam to the Cowlitz Trout Hatchery due to transport capacity exceeding input. The opposite occurs between the I-5 Bridge and the Trout Hatchery, resulting in large accumulations of gravels and transport to downstream reaches (Harza 1999). There are excessive quantities of substrate fines below the Barrier Dam due to land-use activities in the lower basin (Mobrand Biometrics 1999). The limiting factors TAG identified numerous problems with substrate fines in tributary streams. A detailed description can be found in the WRIA 26 Limiting Factors Analysis (Wade 2000).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented in greater detail later in this chapter. IWA model results estimate 'moderately impaired' sediment supply conditions throughout the basin. Exceptions include the lowermost subwatersheds, which are 'impaired', and the Little Salmon Creek, Skook Creek, and portions of the upper Lacamas Creek drainage, which rate as 'functional'. Sediment supply impairments are related to road and vegetative cover conditions. Road densities in the lower Cowlitz basin are consistently greater than 4 mi/mi^2 and are greater than 7 mi/mi^2 in some areas. Approximately 31% of anadromous stream channels have stream-adjacent roads (Lewis County GIS 2000).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

8.5.6 Woody Debris

The lower 20 miles of the Cowlitz mainstem and most of the smaller tributaries have low quantities of stable LWD due to scour from past splash damming and/or active removal. Given its large size, this reach may never have been able to retain LWD (Wade 2000). However, the lower mainstem above the Toutle and Coweeman Rivers historically contained large log jams (Mobrand Biometrics 1999). An analysis of historical aerial photographs revealed many accumulations of logs along channel margins in 1939, attributed to upstream harvest practices and subsequent flood deposition. A lack of wood observed in 1960s photos was attributed to removal for fish habitat improvement and a lack of recruitment potential due to harvest. A slight increase in in-stream wood observed on 1996 photos is assumed to be the result of discontinued stream cleaning practices and increased recruitment due to the re-growth of riparian forests (Harza 2000). Stream surveys and observations in the Cowlitz tributaries between RM 20 and 52 have identified a general lack of in-stream LWD.

8.5.7 Channel Stability

Bank stability is generally good along the lower Cowlitz mainstem though erosion of dredge spoils may be a concern in some areas. Bank stability problems have been observed from RM 20 – 25, however, overall stability may have been enhanced along the lower mainstem due to hydropower regulation (Mobrand Biometrics 1999). Bank stability problems in the small lower Cowlitz tributaries are identified in the limiting factors analysis. Many of these are related to cattle impacts (Wade 2000).

8.5.8 Riparian Function

Riparian forests along the lower 20 miles of the Cowlitz River and within the lower reaches of the smaller tributaries have been severely degraded through industrial and commercial development. Agriculture and forestry activities have also impacted riparian areas. Riparian forests on the Cowlitz River from RM 20 – 52 lack mature forests and adequate buffer widths (Wade 2000). An aerial photo analysis on this reach revealed that coniferous cover types currently make up less of the riparian forest than they did historically. Gravel bars currently have more vegetative cover compared to conditions in 1939, possibly due to reduction of flood flows by upstream dams. Another change since 1939 is a decrease in the meadow/grasslands cover type, likely related to current agriculture, shrub encroachment, and residential uses (Harza 2000).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, about half of the subwatersheds in the lower Cowlitz basin are ‘impaired’ and half are ‘moderately impaired’. One subwatershed, located in the headwaters of Cedar Creek (Salmon Creek tributary), was rated as ‘functional’. The greatest impairment occurs in the lower basin that has experienced widespread development. Impaired areas are also located along Olequa and Lacamas Creeks, which have received impacts related to agriculture, grazing, residential development, and forestry activities.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

8.5.9 Floodplain Function

The lower 20 miles of the Cowlitz has experienced severe loss of floodplain connectivity due to dikes, riprap, and/or deposited dredge spoils originating from the Mount St. Helens eruption. Only the Sandy River Bend area near Castle Rock retains connected floodplain habitat. Floodplain loss in the lower reaches of many of the smaller tributaries is a result of I-5, the railroad corridor, and the placement of dredge spoils (Wade 2000).

The mainstem Cowlitz between RM 20 and RM 52 (Mayfield Dam) has scattered areas with bank revetments, though floodplain connection is generally in good shape. However, there has been a decrease in total square feet of habitat per mile from 1936 to 1996 (Mobrand Biometrics 1999). Channel incision, diking, dredging, bank hardening, and various types of development have disconnected floodplains from channels in several tributaries to this reach. A detailed description is given in the limiting factors analysis (Wade 2000).

8.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Lower Cowlitz River fall Chinook, chum, coho, and winter steelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

8.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Lower Cowlitz basin for fall chinook, chum, coho and winter steelhead. Model results indicate the largest proportional decrease in adult productivity has occurred with winter steelhead, though results are similar for both chum and coho (Table 8-1). The estimated proportional changes in adult abundance vary depending on the species, with chum experiencing a dramatic 96% decline from historical numbers (Figure 8-11). This can be attributed to severe degradation of the historically available chum habitat in the lower river. Winter steelhead, coho, and fall chinook declines have also been severe, with respective declines in abundance of 89%, 76%, and 64% (Figure 8-11). Diversity (as measured by the diversity index) has declined for all species (Table 8-1), with winter steelhead and chum diversity declining by 77% and 56%, respectively.

Smolt productivity has also declined from historical levels for each species in the lower Cowlitz basin (Table 8-1). For fall chinook and chum, smolt productivity has decreased by 57% and 44% respectively. For both coho and winter steelhead the decrease was estimated as approximately 75% and 83%, respectively. Smolt abundance in the lower Cowlitz has declined most dramatically for chum, with an estimated 94% decrease from historical levels (Table **8-1**).

Current fall chinook, coho, and winter steelhead smolt abundance levels are modeled at approximately 20-40 % of historical numbers (Table 8-1).

In all cases, model results indicate that restoration of PFC conditions would produce substantial benefits. Chum and winter steelhead would see the greatest proportional benefit in adult returns. Current winter steelhead returns would increase by an estimated 582%, and current chum return would increase by an estimated 639% (Table 8-1). Changes in smolt abundance due to restoration of PFC are similar to the adult trends, with all species greatly benefiting from the restoration (Table 8-1).

Table 8-1. Lower Cowlitz— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	8,873	20,865	24,356	5.9	11.0	14.5	0.65	1.00	1.00	1,484,327	3,049,618	3,809,863	551	998	1,295
Chum	6,239	46,130	166,140	1.9	6.7	9.8	0.44	1.00	1.00	3,080,762	21,871,960	48,310,830	582	883	1,042
Coho	4,144	15,655	17,626	4.2	12.4	17.1	0.81	0.96	1.00	83,989	338,523	381,605	91	264	359
Winter Steelhead	198	1,352	1,727	2.3	10.0	26.1	0.23	0.39	1.00	3,913	25,618	17,101	45	193	271

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

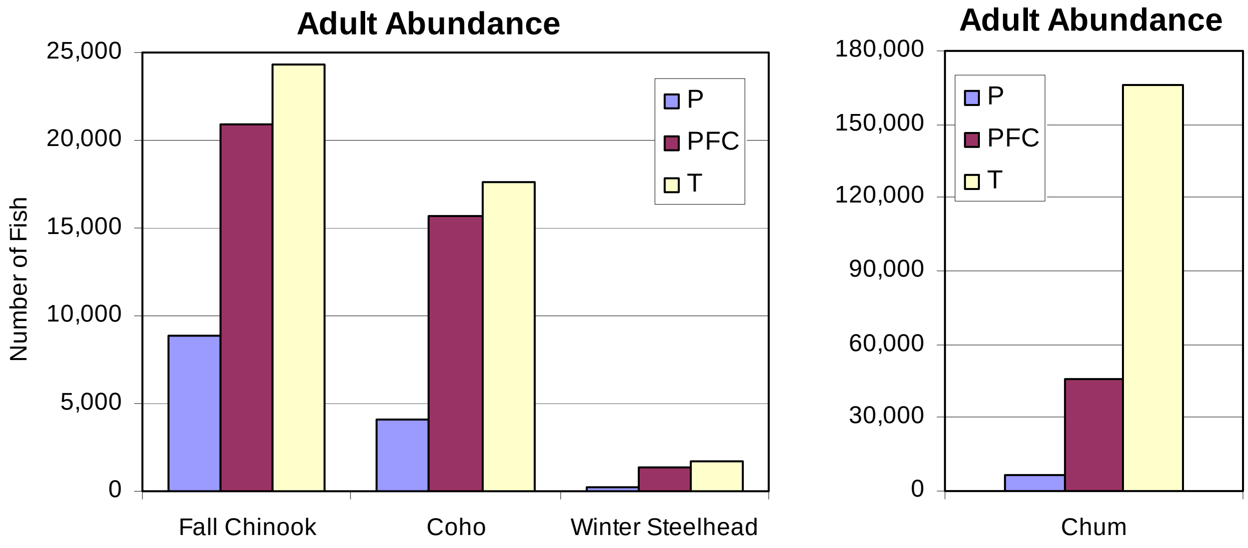


Figure 8-11. Adult abundance of Lower Cowlitz fall chinook, coho, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

8.6.2 Restroration and Preservarion Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Winter steelhead make extensive use of the available lower Cowlitz habitats, reaching well into Olequa, Lacamas, Salmon, Arkansas, Delameter, and Monahan Creeks. In contrast, fall chinook use primarily only mainstem habitats from the mouth to the barrier dam. Chum and coho also use mostly mainstem habitats but will make some use of the lower reaches of tributary habitats. See Figure 8-12 for a map of EDT reaches within the Lower Cowlitz basin.

High priority reaches for fall chinook include the two middle Cowlitz reaches, Mid Cowlitz 3 and Mid Cowlitz 4 (Figure 8-13). These reaches, along with most other important fall chinook reaches, show a strong preservation emphasis. Important reaches for chum include mainstem reaches (Lower Cowlitz 1, and Mid Cowlitz 6 and 7), as well as tributary reaches (Lacamas Cr 1, Olequa Cr 1, and Salmon Cr 1 and 2) (Figure 8-14). These high priority reaches show mixed recovery emphases, with reach Lower Cowlitz 1 having the largest restoration potential of any reach modeled for chum.

For coho, high priority reaches are spread throughout the basin (Figure 8-15). The majority of these important reaches are located in tributaries, such as Olequa Creek, Lacamas Creek, Salmon Creek, and Stillwater Creek. The vast majority of reaches modeled for coho show a restoration recovery emphasis, with reaches Olequa Cr 7 and Arkansas Cr 1 having the largest restoration potential of any reach modeled for coho.

High priority reaches for winter steelhead are located in mainstem areas (Mid Cowlitz 6 and 7) and tributaries (Olequa Cr 2-4, Stillwater Cr 5 and Salmon Cr 2) (Figure 8-16). The importance of these reaches is primarily for juvenile rearing though some limited spawning occurs here. As with coho, the vast majority of reaches modeled for winter steelhead show a restoration recovery emphasis, with Olequa Cr 2 and 3 having the largest restoration potential of any reach modeled for steelhead.

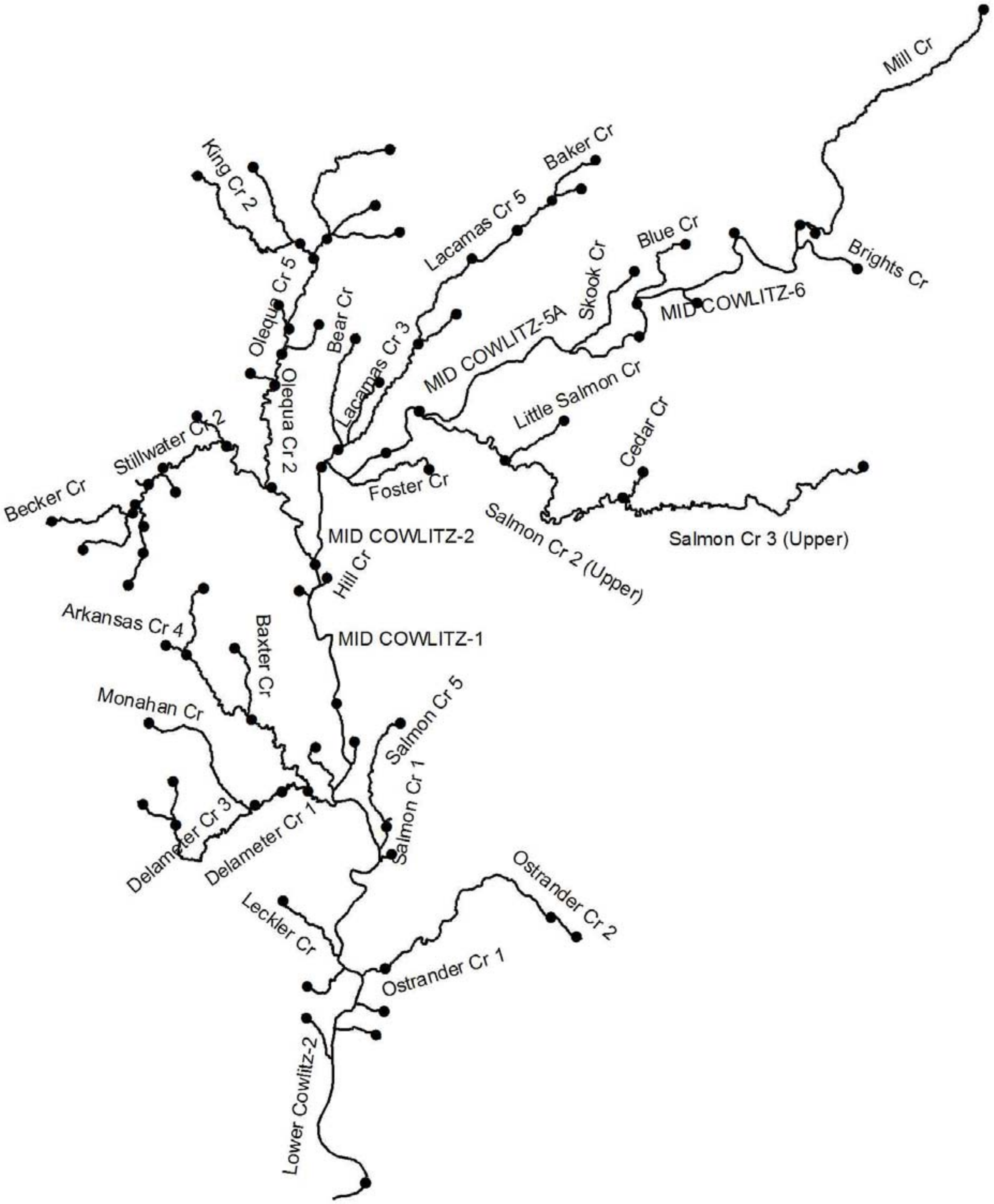
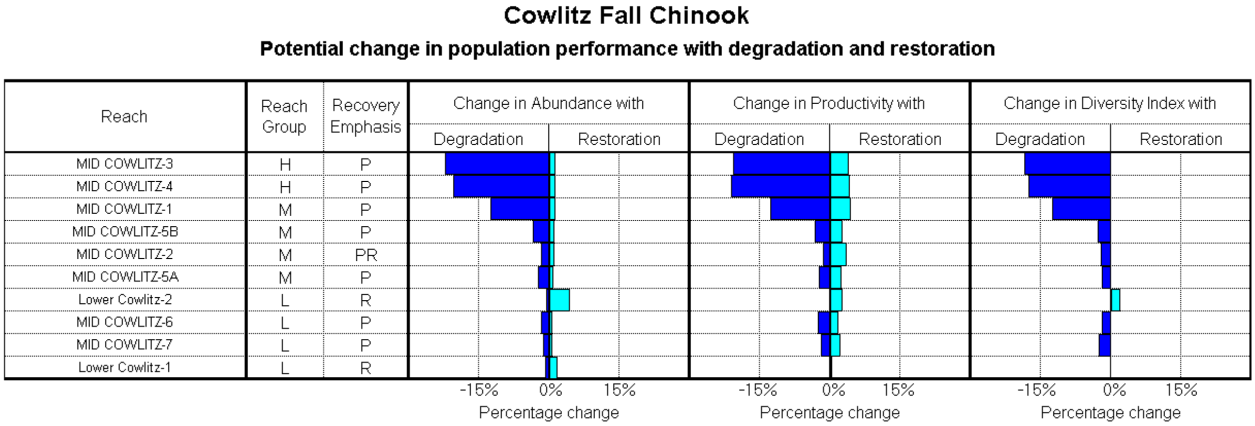
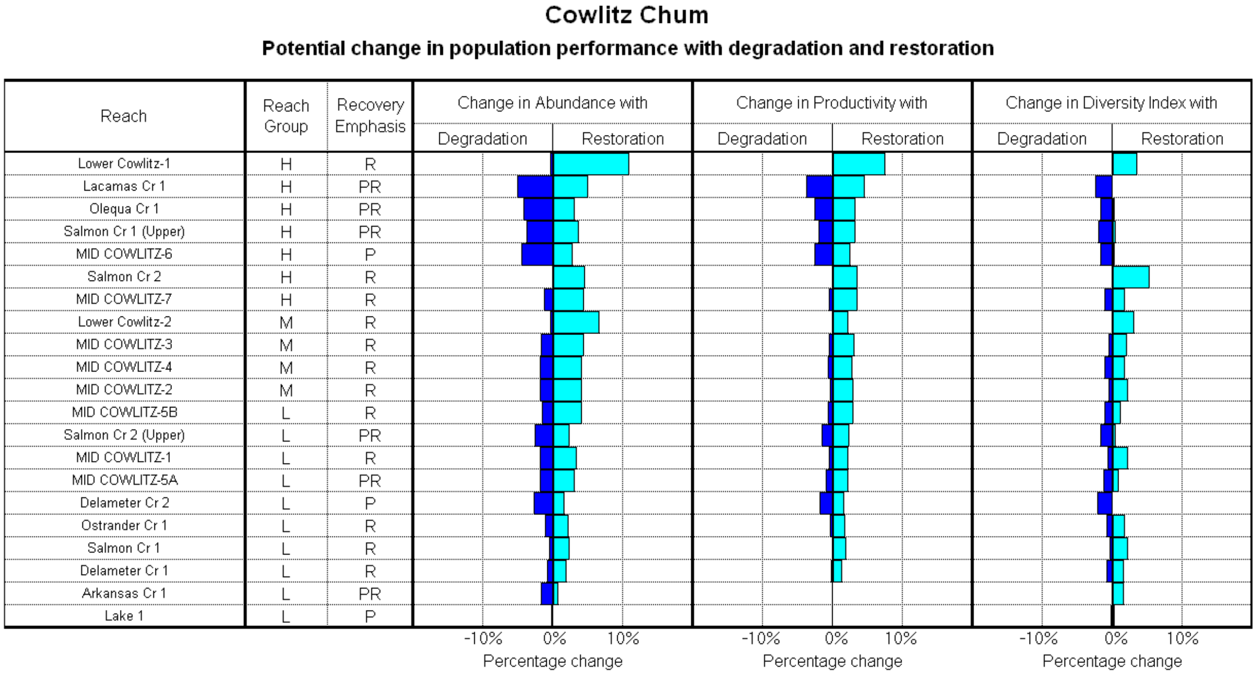


Figure 8-12. Lower Cowlitz basin EDT reaches. Some reaches not labeled for clarity.



Reach	Reach Group	Recovery Emphasis
MID COWLITZ-3	H	P
MID COWLITZ-4	H	P
MID COWLITZ-1	M	P
MID COWLITZ-5B	M	P
MID COWLITZ-2	M	PR
MID COWLITZ-5A	M	P
Lower Cowlitz-2	L	R
MID COWLITZ-6	L	P
MID COWLITZ-7	L	P
Lower Cowlitz-1	L	R

Figure 8-13. Lower Cowlitz fall chinook ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



Reach	Reach Group	Recovery Emphasis
Lower Cowlitz-1	H	R
Lacamas Cr 1	H	PR
Olequa Cr 1	H	PR
Salmon Cr 1 (Upper)	H	PR
MID COWLITZ-6	H	P
Salmon Cr 2	H	R
MID COWLITZ-7	H	R
Lower Cowlitz-2	M	R
MID COWLITZ-3	M	R
MID COWLITZ-4	M	R
MID COWLITZ-2	M	R
MID COWLITZ-5B	L	R
Salmon Cr 2 (Upper)	L	PR
MID COWLITZ-1	L	R
MID COWLITZ-5A	L	PR
Delameter Cr 2	L	P
Ostrander Cr 1	L	R
Salmon Cr 1	L	R
Delameter Cr 1	L	R
Arkansas Cr 1	L	PR
Lake 1	L	P

Figure 8-14. Lower Cowlitz subbasin chum ladder diagram.

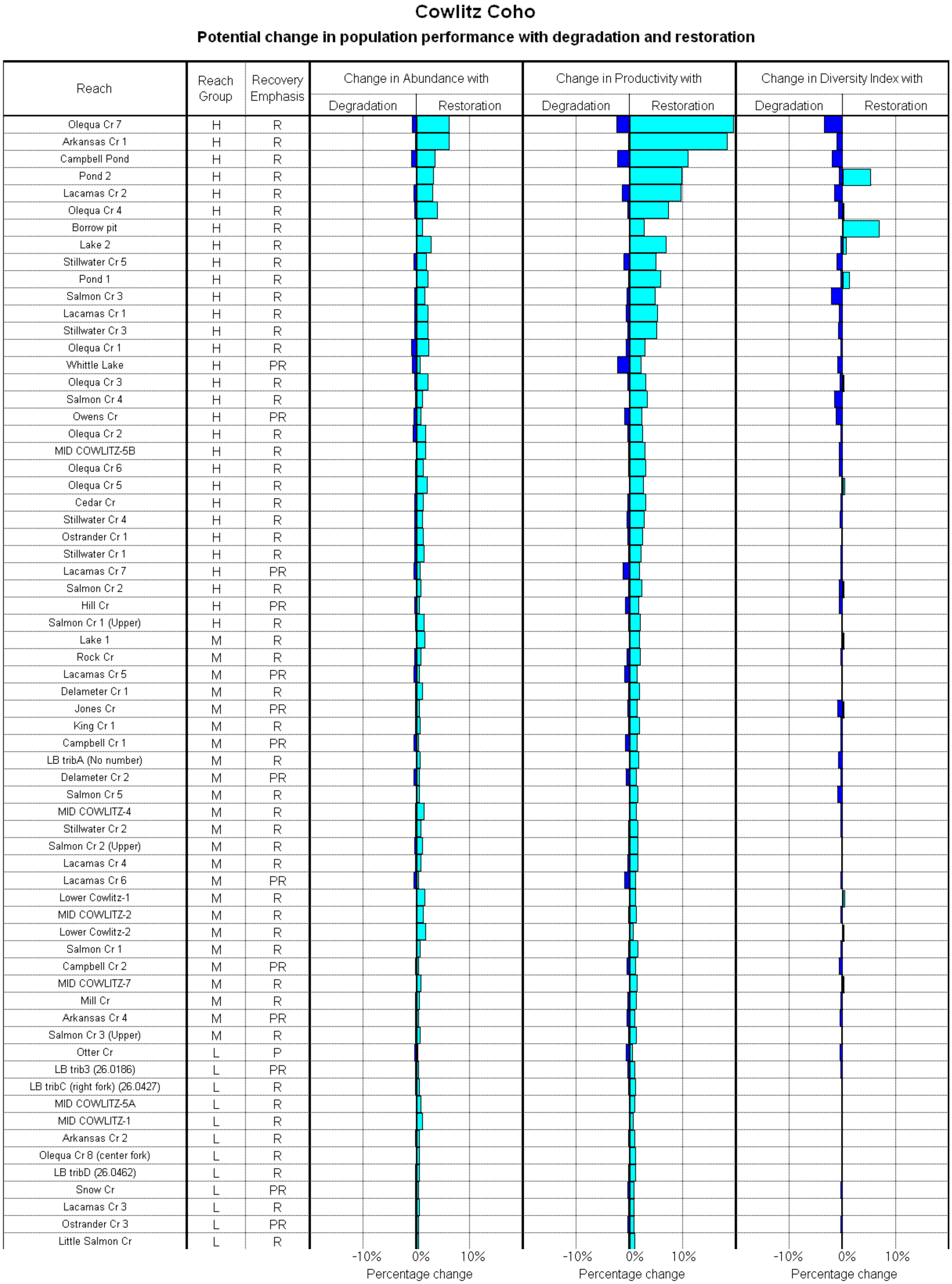


Figure 8-15. Cowlitz River subbasin coho ladder diagram. Some low priority reaches are not included for display purposes.

Cowlitz Winter Steelhead

Potential change in population performance with degradation and restoration

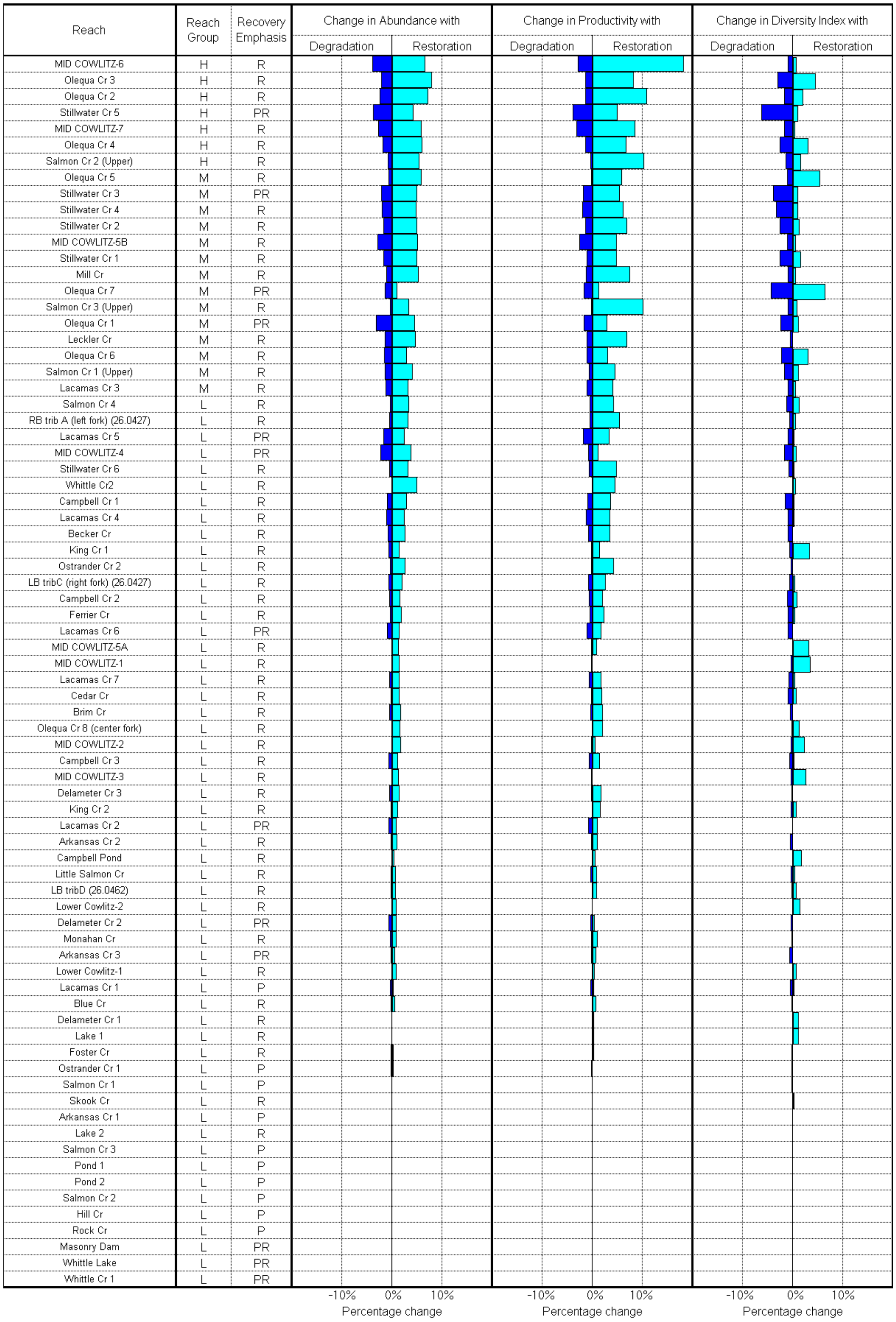


Figure 8-16. Cowlitz River subbasin winter steelhead ladder diagram.

8.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The habitat factor analysis for winter steelhead identified numerous impacts to current population performance. High impact attributes in steelhead stream reaches include habitat diversity, temperature, sediment, flow, and channel stability (Figure 8-17). Habitat diversity is low due to degraded riparian areas, low LWD levels, and incised channels. There is a risk of increased peak flow due to upper basin timber harvest, roads, and an increase in impervious surfaces due to residential and agricultural development. Low flows have been identified as a problem for summer rearing (Caldwell et al. 1999). Sediment contributions stem from high road densities and agriculture/grazing practices. Degraded riparian areas affect temperature, food, and channel stability.

For the fall chinook population, primary habitat impacts are due to sediment, channel stability, and habitat diversity (Figure 8-18). The channel is severely channelized by dikes, which have served to simplify and limit available habitat. Riparian areas are in poor condition and LWD levels are low. Historically, large log jams may have been present in the lower mainstem. Stream cleanouts in the 1960s, reduced recruitment due to riparian harvest, and intercepted transport from upstream due to the dams has significantly reduced LWD levels.

High priority reaches for chum have also been negatively impacted by habitat degradation. In these reaches, habitat diversity, key habitat and sediment have had the greatest impact (Figure 8-19). Loss of habitat diversity is related to increased bed scour as a result of confinement, degraded riparian areas, and a lack of LWD. Key habitat has been reduced due to the dramatic reduction in historically available side-channels. Sediment input is a major factor and primarily stems from sediments originating from the 1980 Mount St. Helens eruption that are delivered via the Toutle River. These same conditions also serve to increase the risk of elevated peak flows. Furthermore, silvaculture, agriculture, and residential development have impacted riparian zones and LWD recruitment rates.

Coho habitat in the lower Cowlitz subbasin has been affected by a variety of factors. These impacts include loss of habitat diversity, increased sediment, loss of key habitat, reduced channel stability and an altered temperature regime (Figure 8-20). The causes of these impacts are the same as those mentioned above.

Lower Cowlitz Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
MID COWLITZ-6	●	⬤	+	●		●			●		•			⬤		✚
Olequa Cr 3	●	⬤	●	●		●			●	●	•			•		•
Olequa Cr 2	●	⬤	⬤	●		●			●	●	•			•		●
Stillwater Cr 5	●	●	⬤	•		•			●	⬤	•			•		•
MID COWLITZ-7	●	⬤	+	●		•			●	●	•			●		•
Olequa Cr 4	●	⬤	●	●		•			●	●	•			•		•
Salmon Cr 2 (Upper)	•	⬤	●	•		•			●	●	•			•		•
Olequa Cr 5	●	⬤	●	•	•	•			●	●	•			•		+
Stillwater Cr 3	●	⬤	●	•		•			●	●	•			•		•
Stillwater Cr 4	●	●	⬤	•		•			●	●	•			•		•
Stillwater Cr 2	●	⬤	●	•		•			●	●	•			•		•
MID COWLITZ-5B	●	⬤	+	●		•			●	•	•			●		●
Stillwater Cr 1	●	⬤	●	•		•			●	●	•			•		●
Mill Cr	•	●	⬤	•		•			●	⬤	+			●		⬤
Olequa Cr 7	•	•	●	•						●						+
Salmon Cr 3 (Upper)	•	●	●	•		•			●	●	•			•		+
Olequa Cr 1	•	⬤	●	●		•			●	●	•			•		•
Leckler Cr	•	●	⬤	•		•			●	⬤	•			•		●
Olequa Cr 6	•	●	●	•		•			●	●	•			•		•
Salmon Cr 1 (Upper)	•	⬤	●	•	•	•			●	●	•			•		+
Lacamas Cr 3	•	●	●	•		•			●	●	•			•		+
Salmon Cr 4	●	●	●	•		•			•	⬤	•			•		●
RB trib A (left fork) (26.0427)	•	●	●	•					●	●	•			•		●
Lacamas Cr 5	•	•	●	•		•			•	●	•			•		•
MID COWLITZ-4	•	●	+	●		•			●	•	•			●		+
Stillwater Cr 6	•	●	●	•					●	●	•			•		●
Whittle Cr2	•	●	●	•		•			⬤	⬤	●			•		
Campbell Cr 1	•	●	●	•		•			●	●	•			•		●
Lacamas Cr 4	•	●	●	•		•			•	●	•			•		
Becker Cr	•	●	●	•					●	●	•			•		●
King Cr 1	•	●	•						•	•				•		•
Ostrander Cr 2	•	●	●	•					●	●	•			•		●
LB tribC (right fork) (26.0427)	•	•	●	•					•	●	•			•		+
Campbell Cr 2	•	•	●						•	●	•			•		●
Ferrier Cr	•	●	●						•	⬤	•			•		●
Lacamas Cr 6		•	●	•					•	●	•			•		•
MID COWLITZ-5A	•	●		•		•			•					•		+
MID COWLITZ-1	•	●		•		•			•	•				•		
Lacamas Cr 7		•	●	•					•	●	•			•		•

High Impact ⬤ Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 8-17. Lower Cowlitz winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Lower Cowlitz Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
MID COWLITZ-3	●	●		•		•			•	⬤	•			•	•	✛
MID COWLITZ-4	●	●		•		•			•	●	•			•	•	✛
MID COWLITZ-1	●	●		•		•			•	⬤	•			•	•	✚
MID COWLITZ-5B	●	●	✛	•					•	•	•			•	•	•
MID COWLITZ-2	●	●		•		•			•	⬤	•			•	•	✛
MID COWLITZ-5A	●	●		•					•	•	•			•	•	✛
Lower Cowlitz-2	⬤	⬤	•	•	•	•			●	⬤	•			•	•	✚
MID COWLITZ-6	●	•		•					•		•			•		✛
MID COWLITZ-7	●	●							•	●	•			•		+
Lower Cowlitz-1	●	●	•	•	•	•			•	•	•			•	•	✛

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 8-18. Lower Cowlitz fall chinook habitat factor analysis diagram.

Lower Cowlitz Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lower Cowlitz-1	●	⬤		•	•				●	●	•			•	●	⬤
Lacamas Cr 1	●	⬤		•	•				●	●	●					●
Olequa Cr 1	•	●		•					•	●	•					●
Salmon Cr 1 (Upper)	•	●			•				•	●	•					●
MID COWLITZ-6	•	●		•					•		•			•	•	
Salmon Cr 2	•	⬤							•	•	•				•	●
MID COWLITZ-7	•	⬤		•					●	•	•			•	•	●
Lower Cowlitz-2	●	⬤		•	•				●	●	•			•	•	⬤
MID COWLITZ-3	•	●		•					•	●	•			•	•	●
MID COWLITZ-4	•	●		•					•	•	•			•	•	●
MID COWLITZ-2	•	⬤		•					•	●	•			•	•	●
MID COWLITZ-5B	•	●		•					•	•	•			•	•	●
Salmon Cr 2 (Upper)	•	●							•	●	•					•
MID COWLITZ-1	•	●		•					•	●	•			•	•	●
MID COWLITZ-5A	•	●		•					•	•	•			•	•	●
Delameter Cr 2	•	●							•	●	•					•
Ostrander Cr 1	•	●							•	●	•					●
Salmon Cr 1	•	●							•	•	•					●
Delameter Cr 1	•	●							•	•	•				•	●
Arkansas Cr 1	•	•							•		•					•
Lake 1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 8-19. Lower Cowlitz chum habitat factor analysis diagram.

Lower Cowlitz Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Olequa Cr 7	⬤	⬤	⬤	●		●			●	⬤	●					⬤
Arkansas Cr 1	⬤	⬤	⬤	•	•	•		•	●	⬤	●					⬤
Campbell Pond	⬤	⬤	⬤	•		•			●	⬤	●					⬤
Pond 2	●	⬤	⬤	•	•	•			●	⬤	●					●
Lacamas Cr 2	⬤	⬤	●	•		●			●	⬤	•			•		●
Olequa Cr 4	●	⬤	●	●		●			●	●	●			•		⬤
Borrow pit	●	●	●			•			●	⬤	•					+
Lake 2	⬤	⬤	●		•	•			●	●	●					⬤
Stillwater Cr 5	●	●	●			•			●	●	•					●
Pond 1	•	⬤	●		•	•			●	⬤	●					✚
Salmon Cr 3	●	●	●	•		•			●	●	●			•		+
Lacamas Cr 1	●	●	●	•	•	●			●	●	●			•		●
Stillwater Cr 3	●	⬤	●			•			●	●	•					•
Olequa Cr 1	●	⬤	●	●		•			●	●	•			•		•
Whittle Lake		●	•						•	●	•					
Olequa Cr 3	●	⬤	●	•		•			●	●	●			•		●
Salmon Cr 4	●	●	●	•		•			●	●	•					+
Owens Cr	●	●	•						•	⬤	•					●
Olequa Cr 2	●	⬤	●	•		•			●	●	•			•		●
MID COWLITZ-5B	●	⬤	+	•		•			•	•	•			●		⬤
Olequa Cr 6	●	●	●	•		•			•	●	•					●
Olequa Cr 5	●	⬤	●	•	•	•			●	•	•					⬤
Cedar Cr	●	●	●						•	●	•					●
Stillwater Cr 4	●	●	●						•	●	•					•
Ostrander Cr 1	●	●	●			•			●	⬤	●					●
Stillwater Cr 1	●	⬤	●						●	•	•					•
Lacamas Cr 7	●	•	●						•	●	•			•		●
Salmon Cr 2	●	●	•						•	●	•					+
Hill Cr	●	•	•						•	●	•					•
Salmon Cr 1 (Upper)	●	⬤	●		•	•			●	●	●			•		●
Lake 1	●	⬤	●		•	•			●	●	•					●
Rock Cr	●	●	•						•	⬤	•					⬤
Lacamas Cr 5	•	•	●	•		•			•	●	•			•		•
Delameter Cr 1	●	●	●		•	•			•	●	•					•
Jones Cr	●	●	•						•	●	•					●
King Cr 1	●	●	•						•	●	•					●
Campbell Cr 1	•	•	•						•	●	•					✚
LB tribA (No number)	●	●	•						•	●	•					●
Delameter Cr 2	•	•	•						•	●	•					+
Salmon Cr 5	●	●	•			•			•	●	•					✛
MID COWLITZ-4	●	⬤		•		•			•	•	•			●		●
Stillwater Cr 2	•	●	•						•	•	•					•
Salmon Cr 2 (Upper)	●	●	●	•		•			•	●	•					+
Lacamas Cr 4	•	●	•	•		•			•	•	•					●
Lacamas Cr 6	•	•	●						•	●	•					•
Lower Cowlitz-1	•	⬤	•	•		•			•	•	•			•		●
MID COWLITZ-2	•	⬤		•		•			•	•	•			●		●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 8-20. Lower Cowlitz coho habitat factor analysis diagram. Some low priority reaches are not included for display purposes.

8.7 Integrated Watershed Assessment (IWA)

The lower Cowlitz watershed, which encompasses a total of 483 square miles, is divided into 40 subwatersheds for the IWA. The upstream end of the lower Cowlitz watershed terminates at Mayfield Dam. Upstream of the dam are the Mayfield-Tilton, Riffe Lake, Cispus River, and Upper Cowlitz watersheds. These seven watersheds comprise the Cowlitz River subbasin. The subbasin is predominantly rain dominated, with little area within the rain-on-snow zone. The subbasin is almost entirely privately owned, with urban, residential, and agricultural development in the lower elevations and private commercial timber land in the middle and upper elevations.

8.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the lower Cowlitz watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). These results are shown in Table 8-2 Very few subwatersheds are rated as functional for any of the processes evaluated using the local- and watershed-level IWA analyses. Based on the local level analysis, 38 of the subwatersheds (95%) were determined to be hydrologically impaired and 2 were rated as moderately impaired (Cedar and Mill Creek). When upstream effects are considered, an estimated 33 and 5 subwatersheds were found to be impaired and moderately impaired, respectively. A reference map showing the location of each subwatershed in the basin is presented in Figure 8-21. Maps of the distribution of local and watershed level IWA results are displayed in Figure 8-22.

Table 8-2. IWA results for the lower Cowlitz watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
80407						TOUTLE
80201	I	M	I	I	M	none, east Willapa
80203	I	I	I	I	M	east Willapa
70606, 80201, 80202, 80203	I	I	I	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407, 60408, 70101, 70102, 70103, 70104, 70105, 70201, 70202, 70203, 70204, 70205, 70501, 70502, 70503, 70504, 70505, 70601, 70605, 80202
80201						60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407, 60408, 70101, 70102, 70103, 70104, 70105, 70201, 70202, 70203, 70204, 70205, 70501, 70502, 70503, 70504, 70505, 70601, 70605, 70606
80202	I	M	I	I	M	none
80203	I	I	I	I	M	none
70504	I	M	I	I	M	70501, 70502, 70503, 70505
70501	I	M	M	I	M	none
70501--70502	I	M	I	I	M	70501
70502	I	M	I	I	M	70501
70503	I	I	M	I	I	none
70504						
70505	I	M	M	I	M	70503
70601	I	M	M	I	M	none
70605	I	M	M	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407, 60408, 70101, 70102, 70103, 70104,70105, 70201, 70202, 70203, 70204, 70205, 70501, 70502, 70503, 70504, 70505, 70601
70606	I	I	I	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407, 60408, 70101, 70102, 70103, 70104, 70105, 70201, 70202, 70203, 70204, 70205, 70501, 70502, 70503, 70504, 70505, 70601, 70605

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
70605, 70606	I	I	I	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407, 60408, 70101, 70102, 70103, 70104, 70105, 70201, 70202, 70203, 70204, 70205, 70501, 70502, 70503, 70504, 70505, 70601, 70605
70104	I	M	M	I	M	70105
70104, 70105	I	M	M	I	M	70105
70103	I	M	M	I	M	70101, 70102, 70104, 70105, 70201, 70202, 70203, 70204, 70205
70102	I	M	I	I	M	70101
70101	I	M	M	I	M	none
70201	I	M	I	I	M	none
70202	I	M	I	I	M	none
70203	I	M	I	I	M	none
70204	I	M	I	I	M	70201, 70202, 70203
70205	I	M	I	I	M	70201, 70202, 70203, 70204
60408	I	M	I	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60304, 60305, 60401, 60402, 60403, 60404, 60405, 60406, 60407
60401	I	F	I	I	F	none
60402	I	M	M	I	M	none
60403	I	F	M	M	M	60101, 60102, 60103, 60104, 60402
60404	M	F	I	M	F	none
60405	I	M	M	I	F	60401
60406	I	M	M	I	F	60401, 60405, 60404
60202	I	M	M	I	M	60201
60103	I	M	M	I	M	60104
60303	I	F	M	I	M	none
60302	I	M	M	I	M	60201, 60202, 60304, 60305
60301, 60304	I	M	M	I	M	60305
60304	I	M	M	I	M	60305
60305	I	M	M	I	M	none

Subwatershed[a]	**Local Process Conditions**[b]			**Watershed Level Process Conditions**[c]		**Upstream Subwatersheds**[d]
	Hydrology	**Sediment**	**Riparian**	**Hydrology**	**Sediment**	
60403, 60407	I	M	I	I	M	60101, 60102, 60103, 60104, 60201, 60202, 60301, 60302, 60303, 60402, 60403
60102	I	M	M	M	M	60103, 60104, 60402
60101, 60102	I	M	M	M	M	60103, 60104, 60402
60101	I	M	M	M	M	60103, 60104
60201	M	M	F	M	M	none
60104	I	M	M	I	M	none
80101	I	M	M	I	M	none
80102	I	M	M	I	M	80101

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

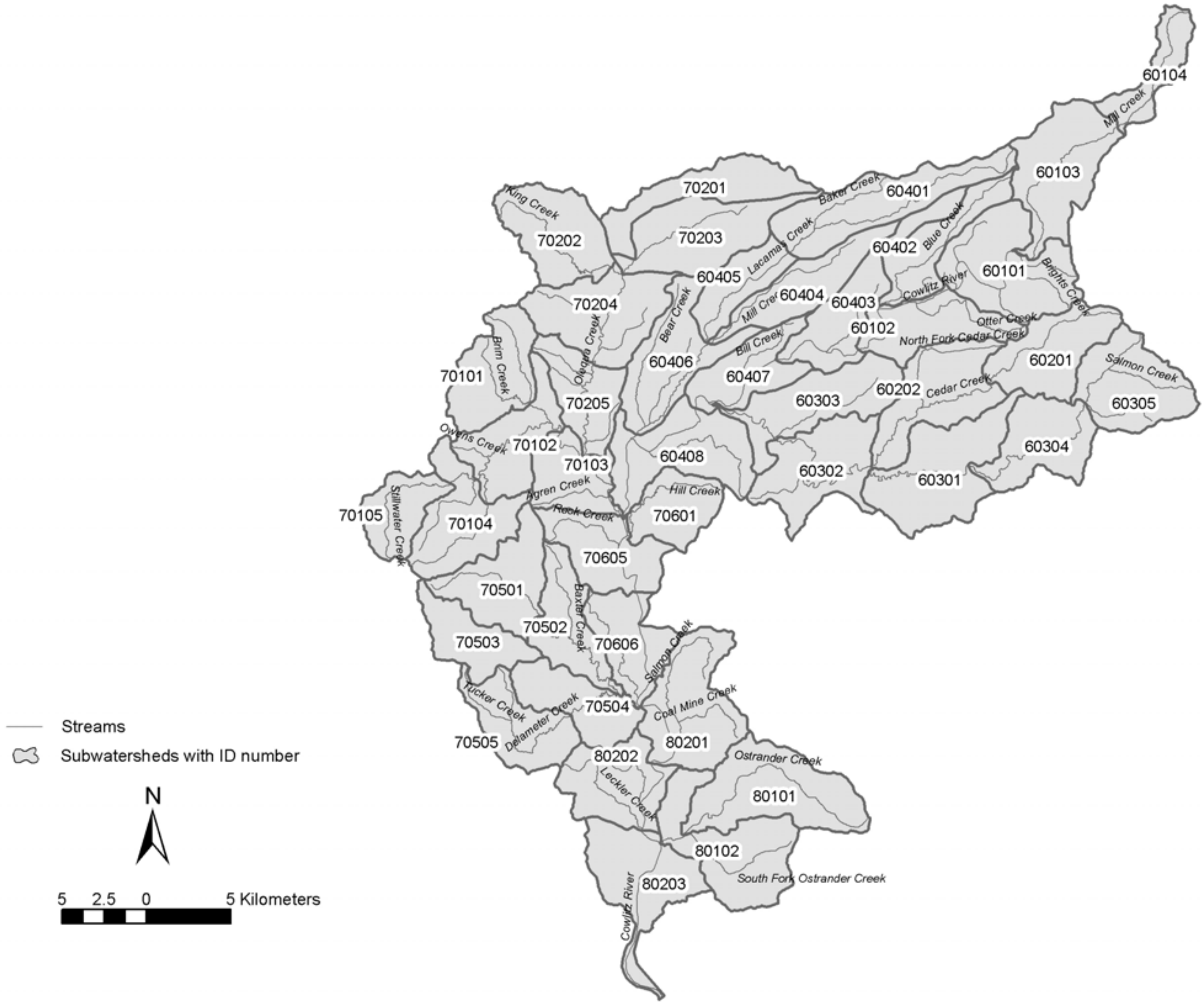


Figure 8-21. Map of the lower Cowlitz basin showing the location of the IWA subwatersheds

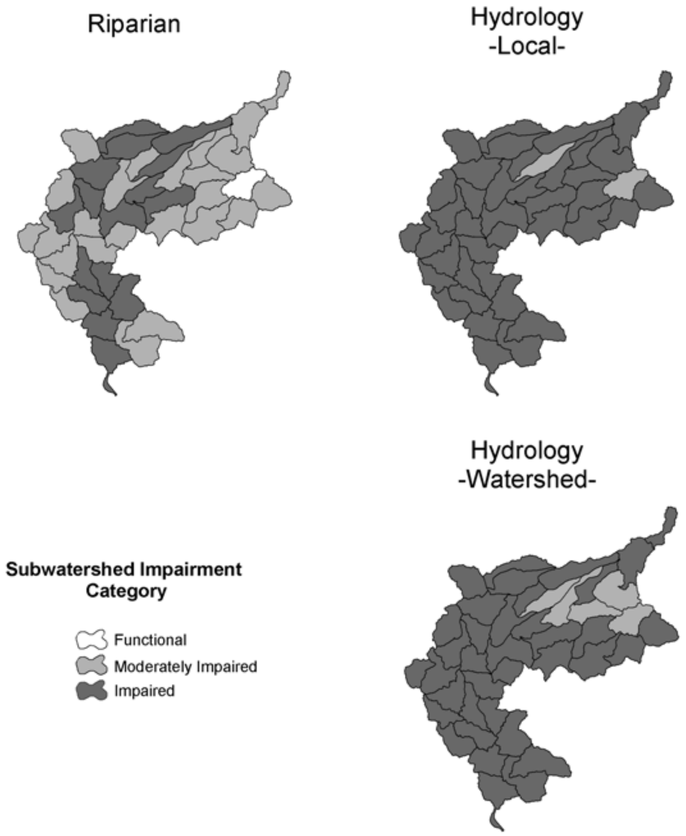


Figure 8-22. IWA subwatershed impairment ratings by category for the lower Cowlitz basin

Most subwatersheds are rated moderately impaired for sediment conditions. Sediment conditions were rated as impaired in three subwatersheds and functional in four. The four subwatersheds rated as functional are located in tributary subwatersheds, notably Little Salmon Creek, Skook Creek, Mill Creek and the Lacamas Creek drainage. Riparian conditions are mixed, but generally degraded with only one subwatershed rated functional and the remainder rated moderately impaired or impaired.

8.7.1.1 Hydrology

Local level hydrologic conditions in the lower Cowlitz watershed are impaired in virtually all subwatersheds, with only two moderately impaired subwatersheds located off the upper mainstem. The lower mainstem of the Cowlitz River has undergone extensive agricultural and residential development. Population centers in the subbasin consist primarily of small rural towns, with the larger towns of Castle Rock, Kelso, and Longview situated along the lower river. The hydrologic impacts of development include increased magnitude, frequency, and intensity of storm runoff, reduced ground water recharge, and lower stream flows during summer baseflow periods. These effects stem from vegetation removal, an increase in the quantity of impervious surfaces, and an increase in the channel network. Thirty-nine of 40 subwatersheds have less than 50% of total area in hydrologically mature forest cover. It should be noted, however, that much of this area is in what was once lowland prairie, and sparse tree cover is a natural condition in some areas. In the mainstem Cowlitz, impacts to streamflow may be overshadowed by the effects of hydro-regulation.

Watershed level results for hydrologic condition are generally similar, with the exception that hydrologic conditions rated as impaired at the local level in three subwatersheds become moderately impaired at the watershed level, due to the influence of upstream contributing subwatersheds. When considering these results it is important to note that the IWA does not explicitly consider the effects of the dams on streamflows within mainstem Lower Cowlitz subwatersheds. The three subwatersheds with improved hydrology ratings at the watershed level are in the Cowlitz mainstem below Mayfield Dam. Given the expected influence of dam operations on mainstem hydrology, the IWA watershed level rating does not accurately represent the effects of upstream influences. For the purpose of the IWA analysis, watershed level effects are calculated as though the watershed terminates at the dam.

8.7.1.2 Sediment

Most subwatersheds are rated as moderately impaired for local sediment supply conditions. Four adjacent subwatersheds (60303, 60403, 60404, and 60401) are rated as locally functional for sediment. A few subwatersheds in the lower portion of the basin, including the mouth subwatershed, are rated impaired. The remainder are moderately impaired. Based on geology type and slope class, subwatersheds rated as functional for sediment were found to have natural erodability ratings in the low-to-intermediate range, ranging from 37 to 43 on a scale of 0 to 126. Road densities are generally moderate to high and streamside road densities are mostly moderate in these subwatersheds.

Locally functional and impaired sediment ratings in two subwatersheds, respectively, become moderately impaired at the watershed level. This implies that hydrologic and sediment conditions in these subwatersheds are potentially affected by upstream as well as local conditions. However, when considering these results it is important to note that the IWA does not explicitly consider the effects of the dams on streamflows within mainstem Lower Cowlitz subwatersheds. Two subwatersheds with changing sediment ratings are located along the lower Cowlitz mainstem, which is affected both by the effect of dams (which capture sediment from the upper subbasin) and the influence of undammed tributaries within the Coweeman and Toutle River watersheds.

8.7.1.3 Riparian

Riparian conditions are rated as moderately impaired or impaired, with only one subwatershed, Cedar Creek (60201), rated as functional. Moderately impaired conditions are present in 23 subwatersheds and the remaining 16 subwatersheds are rated as impaired. Generally, riparian conditions in the Puget Trough subwatersheds in the more northern and eastern portion of the watershed are better than the Willapa Hills subwatersheds to the west and south.

Riparian forests along the lower 20 miles of the Cowlitz and within the lower reaches of the smaller tributaries have been severely degraded through industrial and commercial development. Agriculture and forestry activities have also impacted riparian areas (Wade 2000).

8.7.2 *Predicted Future Trends*

8.7.2.1 Hydrology

Due to the low forest cover within the forested subwatersheds and the low percentage of forested subwatersheds, hydrologic conditions in the lower Cowlitz watershed are predicted to remain unchanged (i.e., impaired) over the next 20 years unless specific actions are taken to ameliorate the problem. Conditions in the mainstem are generally driven by hydropower operations, and are determined to a lesser extent by tributary conditions. Hydropower operations may be modified in the future to benefit salmon recovery, but for the purpose of this analysis these operations are predicted to remain constant over this period.

8.7.2.2 Sediment

Sediment conditions are generally rated as moderately impaired to impaired throughout the lower Cowlitz basin, with the exception of the Mill Creek tributary to Lacamas Creek (functional). The watershed is characterized by a broad array of land uses, ranging from agriculture and timber to urban and industrial development, and also contains the developing I-5 corridor.

Land uses in tributary watersheds are generally predicted to continue, and may in some cases shift towards residential and urban development along the I-5 corridor. Based on the trajectory of predominant land uses, sediment conditions in tributary drainages are predicted to trend towards increasing degradation. These impacts may be mitigated to some degree by improved forestry and road management practices on public and private timberlands, and improved stormwater controls. Nevertheless, the predicted overall trend is toward increasing degradation in tributary drainages.

Sediment conditions in the mainstem Cowlitz are determined by the presence of major dams, sediment delivery from tributary drainages, and significantly, from tributary watersheds such as the Toutle and Coweeman Rivers. Of particular note, the Toutle River watershed was heavily impacted with sediment from the Mt. St. Helens eruption in 1980. Sediment delivery from the Toutle River watershed is a consistent management challenge in the lower Cowlitz mainstem. The trend in sediment conditions in the mainstem is expected to remain constant in subwatersheds above the confluence with the Toutle, and to degrade over the next 20 years in mainstem reaches downstream of the Toutle.

8.7.2.3 Riparian Condition

Riparian forests along the lower 20 miles of the Cowlitz and within the lower reaches of the smaller tributaries have been severely degraded through industrial and commercial development. Riparian conditions are rated functional in Cedar Creek (60201), moderately impaired in 23 subwatersheds, and impaired in the remaining 14 subwatersheds. Conditions in middle and upper tributary subwatersheds are generally predicted to remain stable over the next 20 years, trending towards gradual improvement as regrowth in degraded watersheds proceed.

Riparian conditions along the lower mainstem and in lower tributary drainages are expected to trend downward over the next 20 years, as development pressure around the towns of Castle Rock, Longview, and Kelso increase. Channelization and bank modifications along the mainstem futher limit the potential for riparian recovery in many areas.

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Volume II, Chapter 9
Cowlitz Subbasin—Upper Cowlitz

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9.0 Cowlitz Subbasin—Upper Cowlitz

9.1 Subbasin Description

9.1.1 Topography & Geology

For the purposes of this assessment, the Upper Cowlitz basin is the watershed area contributing to Mayfield Dam. The basin encompasses 1,390 square miles in portions of Lewis, Skamania, Pierce, and Yakima Counties. The basin is within WRIA 26 of Washington State. Major tributaries include the Cispus, Clear Fork, Ohanapecosh, and Tilton.

Headwater streams consist of high gradient canyons in the steep, heavily timbered mountainous areas surrounding Mounts Rainier, Adams, St. Helens, and the Goat Rocks Wilderness. The high point in the basin is the summit of Mt. Rainier at 14,410 feet. An upper alluvial valley extends from the junction of the Muddy Fork and the Ohanapecosh Rivers (near Packwood, Washington) to Cowlitz Falls Reservoir (RM 99.5).

Cowlitz Falls Dam (RM 88.5) was constructed in 1994, creating a long, narrow 11-mile reservoir. Below the Cowlitz Falls Dam, the river enters Riffe Lake, a 23.5 mile long reservoir created by the 606-foot high Mossyrock Dam (RM 66), completed in 1968. Riffe Lake is operated as a storage reservoir by Tacoma Power for flood control and hydropower production. Due to characteristics of the dam and reservoir, no fish passage facilities have been constructed at Mossyrock Dam. A few miles below the dam, the river enters Mayfield Lake, a 13.5 mile long reservoir created by the construction of Mayfield Dam (RM 52) in 1962. Historically, the portion of the stream inundated by the three reservoirs was made up of a series of deep canyons. The salmon hatchery Barrier Dam (RM 49.5) located below Mayfield Dam is a collection facility for trapping and hauling fish into the upper basin, a practice that has been in effect since 1969.

The geology of the headwater streams consists of volcanic rocks of the Cascade Mountains. The upper basin is made up of andesite and basalt flows. The most common forest soils are Haplohumults (reddish brown lateritic soils) and the most common grassland soils are Argixerolls (prairie soils) (WDW 1990).

9.1.2 Climate

The basin has a typical northwest maritime climate. Summers are dry and warm and winters are cool, wet, and cloudy. Mean monthly precipitation ranges from 1.9 inches (July) to 19 inches (November) at Paradise on Mt. Rainier and from 1.1 inches (July) to 8.8 inches (November) at Mayfield Dam. Mean annual precipitation ranges from 56 inches at Mayfield Dam to over 116 inches at Paradise (WRCC 2003). Most precipitation occurs between October-March. Snow and freezing temperatures are common in the upper basin while rain predominates in the middle and lower elevations.

9.1.3 Land Use/Land Cover

Forestry is the dominant land use in the basin, with over 70% of the land managed as public and private commercial forestland. The Upper Cowlitz also has a substantial amount of land in non-commercial forest and reserved forest, owing primarily to the large public land holdings (Gifford Pinchot National Forest and Mt. Rainier National Park) in the basin. Much of the private land in the river valleys is agricultural and residential, with substantial impacts to riparian and floodplain areas in places. Population centers in the subbasin consist primarily of small rural towns including Morton, Randle, and Packwood, WA. Projected population change from 2000 to 2020 for unincorporated areas in WRIA 26 is 22% (LCFRB 2001). A breakdown of land ownership is presented in Figure 9-1. Figure 9-4 displays the pattern of landownership for the basin

Forests above 3,500 feet are mostly Pacific silver fir, with Douglas fir, western hemlock, mountain hemlock, and lodgepole pine as associates. Below 3,500 feet, climax species are western hemlock, Douglas fir, and western red cedar. Alder, cottonwood, maple, and willow dominate the larger stream riparian areas (WDW 1990). A breakdown of land cover is presented in Figure 9-2. Figure 9-6 displays the pattern of land cover / land-use.

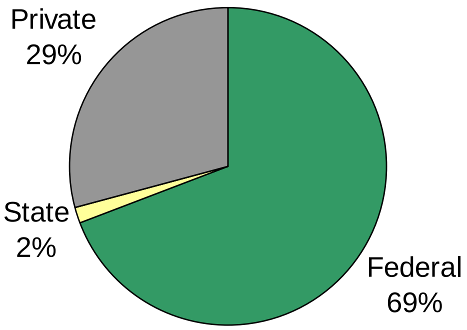


Figure 9-1. Upper Cowlitz River basin land ownership

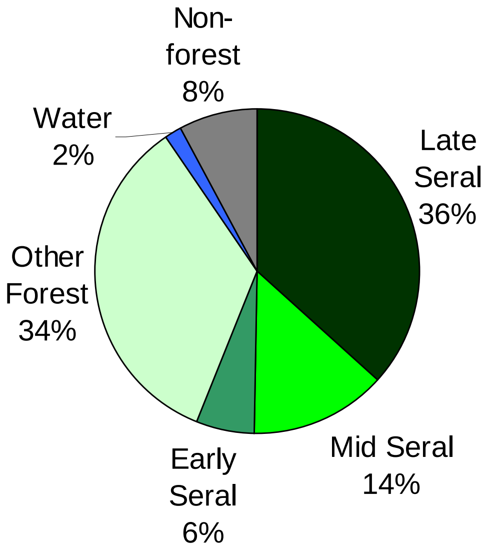


Figure 9-2. Upper Cowlitz River basin land cover

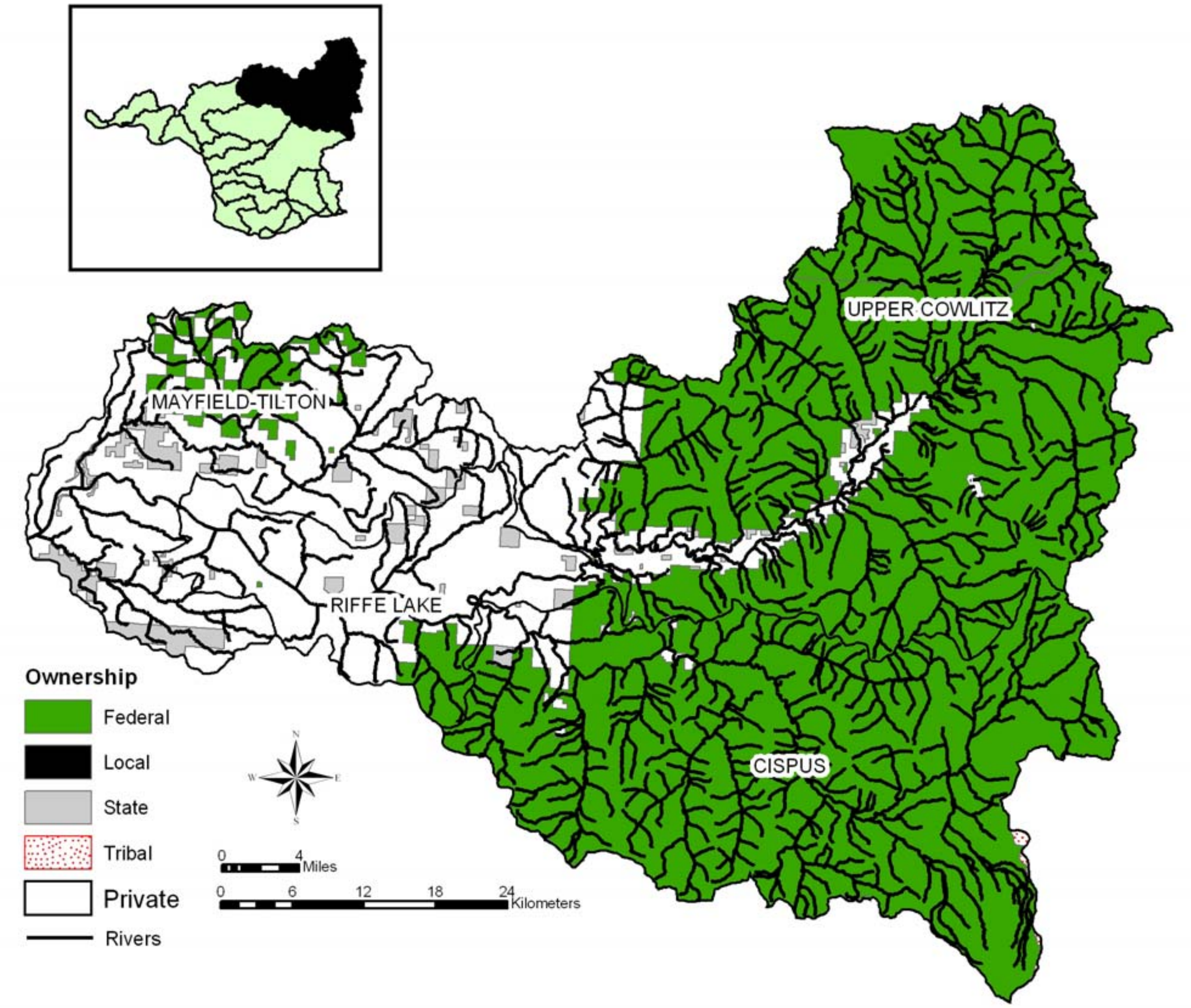


Figure 9-3. Landownership within the upper Cowlitz basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

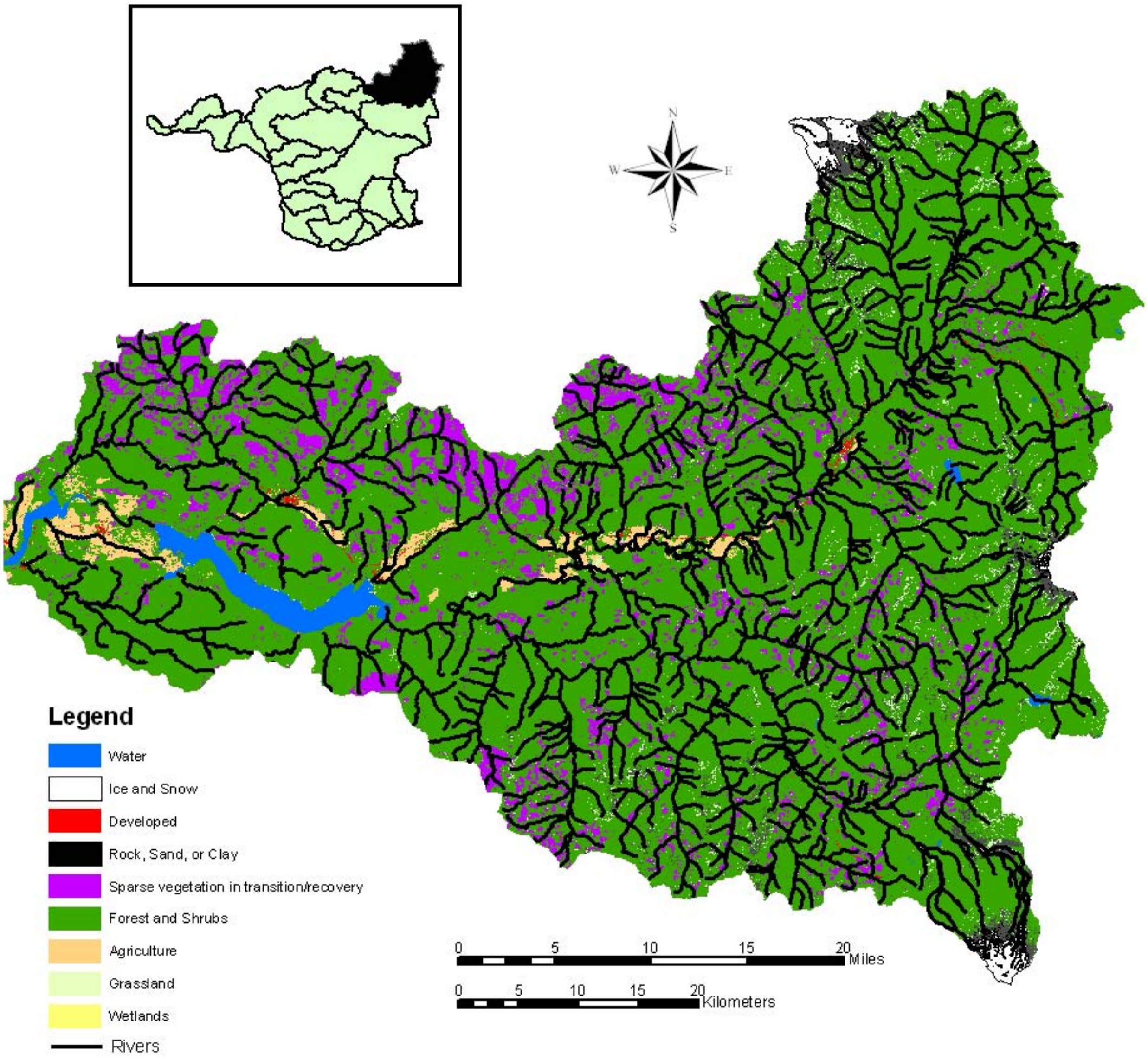
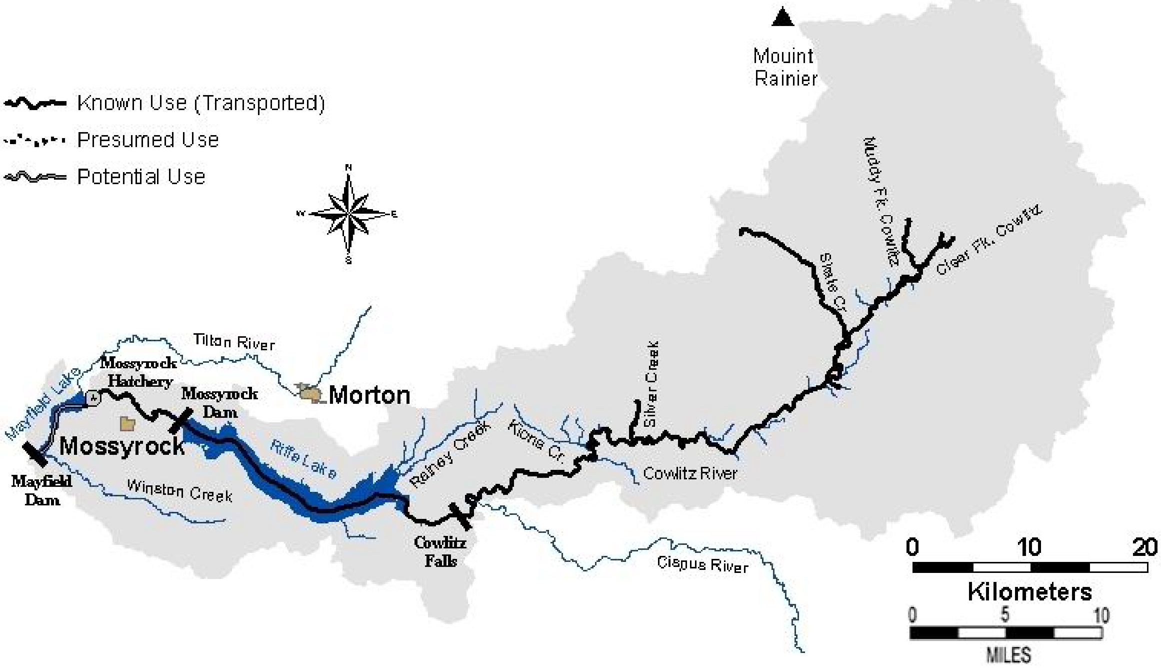


Figure 9-4. Land cover within the upper Cowliz basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

9.2 Focal Fish Species

9.2.1 Spring Chinook—Cowlitz Subbasin (Upper)

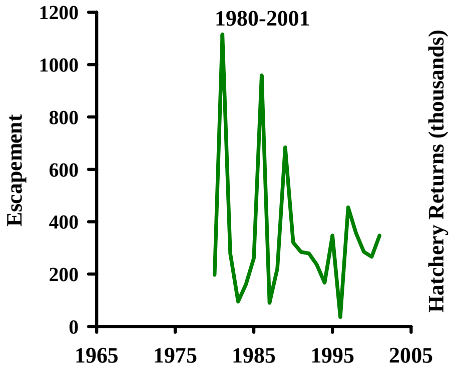
ESA: Threatened 1999 **SASSI: Depressed 2002**



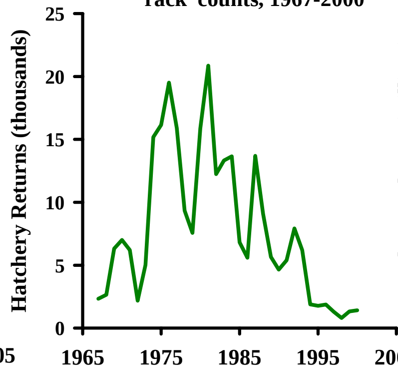
Distribution

- Historically, all spawning in the Cowlitz River occurred above the Mayfield Dam site, particularly in the mainstem Cowlitz River above Packwood and in the Cispus River between Iron and East Canyon Creeks (spring chinook were thought to have also spawned in the Tilton River, but confirmation and distribution of spawning is unknown)
- Completion of Mayfield Dam in 1962 blocked access above the dam (RM 52); fish were passed over the dam from 1962-66; from 1974-80, an average of 2,838 spring chinook were hauled to the Tilton and upper Cowlitz
- An adult trap and haul program began again in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam; spring chinook are now released in the upper Cowlitz and Cispus rivers
- A collection facility is currently operating at the Cowlitz Falls Dam to collect emigrating spring chinook smolts produced from adults released in the upper Cowlitz and Cispus rivers
- Natural spawning below Mayfield Dam is concentrated on the mainstem Cowlitz between the Cowlitz Salmon and Trout Hatcheries (~8.0 miles)

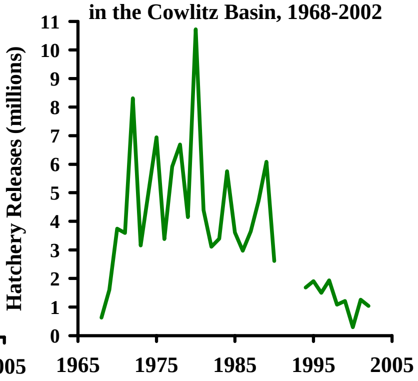
Spring chinook spawner escapement estimatess in the lower Cowlitz River, 1980-2001



Spring chinook Cowlitz Salmon Hatchery rack counts, 1967-2000



Spring chinook hatchery releases (fingerling and smolt) in the Cowlitz Basin, 1968-2002



Life History

- Spring chinook enter the Cowlitz River from March through June
- Natural spawning in the Cowlitz River occurs between late August and early October; the peak is usually around mid-September
- Age ranges from 2 year-old jacks to 6 year-old adults, with 4 year-olds the dominant age class (average is 43.76%)
- Fry emerge between November and March, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts

Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit (ESU)
- The Cowlitz spring chinook stock was designated based on distinct spawning distribution and early spawning timing
- Genetic analyses of Cowlitz River Hatchery spring chinook from 1982 and 1987 determined they were genetically similar to, but distinct from, Kalama Hatchery and Lewis River wild spring chinook and significantly different from other Columbia River spring chinook stocks

Abundance

- In 1948, WDF and WDG estimated that the Cowlitz River produced 32,490 adult spring chinook
- Spring chinook escapement estimates in 1951 were 10,400 in the Cowlitz basin, with 8,100 in the Cispus, 1,700 in the upper Cowlitz, 400 in the upper Toutle, and 200 in the Tilton
- From 1962-1966, an average of 9,928 spring chinook were counted annually at Mayfield Dam
- From 1978-1985 (excluding 1984), an average of 3,894 spring chinook were counted annually at Mayfield Dam
- Cowlitz River below Mayfield Dam spawning escapements from 1980-2001 ranged from 36-1,116 (average 338)
- Hatchery strays account for most spring chinook currently returning to the Cowlitz River

Productivity & Persistence

- NMFS Status Assessment for the Cowlitz River indicated a 0.03 risk of 90% decline in 25 years and a 0.25 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- Smolt density model predicted natural production potential for the Cowlitz River below Mayfield Dam of 329,400 smolts and 788,400 smolts for the Toutle River; above Mayfield Dam the model predicts production potential of 1,600,000 smolts
- Juvenile production from natural spawning is presumed to be low in the lower Cowlitz River

Hatchery

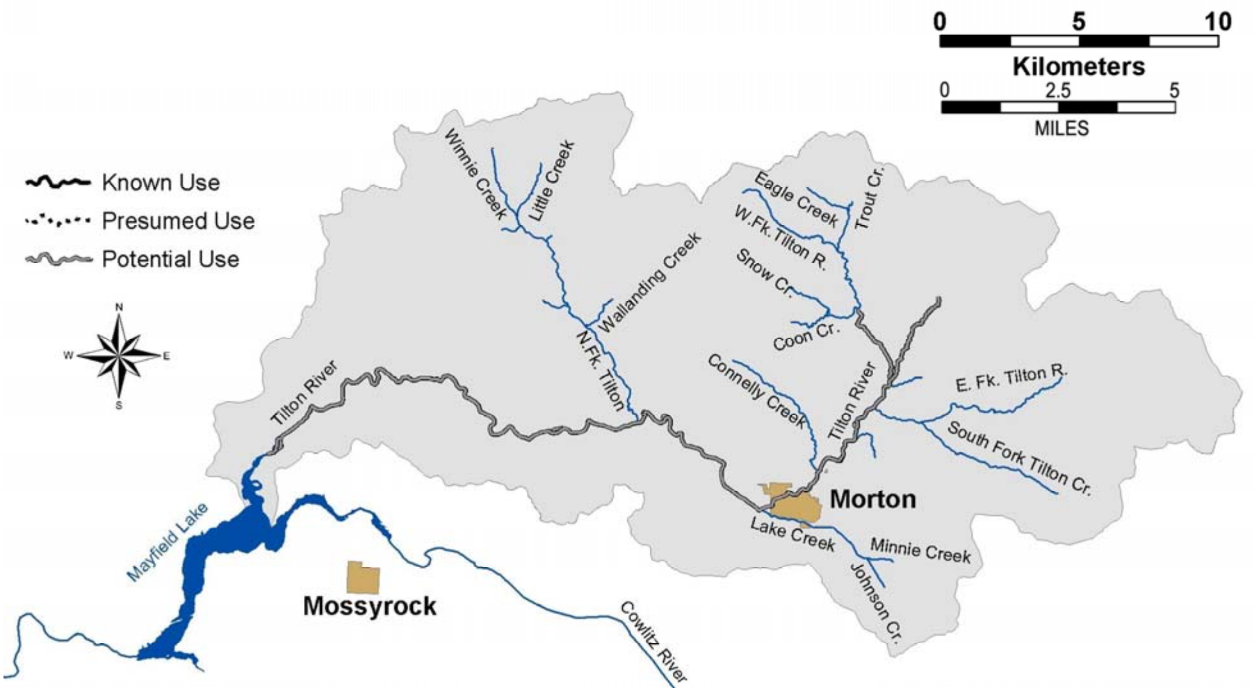
- Cowlitz River Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; the hatchery was completed in 1967
- Hatchery releases of spring chinook in the Cowlitz began in the 1940s; releases from the Salmon Hatchery into the Cowlitz River averaged 3,495,517 from 1968-1990, releases into the Toutle averaged 651,369 from 1972-1984
- In 2002, the Cowlitz Salmon and Trout Hatcheries reared and released 1,131,000 spring chinook smolts: 929,000 into the lower Cowlitz, 106,600 into the Toutle and 95,900 to Deep River
- Yearling and sub-yearling spring chinook are also released above Cowlitz Falls Dam into the upper Cowlitz and Cispus rivers

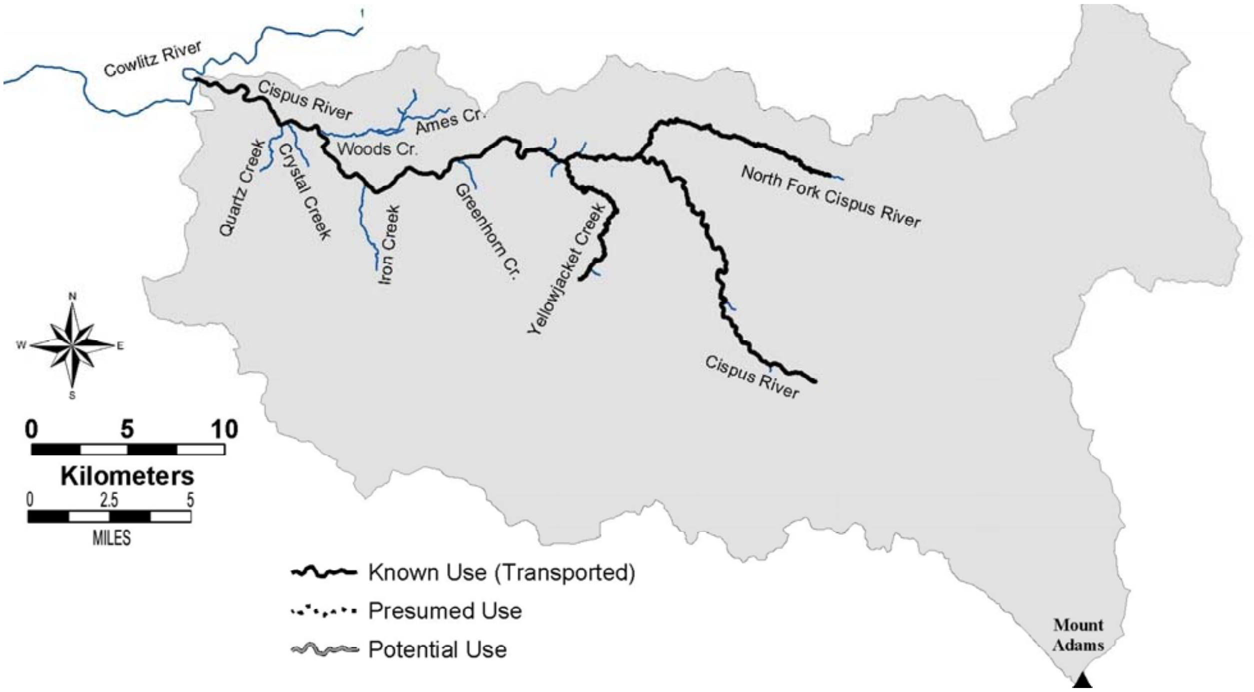
Harvest

- Cowlitz spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial and sport fisheries
- Coded-wire tag (CWT) data analysis of the 1989-1994 brood years indicates that 40% of the Cowlitz spring chinook were harvested and 60% escaped to spawn
- Fishery recoveries of the 1989-1994 brook Cowlitz River Hatchery spring chinook: Cowlitz sport (35%), British Columbia (29%), Washington Coast (22%), Columbia River (6%), Oregon coast (5%) and Alaska (3%)
- Mainstem Columbia River Harvest of Cowlitz spring chinook was substantially reduced and after 1977 when April and May spring chinook seasons were eliminated to protect upper Columbia and Snake wild spring chiook.
- Mainstem Columbia harvest of Cowlitz River Hatchery spring chinook increased in 2001-2002 when selective fisheries for adipose marked hatchery fish enabled mainstem spring fishing in April (and in May, 2002) again
- Sport harvest in the Cowlitz River averaged 7,100 spring chinook annually from 1980-1984, but reduced to 2,100 from 1985–94 and to only 200 from 1995–2002.
- Tributary harvest is managed to attain the Cowlitz Hatchery adult broodstock escapement goal

9.2.2 Spring Chinook—Cowlitz Subbasin (Tilton & Cispus)

ESA: Threatened **SASSI Depressed 2002**





Distribution

- Historically, all spawning in the Cowlitz River occurred above the Mayfield Dam site, particularly in the mainstem Cowlitz above Packwood and in the Cispus River between Iron and East Canyon Creeks (spring chinook were thought to also have spawned in the Tilton River, but confirmation and distribution of spawning is unknown)
- Completion of Mayfield Dam in 1962 blocked access above the dam (RM 52); fish were passed over the dam from 1962-66; from 1974-80, an average of 2,838 spring chinook were hauled to the Tilton and upper Cowlitz
- An adult trap and haul program began again in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam; spring chinook are released in the upper Cowlitz and Cispus
- A collection facility is currently operating at the Cowlitz Falls Dam to collect emigrating spring chinook smolts produced from adults released in the upper Cowlitz and Cispus Rivers
- Natural spawning in the Cowlitz River below Mayfield Dam is concentrated in the mainstem between the Cowlitz Salmon and Trout Hatcheries (~8.0 miles)

Life History

- Spring chinook enter the Cowlitz River from March through June
- Natural spawning in the Cowlitz River occurs between late August and early October; the peak is usually around mid-September
- Age ranges from 2-year-old jacks to 6-year-old adults, with 4-year-olds the dominant age class (average is 43.76%)
- Fry emerge between November and March, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts

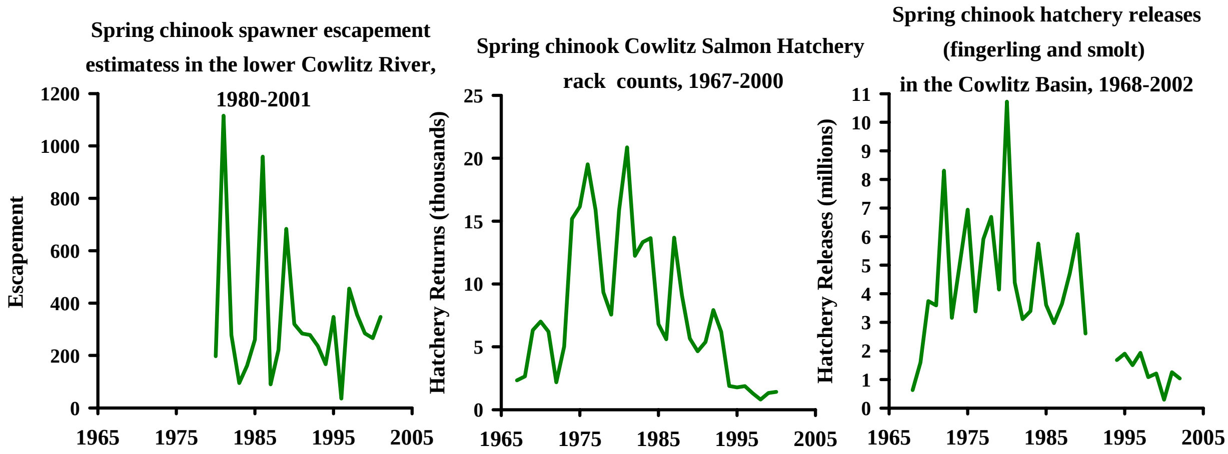
Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit (ESU)
- The Cowlitz spring chinook stock was designated based on distinct spawning distribution and early spawning timing
- Genetic analyses of Cowlitz River Hatchery spring chinook from 1982 and 1987 determined they were genetically similar to, but distinct from, Kalama Hatchery and Lewis River wild spring chinook and significantly different from other Columbia River spring chinook stocks

Abundance

- In 1948, WDF and WDG estimated that the Cowlitz River produced 32,490 adult spring chinook
- Spring chinook escapement estimates in 1951 were 10,400 in the Cowlitz basin, with 8,100 in the Cispus, 1,700 in the upper Cowlitz, 400 in the upper Toutle, and 200 in the Tilton
- From 1962-1966, an average of 9,928 spring chinook were counted annually at Mayfield Dam
- From 1978-1985 (excluding 1984), an average of 3,894 spring chinook were counted annually at Mayfield Dam
- Cowlitz River below Mayfield Dam spawning escapements from 1980-2001 ranged from 36 to 1,116 (average 338)

- Hatchery strays account for most spring chinook returning to the Cowlitz River



Spring chinook spawner escapement estimatess in the lower Cowlitz River, 1980-2001

Spring chinook Cowlitz Salmon Hatchery rack counts, 1967-2000

Spring chinook hatchery releases (fingerling and smolt) in the Cowlitz Basin, 1968-2002

Productivity & Persistence

- NMFS Status Assessment for the Cowlitz River indicated a 0.03 risk of 90% decline in 25 years and a 0.25 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- Smolt density model predicted natural production potential for the Cowlitz River below Mayfield Dam of 329,400 smolts and 788,400 smolts for the Toutle River; above Mayfield Dam the model predicts production potential of 1,600,000 smolts
- Juvenile production from natural spawning is presumed to be low

Hatchery

- Cowlitz Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; hatchery was completed in 1967
- Hatchery releases of spring chinook in the Cowlitz began in the 1940s; releases from the salmon hatchery into the Cowlitz River averaged 3,495,517 from 1968-1990, releases into the Toutle River averaged 651,369 from 1972-1984
- Some yearling and sub-yearling spring chinook are also released above Mayfield Dam as part of a spring chinook reintroduction program
- In 2002, the Cowlitz Salmon and Trout Hatcheries reared and released 1,131,000 spring chinook smolts: 929,000 into the lower Cowlitz, 106,600 into the Toutle River and 95,900 to Deep River

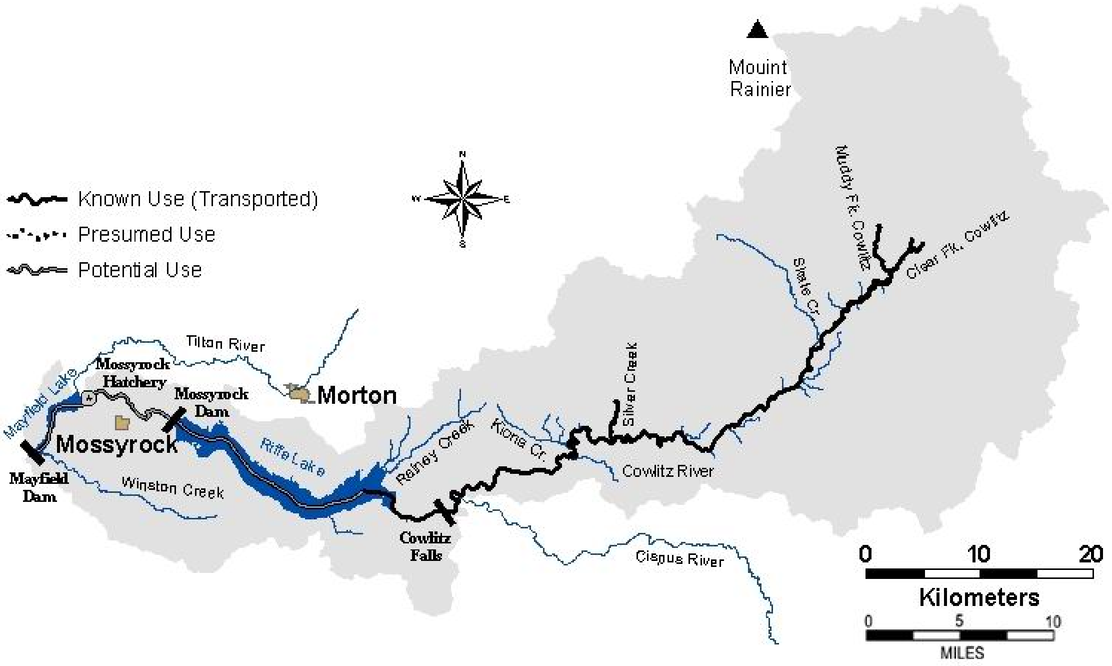
Harvest

- Cowlitz spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial and sport fisheries
- Coded-wire tag (CWT) data analysis of the 1989-1994 brood years indicates that 40% of the Cowlitz spring chinook were harvested and 60% escaped to spawn
- Fishery recoveries of the 1989-1994 brood Cowlitz River Hatchery spring chinook: Cowlitz sport (35%), British Columbia (29%), Washington Coast (22%), Columbia River (6%), Oregon coast (5%) and Alaska (3%)
- Mainstem Columbia River harvest of Cowlitz River spring chinook was substantially reduced after 1977 when April and May spring chinook seasons were eliminated to protect upper Columbia and Snake wild spring chinook.

- Mainstem Columbia River harvest of Cowlitz River Hatchery spring chinook increased in 2001-2002 when selective fisheries for adipose marked hatchery fish enabled mainstem spring fishing in April (and in May, 2002) again
- Sport harvest in the Cowlitz River averaged 7,100 spring chinook annually from 1980-1984, but reduced to 2,100 from 1985-1994 and only 200 from 1995-2002.
- Tributary harvest is managed to attain the Cowlitz River hatchery adult broodstock escapement goal

9.2.3 Fall Chinook—Cowlitz Subbasin (Cowlitz)

ESA: Threatened 1999 **SASSI: Depressed 2002**

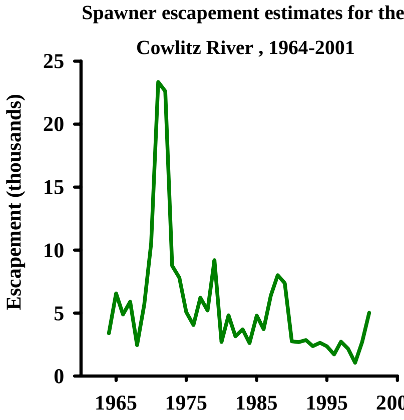


Distribution

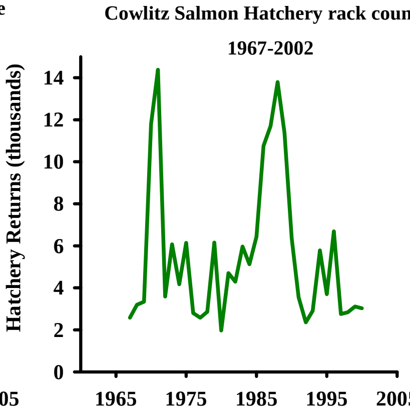
- In the Cowlitz River, spawning occurs in the mainstem between the Cowlitz River Salmon Hatchery and the Kelso Bridge (~45 miles), but is concentrated in the area between the Cowlitz Salmon and Trout Hatcheries (RM 52 and 41.3)
- Historically, Cowlitz River fall chinook were distributed from the mouth to upper tributaries such as the Ohanapecosh and Tilton Rivers and throughout the upper basin
- Completion of Mayfield Dam in 1962 blocked access above the dam (RM 52); all fish were passed over the dam from 1962–66; from 1967–80, small numbers of fall chinook were hauled to the Tilton and upper Cowlitz
- An adult trap and haul program began again in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam; fall chinook are currently released in the upper Cowlitz and Cispus Rivers

Life History

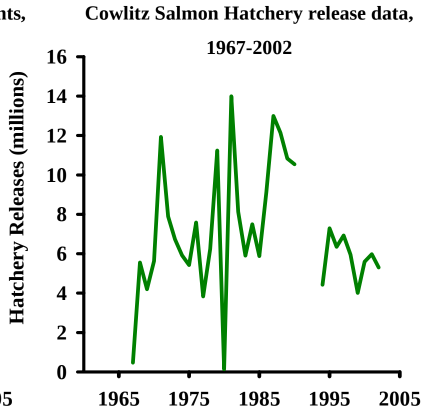
- Fall chinook enter the Cowlitz River from early September to late November
- Natural spawning in the Cowlitz River occurs between September and November, over a broader time period than most fall chinook; the peak is usually around the first week of November
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult age of 3, 4, and 5 (averages are 16.49%, 58.05%, and 19.31%, respectively)
- Fry emerge around March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings
- Cowlitz fall chinook display life history characteristics (spawn timing, migration patterns) that fall between tules and Lewis River late spawning wild fall chinook



Spawner escapement estimates for the Cowlitz River , 1964-2001



Cowlitz Salmon Hatchery rack counts, 1967-2002



Cowlitz Salmon Hatchery release data, 1967-2002

Diversity

- The Cowlitz fall chinook stock is designated based on distinct spawning timing and distribution
- Genetic analysis of Cowlitz River Hatchery fall chinook from 1981, 1982, and 1988 determined they were similar to, but distinct from, Kalama Hatchery fall chinook and distinct from other Washington chinook stocks

Abundance

- Historical abundance of natural spawning fall chinook in the Cowlitz River is estimated to have once been 100,000 adults, declining to about 18,000 adults in the 1950s, 12,000 in the 1960s, and recently to less than 2,000
- In 1948, WDF and WDG estimated that the Cowlitz River produced 63,612 adult fall chinook; escapement above the Mayfield Dam site was at least 14,000 fish
- Fall chinook escapement estimates in 1951 were 10,900 in the Cowlitz and minor tributaries, 8,100 in the Cispus, and 500 in the Tilton
- From 1961–66, an average of 8,535 fall chinook were counted annually at Mayfield Dam
- Cowlitz River spawning escapement from 1964-2001 ranged from 1,045 to 23,345 (average 5,522)
- Currently hatchery production accounts for most fall chinook returning to the Cowlitz River
- Natural spawning escapement goal is 3,000 fish; the goal was not met from 1990-2000

Productivity & Persistence

- NMFS Status Assessment for the Cowlitz River indicated a 0.15 risk of 90% decline in 25 years and a 0.33 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0
- Two adult production potential estimates have been reported for the upper Cowlitz: 63,818 and 93,015
- Smolt density model predicted natural production potential for the Cowlitz River below Mayfield Dam of 2,183,000 smolts; above Mayfield Dam the model predicts production potential of 357,000 smolts from the Tilton River and 4,058,000 smolts above Cowlitz Falls
- Current juvenile production from natural spawning is presumed to be low

Hatchery

- Cowlitz River Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; hatchery was completed in 1967; broodstock is primarily native Cowlitz fall chinook

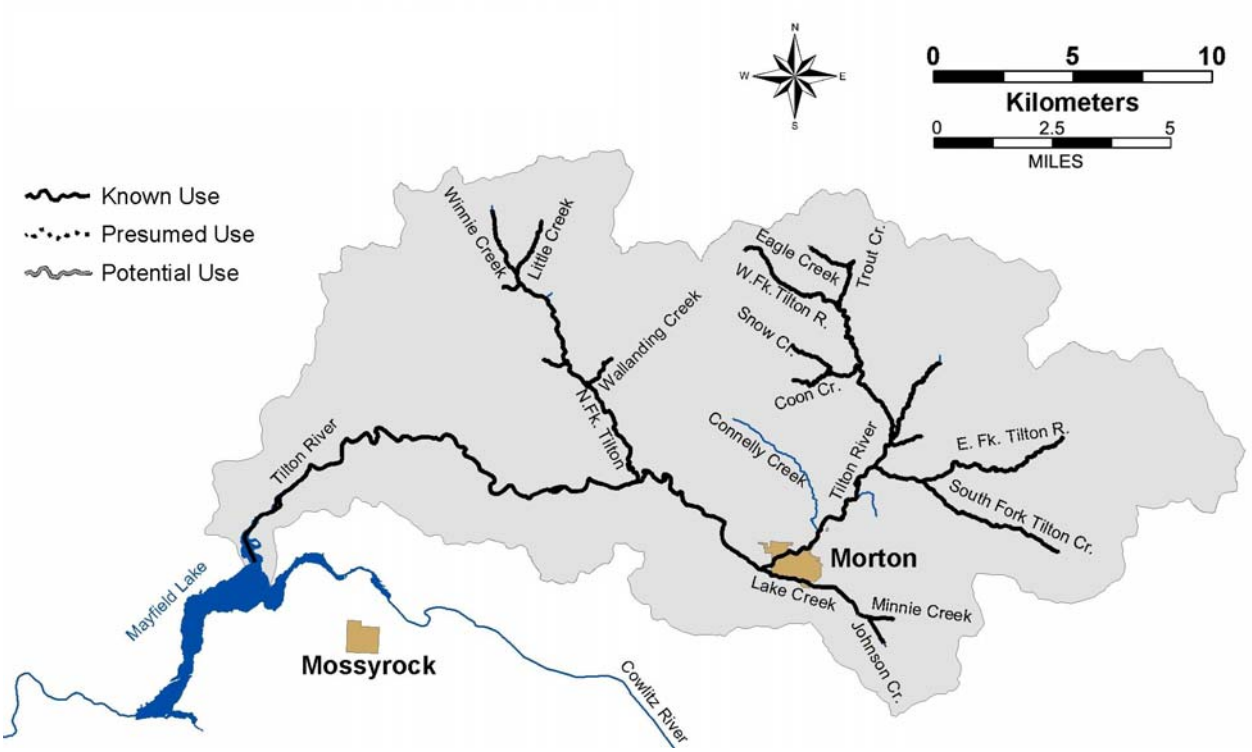
- Hatchery releases of fall chinook in the Cowlitz River began in 1952; hatchery release data are displayed for 1967-2002
- The current hatchery program goal is 5 million fall chinook juveniles released annually

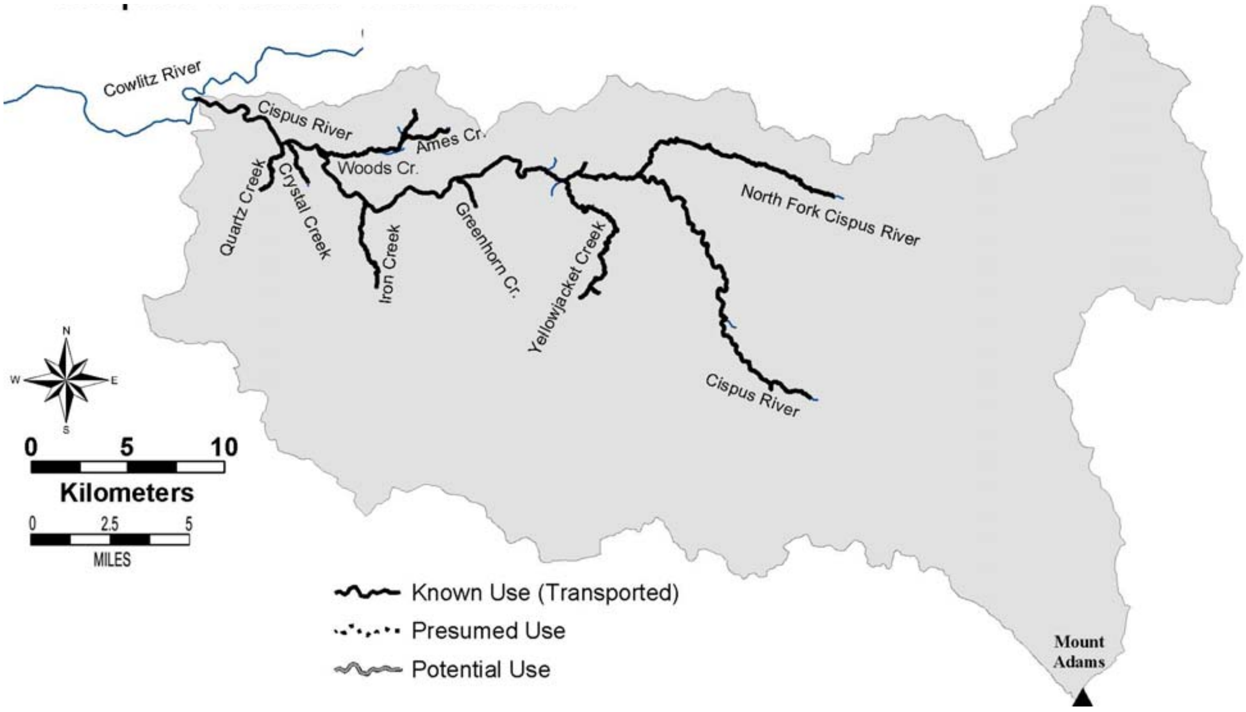
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial and sport fisheries
- Ocean and mainstem Columbia River fisheries are managed for Snake and Coweeman River wild fall chinook ESA harvest rate limits which limits the harvest of Cowlitz fall chinook
- Cowlitz fall chinook are important contributors to Washington ocean sport and troll fisheries and to the Columbia River estuary sport (Buoy 10) fishery
- CWT data analysis of the 1989–94 brood years indicates a total Cowlitz Hatchery fall chinook harvest rate of 33% with 67% accounted for in escapement
- The majority of fishery CWT recoveries of 1989–94 brood Cowlitz Hatchery fall chinook were distributed between Washington ocean (30%), British Columbia (21%), Alaska (15%), Cowlitz River (11%), and Columbia River (8%) sampling areas
- Annual harvest is variable depending on management response to annual abundance in PSC (US/Canada), PFMC (US ocean), and Columbia River Compact Forums
- Sport harvest in the Cowlitz River averaged 2,672 fall chinook annually from 1977–86
- Freshwater sport fisheries in the Cowlitz River are managed to achieve adult fall chinook hatchery escapement goals

9.2.4 Winter Steelhead—Cowlitz Subbasin (Tilton and Cispus)

ESA: Threatened 1998 **SASSI: Unknown 2002**





Distribution

- Winter steelhead are distributed throughout the mainstem Cowlitz River below Mayfield Dam; natural spawning occurs in Olequa, Ostrander, Salmon, Arkansas, Delameter, Stillwater and Whittle Creeks
- Historically, winter steelhead were distributed throughout the upper Cowlitz, Cispus, and Tilton Rivers; known spawning areas include the mainstem Cowlitz near Riffle and the reach between the Muddy Fork and the Clear Fork and the lower Ohanapecosh River
- Construction of Mayfield Dam in 1963 blocked winter steelhead access to the upper watershed; approximately 80% of the spawning and rearing habitat are not accessible
- In 1994, a trap and haul program began to reintroduce anadromous salmonids to the watershed above Cowlitz Falls Dam; adult winter steelhead are collected at the Cowlitz hatcheries and released in the upper Cowlitz, Cispus, and Tilton basins; smolts resulting from natural production in the upper watershed are collected at the Cowlitz Falls Fish Collection Facility, acclimated at the Cowlitz Salmon Hatchery, and released in the mainstem Cowlitz

Life History

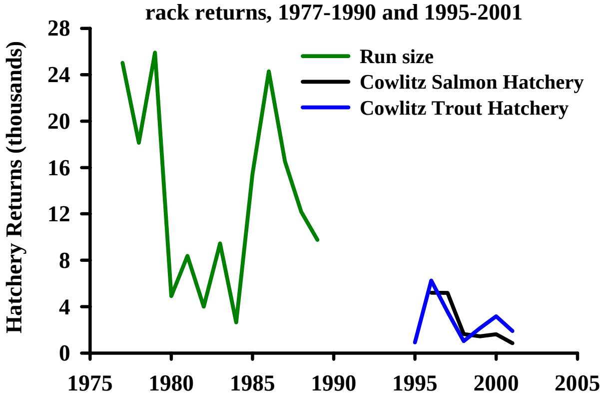
- Adult migration timing for Cowliltz winter steelhead is from December through April
- Spawning timing on the Cowlitz is generally from early March to early June
- Limited age composition data for Cowlitz River winter steelhead indicate that the dominant age classes are 2.2 and 2.3 (54.2% and 32.2 %, respectively)
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

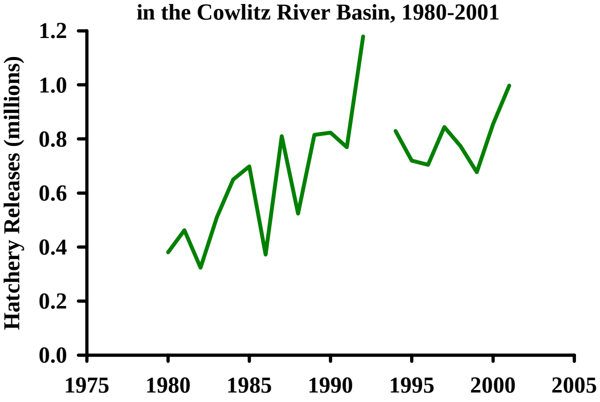
Diversity

- Cowlitz winter steelhead stock designated based on distinct spawning distribution
- Concern with wild stock interbreeding with hatchery brood stock from Chambers Creek and the Cowlitz River (Cowlitz and late Cowlitz stock)
- Allele frequency analysis of Cowlitz Hatchery late winter steelhead in 1996 was unable to determine the distinctiveness of the stock compared to other lower Columbia steelhead stocks

Abundance

- Historically, annual wild winter steelhead runs to the Cowlitz River were estimated at 20,000 fish; escapement was estimated as 11,000 fish
- In 1936, steelhead were observed in the Cispus River and reported in the Tilton River during escapement surveys
- Between 1961 and 1966, an average of 11,081 adult steelhead were collected annually at the Mayfield Dam Fish Passage Facility
- In the late 1970s and 1980s, wild winter steelhead annual average run size in the Cowlitz River was estimated to be 309 fish
- From 1983–95, the annual escapement of Cowlitz River winter steelhead ranged from 4,067-30,200 (average 16,240)


Estimated hatchery steelhead run size and Cowlitz Salmon and Trout Hatcheries steelhead rack returns, 1977-1990 and 1995-2001


Winter steelhead smolt hatchery releases in the Cowlitz River Basin, 1980-2001

Productivity & Persistence

- In the late 1970s and 1980s, wild winter steelhead contribution to the annual winter steelhead return was estimated to be 1.7%
- Estimated potential winter steelhead smolt production for the Cowlitz River is 63,399

Hatchery

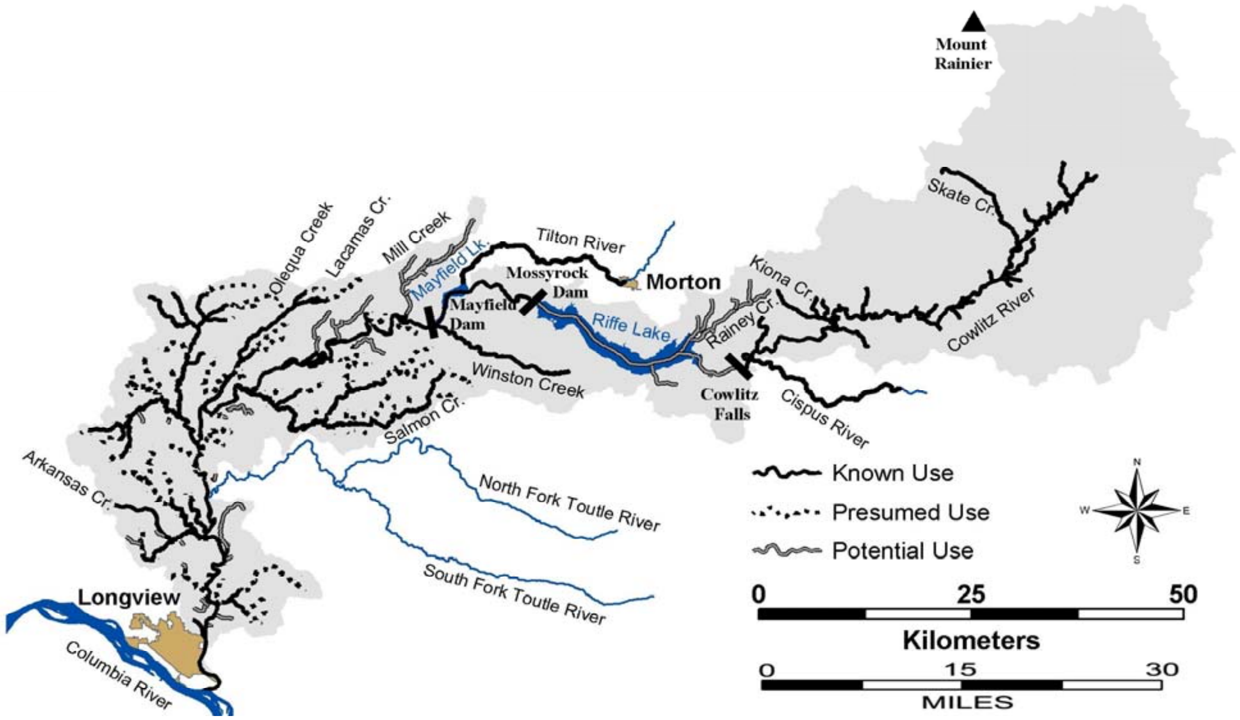
- The Cowlitz Trout Hatchery, located on the mainstem Cowlitz at RM 42, is the only hatchery in the Cowlitz basin producing winter steelhead
- Hatchery winter steelhead have been planted in the Cowlitz River basin since 1957; broodstock from the Cowlitz River and Chambers Creek have been used; an annual average of 180,000 hatchery winter steelhead smolts were released in the Cowlitz River from 1967–94; smolt release data are displayed from 1980–2001
- Hatchery fish account for the majority of the winter steelhead run to the Cowlitz River basin

Harvest

- No directed commercial or tribal fisheries target Cowlitz winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Steelhead sport fisheries in the Columbia must release wild winter steelhead which are not marked with an adipose fin clip
- ESA limits fishery impact of wild winter steelhead in the mainstem Columbia and in the Cowlitz basin
- Approximately 6.2% of returning Cowlitz River steelhead are harvested in the Columbia River sport fishery
- Wild winter steelhead sport harvest in the Cowlitz River from in the late 1970s and early 1980s ranged from 102-336; wild winter steelhead contribution to the total annual sport harvest was less than 2%
- The Cowlitz River may be the most intensely-fished basin in the Washington sport fisheries; the Cowlitz has been the top winter steelhead river in Washington

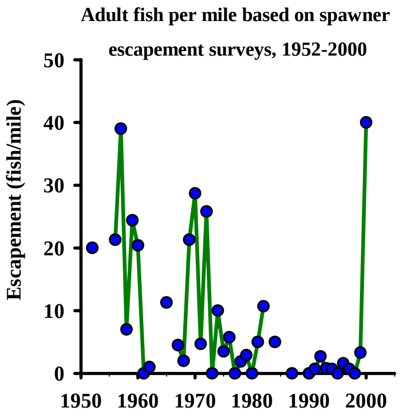
9.2.5 Coho—Cowlitz Subbasin

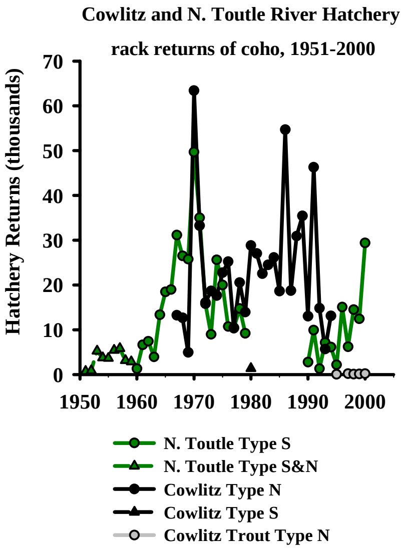
ESA: Candidate 1995 **SASSI: Cowlitz—Depressed 2002;**

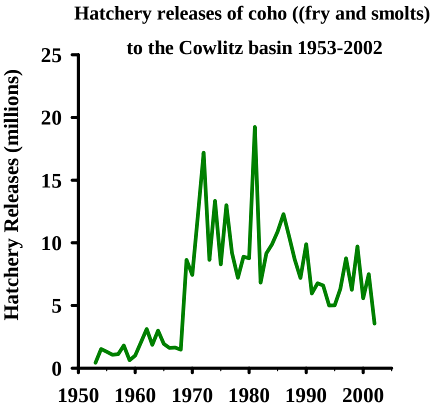


Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River and late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho, including the Toutle, SF Toutle, Coweeman, and Green Rivers and all accessible tributaries
- Natural spawning in lower Cowlitz tributaries occurs primarily in Olequa, Lacamas, Brights, Ostrander, Blue, Otter, Mill, Arkansas, Foster, Stillwater, Campbell, and Hill Creeks
- Natural spawning in the Coweeman River basin is primarily in tributaries downstream of the confluence of Mulholland Creek
- The post Mt. St. Helens eruption Toutle River system includes tributaries at various stages of recovery and some tributaries (primarily on the Green and South Toutle) with minor effects of the eruption. Bear, Hoffstadt, Johnson, Alder, Devils, and Herrington Creeks are examples of tributaries important to coho; coho adults are collected and passed to tributaries above the North Toutle Sediment Retention Dam
- Completion of Mayfield Dam in 1962 blocked access above the dam; a returning adult trap and haul program began in 1994 where fish were collected below Mayfield Dam and released above Cowlitz Falls Dam, restoring some access to the upper watershed.


Adult fish per mile based on spawner escapement surveys, 1952-2000


Cowlitz and N. Toutle River Hatchery rack returns of coho, 1951-2000


Hatchery releases of coho ((fry and smolts) to the Cowlitz basin 1953-2002

Life History

- Adults enter the Columbia River from August through January (early stock primarily from mid-August through September and late stock primarily from late September to October)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge from January through April on the Cowlitz, depending on water temperature
- Coho spend one year in fresh water, and emigrate as age-1 smolts in the spring

Diversity

- Late stock (or Type-N) coho are informally considered synonymous with Cowlitz River stock
- Early stock(or Type-S) coho are informally considered synonymous with Toutle River stock
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Cowlitz River wild coho run is a fraction of its historical size
- In 1948, WDF estimated coho escapement to the basin was 77,000; in the early 1950s, escapement to the basin was estimated as 32,500 coho
- Escapement surveys on Olequa Creek from 1952-1990 established a range of 0-40 fish/mile
- Average total escapement of natural coho to the Toutle River was estimated as 1,743 for the years 1972-1979, prior to the 1980 eruption of Mt. St. Helens
- In 1985, an estimated 5,229 coho naturally spawned in lower Cowlitz River tributaries (excluding the Coweeman and Toutle systems), but the majority of spawners were fish originating from the Cowlitz Hatchery
- Hatchery production accounts for most coho returning to the Cowlitz River

Productivity & Persistence

- Natural coho production is presumed to be very low in the lower Cowlitz basin with Olequa Creek the most productive
- The Toutle River system likely provided the most productive habitat in the basin in the 1960s and 1970s, but was greatly reduced after the 1980 Mt. St. Helens eruption
- Reintroduction efforts in the upper Cowlitz River basin have demonstrated good production capabilities in tributaries above the dams, but efforts are challenged in passing juvenile production through the system
- Smolt density model natural production potential estimates were made on various sections of the Cowlitz River basin: 123,123 smolts for the lower Cowlitz River, 131,318 smolts for the Tilton River and Winston Creek, 155,018 smolts above Cowlitz Falls, 142,234 smolts for the Toutle River, and 37,797 smolts for the Coweeman River

Hatchery

- The Tilton River Hatchery released coho in the Cowlitz basin from 1915-1921
- A salmon hatchery operated in the upper Cowlitz River near the mouth of the Clear Fork until 1949
- The Cowlitz Salmon Hatchery is located about 2 miles downstream of Mayfield Dam; hatchery was completed in 1967; the hatchery is programmed for an annual release of 4.2 million late coho smolts
- Cowlitz Hatchery coho are important to the reintroduction effort in the upper basin
- The North Toutle Hatchery is located on the Green River less than a mile upstream of the confluence with the North Fork Toutle River; the hatchery is programmed for an annual release of 1 million early coho smolts

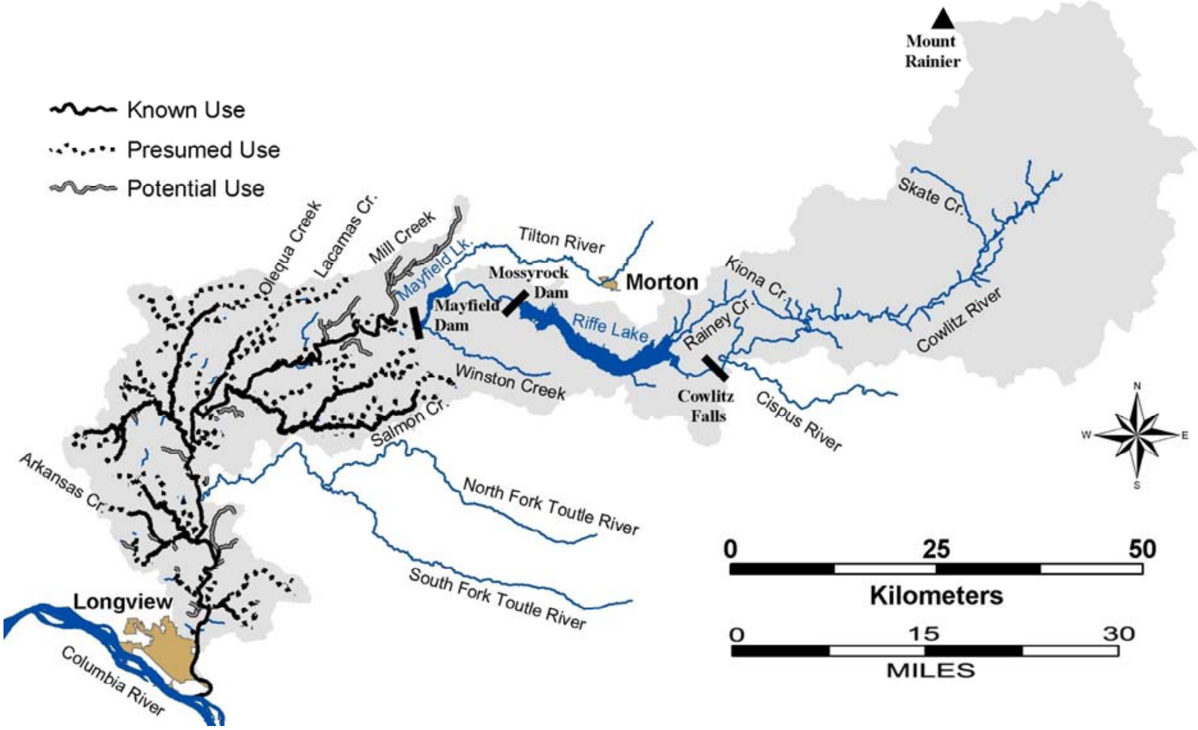
Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest of Columbia produced coho ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho stocks
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, Columbia River hatchery fish have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late coho harvest can also be substantial
- An average of 1,494 coho (1986-1990) were harvested annually in the Cowlitz River sport fishery

- The Toutle River sport fishery was closed in 1982 after the eruption of Mt. St. Helens; the Green River sport fishery was closed from 1981 to 1988 after the eruption of Mt. St. Helens and was reopened in 1989
- CWT data analysis of the 1995-97 North Toutle Hatchery early coho indicates 34% were captured in fisheries and 66% were accounted for in escapement
- CWT data analysis of the 1994 and 1997 brood Cowlitz Hatchery late coho indicates 64% were captured in fisheries and 36% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 Toutle coho were distributed between Columbia River (47%), Washington ocean (37%), and Oregon ocean (15%) sampling areas
- Fishery CWT recoveries of 1994 and 1997 brood Cowlitz coho were distributed between Columbia River (55%), Washington ocean (30%), and Oregon ocean (15%) sampling areas

9.2.6 Cutthroat Trout—Cowlitz River Subbasin

ESA: Not Listed **SASSI: Depressed 2000**

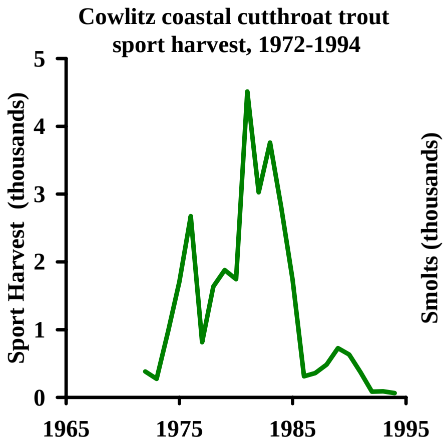


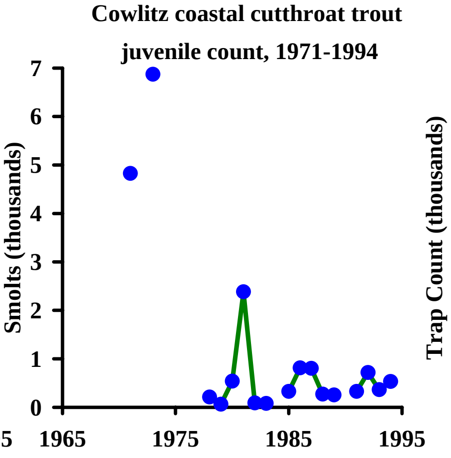
Distribution

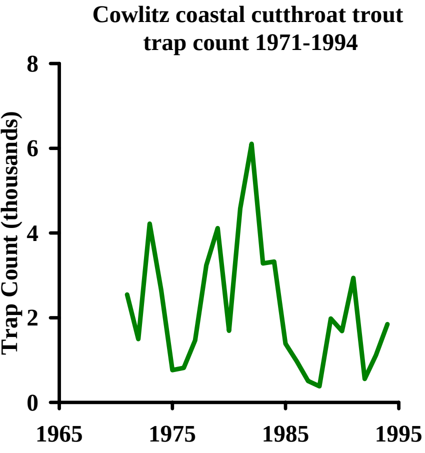
- Anadromous forms were historically present throughout the watershed, but are now limited to the area downstream of Mayfield Dam, which block passage
- Adfluvial forms are present in Mayfield, Riffe, and Scanewa Reservoirs
- Resident forms are documented throughout the system and are the only form present upstream of Mayfield Dam

Life History

- Anadromous, adfluvial, fluvial and resident forms are present
- Anadromous river entry is from July through October, with peak entry in August and September
- Anadromous spawning occurs from January through mid-April
- Fluvial and resident spawn timing is not documented but is believed to be similar to anadromous timing
- Spawn timing at higher elevations is likely later, and may occur as late as June
- Hatchery cutthroat spawn from November to February, due to artificial selection for early spawn timing
- Smolt migration occurs in the spring after juveniles have spend 2 to 3 years in fresh water


Cowlitz coastal cutthroat trout sport harvest, 1972-1994


Cowlitz coastal cutthroat trout juvenile count, 1971-1994


Cowlitz coastal cutthroat trout trap count 1971-1994

Diversity

- Distinct stock based on geographic distribution of spawning areas
- Genetic sampling of ten groups within the Cowlitz system showed little difference among the groups
- Cowlitz collections were significantly different from other lower Columbia samples, except for Elochoman/Skamakowa Creek.

Abundance

- Anadromous counts at Mayfield Dam from 1962 to 1996 ranged from 5458 to 12,324 fish, and averaged 8698
- Outmigrant trapping at Mayfield migrant trap shows a long term declining trend
- Recent years' counts average about 10% of outmigrant counts when sampling began in the early 60s
- Smolt counts have been under 1000 every year since 1978, with the exception of 1982
- No population size data for resident forms

Hatchery

- Cowlitz Trout Hatchery began producing anadromous cutthroat in 1968
- The goal is 115,000 smolts larger than 210 mm to produce a return to the hatchery of 5000 adults

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia River summer fisheries downstream of the Cowlitz River
- Cowlitz River sport harvest for hatchery cutthroat can be significant in year of large adult returns.
- Wild cutthroat (unmarked fish) must be released

9.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Fall chinook, spring chinook, winter steelhead and coho in the Upper Cowlitz, Cispus and Tilton suffer the greatest loss from hydrosystem impacts of all impact factors.
- Loss of tributary and estuary habitat quality and quantity has significant impacts on all four populations. Losses are greatest for fall and spring chinook.
- Coho, spring chinook and fall chinook sustain moderate losses from harvest impacts. Impacts to winter steelhead are relatively minor.
- Hatchery impacts are moderately important to winter steelhead, but are relatively minor for spring and fall chinook and coho.
- Predation impacts in the upper Cowlitz, Tilton and Cispus are relatively minor for all four populations.

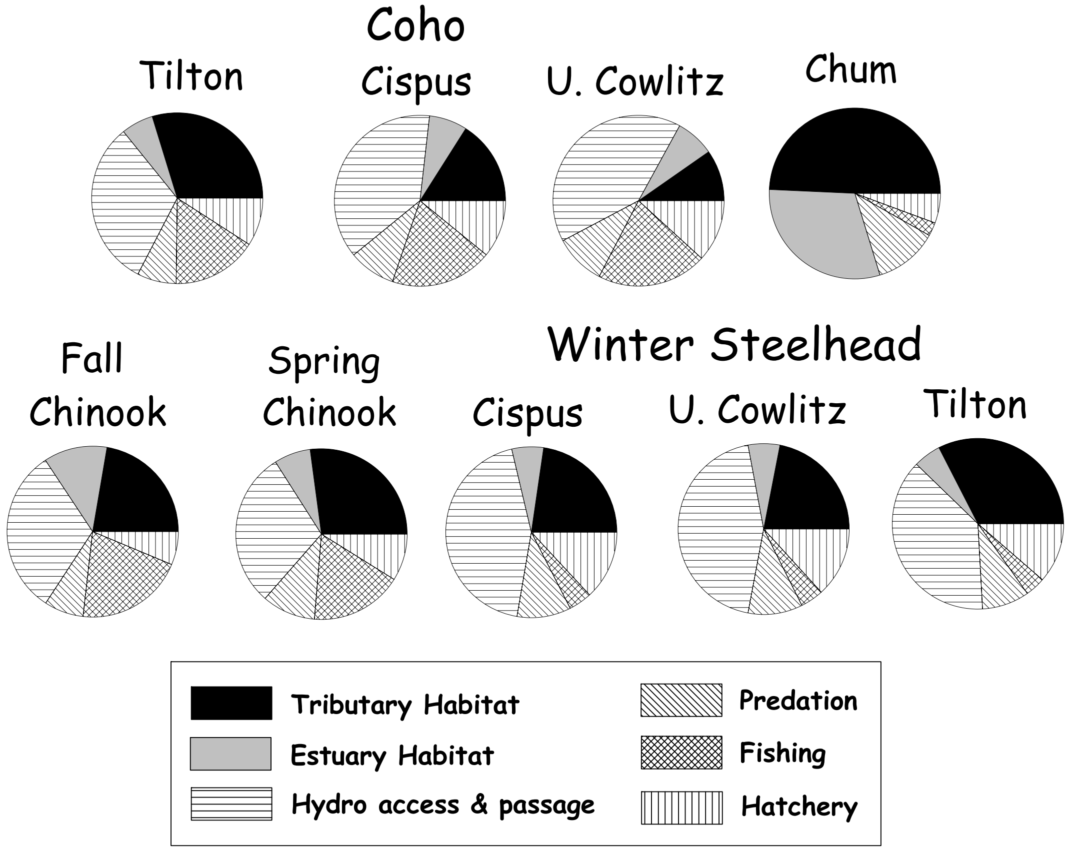


Figure 9-5. Relative index of potentially manageable mortality factors for each species in the Upper Cowlitz subbasin.

9.4 Hatchery Programs

Vol II, Chapter 7.4 cotains a discussion of the hatcheries in the Cowlitz basin

9.5 Fish Habitat Conditions

9.5.1 Passage Obstructions

The hydropower system is the primary factor for decline in the upper Cowlitz basin. Historically, spawning grounds in the upper basin produced 20% of the fall chinook and 38% of the steelhead in the Cowlitz basin (Mobrand Biometrics 1999). The hydropower facilities impede volitional access to upstream habitats. Furthermore, over 48 miles of stream habitat was flooded by the Mayfield, Mossyrock, and Cowlitz Falls Dams.

The Barrier Dam and Mayfield Dam prevent all volitional passage of anadromous fish above RM 52. A facililty at the Barrier Dam (RM 49) collects coho, winter steelhead, and coastal cutthroat, which are hauled upstream of the Cowlitz Falls Dam. Outmigrating smolts are collected at the Cowlitz Falls Fish Collection Facility (CFFCF) above Cowlitz Falls Dam and are hauled below the Barrier Dam. Some fish may avoid collection at the CFFCF and pass through the Cowlitz Falls Dam turbines or through the dam spill. Passage of juvenile migrants through Riffe Lake is a major problem for maintaining sustainable anadromous fish runs in the upper basin. A 1999 study revealed that only 63% of radio tagged steelhead smolts traveled successfully from the Cowlitz Falls Dam tailrace to a collection facility at Mossyrock Dam. None of the tagged coho and chinook were detected at Mossyrock. This study revealed potential problems with migration through the reservoir as well as problems with smolt collection at Mossyrock Dam (Harza 2000). Currently, there is no regular juvenile collection at Mossyrock Dam. Regular collection of downstream migrants was discontinued in 1974. The 606 foot tall Mossyrock Dam prevents access to several Riffe Lake tributaries, including Rainey Creek, which is believed to have a substantial amount of potentially productive habitat (Wade 2000). Radio-telemetry studies of coho and steelhead revealed a low (<50%) survival rate of juvenile migrants negotiating Mayfield Lake. Results could be due to predation, water quality, flow, or monitoring error (Harza 1999 as cited in Wade 2000).

Apart from the mainstem Cowlitz dams, passage problems in the Mayfield Lake basin include numerous culverts and road crossings in the Winston Creek, Connelly Creek, East Fork Tilton, South Fork Tilton, and West Fork Tilton basins. A full description is given in Wade (2000). Passage problems in the Cispus include subsurface flows in Copper Creek, Crystal Creek, and Camp Creek. A culvert in Woods Creek blocks approximately 1 mile of potential anadromous habitat. Subsurface and/or low flow conditions related to excessive sediment aggradation are believed to create passage problems in some areas of the upper Cowlitz basin. Ten such barriers are identified by the USFS (1997a and 1997b). The USFS has also identified several artificial barriers including culverts and other features.

9.5.2 Stream Flow

Runoff is predominantly generated by rainfall, with a portion of spring flows coming from snowmelt in the upper elevations and occasional winter peaks related to rain-on-snow events. A few upper tributaries drain glaciers and contribute meltwater during dry summer months. Most of the lower elevation streamflows are controlled by winter rainfall.

Flow in the mainstem is regulated in large part by the hydropower system. See Figure 9-6 for a comparison of flows upstream and downstream of the reservoirs:

- Cowlitz Falls Dam is the uppermost hydropower project (RM 88.5). It is owned and operated by Lewis County Public Utility District (PUD) No. 1 and is a run-of-the-river facility (no significant storage) that creates daily fluctuations related to power production.
- Mossyrock Dam (RM 66) is operated by Tacoma Power and provides 1,686,000 acre-feet of storage in Riffe Lake. The lake's levels are raised in the spring and drawn down in the fall in preparation for winter flows.
- Mayfield Dam (RM 52) is also operated by Tacoma Power and has a relatively small 133,764 acre-foot capacity. Behind Mayfield Dam, Mayfield Lake provides little flood storage capacity and flows from Mayfield Dam are largely in response to the regulation of flows through Mossyrock Dam.
- The Barrier Dam and salmon hatchery at RM 49.5 also are operated by Tacoma Power.

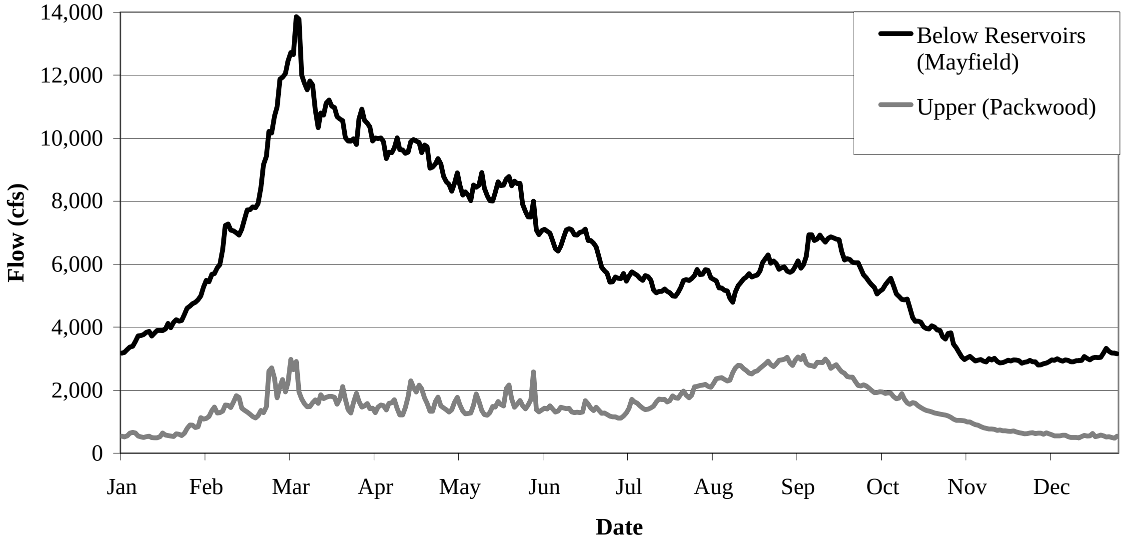


Figure 9-6. Cowlitz River hydrographs (mean daily flows 1972-2001). Both stations exhibit winter peaks due to rain and rain-on-snow events. There is a rise in flows in the fall in the Cowlitz near Packwood due to late summer snowmelt from snowfield and glacial melt. The rise in flows below the reservoirs is due partly to snowmelt flows and partly to flow releases at the dams in preparation for winter rains. USGS Gage #14238000; Cowlitz River below Mayfield Dam, Wash, and USGS Gage #14226500; Cowlitz River at Packwood, Wash.

Runoff conditions may be impaired in portions of the basin as a result of forest and road conditions. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that approximately 30% of the upper Cowlitz basin is 'impaired' with regards to runoff properties. These impaired areas are located primarily in subwatersheds in the Tilton, Mayfield Lake, Rainey Creek, and the upper Cowlitz mainstem just above the reservoirs; areas with high road densities, immature forest vegetation, and developed land. About 27% of the basin is rated as 'moderately impaired'. These areas are located primarily in the northern portion of the upper Cowlitz mainstem watershed, the lower Cispus watershed, and scattered subwatersheds throughout the basin. Approximately 43% of the basin is rated as 'functional' according to the IWA. Hydrologically functional subwatersheds have mature forest cover and low road densities and are located primarily in the upper elevation areas in the upper Cowlitz mainstem and Cispus watersheds.

Impaired runoff conditions identified by the IWA in the Tilton and Mayfield Lake basins are supported by reports of extreme high and low flows in Mayfield Lake tributaries, which are believed to be the result of extensive timber harvesting (Mobrand Biometrics 1999, Wade 2000). Elevated winter peaks in the Tilton risk flushing out juveniles and scouring spawning gravels (Wade 2000). Average peak flow increases of 10%, 22%, 20%, and 17% were estimated for Tilton tributaries Connelly Creek, Lake Creek, EF Tilton, and SF Tilton, respectively (Murray Pacific 1994 and 1996a). Landslides causing dam break floods are very damaging in Connelly Creek and are associated with logging roads and clearcuts (Murray Pacific 1993). Low flows degrade habitat in the NF, SF, EF, and WF Tilton (Harza 1997).

Peak flow analyses by the USFS in the Cispus basin revealed that 14 out of 24 subbasins had a significant risk of increased peak flows as a result of impacts to vegetation structure (USFS 1996a, 1996b, and 1995). Similar analyses in the upper Cowlitz revealed that 9 out of 24 subbasins had a significant risk of increased peak flows, roughly corresponding to the IWA results.

Low and subsurface flows are a concern in many of the upper Cowlitz tributaries, generally due to excessive in-channel sediment aggradation. Flow regulation at Mossyrock Dam affects Riffe Lake levels, which can affect low flow habitat in the alluvial fan through which Riffe Lake tributaries Rainey, Stiltner, and Philips Creek flow. Low flow in this area can cause increased temperature and vulnerability to predation. There may also be low flow issues related to a private hatchery that has water rights to 50% of the flow of Rainey Creek and 100% of the flow of an unnamed tributary (Murray Pacific 1996b).

The projected 20 year increase in combined surface and groundwater demand in the upper Cowlitz basin ranges from 0.5% (Cispus) to 36.4% (Tilton). However, the presence of Mayfield and Riffe Lakes, combined with the low population of the subbasin, suggests that the impact from current or projected water withdrawals on stream flow rates will be minimal (LCFRB 2001).

9.5.3 Water Quality

Elevated water temperatures (>18ºC) in the Tilton basin have been found in Winston Creek, the mainstem Tilton, Connelly Creek, Slam Creek (EF Tilton basin), the WF Tilton, and Coon Creek (WF Tilton basin). High temperatures are attributed to low stream shade levels and low summer flows (Murray Pacific 1998 and 1994). High turbidity and low dissolved oxygen levels have been measured in Mayfield Lake and the Tilton (Wade 2000).

High temperatures in Riffe Lake have been recorded as deep as 20 meters (Harza 2000). Temperatures above state standards measured in the Rainey Creek basin were believed to be related to low canopy cover (Murray Pacific 1996b). High turbidity levels have also been measured in Rainey Creek (Harza 2000).

In the Cispus basin, the mainstem Cispus above Quartz Creek, Woods Creek, Chambers Creek, and East Canyon Creeks have exceeded the state temperature standard of 16ºC (USFS 1995). Four stream segments in the Cispus basin, including two on the mainstem, one on the North Fork, and one on Baird Creek were included on the State’s 1998 303(d) list for temperature exceedances (WDOE 1998). High turbidity was measured in Quartz Creek following the St. Helens eruption (354 NTU in 1981 and 64 NTU in 1983). High (240 NTU) turbidity was measured in the lower Cispus during the December 1995 flood, attributable to streambank erosion, road failures, and road surface erosion (USFS 1996a).

In upper mainstem Cowlitz tributaries, Silver Creek and Willame Creek were listed on the 1996 and 1998 WA State 303(d) list for exceedances of temperature standards (WDOE 1996 and 1998). State temperature standards (16ºC) have also been exceeded on Kiona Creek and tributaries (Murray Pacific 1995) and Lake Creek (USFS 1997b). Miller Creek may have water quality issues associated with sewage and garbage disposal into the creek at Randle (USFS 1997a).

Nutrient levels in all streams above the dams are assumed to be lower than in historical times due to lower current numbers of anadromous fish (Wade 2000).

9.5.4 Key Habitat

The 3 dams inundated a significant amount of pool and side channel habitat in the mainstem and in the lower reaches of tributaries. Riffe Lake may provide some refuge for fish displaced from tributaries during high flows, but in general, the reservoir does not provide favorable habitat (Murray Pacific 1996b).

Pool frequency and quality in the Mayfield Lake basin is low. This is largely attributed to low LWD concentrations. Streams containing LWD had 15 times the amount of pools than streams without LWD (EA 1998). Of 5 creeks surveyed (Tilton, EF Tilton, SF Tilton, Lake Creek, Winston Creek), 4 of them had low (<35% pool area) pool frequency (Harza 1997). In the WF Tilton, mass wasting between 1974 and 1996 reduced pool frequency and quality (Murray Pacific 1998). Pool frequency was generally low in reaches surveyed in the Rainey Creek (Riffe Lake tributary) basin. Fifty percent of the pools were associated with LWD.

Pool frequency and quality in the Cispus basin is low due in part to channel widening, sediment aggradation, and low LWD quantities (USFS 1995). The Cispus mainstem has a low amount of pool habitat in places but conditions are expected to improve as forest practices improve. Pools in Crystal Creek are of poor quality but are also expected to improve (USFS 1996a). Side channel habitat in the Cispus basin is assumed to be lacking due to roads and other activities that have blocked historical flood channels and have disconnected floodplains, however, a few decent off-channel habitats conducive to coho rearing are available in some places (USFS 1995).

Pool frequency and quality in the upper Cowlitz mainstem basin is low. Width-to-depth ratios are high, sediment pulses often fill existing pools, and pools lack adequate cover (USFS 1997a and 1997b). Excessive sediment deposits and lack of LWD are thought to be responsible for poor pool quality and frequency in most of the smaller tributaries (Wade 2000). The channel between RM 100 and RM 115 on the Cowlitz may have experienced side channel loss due to downcutting following the 1996 flood (USFS 1997b). Side channel habitats have been lost on the lower reaches of most of the smaller tributaries due to residential, agricultural, and industrial development (Wade 2000).

9.5.5 Substrate & Sediment

A 1996 study found that over half of the surveyed habitat units in the SF Tilton, Lake Creek, and Winston Creek basins had greater than 35% embeddedness (Harza 1997). Connelly Creek has experienced an increase in fines (7% in 1993 to 18% in 1996) due to mass wasting associated with large storms and logging activities on steep slopes (Murray Pacific 1996a). Fines are a problem in the WF Tilton from the Coon Creek confluence to the mouth. Mass wasting is a concern due to high harvest levels in this basin (Murray Pacific 1998). There are also concerns with mass wasting and fine sediment input between Nineteen Creek and the falls on the mainstem Tilton. A lack of good spawning sized substrate may be due to transport capacity exceeding input in the EF Tilton and in Coal Creek (Murray Pacific 1994). Poor gravel quality due to excessive fines (>20% fine sediment) was identified for 3 of 7 survey locations in the Rainey Creek basin (Murray Pacific 1996b).

Excessive stream sedimentation occurs in the Cispus basin due to mass wasting and erosion from roads, concentrated overland runoff, and harvest-related mass wasting (USFS 1995). Excessive fine sediments are considered a major problem in the upper mainstem Cowlitz. Increased sediment delivery from floodplain development, riparian impacts, channelization, and lack of LWD has increased channel migration, raised width-to-depth ratios, and reduced pool quality (USFS 1997b, Lanigan et al. 1998). Erosion and sedimentation in many of the upper Cowlitz tributaries are believed to be impacting fish production. In some cases, sediment accumulations have created subsurface flow conditions, eliminating anadromous habitat (USFS 1997a).

Sediment supply conditions from hillslopes was evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results indicate that only 4 of 131 subwatershed are ‘impaired’ with regards to sediment supply, however, 95 of the 131 (73%) subwatersheds were rated as ‘moderately impaired’. The remainder, which are located primarily in the upper Cispus and upper Cowlitz mainstem basins, were rated as ‘functional’. Sediment supply impairments are related to the high number of forest roads and unstable slopes in some areas.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

9.5.6 Woody Debris

LWD levels in the Tilton watershed have been reduced since historical times due to channel cleaning, timber harvest in riparian zones, debris torrents, dam-break floods, and increased peak flows (EA 1998). It is believed that large wood was present in channels throughout the watershed in historical times (Mobrand Biometrics 1999). Low LWD levels also exist in Winston Creek (Wade 2000). Approximately 97% of the fish-bearing streams in the Rainey Creek basin contain below target levels of LWD. Near term recruitment of LWD is considered “high” on only 3% of the fish-bearing streams (Murray Pacific 1996b).

Adequate LWD is lacking in the Cispus basin due to channel clearing and timber harvest. Lower Iron Creek and the NF Cispus have particularly low levels of instream LWD (USFS 1996a). The upper Cowlitz mainstem historically had abundant LWD but now has very little (Mobrand Biometrics 1999, USFS 1997a). LWD was removed from the floodplains and harvested from riparian areas. Low LWD levels in nearly all of the tributary streams have been attributed to debris flows, riparian cleaning, active removal, loss of recruitment, natural decay, and attrition (Murray Pacific 1995).

9.5.7 Channel Stability

There are bank stability concerns in the lower NF Tilton due to glacial till parent material. There are also bank stability concerns in the lower mainstem Tilton, Winston Creek, WF Tilton, and Otter and Tumble Creeks (NF Tilton tributaries) (EA 1998).

A total of 210 slides have occurred in the Rainey Creek basin between 1937 and 1996; an estimated 80% are associated with forestry activities. Major debris torrents and channel avulsions occurred on Rainey and Stiltner Creeks during floods in 1995 and 1996. Other areas of bank instability are related to logging and grazing impacts on riparian vegetation (Murray Pacific 1996b).

Increased sediment deposition, combined with increased peak flow associated with upslope vegetation removal, has contributed to channel widening and bank erosion in the Cispus basin. Numerous incidences of bank instability and channel widening are described in the limiting factors analysis (Wade 2000).

Bank instability is a problem in the upper mainstem Cowlitz due to excessive sediment accumulations causing channel widening. Bank stability has also been compromised as a result of farming and grazing practices (USFS 1997b). Specific bank stability problem areas are identified in Wade (2000).

9.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, riparian conditions are 'impaired' in 6 of the 131 upper Cowlitz subwatersheds (5%) , 'moderately impaired' in 85 of the 131 subwatersheds (65%), and 'functional' in 40 of the subwatersheds (30%). The greatest impairments are in the Mayfield Lake and Rainey Creek basins. Functional riparian conditions are located primarily along higher elevation streams in the upper Cispus and upper Cowlitz mainstem basins.

These results are supported by an analysis by Lewis County GIS (2000), which revealed that over 87% of riparian corridors in the Mayfield / Tilton basin are clearly lacking vegetation or have early-seral riparian conditions. Stream surveys revealed that the mainstem Tilton, EF Tilton, SF Tilton, and Lake Creek all had greater than 60% of surveyed habitat units with only 0-20% canopy cover (Harza 1997). Wade (2000), however, identifies several areas where good riparian conditions exist in the Tilton basin.

Small and medium-sized hardwoods make up 68% of riparian areas along fish bearing streams in the Rainey Creek basin. This is attributed to soil types, conversion to agriculture, and logging (Murray Pacific 1996b). In the entire Riffe Lake basin only 17.4% of the basin has riparian areas with greater than 70% mature coniferous cover (Lewis County GIS 2000).

In the Cispus basin, areas of concern for poor riparian conditions include upper Quartz Creek (Mount St. Helens eruption impacts), Crystal Creek, Iron Creek, Camp Creek, McCoy Creek, East Canyon Creek, and private lands on the mainstem Cispus. Lower Quartz Creek and the NF Cispus have some of the best conditions (USFS 1996a, 1999b, and 1995). Throughout the entire Cispus basin, 70% of riparian areas are in early seral structural stages (Lewis County GIS 2000, Wade 2000).

The bulk of the mature riparian forest cover on the upper mainstem Cowlitz and on the lower reaches of most upper mainstem tributaries has been removed by agriculture, timber harvest, and development (Harza 1997). Kiona Creek in particular is in bad shape, with 100% of the riparian areas in either grass/pole or small tree (9" to 20.9" diameter) vegetation structures (USFS 1997a). In the entire upper Cowlitz basin, over 72% of the riparian areas are either in early-seral stand structures or are clearly lacking vegetation (Lewis County GIS 2000, Wade 2000).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

9.5.9 Floodplain Function

The 23.5 miles of stream inundated by Mossyrock Dam was historically a braided, alluvial channel that provided abundant salmon habitat (Mobrand Biometrics 1999). Cowlitz Falls Dam inundated approximately 11 miles of stream also in an unconfined alluvial valley bottom.

Most of the smaller streams in the Mayfield Lake basin have little potential for floodplain habitat. Many of the floodplains that do exist are likely affected by roads since 33% of anadromous streams in the basin have stream-adjacent roads (Lewis County GIS 2000). The WRIA 26 Limiting Factors Analysis (Wade 2000) describes several areas where stream-adjacent roads, railroads, and road crossings impact floodplain function. Channelization has occurred along the Rainey Creek (Riffe Lake tributary) alluvial fan due to diking and at the mouths of several Rainey Creek tributaries (Murray Pacific 1996b).

Wetlands and floodplains have been altered in the Cispus basin due to roads and manipulation of channel locations (USFS 1996b). Twenty-one percent of anadromous streams in the Cispus basin have stream-adjacent roads (Lewis County GIS 2000). Floodplains along the mainstem Cispus, Iron Creek, Camp Creek, and Yellowjacket Creek have all been affected by channelization, roads, or timber salvage (USFS 1996a and 1996b).

The mainstem Cowlitz above Scanewa Lake (created by Cowlitz Falls Dam) has lost floodplain habitat due to encroachment of agricultural uses. Most tributaries to the upper Cowlitz mainstem have been affected by diking, dredging, bank hardening, straightening, road building, and/or floodplain structures associated with residential, commercial, and industrial development (Wade 2000).

9.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Upper Cowlitz spring chinook, fall chinook, winter steelhead, and coho populations. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI. Model results are discussed in separate sections for the Upper Cowlitz/Cispus and for the Tilton.

Three general categories of EDT output are discussed in the following sections: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

9.6.1 Upper Cowlitz - Cispus

9.6.1.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for spring chinook, fall chinook, winter steelhead and coho in the upper Cowlitz and Cispus basins. Model results indicate adult productivity in the upper Cowlitz has been reduced to 15-30% of historical levels for all species (Table 9-1). Adult abundance of both spring chinook and fall chinook has declined by more than 80% from historical levels, while winter steelhead and coho abundance has declined by 57% and 37%, respectively (Figure 9-7). Diversity (as measured by the diversity index) is estimated to have declined by 40%, 60%, and 38% for fall chinook, spring chinook, and coho, respectively (Table 9-1). Diversity for winter steelhead has remained more stable, decreasing by an estimated 16% (Table 9-1).

Smolt productivity has also decreased sharply for all species in the upper Cowlitz basin. Smolt productivity for fall chinook and winter steelhead has declined by 54% and 56%, respectively, while spring chinook and coho smolt productivities have declined by 72% and

76%, respectively (Table 9-1). Smolt abundance levels have also declined for spring chinook, fall chinook, and winter steelhead (Table 9-1). For coho, the model indicates a 16% increase in smolt abundance levels (Table 9-1).

Declines in adult productivity in the Cispus basin are similar to those in the upper Cowlitz. Adult productivity in the Cispus is estimated to have declined by 68-87% for all species (Table 9-2). Adult abundance of spring and fall chinook has fallen to 10-15% of historical levels, and winter steelhead and coho runs are estimated at less than half of historical levels (Figure 9-8). Diversity of spring chinook, fall chinook, and coho has decreased by 50-75%, though winter steelhead diversity has only decreased by 13% (Table 9-2).

Smolt productivity in the Cispus basin has declined by 55-73% from historical levels for all species (Table 9-2). These declines have been greater for spring chinook and coho than for fall chinook and winter steelhead. Smolt abundance has been reduced for all species as well, however fall and spring chinook have been impacted the most, with current abundance levels only 21% and 7% of the historical levels, respectively (Table 9-2). Coho have suffered the least impact with an abundance reduction of only 18% (Table 9-2).

Model results indicate that restoration of PFC conditions in both of the basins would produce substantial benefits. Adult returns to the upper Cowlitz and the Cispus would increase by 40-150%, with the greatest benefits for spring and fall chinook (Table 9-1 and Table 9-2). Similarly, smolt abundance levels would increase by 30-260% with the spring chinook gaining the most production in both the upper Cowlitz and Cispus (Table 9-1 and Table 9-2). Productivity and diversity would also increase with restoration to PFC conditions.

Table 9-1. Upper Cowlitz River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	3,097	6,516	17,613	2.5	3.6	9.1	0.60	0.70	1.00	465,080	818,516	1,779,088	237	274	518
Spring Chinook	3,019	6,426	21,750	2.5	4.5	15.8	0.41	0.45	1.00	175,993	384,052	1,707,591	77	115	270
Coho	11,039	23,633	17,654	3.0	7.3	21.4	0.57	0.61	0.92	317,625	644,219	272,111	76	157	316
Winter Steelhead	855	1,402	1,973	4.8	9.3	15.1	0.72	0.78	0.86	17,196	25,080	28,802	94	163	213

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

Table 9-2. Cispus River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	934	2,055	5,792	1.8	2.9	7.2	0.49	0.70	1.00	129,631	282,394	607,842	176	245	426
Spring Chinook	718	1,803	7,791	1.9	3.5	14.0	0.27	0.37	1.00	52,519	191,009	790,464	79	141	297
Coho	3,752	5,351	8,029	4.0	7.5	22.1	0.33	0.37	0.73	98,166	124,684	120,143	90	153	309
Winter Steelhead	624	1,001	1,504	4.2	7.4	13.1	0.85	0.94	0.98	12,576	18,112	22,084	83	131	185

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

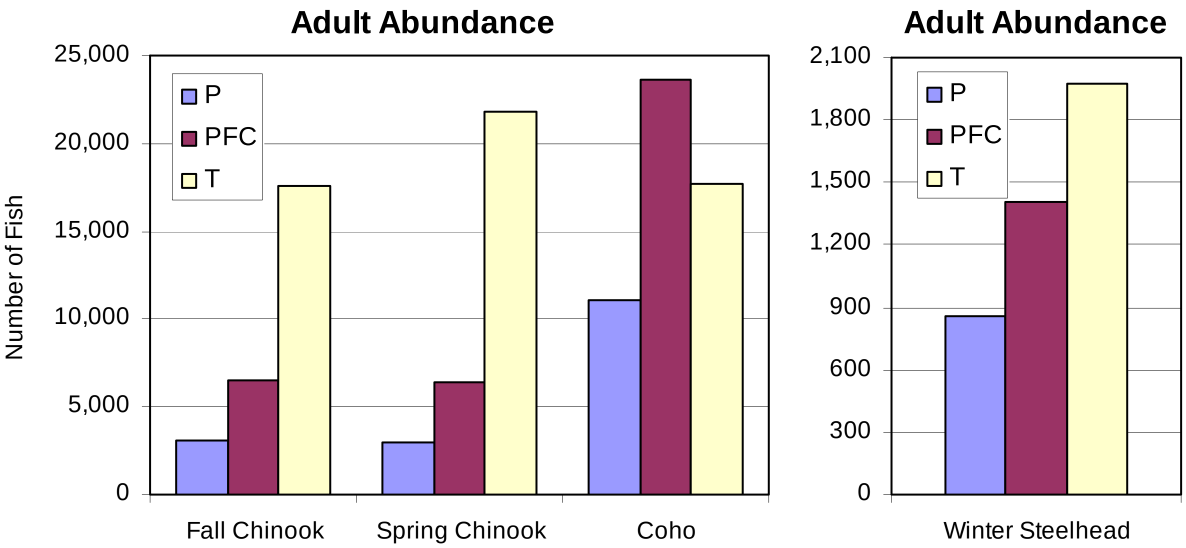


Figure 9-7. **Adult abundance of Upper Cowlitz fall chinook, spring chinook, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.**

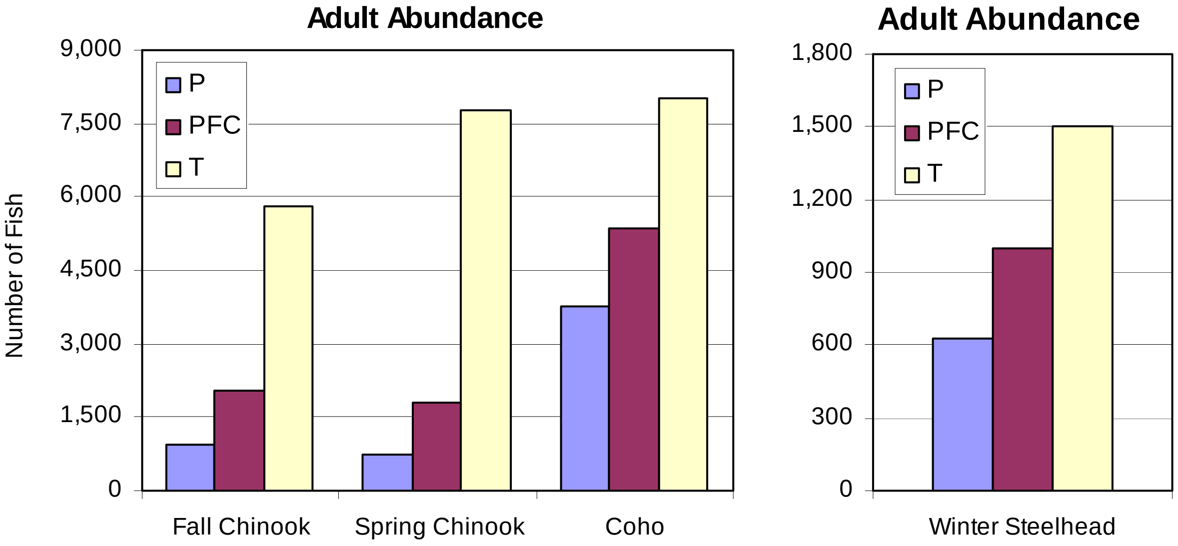


Figure 9-8. **Adult abundance of Cispus fall chinook, spring chinook, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.**

9.6.1.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given basin. For this reach analysis, the Upper Cowlitz and Cispus basins were combined for EDT modeling purposes. See Figure 9-9 for a map of EDT reaches within the Upper Cowlitz and Cispus basins.

Winter steelhead, spring chinook, and fall chinook are transported above the hydropower system and make extensive use of mainstem habitat in the upper Cowlitz and Cispus basins. Winter steelhead and spring chinook make use of mainstem tributaries to a greater degree than fall chinook. Coho primarily use mainstem tributaries for spawning and rearing.

High priority areas for winter steelhead in the Upper Cowlitz and Cispus include the mainstem reaches Upper Cowlitz 1C, 1D, 1E and 1CC, as well as Cispus 2, 3, and 1F (Figure 9-10). The tributary reaches Yellowjacket 1, Silver Cr 1, and Johnson Cr 1 are also key areas. The majority of high priority reaces for winter steelhead show a combined preservation and restoration recovery emphasis (Figure 9-10). Silver Cr 1 is the only high priority reach with a restoration emphasis. Upper Cowlitz 1E shows the highest preservation rating of any winter steelhead reach.

Important reaches in the Upper Cowlitz and Cispus for fall chinook (Figure 9-11) include primarily the upper mainstem reaches of the Cowlitz (Upper Cowlitz 1A-1E, and Upper Cowlitz 1CC and 1CCC). Only one reach in the Cispus, Cispus 1C, was considered high priority for fall chinook. The majority of these reaches show a preservation recovery emphasis (Figure 9-11). Only the reaches of Cispus 1C and Upper Cowlitz 1A and 1B show a combined preservation and restoration recovery emphasis. The reach Upper Cowlitz 1E shows the highest preservation rating of any fall chinook reach.

For spring chinook in the Upper Cowlitz and Cispus, high priority reaches are concentrated in the mainstem Cowlitz, with only one high priority reach located in the Cispus (Figure 9-12). These reaches are split with regard to recovery emphasis (Figure 9-12). Three reaches, Upper Cowlitz 1AA and 1B, and Cispus 1C, show a combined preservation and restoration recovery emphasis. All other reaches show a preservation emphasis only. Reach Upper Cowlitz 1E shows the highest preservation rating of any spring chinook reach.

High priority areas for coho in the Cowlitz include the reaches Upper Cowlitz 1A, 1AA, 1B and 1E (Figure 9-13). In the Cispus, the reaches Cispus 2 and 3 are considered high priority reaches (Figure 9-13). As with spring chinook, these reaches are split with regard to recovery emphasis. Again, reach Upper Cowlitz 1E is ranked as the highest priority reach.

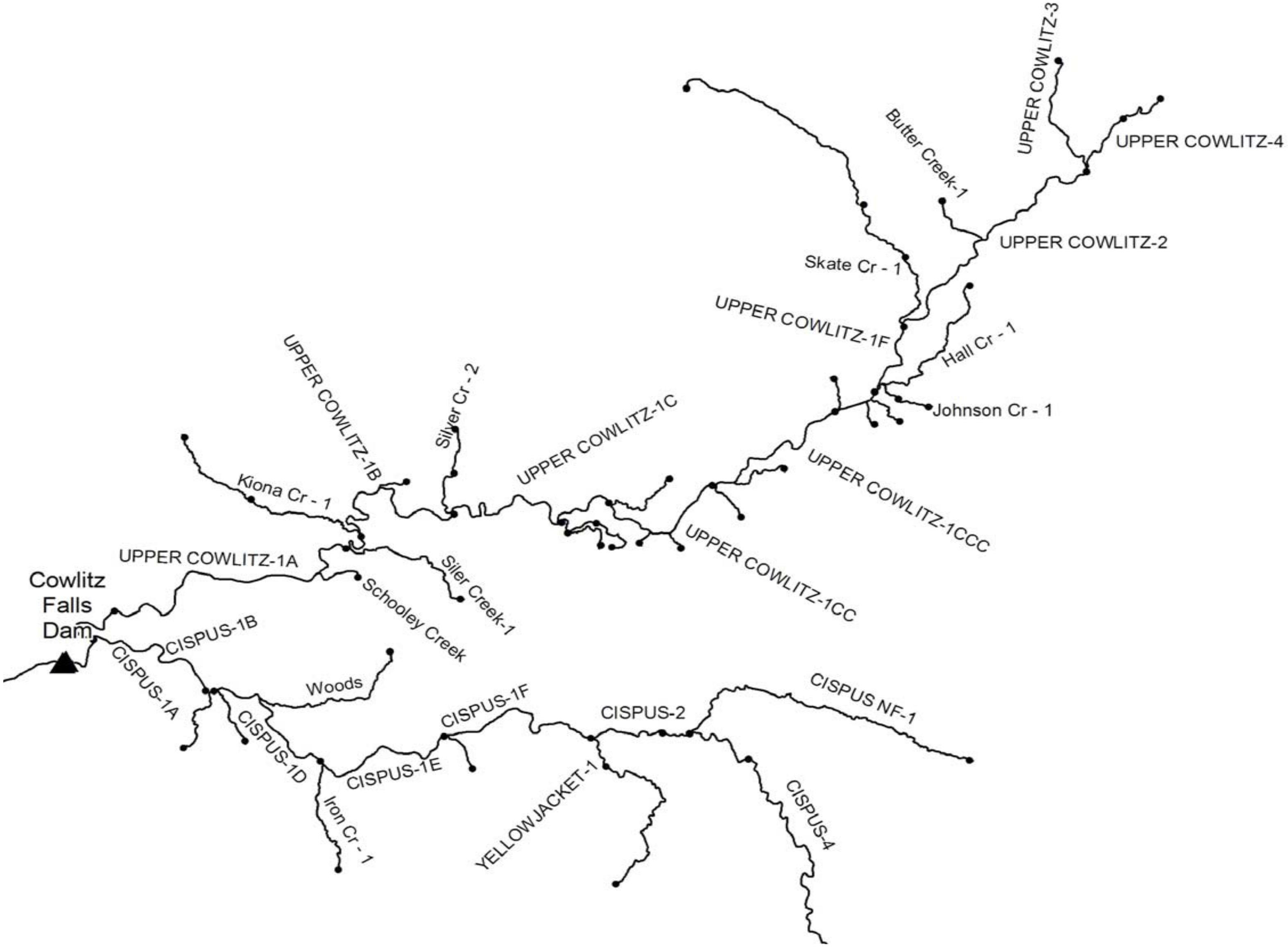
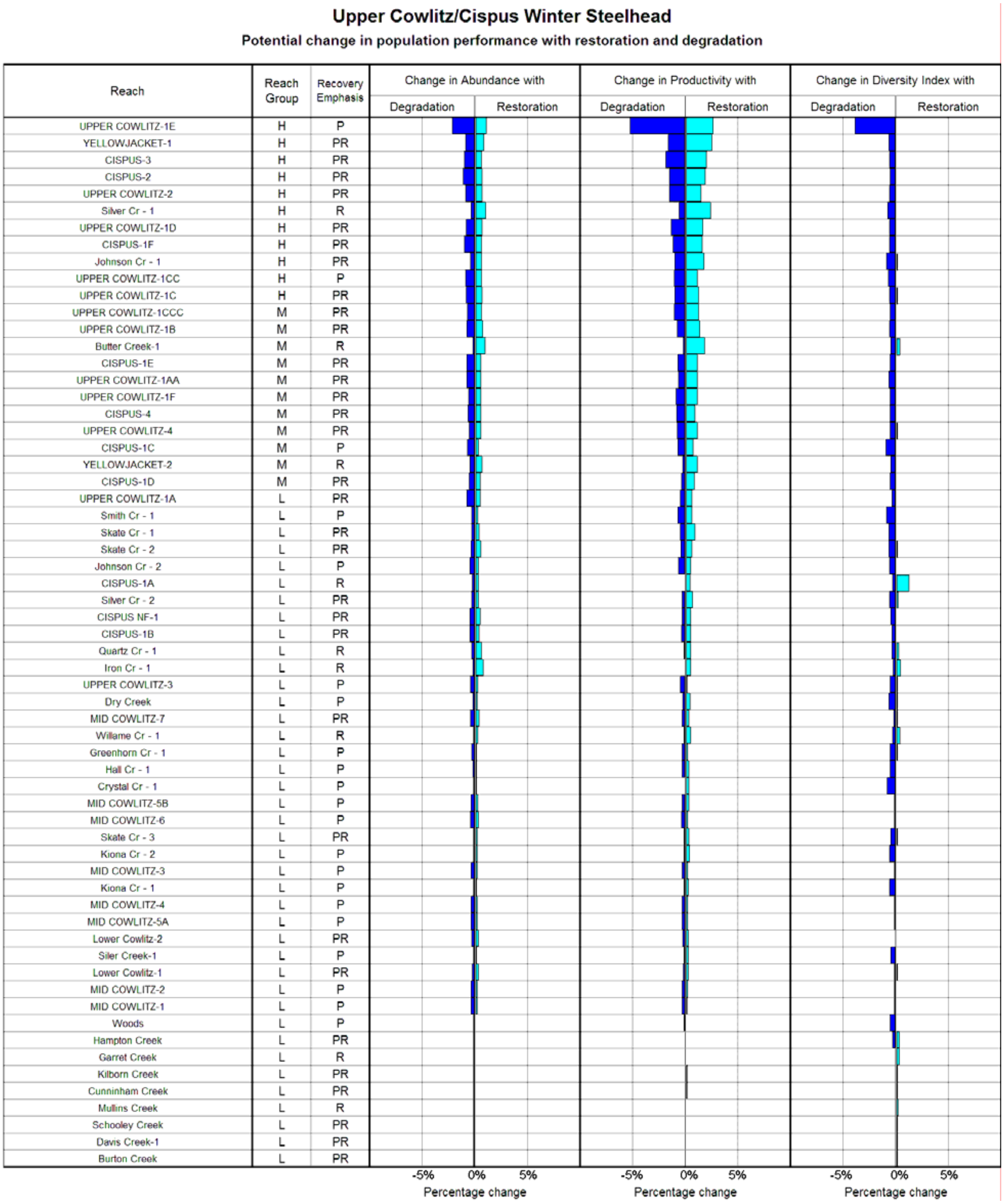
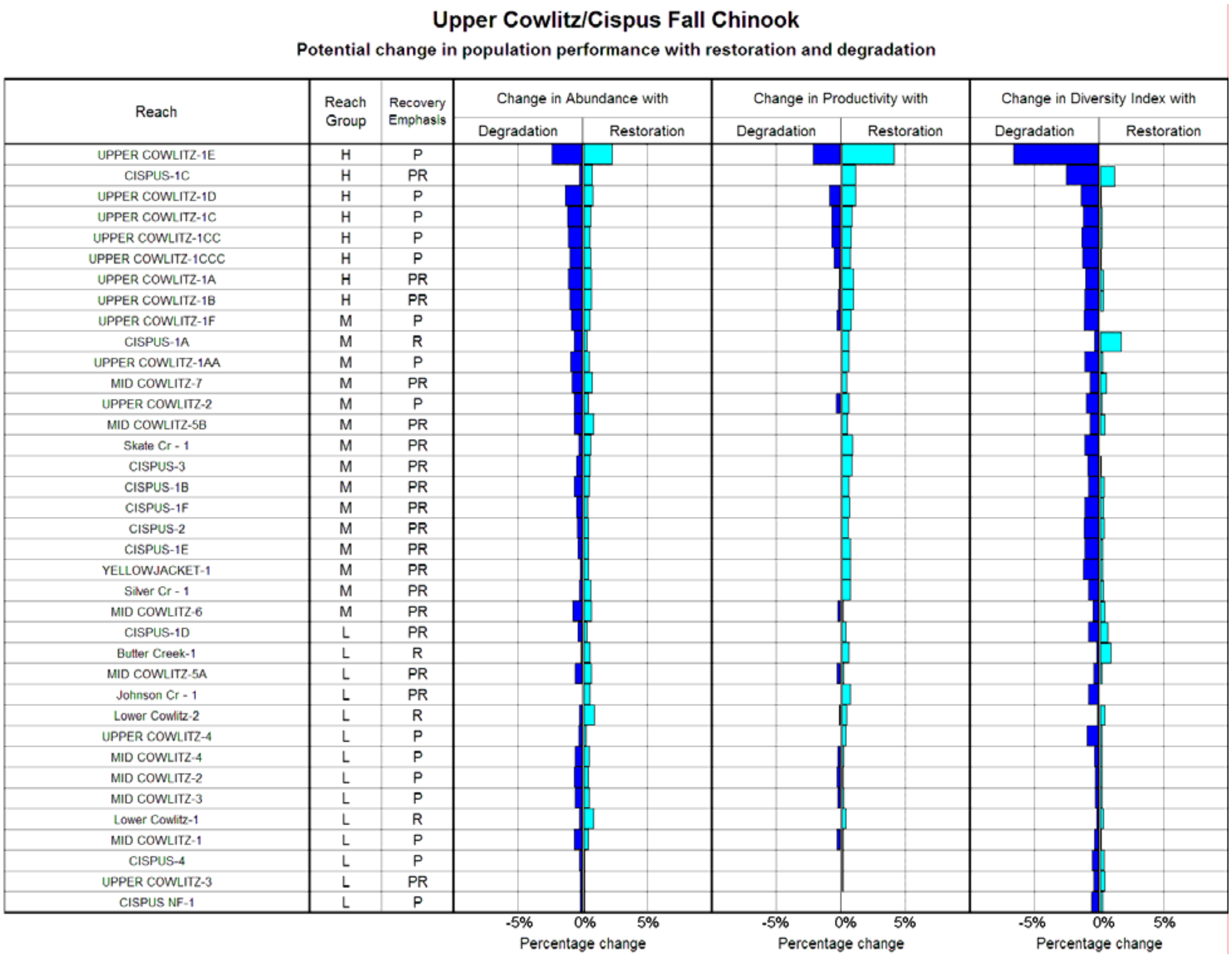


Figure 9-9. Upper Cowlitz and Cispus subbasin EDT reaches. Some reaches not labeled for clarity.



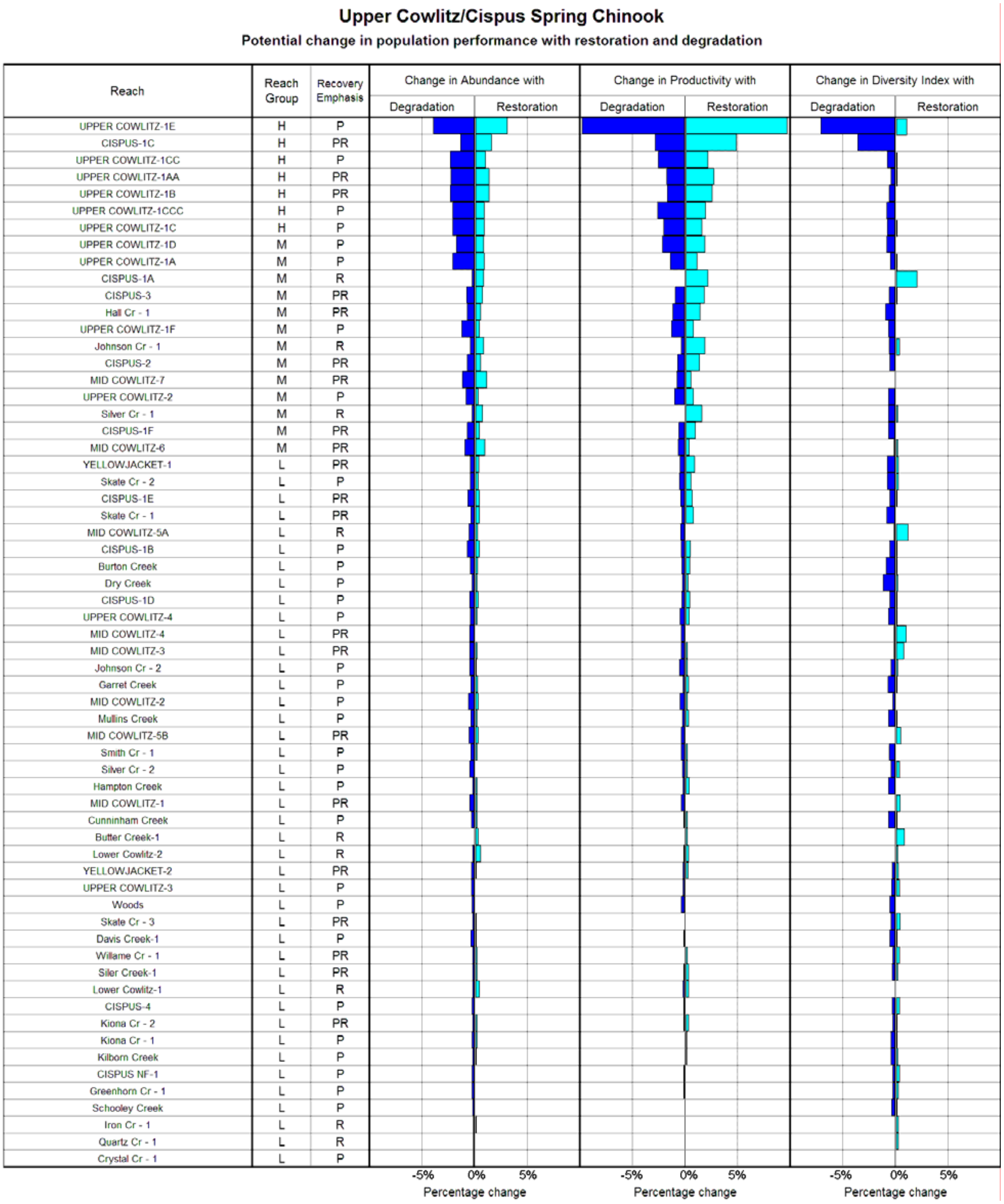
Reach	Reach Group	Recovery Emphasis
UPPER COWLITZ-1E	H	P
YELLOWJACKET-1	H	PR
CISPUS-3	H	PR
CISPUS-2	H	PR
UPPER COWLITZ-2	H	PR
Silver Cr - 1	H	R
UPPER COWLITZ-1D	H	PR
CISPUS-1F	H	PR
Johnson Cr - 1	H	PR
UPPER COWLITZ-1CC	H	P
UPPER COWLITZ-1C	H	PR
UPPER COWLITZ-1CCC	M	PR
UPPER COWLITZ-1B	M	PR
Butter Creek-1	M	R
CISPUS-1E	M	PR
UPPER COWLITZ-1AA	M	PR
UPPER COWLITZ-1F	M	PR
CISPUS-4	M	PR
UPPER COWLITZ-4	M	PR
CISPUS-1C	M	P
YELLOWJACKET-2	M	R
CISPUS-1D	M	PR
UPPER COWLITZ-1A	L	PR
Smith Cr - 1	L	P
Skate Cr - 1	L	PR
Skate Cr - 2	L	PR
Johnson Cr - 2	L	P
CISPUS-1A	L	R
Silver Cr - 2	L	PR
CISPUS NF-1	L	PR
CISPUS-1B	L	PR
Quartz Cr - 1	L	R
Iron Cr - 1	L	R
UPPER COWLITZ-3	L	P
Dry Creek	L	P
MID COWLITZ-7	L	PR
Willame Cr - 1	L	R
Greenhorn Cr - 1	L	P
Hall Cr - 1	L	P
Crystal Cr - 1	L	P
MID COWLITZ-5B	L	P
MID COWLITZ-6	L	P
Skate Cr - 3	L	PR
Kiona Cr - 2	L	P
MID COWLITZ-3	L	P
Kiona Cr - 1	L	P
MID COWLITZ-4	L	P
MID COWLITZ-5A	L	P
Lower Cowlitz-2	L	PR
Siler Creek-1	L	P
Lower Cowlitz-1	L	PR
MID COWLITZ-2	L	P
MID COWLITZ-1	L	P
Woods	L	P
Hampton Creek	L	PR
Garret Creek	L	R
Kilborn Creek	L	PR
Cunninham Creek	L	PR
Mullins Creek	L	R
Schooley Creek	L	PR
Davis Creek-1	L	PR
Burton Creek	L	PR

Figure 9-10. Upper Cowlitz and Cispus winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



Reach	Reach Group	Recovery Emphasis
UPPER COWLITZ-1E	H	P
CISPUS-1C	H	PR
UPPER COWLITZ-1D	H	P
UPPER COWLITZ-1C	H	P
UPPER COWLITZ-1CC	H	P
UPPER COWLITZ-1CCC	H	P
UPPER COWLITZ-1A	H	PR
UPPER COWLITZ-1B	H	PR
UPPER COWLITZ-1F	M	P
CISPUS-1A	M	R
UPPER COWLITZ-1AA	M	P
MID COWLITZ-7	M	PR
UPPER COWLITZ-2	M	P
MID COWLITZ-5B	M	PR
Skate Cr - 1	M	PR
CISPUS-3	M	PR
CISPUS-1B	M	PR
CISPUS-1F	M	PR
CISPUS-2	M	PR
CISPUS-1E	M	PR
YELLOWJACKET-1	M	PR
Silver Cr - 1	M	PR
MID COWLITZ-6	M	PR
CISPUS-1D	L	PR
Butter Creek-1	L	R
MID COWLITZ-5A	L	PR
Johnson Cr - 1	L	PR
Lower Cowlitz-2	L	R
UPPER COWLITZ-4	L	P
MID COWLITZ-4	L	P
MID COWLITZ-2	L	P
MID COWLITZ-3	L	P
Lower Cowlitz-1	L	R
MID COWLITZ-1	L	P
CISPUS-4	L	P
UPPER COWLITZ-3	L	PR
CISPUS NF-1	L	P

Figure 9-11. Upper Cowlitz and Cispus fall chinook ladder diagram.



Reach	Reach Group	Recovery Emphasis
UPPER COWLITZ-1E	H	P
CISPUS-1C	H	PR
UPPER COWLITZ-1CC	H	P
UPPER COWLITZ-1AA	H	PR
UPPER COWLITZ-1B	H	PR
UPPER COWLITZ-1CCC	H	P
UPPER COWLITZ-1C	H	P
UPPER COWLITZ-1D	M	P
UPPER COWLITZ-1A	M	P
CISPUS-1A	M	R
CISPUS-3	M	PR
Hall Cr - 1	M	PR
UPPER COWLITZ-1F	M	P
Johnson Cr - 1	M	R
CISPUS-2	M	PR
MID COWLITZ-7	M	PR
UPPER COWLITZ-2	M	P
Silver Cr - 1	M	R
CISPUS-1F	M	PR
MID COWLITZ-6	M	PR
YELLOWJACKET-1	L	PR
Skate Cr - 2	L	P
CISPUS-1E	L	PR
Skate Cr - 1	L	PR
MID COWLITZ-5A	L	R
CISPUS-1B	L	P
Burton Creek	L	P
Dry Creek	L	P
CISPUS-1D	L	P
UPPER COWLITZ-4	L	P
MID COWLITZ-4	L	PR
MID COWLITZ-3	L	PR
Johnson Cr - 2	L	P
Garret Creek	L	P
MID COWLITZ-2	L	P
Mullins Creek	L	P
MID COWLITZ-5B	L	PR
Smith Cr - 1	L	P
Silver Cr - 2	L	P
Hampton Creek	L	P
MID COWLITZ-1	L	PR
Cunninham Creek	L	P
Butter Creek-1	L	R
Lower Cowlitz-2	L	R
YELLOWJACKET-2	L	PR
UPPER COWLITZ-3	L	P
Woods	L	P
Skate Cr - 3	L	PR
Davis Creek-1	L	P
Willame Cr - 1	L	PR
Siler Creek-1	L	PR
Lower Cowlitz-1	L	R
CISPUS-4	L	P
Kiona Cr - 2	L	PR
Kiona Cr - 1	L	P
Kilborn Creek	L	P
CISPUS NF-1	L	P
Greenhorn Cr - 1	L	P
Schooley Creek	L	P
Iron Cr - 1	L	R
Quartz Cr - 1	L	R
Crystal Cr - 1	L	P

Figure 9-12. Upper Cowlitz and Cispus spring chinook ladder diagram.

Upper Cowlitz/Cispus Coho

Potential change in population performance with restoration and degradation

Reach	Reach Group	Recovery Emphasis
UPPER COWLITZ-1E	H	PR
MID COWLITZ-7	H	R
UPPER COWLITZ-1AA	H	PR
CISPUS-3	H	R
UPPER COWLITZ-1A	H	P
CISPUS-2	H	R
UPPER COWLITZ-1B	H	PR
CISPUS-1A	M	R
UPPER COWLITZ-1C	M	PR
CISPUS-1C	M	PR
UPPER COWLITZ-1CC	M	R
Skate Cr - 1	M	R
UPPER COWLITZ-1D	M	PR
UPPER COWLITZ-1CCC	M	PR
Silver Cr - 1	M	R
YELLOWJACKET-1	M	R
Schooley Creek	M	P
CISPUS-1F	M	PR
UPPER COWLITZ-1F	M	PR
Hall Cr - 1	M	PR
Johnson Cr - 1	L	R
Kiona Cr - 1	L	P
Hampton Creek	L	PR
CISPUS-1E	L	PR
Kilborn Creek	L	R
Smith Cr - 1	L	P
CISPUS-1D	L	PR
CISPUS-1B	L	PR
Siler Creek-1	L	R
Mullins Creek	L	PR
Davis Creek-1	L	PR
Garret Creek	L	PR
Kiona Cr - 2	L	PR
Cunninham Creek	L	PR
Silver Cr - 2	L	P
UPPER COWLITZ-2	L	PR
Burton Creek	L	PR
Woods	L	P
Skate Cr - 3	L	PR
Dry Creek	L	PR
Greenhorn Cr - 1	L	P
Crystal Cr - 1	L	R
Willame Cr - 1	L	R
UPPER COWLITZ-4	L	R
CISPUS NF-1	L	R
MID COWLITZ-6	L	R
Butter Creek-1	L	R
Quartz Cr - 1	L	PR
MID COWLITZ-5B	L	R
Lower Cowlitz-1	L	R
Johnson Cr - 2	L	P
Lower Cowlitz-2	L	R
MID COWLITZ-5A	L	PR
YELLOWJACKET-2	L	P
MID COWLITZ-4	L	R
MID COWLITZ-1	L	R
Skate Cr - 2	L	P
MID COWLITZ-2	L	R
MID COWLITZ-3	L	R
CISPUS-4	L	P
Iron Cr - 1	L	PR
UPPER COWLITZ-3	L	P
BARRIER RESERVOIR	L	R
BARRIER DAM	L	PR

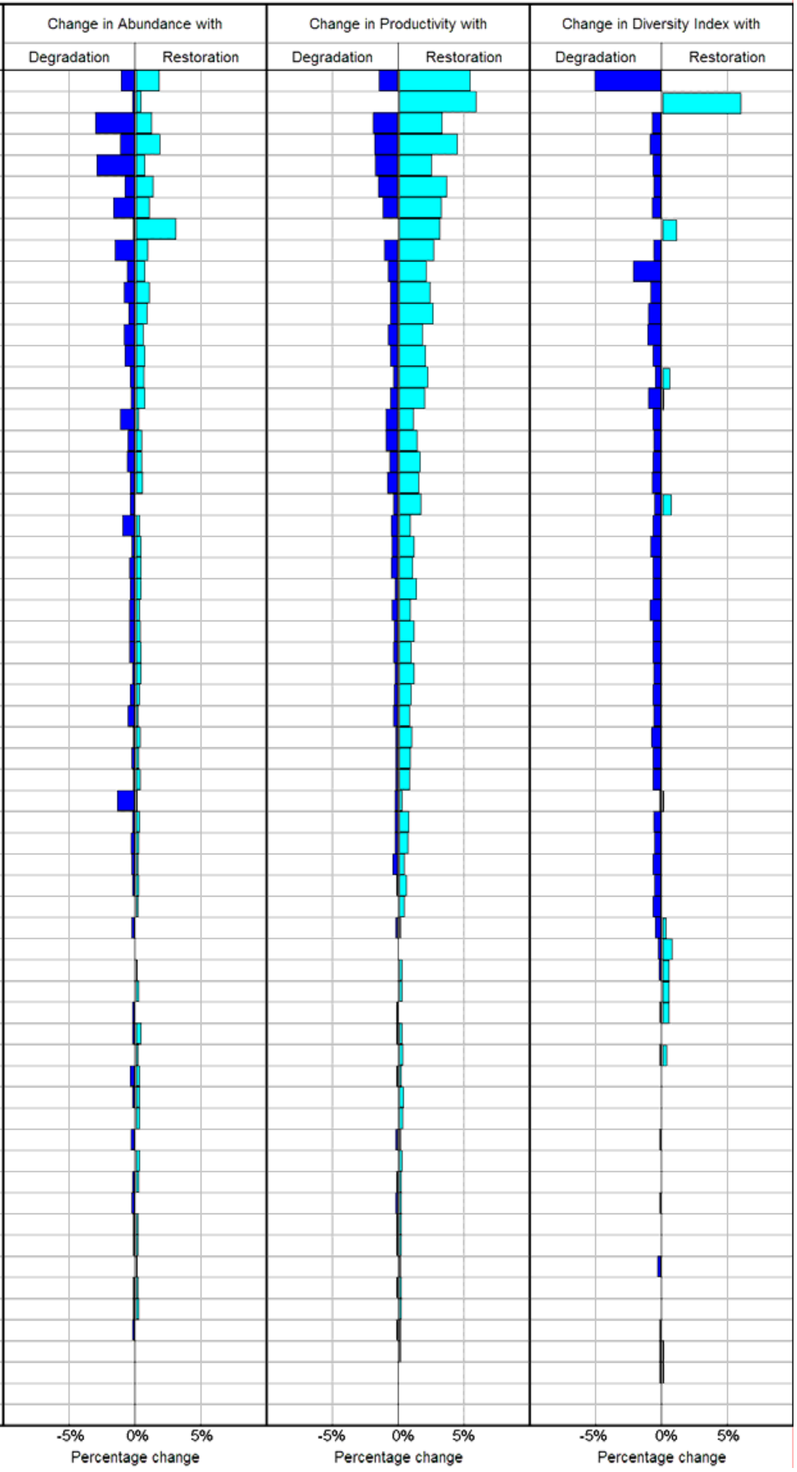


Figure 9-13. Upper Cowlitz and Cispus coho ladder diagram.

9.6.1.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Key winter steelhead restoration reaches are in both mainstem and tributary locations. These reaches are most negatively influenced by low habitat diversity, sediment, poor channel stability, altered flow regimes, competition with hatchery fish, and pathogens (Figure 9-14). Low habitat diversity is a result of loss of side channel habitat in these mainstem reaches. Historically, these reaches had abundant LWD, but now have very little (Mobrand Biometrics 1999, USFS 1997a). LWD was removed from the floodplains and harvested from riparian areas. The loss of LWD has contributed to the loss of habitat diversity and channel stability. Bank stability is a problem due to excessive sediment accumulations causing channel widening. Sediment problems arise because of mass wasting, road erosion, and concentrated overland runoff associated with land use throughout the basin. Disease and competition concerns arise because of the extensive hatchery influence in the basin.

Almost all of the key fall chinook (Figure 9-15) and spring chinook (Figure 9-16) restoration reaches within the upper Cowlitz and Cispus watersheds are in the mainstem Cowlitz (only one high priority reach in the Cispus). These reaches are primarily affected by loss of habitat diversity, decreased channel stability, and excessive fine sediment, and in the case of spring chinook, by competition and pathogens. The causes of these impacts are the same as those described for winter steelhead restoration reaches.

Key coho restoration reaches exist in both the upper Cowlitz and Cispus watersheds. The habitat impacts affecting these areas are loss of habitat diversity, loss of channel stability, increased sediments, and loss of key habitat (Figure 9-17). The cause of these impacts is the same as described earlier for winter steelhead reaches.

Upper Cowlitz/Cispus Winter Steelhead

ReachName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
UPPER COWLITZ-1E	●	⬤		•		●			●		●			●	•	+
YELLOWJACKET-1	•	●		●		●			●	⬤	●			●		✚
CISPUS-3	•	●		●		●			●	⬤	•			●		✚
CISPUS-2	●	●		●		●			●	⬤	•			●		✚
UPPER COWLITZ-2	●	●		•		●			●		●			●	•	●
Silver Cr - 1	●	⬤	●	•		●		•	⬤	●	●			●	•	✛
UPPER COWLITZ-1D	●	●		•		●			●		•			●	•	+
CISPUS-1F	•	●		●		●			●	⬤	•			●		✛
Johnson Cr - 1	●	⬤		•		•			●	●	•			•	•	✚
UPPER COWLITZ-1CC	●	●		•		●			●		•			●	•	+
UPPER COWLITZ-1C	●	●		•		●			●		•			●	•	+
UPPER COWLITZ-1CCC	●	●		•		●			●		•			●	•	+
UPPER COWLITZ-1B	●	●		•		●			●	●	•			●	•	+
Butter Creek-1	●	⬤	•	•		•		•	●	●	●			•	•	⬤
CISPUS-1E	•	●		•		●			●	⬤	•			●		•
UPPER COWLITZ-1AA	●	●		•		●			●	⬤	•			●		+
UPPER COWLITZ-1F	●	●		•		●			●		•			●	•	•
CISPUS-4	●	●		•		●			●		•			•		●
UPPER COWLITZ-4	•	⬤				•			●		•			•		
CISPUS-1C	•	●		•		•			•	⬤	•			•		
YELLOWJACKET-2	•	⬤		•		●			●	⬤	•			•		✛
CISPUS-1D	●	●		•		•			●	●	•			•		•
UPPER COWLITZ-1A	●	●		•		●			●	●	•			●		+
Smith Cr - 1	•	●				•			•	●	•			•	•	•
Skate Cr - 1	•	●	•	•		•			●	●	•			•	•	✚
Skate Cr - 2	•	●	•	•		•			●	●	•			●	•	●
Johnson Cr - 2	•	●		•		•			•	●	•			•		
CISPUS-1A		●	•			•			•	●				•		
Silver Cr - 2	•	●	•	•		•		•	●	•	•			•		✚
CISPUS NF-1	•	●		•		•			●		•			•		●
CISPUS-1B	•	●		•		•			•	●	•			•		•
Quartz Cr - 1	●	●		•	•	●			●	●	●			•		✛
Iron Cr - 1	●	⬤		•	•	●			●		●			•	•	⬤
UPPER COWLITZ-3	•	●	•			•			●		•			•		•
Dry Creek	•	●				•			•	•	•			•		•
MID COWLITZ-7	•	●		•		•			•		•			●		•
Willame Cr - 1	•	●	•			•			●	●	•			•		•
Greenhorn Cr - 1		•				•			•							✛
Hall Cr - 1		•	•	•		•		•	•	●	•			•		✛
Crystal Cr - 1	•	•				•			•		•			•		•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-14. Upper Cowlitz and Cispus winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Upper Cowlitz/Cispus Fall Chinook

ReachName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
UPPER COWLITZ-1E	⬤	⬤				•			●		•			•	•	●
CISPUS-1C	●	●				•			●	⬤	•			•		●
UPPER COWLITZ-1D	●	●		•		•			•		•			•	•	•
UPPER COWLITZ-1C	●	●		•		•			•		•			•	•	•
UPPER COWLITZ-1CC	●	●		•		•			•		•			•	•	•
UPPER COWLITZ-1CCC	●	●		•		•			•		•			•	•	•
UPPER COWLITZ-1A	●	●		•		•			•	⬤	•			•		•
UPPER COWLITZ-1B	●	●		•		•			•	⬤	•			•		•
UPPER COWLITZ-1F	●	●		•		•			•		•			•	•	•
CISPUS-1A	+	●	•			•			•	●	•			•		
UPPER COWLITZ-1AA	●	●		•		•			•	⬤	•			•		•
MID COWLITZ-7	•	●		•		•			•		•			●		•
UPPER COWLITZ-2	●	●		•		•			•		•			•		•
MID COWLITZ-5B	•	●		•		•			✛		•			⬤	•	●
Skate Cr - 1	●	●	•						•	●	•			•	•	✚
CISPUS-3	●	●		•		•			●	⬤	•			•		•
CISPUS-1B	●	●		•		•			•	⬤	•			•		•
CISPUS-1F	•	●		•		•			•	⬤	•			•		•
CISPUS-2	•	●		•		•			•	⬤	•			•		•
CISPUS-1E	•	●		•		•			•	⬤	•			•		•
YELLOWJACKET-1	●	●							•	⬤	•			•		+
Silver Cr - 1	●	●	•					•	•	●	•				•	●
MID COWLITZ-6	•	●		•		•			✛		•			●	•	✛
CISPUS-1D	●	•				•			•	●	•			•		•
Butter Creek-1	●	●							•	●	•				•	⬤
MID COWLITZ-5A	•	●		•		•			✛		•			●	•	✚
Johnson Cr - 1	●	●							•	●	•				•	✚
Lower Cowlitz-2	•	●	●	●		•			✛	•	•			●	•	✚
UPPER COWLITZ-4	●	●							•							
MID COWLITZ-4	•	●		•		•			✛		•			●	•	✛
MID COWLITZ-2		•	•	•		•			✛		•			●	•	✛
MID COWLITZ-3	•	●	•	•		•			✛		•			●	•	✛
Lower Cowlitz-1	•	●	●	●		•			✛	•	•			●	•	✚
MID COWLITZ-1		•	•	•		•			✛		•			●	•	✛
CISPUS-4	•	•														•
UPPER COWLITZ-3	•	•							•							•
CISPUS NF-1	•	•														•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-15. Upper Cowlitz and Cispus fall chinook habitat factor analysis.

Upper Cowlitz/Cispus Spring Chinook

ReachName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
UPPER COWLITZ-1E	⬤	⬤		•		●			●		●			●	●	●
CISPUS-1C	⬤	⬤		•		●			●	⬤	●			●		●
UPPER COWLITZ-1CC	●	⬤		•		●			●		●			●	•	•
UPPER COWLITZ-1AA	●	⬤		●		●			●	⬤	●			●		•
UPPER COWLITZ-1B	⬤	⬤		•		●			●	⬤	●			●		•
UPPER COWLITZ-1CCC	●	⬤		•		●			●		●			●	•	•
UPPER COWLITZ-1C	●	⬤		•		●			●		●			●	•	•
UPPER COWLITZ-1D	●	⬤		•		●			●		●			●	•	•
UPPER COWLITZ-1A	●	●		•		●			●	⬤	●			●		•
CISPUS-1A	+	⬤	●	•		•			●	⬤	•			•		
CISPUS-3	●	●		•		●			●	⬤	•			●		
Hall Cr - 1	•	●	●	•		•		●	•	⬤	●			•		●
UPPER COWLITZ-1F	●	●		•		•			•		•			•	•	•
Johnson Cr - 1	●	⬤				•			●	●	•			•	•	✚
CISPUS-2	●	●		•		●			●	⬤	•			●		+
MID COWLITZ-7	•	⬤	+	●		•			●	•	●			⬤	•	•
UPPER COWLITZ-2	●	●				•			•		•			•	•	•
Silver Cr - 1	●	⬤	•			•		•	●	●	•			•	•	+
CISPUS-1F	•	●		•		•			•	⬤	•			•		+
MID COWLITZ-6	•	●	+	●		•			•	•	•			⬤	•	✚
YELLOWJACKET-1	•	●		•		•			•	⬤	•			•		+
Skate Cr - 2	•	●	•						•	•	•			•		●
CISPUS-1E	•	●		•		•			•	⬤	•			•		•
Skate Cr - 1	•	●	●			•			•	●	•			•	•	+
MID COWLITZ-5A	•	•		•		•			•		•			●	•	
CISPUS-1B	●	●		•		•			•	●	•			•		•
Burton Creek	•	●	•			•		•	•	•	•			•	•	✚
Dry Creek	•	●							•	●	•			•	•	•
CISPUS-1D	●	●		•		•			•	●	•			•		•
UPPER COWLITZ-4	•	●							•							
MID COWLITZ-4		•		•										•		
MID COWLITZ-3	•	•		•					•		•			•		•
Johnson Cr - 2	•	•								•						
Garret Creek	•	●	•			•		•	•	•	•			•	•	✚
MID COWLITZ-2	•	●	•	•		•			•	•	•			●	•	•
Mullins Creek	•	●	•			•		•	•	•	•			•		✚
MID COWLITZ-5B	•	•		•		•			•		•			●	•	●
Smith Cr - 1	•	●							•	●					•	•
Silver Cr - 2		•														+
Hampton Creek	•	•	•			•		•	•	•	•			•		✚
MID COWLITZ-1	•	•		•					•	•	•			•	•	•
Cunninham Creek	•	•	•					•	•	•	•			•		✚
Butter Creek-1	•	●	•					•	•	•	•				•	●
Lower Cowlitz-2	•	●	•	●		•				•	•			●	•	●
YELLOWJACKET-2		•							•	•						•
UPPER COWLITZ-3	•	•														•
Woods																
Skate Cr - 3		•	•						•	•						•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-16. Upper Cowlitz and Cispus spring chinook habitat factor analysis. Some low priority reaches are not included for display purposes.

Upper Cowlitz/Cispus Coho

ReachName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
UPPER COWLITZ-1E	⬤	⬤		•		●			●		●			●		●
MID COWLITZ-7	•	●		•		•			•		•			•		✛
UPPER COWLITZ-1AA	⬤	⬤		●		●			●	⬤	●			●		•
CISPUS-3	⬤	⬤		●		●			●	⬤	●			●		⬤
UPPER COWLITZ-1A	●	●		•		•			•	●	•			•		✛
CISPUS-2	●	⬤		●		●			●	⬤	●			●		⬤
UPPER COWLITZ-1B	⬤	⬤		•		●			●	●	●			•		
CISPUS-1A	✛	⬤	•	•		●			●	⬤	●			•		
UPPER COWLITZ-1C	●	⬤		•		●			●		•			•		●
CISPUS-1C	●	●		•		●			•	⬤	•			●		•
UPPER COWLITZ-1CC	●	⬤		•		●			●		•			•		●
Skate Cr - 1	●	⬤	•	•		●			●	●	●			•	•	●
UPPER COWLITZ-1D	●	●		•		•			•		•			•		●
UPPER COWLITZ-1CCC	●	⬤		•		•			•		•			•		•
Silver Cr - 1	●	⬤		•		•			•	•	•			•	•	●
YELLOWJACKET-1	●	⬤		•		•			●	●	•			•		●
Schooley Creek	•	●		•		•			•	•	•			•	•	✚
CISPUS-1F	●	●		•		•			•	●	•			•		+
UPPER COWLITZ-1F	●	●		•		•			•		•			•		●
Hall Cr - 1	•	●	•	•		●		•	●	●	●			●		●
Johnson Cr - 1																
Kiona Cr - 1	•	●	•	•		•			•	●	•			•		✚
Hampton Creek	•	●	•	•	•	•		•	•	●	●			•	•	✛
CISPUS-1E	•	●		•		•			•	●	•			•		•
Kilborn Creek	•	●	•	•	•	•		•	•	●	●			•	•	✚
Smith Cr - 1	•	●		•		•			•	•	•			•	•	●
CISPUS-1D	●	●		•		•			•	•	•			•		•
CISPUS-1B	●	●		•		•			•	●	•			•		•
Siler Creek-1	•	●		•	•	•			●	●	●			•	•	●
Mullins Creek	•	●		•		•			•	•	•			•	•	✚
Davis Creek-1	•	•		•		•			•	•	•			•		✛
Garret Creek	•	●	•	•	•	•		•	•	•	●			•	•	✚
Kiona Cr - 2	•	●		•		•			•	•	•			•		✛
Cunninham Creek	•	●	•	•		•			•	•	•			•	•	✚
Silver Cr - 2	•	•								•						✛
UPPER COWLITZ-2	●	●		•		•			•		•			•		●
Burton Creek	•	●		•		•			•	•	•			•	•	✚
Woods	•	•		•		•			•		•			•		●
Skate Cr - 3	•	●		•		•			•	•	•			•	•	●
Dry Creek	•	•		•		•			•	•	•			•		●
Greenhorn Cr - 1																
Crystal Cr - 1																
Willame Cr - 1	•	•							•	•						•
UPPER COWLITZ-4	•	●							•					•		•
CISPUS NF-1																
MID COWLITZ-6		●		●						•				●		✛
Butter Creek-1	•	•							•	•	•					●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-17. Upper Cowlitz and Cispus coho habitat factor analysis. Some low priority reaches are not included for display purposes.

9.6.2 Tilton

9.6.2.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for spring chinook, fall chinook, winter steelhead and coho in the Tilton watershed. Model results indicate that both adult productivity and adult abundance have been severely reduced. Current productivity estimates range from only 10-24% of historical levels (Table 9-3). Current abundance estimates range from only 4-22% of historical levels (Figure 9-18). Diversity (as measured by the diversity index) has also declined sharply (Table 9-3). Fall chinook and coho diversity is estimated at only 39% and 36% of historical levels, respectively. Spring chinook and winter steelhead diversity has declined by 78% and 79%, respectively.

Smolt productivity in the Tilton has also declined (Table 9-3), though losses have not been as great as for adult productivity, suggesting that out of basin factors may be contributing to losses in adult productivity. Relative declines in smolt abundance have been greatest for coho and winter steelhead, but similar losses have also occurred for spring chinook and fall chinook (Table 9-3).

Model results indicate that restoration of PFC conditions would produce substantial benefits for all species (Table 9-3). Adult abundance for coho would benefit the most, with runs increasing to approximately 12 times current levels. Similarly, returns of fall chinook, spring chinook, and winter steelhead all would increase by 140- 400% (Table 9-3). Smolt abundance would also increase for all species (Table 9-3). Benefits to smolt abundance would range from a 92% increase for fall chinook smolts to a 669% increase for coho smolts.

Table 9-3. Tilton River — Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	1,025	2,475	4,610	2.0	4.5	8.6	0.35	0.90	0.90	137,656	264,812	337,240	211	359	465
Spring Chinook	868	3,176	5,436	1.9	7.2	15.1	0.20	0.78	0.93	63,454	195,918	246,459	92	188	251
Coho	261	3,233	5,599	2.6	12.6	24.9	0.32	0.84	0.90	8,741	67,197	82,075	72	256	352
Winter Steelhead	219	1,093	1,741	2.3	9.7	16.5	0.21	0.91	1.00	4,484	19,991	26,042	44	170	234

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

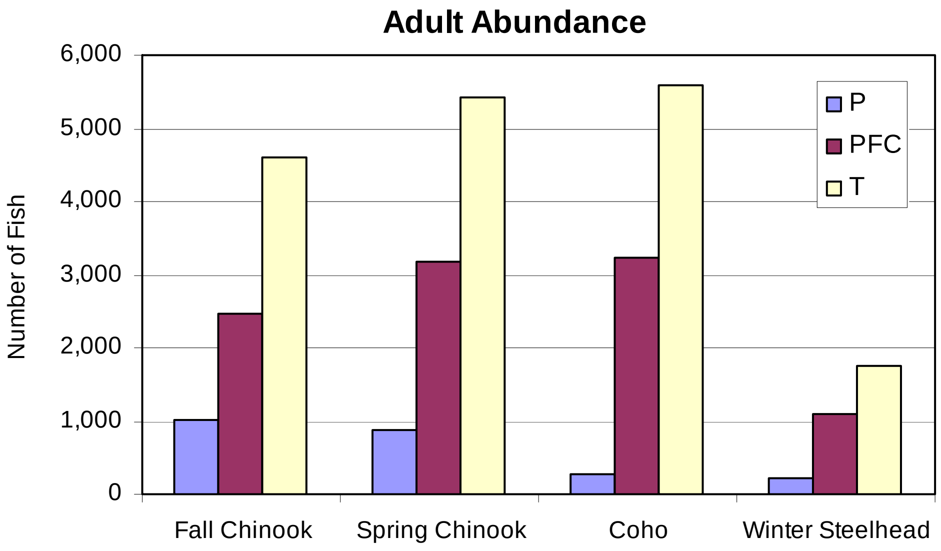


Figure 9-18. Adult abundance of Tilton River fall chinook, spring chinook, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

9.6.2.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin. See Figure 9-19 for a map of EDT reaches in the Tilton basin.

High priority reaches for winter steelhead include the lower sections of the EF Tilton (Tilton EF1 and Tilton EF2) as well as mainstem sections of the Tilton (Tilton 1, 3, 5 and 6) (Figure 9-20). All high and medium priority reaches for winter steelhead show a restoration emphasis.

For fall chinook (Figure 9-21) and spring chinook (Figure 9-22), the high priority locations are similar and include mainstem reaches from Bear Canyon to the EF Tilton and sections in the EF Tilton. In these reaches, as in the reaches for winter steelhead, all high and medium priority reaches show a restoration emphasis. Reaches Tilton 5 and Tilton 6 show one of the strongest restoration emphasis for both fall and spring chinook in the Tilton.

Important sections for coho include mainstem reaches (Tilton1, 3, 5 and 6), the lower EF Tilton (Tilton EF1), and Lake Creek (Figure 9-23). Again, all reaches show a strong habitat restoration emphasis, with Tilton 5 having the most potential improvement due to restoration.

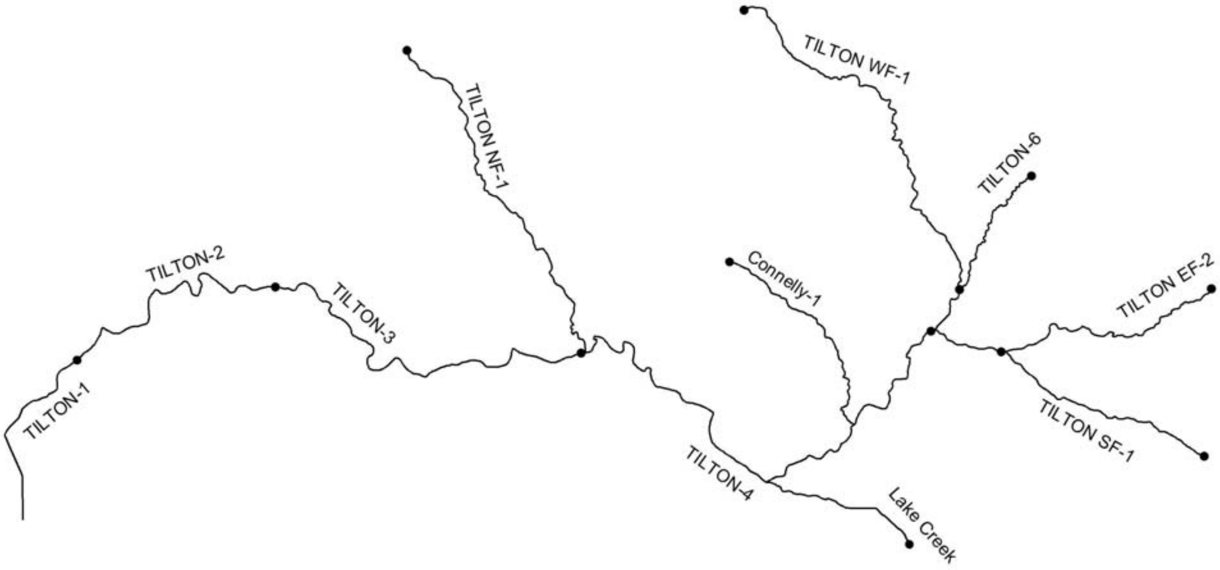


Figure 9-19. Tilton River basin EDT reaches. Some reaches are not labeled for clarity.

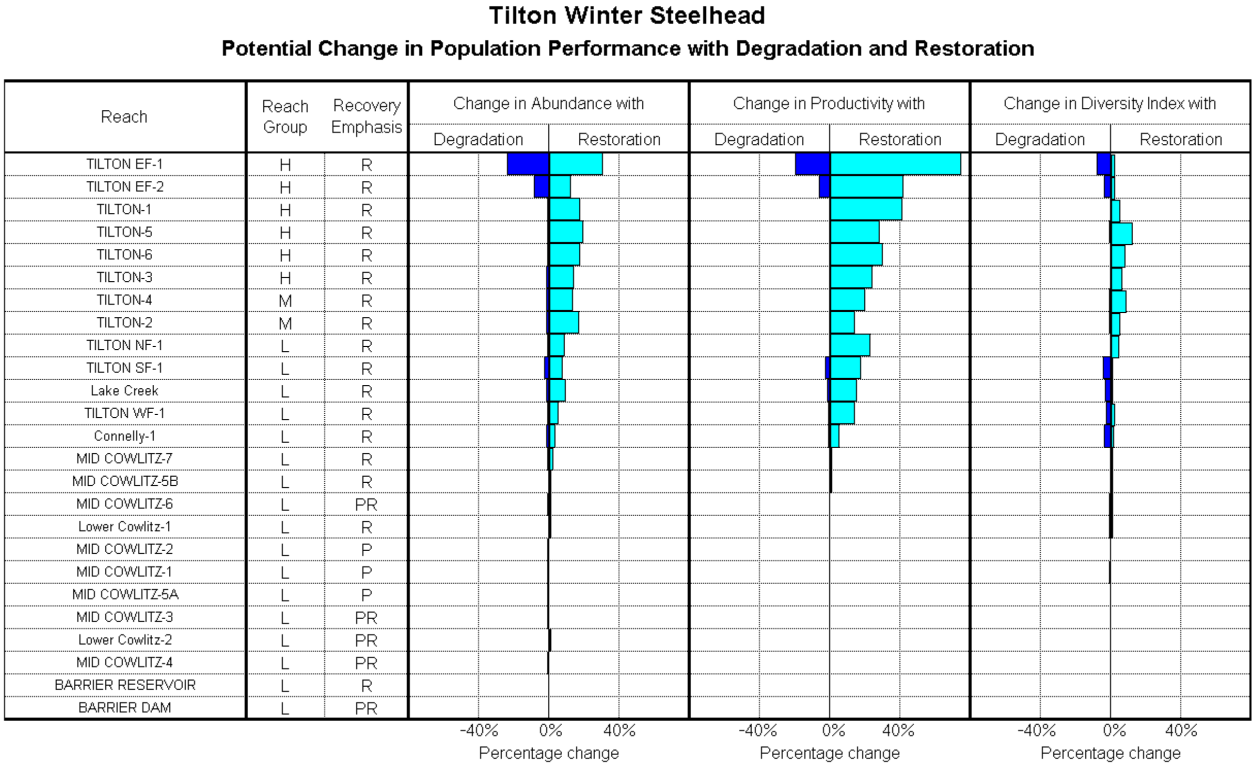


Figure 9-20. Tilton River winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

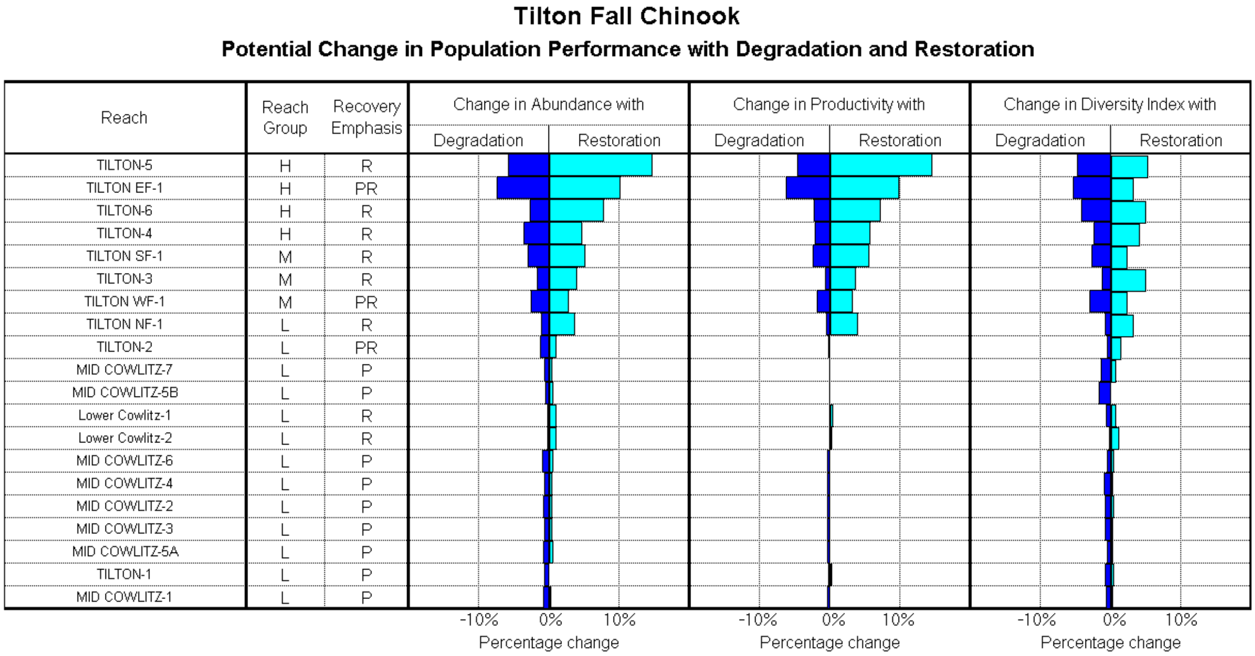
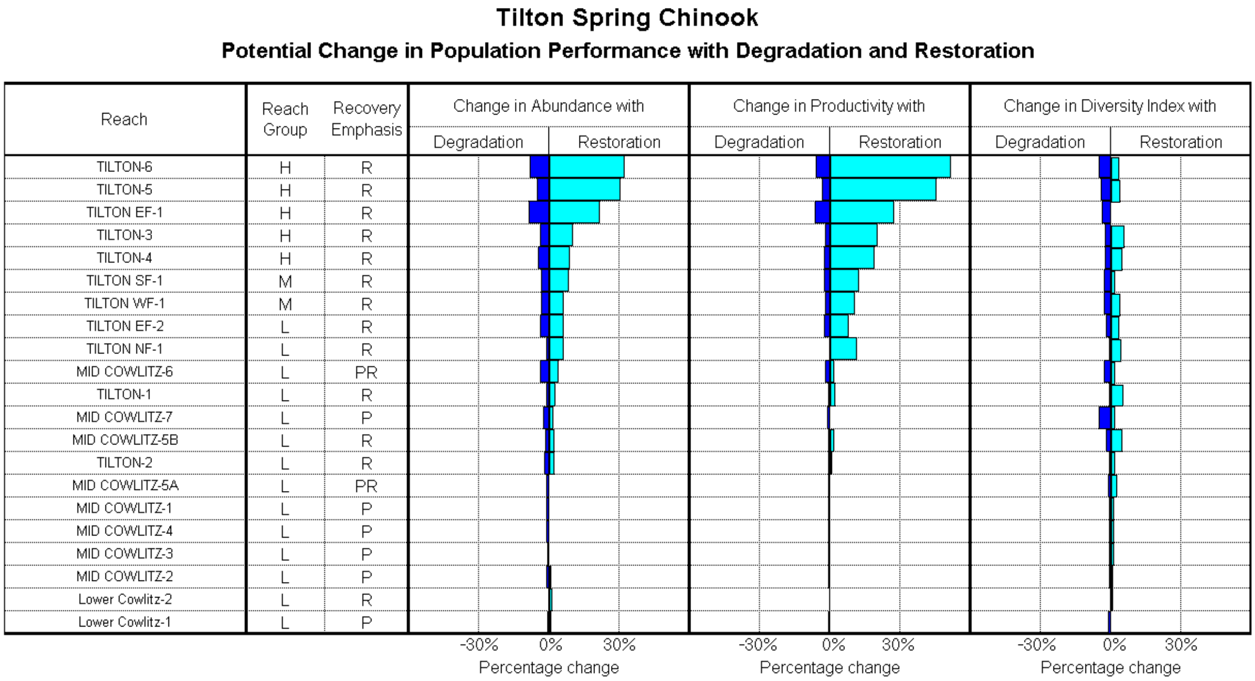


Figure 9-21. Tilton fall chinook ladder diagram.

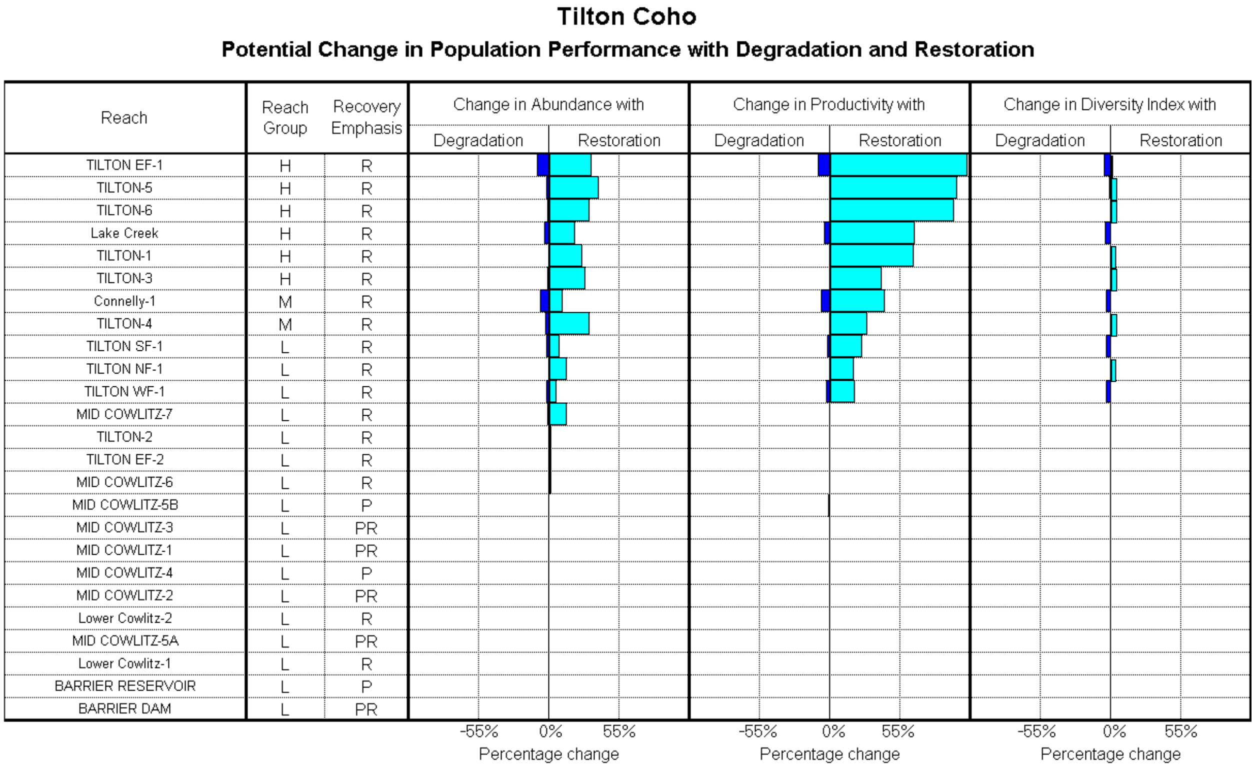


Tilton Spring Chinook

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
TILTON-6	H	R
TILTON-5	H	R
TILTON EF-1	H	R
TILTON-3	H	R
TILTON-4	H	R
TILTON SF-1	M	R
TILTON WF-1	M	R
TILTON EF-2	L	R
TILTON NF-1	L	R
MID COWLITZ-6	L	PR
TILTON-1	L	R
MID COWLITZ-7	L	P
MID COWLITZ-5B	L	R
TILTON-2	L	R
MID COWLITZ-5A	L	PR
MID COWLITZ-1	L	P
MID COWLITZ-4	L	P
MID COWLITZ-3	L	P
MID COWLITZ-2	L	P
Lower Cowlitz-2	L	R
Lower Cowlitz-1	L	P

Figure 9-22. Tilton spring chinook ladder diagram.



Tilton Coho

Potential Change in Population Performance with Degradation and Restoration

Reach	Reach Group	Recovery Emphasis
TILTON EF-1	H	R
TILTON-5	H	R
TILTON-6	H	R
Lake Creek	H	R
TILTON-1	H	R
TILTON-3	H	R
Connelly-1	M	R
TILTON-4	M	R
TILTON SF-1	L	R
TILTON NF-1	L	R
TILTON WF-1	L	R
MID COWLITZ-7	L	R
TILTON-2	L	R
TILTON EF-2	L	R
MID COWLITZ-6	L	R
MID COWLITZ-5B	L	P
MID COWLITZ-3	L	PR
MID COWLITZ-1	L	PR
MID COWLITZ-4	L	P
MID COWLITZ-2	L	PR
Lower Cowlitz-2	L	R
MID COWLITZ-5A	L	PR
Lower Cowlitz-1	L	R
BARRIER RESERVOIR	L	P
BARRIER DAM	L	PR

Figure 9-23. Tilton coho ladder diagram.

9.6.2.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Key winter steelhead reaches in the Tilton include the mainstem Tilton from Bear Canyon to the East Fork Tilton, and in the East Fork Tilton. These reaches have been most negatively impacted by sediment, flow alterations, and temperature regime changes, with lesser impacts from decreased habitat diversity, pathogens, and loss of key habitat (Figure 9-24). There is an increased peak flow risk due to high road densities and reductions in forest cover throughout the basin. Low flows have also been cited as a problem (Harza 1997 as cited in Wade 2000). High road densities have also been implicated in increased fine sediment delivery rates within the basin. Habitat diversity has been reduced due to LWD reductions related to channel cleaning, timber harvest in riparian zones, debris torrents, dam break floods, and increased peak flows (EA 1998 as cited in Wade 2000). Temperature regimes have been influenced by changes in riparian vegetation. Over 87% of riparian corridors in the Mayfield/Tilton basin lack riparian vegetation or have early-seral stage riparian conditions. Pathogenic and competition concerns arise from the extensive distribution of hatchery fish in the Cowlitz basin.

Important reaches for both fall chinook (Figure 9-25) and spring chinook (Figure 9-26) are located in the mainstem, EF, SF, and WF Tilton. These reaches have been primarily impacted by sediment, habitat diversity, flow, temperature, and channel stability. The causes of these impacts are the same as those discussed above for winter steelhead.

For coho, important reaches include mainstem reaches, the lower EF Tilton, and Lake and Connelly Creeks. These reaches have been degraded in the form increased sediment, lost habitat diversity, altered flow regimes, decreased channel stability, and loss of key habitat (Figure 9-27). The causes of these impacts are the same as those discussed above for winter steelhead.

Tilton Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
TILTON EF-1	●	●	⬤	●		●			⬤	⬤	•			●	•	⬤
TILTON EF-2	•	●	●	•		•			●	⬤	•			●	•	⬤
TILTON-1	•	●	●	•		•		•	●	⬤	•			●	•	✚
TILTON-5	•	●	⬤	•		●			⬤	⬤	•			●		•
TILTON-6	•	●	●	•		●			⬤	⬤	•			●	•	+
TILTON-3	●	●	●	•		•			●	⬤	•			●	•	✚
TILTON-4	•	•	●	•		•			●	⬤	•			●		✚
TILTON-2	●	●	●	•		•			●	⬤	+			●		
TILTON NF-1	•	●	●	•		•			●	●	•			•		●
TILTON SF-1	•	●	●	•		•			●	●	•			•		●
Lake Creek	•	●	●	•		•			●	⬤	•			•	•	✚
TILTON WF-1		•	●	•		•			●	●	•			•		●
Connelly-1	•	•	•	•		•			•	●	•			•		●
MID COWLITZ-7		•		•		•			•					•		•
MID COWLITZ-5B		•		•										•	•	•
MID COWLITZ-6		•												•		
Lower Cowlitz-1		•													•	•
MID COWLITZ-2																
MID COWLITZ-1																
MID COWLITZ-5A																
MID COWLITZ-3		•														•
Lower Cowlitz-2		•													•	•
MID COWLITZ-4																
BARRIER RESERVOIR		•														
BARRIER DAM																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-24. Tilton winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Tilton Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
TILTON-5	⬤	⬤	●	•		•			⬤	⬤	●			•	•	●
TILTON EF-1	●	⬤	•	•		•			●	⬤	•			•	●	●
TILTON-6	●	⬤	•	•					⬤	⬤	•			•	•	•
TILTON-4	●	●	•	•		•			●	⬤	●			•		+
TILTON SF-1	●	⬤	•	•					●	⬤	●			•	•	●
TILTON-3	●	●	•	•		•			●	⬤	•			•	•	+
TILTON WF-1	•	●	•	•		•			•	⬤	•			•		•
TILTON NF-1	•	●	•	•		•			●	⬤	•			•	•	●
TILTON-2		●				•			•	•				•		
MID COWLITZ-7		•				•								•		
MID COWLITZ-5B		•				•			+					•		•
Lower Cowlitz-1		•	•	•					+					•		+
Lower Cowlitz-2		•	•	•		•			+					•		+
MID COWLITZ-6		•				•								•		+
MID COWLITZ-4		•							+					•		+
MID COWLITZ-2		•												•		+
MID COWLITZ-3		•							+					•		+
MID COWLITZ-5A		•				•			+					•		+
TILTON-1		•														+
MID COWLITZ-1		•												•		+

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 9-25. Tilton fall chinook habitat factor analysis.

Tilton Spring Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
TILTON-6	●	⬤	⬤	•		●			⬤	⬤	•			●	•	⬤
TILTON-5	●	⬤	⬤	•		•			⬤	⬤	•			●	•	●
TILTON EF-1	●	⬤	●	•		•			●	⬤	•			●	•	●
TILTON-3	●	●	●	•		•			●	⬤	•			•	•	✛
TILTON-4	•	●	●	•		•			●	⬤	•			•		✛
TILTON SF-1	•	●	●			•			●	⬤	•			•	•	●
TILTON WF-1	•	●	●			•			●	●	•			•		●
TILTON EF-2	•	●	•			•			●	●	•			•	•	●
TILTON NF-1	•	●	●			•			●	●	•			•		●
MID COWLITZ-6	•	●		•		•			•		•			●		✛
TILTON-1		●	•			•			•	●	•			•		✚
MID COWLITZ-7		•		•					•					•		
MID COWLITZ-5B	•	•		•		•			•		•			•		•
TILTON-2	•	●	•						•	•				•		
MID COWLITZ-5A																
MID COWLITZ-1																
MID COWLITZ-4																
MID COWLITZ-3																
MID COWLITZ-2		•												•		
Lower Cowlitz-2		•		•										•		•
Lower Cowlitz-1		•														•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-26. Tilton spring chinook habitat factor analysis.

Tilton Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
TILTON EF-1	●	⬤	•	•		●			●	⬤	•			●	•	●
TILTON-5	●	⬤	●	•		●			⬤	⬤	•			●		●
TILTON-6	●	⬤	•	•		●			⬤	⬤	•			●		●
Lake Creek	●	⬤	•	•		●			●	⬤	•			●		⬤
TILTON-1	•	⬤	•	•		•		•	●	⬤	•			•		✚
TILTON-3	⬤	⬤	•	•		•			●	⬤	•			•		✚
Connelly-1	●	•	•	•		•			●	⬤	•			•		⬤
TILTON-4	●	●	●	•		●			●	⬤	●			●		✚
TILTON SF-1	•	●	•	•		•			•	●	•			•		•
TILTON NF-1	•	●	•	•		•			●	●	•			•		✛
TILTON WF-1	•	●	•	•		•			•	●	•			•		✛
MID COWLITZ-7	•	⬤		•		•			•	•	•			●		✛
TILTON-2		•		•						●						
TILTON EF-2		•								•						•
MID COWLITZ-6		•		•										•		✛
MID COWLITZ-5B																
MID COWLITZ-3																
MID COWLITZ-1																
MID COWLITZ-4																
MID COWLITZ-2																
Lower Cowlitz-2		•														
MID COWLITZ-5A																
Lower Cowlitz-1																
BARRIER RESERVOIR																
BARRIER DAM																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 9-27. Tilton coho habitat factor analysis.

9.7 Integrated Watershed Assessments (IWA)

The Integrated Watershed Assessment analysis was performed independently for the Mayfield-Tilton, Riffe Lake, Cispus River and Upper Cowlitz River Watersheds which collectively make up the upper Cowlitz River basin. These watersheds were analyzed separately because the upper Cowlitz basin is dissected by dams and storage reservoirs which interrupt watershed processes at the basin level. The results of IWA analyses for each watershed are described below.

9.7.1 Mayfield-Tilton

The Mayfield-Tilton watershed is located in the north-central portion of WRIA 26, and in the northwestern portion of the upper Cowlitz basin. For the purpose of recovery planning, the watershed is divided into 25 planning subwatersheds covering a total of approximately 154,000 acres (240 sq mi). In addition to the mainstem Cowlitz River, principal tributaries in the watershed include the Tilton River, the North, South, and WF Tilton River, and Winston Creek. Historically, this watershed supported miles of productive habitat for anadromous species. Today anadromous migration in the drainage is impeded by Mayfield Dam, which blocks all natural upstream passage and inhibits downstream migration. Mayfield Lake Reservoir has inundated the once productive spawning and rearing habitats in the portions of the mainstem Cowlitz River within the watershed. Primary land uses in this watershed include agriculture, timber harvest, and recreation centered on public lands and large reservoirs. Private timber land is the predominant form of private land ownership. The northern portion of the watershed is within the GPNF, while state lands cover between 20% and 50% of total area in five subwatersheds. Population centers in the watershed include the towns of Morton and Mossy Rock.

The Mayfield-Tilton River watershed is primarily a high elevation system, with approximately 40% of the watershed lying in the rain-on-snow zone. The streams comprising the watershed flow mostly through Cascade volcanic and granitic rocks, and therefore, natural erodability within the watershed is low. Twelve of the 25 subwatersheds are higher elevation headwaters and tributary subwatersheds. Seven subwatersheds are defined by moderate-size, mainstem rivers, including the Tilton and the lower reaches of the North Tilton. The Cowlitz River flows through two subwatersheds, in what were historically large mainstem type reaches fed by significant drainage area. The majority of this historical channel is inundated under the Mayfield Lake Reservoir, with only a short stretch of hydrologically modified mainstem channel remaining between the impoundment and Mossy Rock Dam upstream. Finally, lower stretches of Winton Creek are characterized by small to medium, low elevation, rain-dominated, streams and rivers.

9.7.1.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Mayfield-Tilton watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 9-4. A reference map showing the location of each subwatershed in the basin is presented in Figure 9-28. Maps of the distribution of local and watershed level IWA results are displayed in Figure 9-29. The majority of subwatersheds are rated moderately impaired to impaired at the local level for all three watershed processes, although two are rated functional with respect to riparian conditions, and one is rated functional for sediment. The results are similar at the watershed level. IWA results are described in more detail by process category below.

Table 9-4. Summary of IWA results for the Mayfield-Tilton River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
10101	I	M	M	I	M	none
10102	I	M	M	I	M	10103
10103	I	M	M	I	M	none
10104	I	M	M	I	M	10102, 10103
10201	I	M	M	I	M	none
10202	I	M	M	I	M	10201
10301	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202, 10302, 10303, 10401, 10402, 10403
10302	I	M	I	I	M	none
10303	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202
10401	I	M	M	I	M	none
10402	I	I	M	I	M	10401
10403	I	I	M	I	M	10401, 10402
10501	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202, 10301, 10302, 10303, 10401, 10402, 10403, 10502, 10504
10502	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202, 10301, 10302, 10303, 10401, 10402, 10403, 10504
10503	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202, 10301, 10302, 10303, 10401, 10402, 10403, 10501, 10502, 10504, 10505
10504	I	M	M	I	M	10101, 10102, 10103, 10104, 10201, 10202, 10301, 10302, 10303, 10401, 10402, 10403
10505	I	M	M	I	M	none
20501	I	M	M	I	M	20503
20502	I	M	M	M	M	20504
20503	M	M	F	M	M	none
20504	M	M	F	M	M	none
20505	I	M	M	I	M	20501, 20502, 20503, 20504
20601	I	M	I	F	M	none
20602	I	F	I	I	F	none
20603	I	M	I	F	M	10101, 10102, 10103, 10104, 10201, 10202, 10301, 10302, 10303, 10401, 10402, 10403, 10501, 10502, 10503, 10504, 10505, 20501, 20502, 20503, 20504, 20505, 20601, 20602

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800040#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

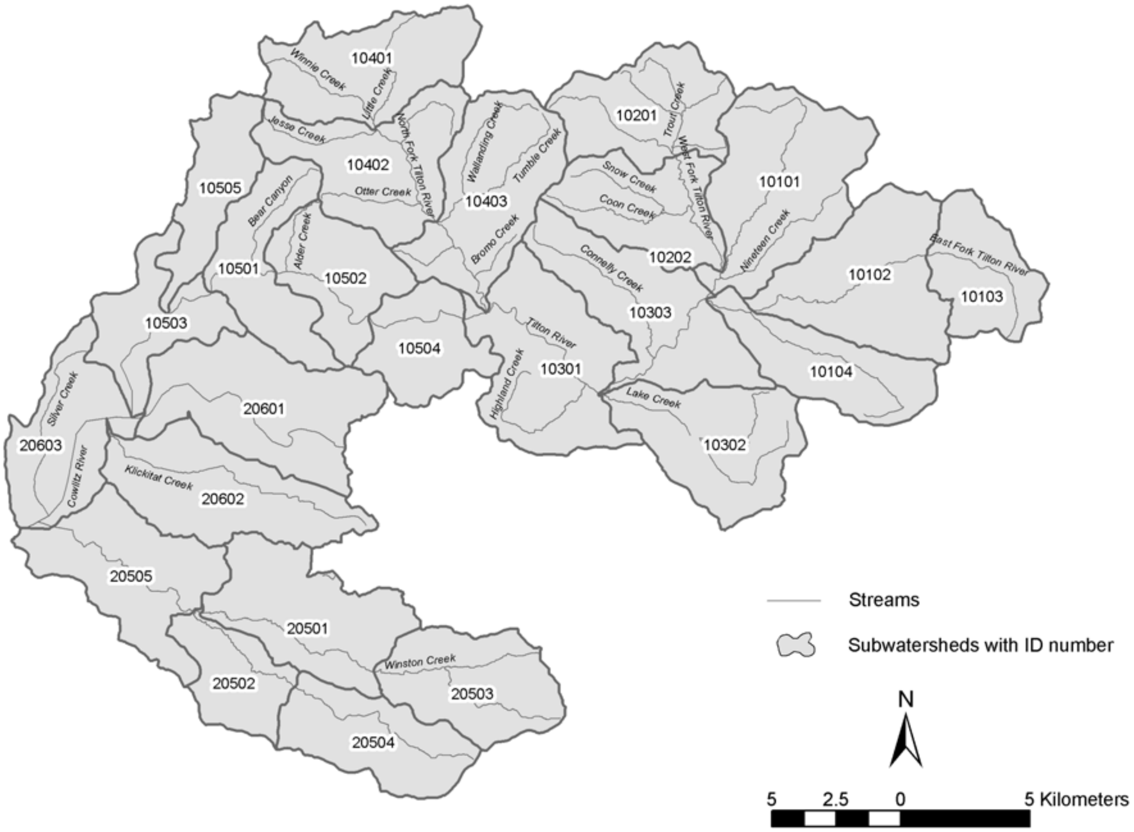


Figure 9-28. Map of the Mayfield-Tilton watershed showing the location of the IWA subwatersheds

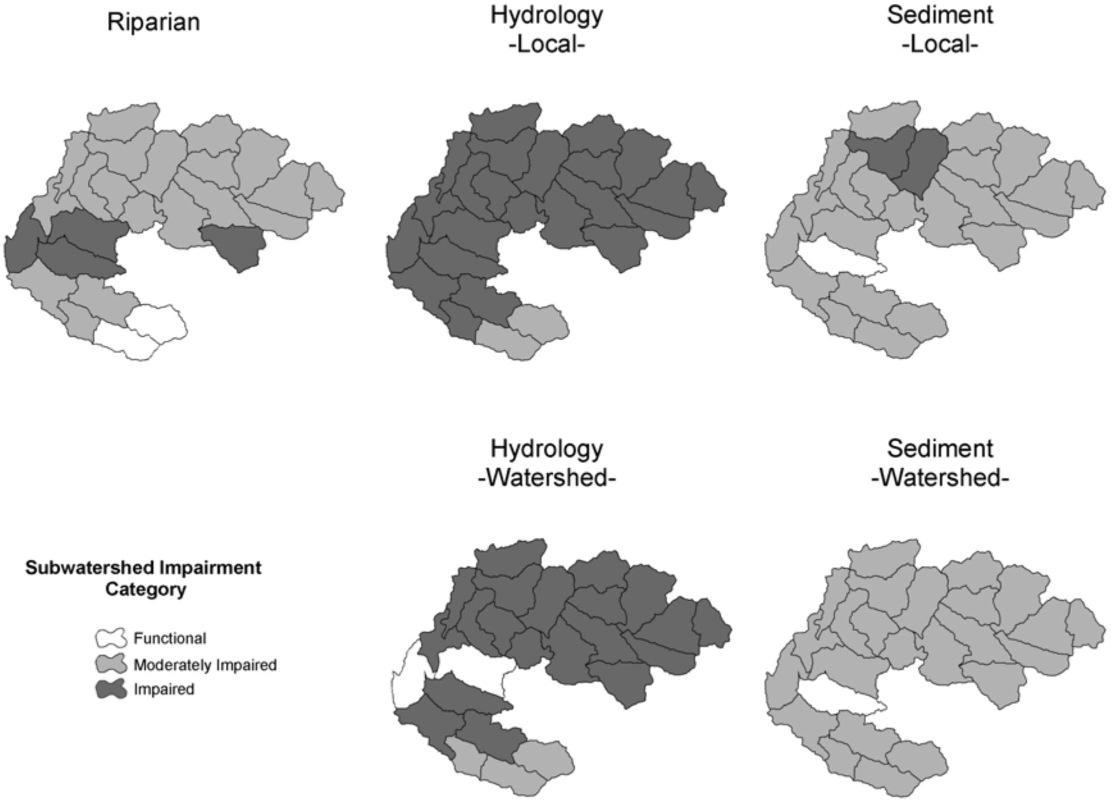


Figure 9-29. IWA subwatershed impairment ratings by category for the Mayfield-Tilton basin

9.7.1.1.1 Hydrology

Hydrologic conditions across the Mayfield-Tilton River watershed are generally rated as impaired. Moderately impaired subwatersheds occurring in the upper area of the Winston Creek drainage (20502-20504) make up the exceptions. Most of the land north of the Tilton River is within the Gifford Pinchot National Forest, but land around the lake is primarily under state and private ownership. Wetland area in the uplands of the Mayfield-Tilton River watershed is limited, and the percentage of watershed lying in the rain-on-snow zone is 35%. The low percentage of buffering wetlands, and the moderately high percentage of area in the rain-on-snow zone suggest a relatively high potential for adverse hydrologic impacts on channel conditions.

Hydrologic conditions within the subwatersheds along the Cowlitz (20602, 20603) are considered functional at the watershed level by the IWA analysis. This condition is an artifact of the influence of Mossyrock Dam and the Riffe Lake watershed situated directly upstream. However, hydrologic conditions along the mainstem Cowlitz within the watershed are impacted by Mayfield Dam, and therefore cannot be considered truelly functional. In most cases, upstream impairments in the Mayfield-Tilton watershed are muted by the reservoir, and therefore, they have little effect on downstream subwatersheds.

9.7.1.1.2 Sediment

Sediment conditions in the Mayfield-Tilton watershed range from functional to impaired at the local level. The middle and lower subwatersheds of the NF Tilton drainage (10402, 10403) are rated as impaired for sediment. In contrast, functional sediment conditions are found in Klickitat Creek (20602). The remainder of the watershed is rated as moderately impaired for sediment at the local level. Conditions are generally similar at the watershed level. However, sediment conditions in the NF Tilton drainage (10402, 10403) become moderately impaired at the local level, reflecting a buffering influence by only moderately impaired conditions in the Tilton headwaters (10401). All of the subwatersheds in the Mayfield-Tilton watershed have low to moderate natural erodability ratings, based on geology type and slope class, averaging 20 on a scale of 0-126. Mature vegetation cover is relatively low within the watershed, and road densities and road crossing densities are relatively high.

Sediment conditions along the Cowlitz mainstem (20601, 20603) are rated as moderately impaired at the watershed level. However, these ratings do not fully reflect the modified sediment regime of this portion of the watershed. The mainstem Cowlitz in these subwatersheds is inundated under storage reservoirs, and sediment transport to these reaches from upstream areas of the basin is disconnected by dams. Therefore, these ratings best reflect the influence of local subwatershed level sediment inputs.

9.7.1.1.3 Riparian

Riparian condition ratings for the Mayfield-Tilton watershed range from functional to impaired. Riparian conditions in the upper subwatersheds of Winston Creek (20503, 20504) are rated as functional, while subwatersheds along the Cowlitz mainstem (20602, 20603) and Klickitat Creek (20602) are rated as impaired. The remaining subwatersheds are rated as moderately impaired for riparian conditions.

9.7.1.2 Predicted Future Trends

9.7.1.2.1 Hydrology

Subwatersheds with a high percentage of public lands (10401-10403, 20504) are predicted to trend towards gradual improvement in hydrologic conditions as vegetation slowly matures and the influence of improved forestry and road management practices is manifest. Subwatersheds located on private timber lands are predicted to trend stable, given the likelihood of ongoing timber harvest rotations and high forest road densities, offset by improved forestry and road management practices. Hydrologic conditions on private lands not in large commercial forestry operations may continue to degrade if timber harvest continues and commercial and residential development expands.

A.1.1.1.1 Sediment

In subwatersheds with high percentage public land ownership (10401-10403), sediment conditions are predicted to trend towards gradual improvement over the next 20 years as improved road management practices and vegetation recovery mitigate the impacts of high forest road densities. Sediment supply conditions in the other subwatersheds, which are mostly comprised of private timber lands, are expected to trend stable or slightly improve due to new forest practices regulations that govern timber harvest and road building/maintenance practices.

9.7.1.2.2 Riparian Condition

The predicted trend for riparian conditions is for general improvement over the next 20 years due to riparian buffer timber harvest protections. The exceptions are private lands in the southern portion of the watershed that are at risk of increased residential development.

9.7.2 Riffe Lake

The Riffe Lake watershed is located in the center of WRIA 26, in the north-central portion of the region. The watershed is comprised of 15 subwatersheds covering a total of approximately 92,200 acres. Principal tributaries in the watershed include the Cowlitz River mainstem, Rainey Creek, and Goat Creek. Mossyrock Dam forms a 23-mile long lake in the center of the watershed, and together, the dam and reservoir (Riffe Lake) act as a complete barrier to both upstream and downstream fish passage. The land area in these subwatersheds is primarily under private ownership, with much of the uplands being utilized for timber production and lowlands being used for development, recreation, and timber. Wetland area along the reservoir is high, but it decreases dramatically along the upland tributaries. Mature forest cover in these subwatersheds averages only 30%. The average road density is moderately high, at 3.7 mi/sq mi, and so is the average stream crossing density at 3.2 crossings per mile.

The Riffe Lake watershed is primarily a high elevation system, supporting a large mainstem river, the Cowlitz. Eight of 15 subwatersheds are dominated by the mainstem Cowlitz. The tributary subwatersheds are characterized by small, high elevation streams feeding the reservoir (six subwatersheds), except Rainey-Frost Creek subwatershed (20502), which is a medium sized, high elevation subwatershed. Over 20% of the watershed is in the rain-on-snow zone, and between 32% and 64% of the southern watersheds lie in this zone. The rain-on-snow events cause local impacts; however, the reservoir mutes their effects downstream. Natural erodability within the watershed is low to moderate.

9.7.2.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Riffe Lake watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 9-5. A reference map showing the location of each subwatershed in the basin is presented in Figure 9-30. Maps of the distribution of local and watershed level IWA results are displayed in Figure 9-31. The majority of subwatersheds are impaired at the local level for hydrologic processes, and moderately impaired for sediment and riparian conditions. Although eight are impaired with respect to hydrology, only one is impaired for sediment and one is impaired with respect to riparian conditions. Local level conditions differ considerably from watershed level conditions for hydrology, but remain similar with respect to sediment supply.

Table 9-5. IWA results for the Riffe Lake watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30801	I	M	M	F	M	30802
30802	I	M	M	F	M	none
20101	I	M	M	F	M	none
20102	I	M	I	I	M	20101
20103	I	M	M	I	M	none
20201	F	M	M	F	M	30801, 30802
20202	F	M	F	F	M	none
20301	I	M	M	F	M	30801, 30802, 20101, 20102, 20103, 20201, 20202, 20302
20302	I	M	M	F	M	30801, 30802, 20201, 20202
20303	M	M	F	M	M	none
20401	I	M	M	F	M	30801, 30802, 20101, 20102, 20103, 20201, 20202, 20301, 20302, 20303, 20401, 20402, 20403, 20404, 20405
20402	M	M	M	M	M	none
20403	F	M	M	F	M	30801, 30802, 20101, 20102, 20103, 20201, 20202, 20301, 20302, 20303, 20403, 20405
20404	I	M	M	I	M	none
20405	M	M	M	F	M	30801, 30802, 20101, 20102, 20103, 20201, 20202, 20301, 20302, 20303

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800040#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

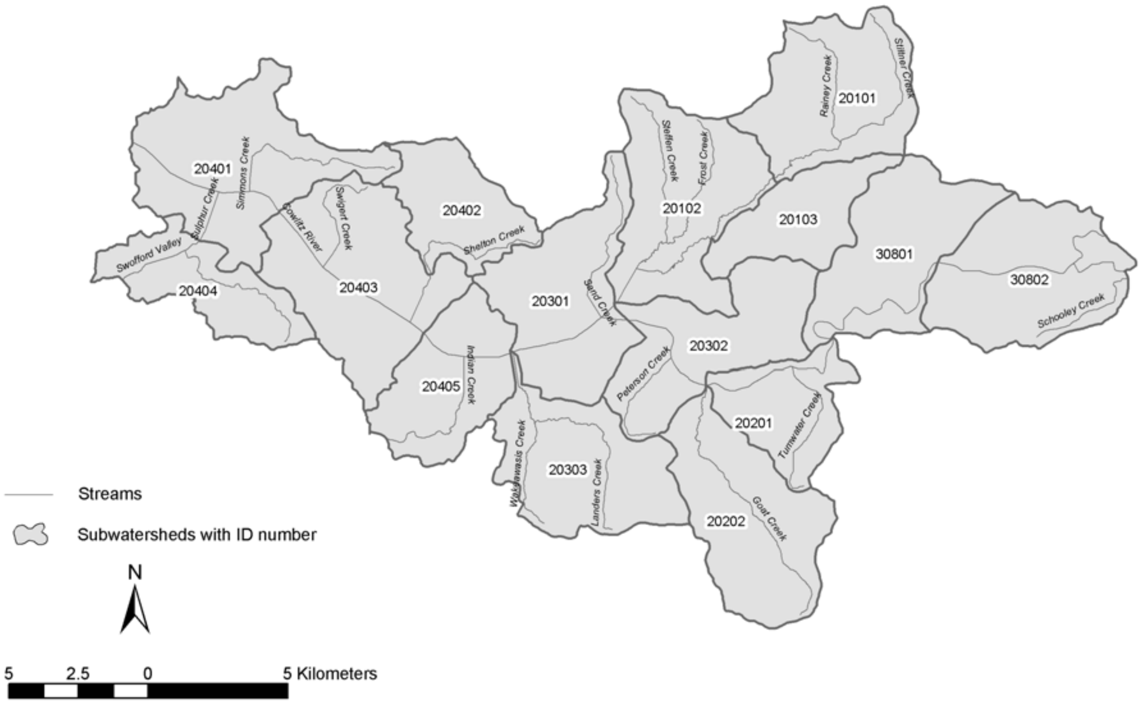


Figure 9-30. Map of the Riffe Lake watershed showing the location of the IWA subwatersheds

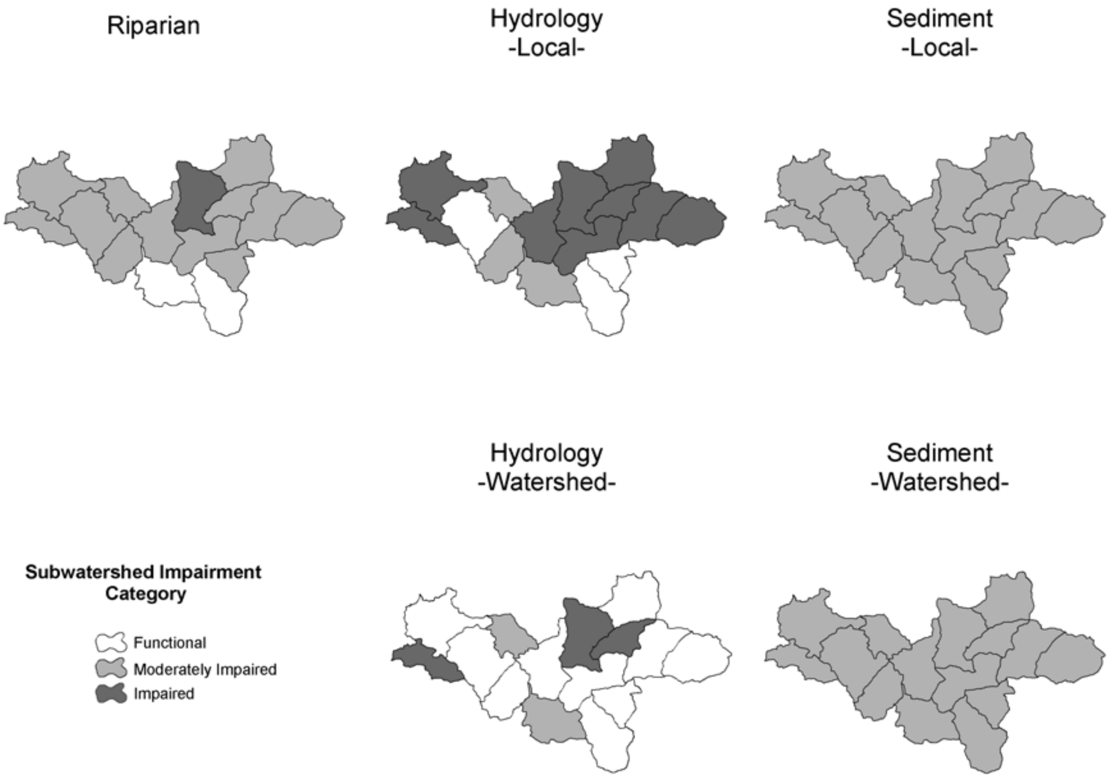


Figure 9-31. IWA subwatershed impairment ratings by category for the Riffe Lake watershed.

9.7.2.1.1 Hydrology

Local hydrologic conditions across the Riffe Lake watershed range from functional to impaired, with subwatersheds rated as functional located in most headwaters areas and along the mainstem of the upper Cowlitz River. Functional hydrologic conditions are located in the southwest portion of the watershed, including Tumwater Creek (20203) and Goat Creek (20202), which lies partly in Mt. St. Helens National Monument. Moderately impaired hydrologic conditions are in the central part of the watershed, including Landers (20303), Shelton (20402), and Indian Creeks (20405). Impaired conditions lie along the Cowlitz mainstem at the west and east ends, and in the Rainey Creek drainage (20101, 20102). Most of these impaired conditions are buffered by the reservoir and therefore do not impact downstream conditions greatly. Potentially important subwatersheds for reintroduction of anadromous fish in this watershed are located along the Cowlitz (10303-10307), which are partially inundated by the storage reservoirs.

The situation for hydrology changes drastically when looking at watershed level conditions, reflecting the influence of conditions in upstream subwatersheds on the IWA analysis. The number of subwatersheds with functional ratings increases from 3 to 10, and the number with impaired ratings drops from 9 to 3.

9.7.2.1.2 Sediment

According to IWA model results, all of the subwatersheds within the Riffe Lake watershed possess moderately impaired sediment process conditions at both the local and watershed levels. These conditions are probably driven by both local and upstream problems. Most of the local sediment condition issues are the same as the hydrology condition issues: low mature vegetation cover, moderately high road densities, and moderately high stream crossing densities. As with hydrology, the downstream effects are minimal due to the reservoir.

Watershed level sediment ratings in subwatersheds along the mainstem Cowlitz do not fully reflect the influence of dams and storage reservoirs on sediment dynamics. These ratings more accurately reflect the influence of local subwatershed level conditions on sediment delivery to the reservoir.

9.7.2.1.3 Riparian

Riparian conditions are primarily moderately impaired throughout the Riffe Lake watershed, with impaired conditions in the Frost-Rainey Creek subwatershed (20502).

9.7.2.2 Predicted Future Trends

9.7.2.2.1 Hydrology

The high percentage of private land ownership, coupled with the amount of logging, development around the reservoir, and road density, indicates that the watershed conditions will either trend stable or gradually degrade over the next 20 years. As long as the dams are in place, protection of the intact hydrologic process will probably only improve local conditions for resident fish and the few fish that reach the reservoir.

9.7.2.2.2 Sediment

Given that most of this area will be actively managed as timberland, the trend in sediment conditions is expected to remain relatively constant over the next 20 years.

9.7.2.2.3 Riparian Condition

Riparian conditions are predicted to remain stable, with a gradual trend towards improvement as improved forestry and road management practices are more broadly implemented on private timber lands.

9.7.3 Cispus River Watershed

The Cispus River watershed is located in the eastern half of WRIA 26, in the northeast portion of the region. The Cispus River originates on the flanks of Mt. Adams and the higher peaks along the Cascade Crest. The watershed is comprised of 37 subwatersheds covering a total of approximately 278,800 acres (436 sq mi). Principal tributaries in the watershed include the mainstem Cispus River, and the NF Cispus River. The entire drainage is located upstream of the Cowlitz Falls Dam. Currently, the system of dams blocks all natural upstream passage and downstream migration. Migrants are captured at the Cowlitz Falls Dam and transported around the dams. The vast majority of the watershed lies within the GPNF, with significant portions of the headwaters in the Mt. Adams and Goat Rocks Wilderness Areas.

The Cispus River watershed is primarily a high elevation, snow dominated system. Only 13% lies in the rain-on-snow zone, with the remainder at higher elevation. Natural erodability within the watershed is low. Twenty-one subwatersheds are higher elevation headwaters subwatersheds. Twelve subwatersheds are defined by moderate size mainstem rivers flowing through higher elevation granitic rocks with low/moderate erodability levels. Three subwatersheds are characterized by large mainstem rivers with low/moderate natural erodability levels, and one subwatershed is classified as a lowland, rain-dominated system.

9.7.3.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Cispus River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 9-6. A reference map showing the location of each subwatershed in the basin is presented in Figure 9-32. Maps of the distribution of local and watershed level IWA results are displayed in Figure 9-33. The majority of subwatersheds are functional to moderately impaired at the local level for all three watershed processes, with only one of the subwatersheds having impaired sediment conditions, and none having impaired hydrologic or riparian conditions. Watershed level results for hydrology and sediment are generally similar to the local level results, with some locally moderately impaired subwatersheds rated functional due to the buffering effects of upstream drainage areas.

Table 9-6. Summary of IWA results for the Cispus River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
40101	M	M	M	M	M	none
40102	F	M	F	F	M	none
40201	F	F	F	F	F	none
40301	F	M	F	F	F	40101, 40102, 40201
40302	F	F	M	F	F	40101, 40102, 40201, 40301
40401	M	M	F	M	F	40402
40402	M	F	M	M	F	none
40501	F	M	F	F	F	40502
40502	M	F	M	M	F	none
40601	F	M	M	F	M	40602
40602	F	M	F	F	M	none
40701	F	F	M	F	F	none
40702	F	F	F	F	F	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40701
40703	F	F	F	F	M	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704
40801	F	F	M	F	F	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704, 40802
40802	F	F	M	F	M	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704
40901	M	M	F	F	M	40902, 40903, 40904
40902	M	M	M	M	M	none
40903	M	M	M	M	M	40902, 40904
40904	M	F	M	M	F	40902
50101	F	M	M	F	M	50102
50102	M	I	M	M	I	none
50201	F	M	M	F	M	50101, 50102, 50202, 50203, 50204, 50205
50202	F	M	F	F	M	50203, 50204, 50205
50203	F	M	M	F	M	none
50204	F	M	F	F	M	50203, 50205
50205	F	M	M	F	M	none
50301	M	M	M	F	F	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704, 40801, 40802, 40901, 40902, 40903, 40904

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
50302	M	M	M	F	M	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704, 40801, 40802, 40901, 40902, 40903, 40904, 50101, 50102, 50201, 50202, 50203, 50204, 50205, 50301
50401	F	M	F	F	M	none
50501	F	M	F	M	M	50502, 50503
50502	M	M	F	M	M	50503
50503	M	M	M	M	M	none
50601	M	M	M	M	M	none
50602	M	M	F	F	M	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704, 40801, 40802, 40901, 40902, 40903, 40904, 50101, 50102, 50201, 50202, 50203, 50204, 50205, 50301, 50302, 50401, 50501, 50502, 50503, 50601, 50602
50701	M	M	M	F	M	40101, 40102, 40201, 40301, 40302, 40401, 40402, 40501, 40502, 40601, 40602, 40701, 40702, 40703, 40704, 40801, 40802, 40901, 40902, 40903, 40904, 50101, 50102, 50201, 50202, 50203, 50204, 50205, 50301, 50302, 50401, 50501, 50502, 50503, 50601, 50602, 50702
50702	F	M	M	F	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800040#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

Figure 9-32. Map of the Cispus watershed showing the location of the IWA subwatersheds.

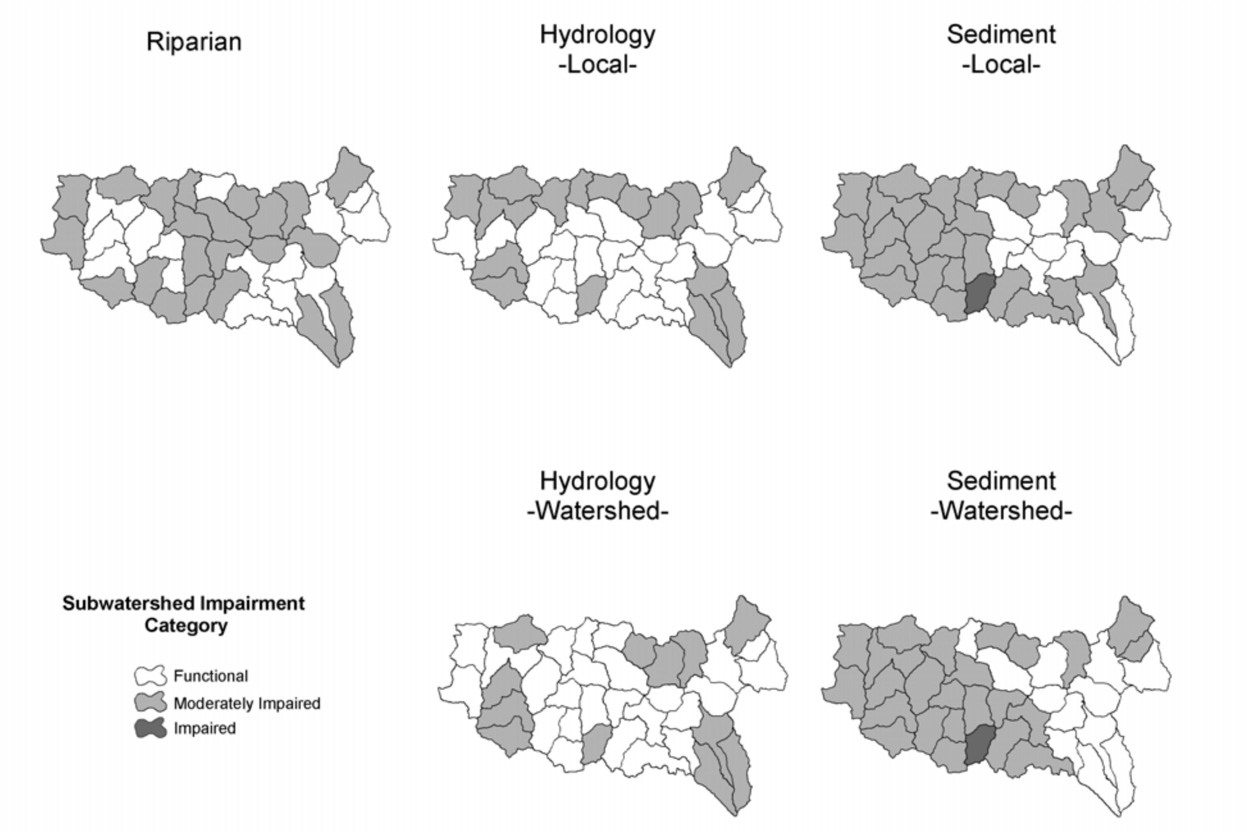


Figure 9-33. IWA subwatershed impairment ratings by category for the Cispus watershed.

9.7.3.1.1 Hydrology

Hydrologic conditions across the Cispus River watershed range from functional to moderately impaired, with functional subwatersheds located in most headwaters areas and along the mainstem of the Cispus River. Subwatersheds rated moderately impaired include the upper NF Cispus (40902-40904), Iron Creek (50501-50503), and Muddy Creek (40401, 40402), upper Adams Creek (40502) and Goat Creek (40101). The Muddy Fork, Adams Creek and Goat Creek subwatersheds are all located in Wilderness Areas, and originate in high elevation areas above the tree line. Therefore, hydrologic conditions within these subwatersheds are expected to be functional as opposed to moderately impaired. Hydrologic conditions in the Cispus and its smaller tributaries subwatersheds, including Yellowjacket Creek, are in good condition. As shown in Figure 9-33, the relatively intact hydrologic conditions in the Cispus headwaters appear to buffer hydrologic conditions in the mainstem subwatersheds and the lower areas of the NF.

9.7.3.1.2 Sediment

The majority of subwatersheds in the Cispus watershed possess moderately impaired sediment conditions. Functional sediment conditions at both the local and watershed levels can be found in headwaters subwatersheds, especially in the western portion of the watershed above the mouth of Adams Creek (40501) and Orr Creek (40702). Sediment condition ratings trend towards moderately impaired on a downstream gradient. The subwatershed encompassing the upper reaches of McCoy Creek (50102) is rated impaired for sediment conditions at the local and watershed level.

Within the NF Cispus River drainage (40901-40904), three out the four subwatersheds possess moderately impaired sediment conditions. Subwatershed 40904, which includes Timothy Creek, is functional with respect to sediment. The other subwatersheds in the drainage are moderately impaired for sediment for many of the same reasons they were moderately impaired for hydrology, moderate to high unsurfaced road densities in sensitive areas (e.g., steep slopes with erodable geology).

Except for a few headwater subwatersheds such as Camp Creek (50301), most of the middle and lower mainstem Cispus watershed is rated moderately impaired with respect to sediment. The reach between Iron Creek and the North Fork lies downstream from moderately impaired subwatersheds including the North Fork drainage, Yellowjacket Creek drainage (50201-50205, 50101-50102), Greenhorn Creek subwatershed (50401) and Woods Creek subwatershed (50601) Most of these subwatersheds have low natural erodability ratings, ranging from 1-21. Road densities in most of these subwatersheds are moderate to low, usually falling between 2-3 mi/sq mi. Stream crossings and percent of mature forest cover vary, but they also tend to be moderate to low.

9.7.3.1.3 Riparian

Riparian conditions are rated functional to moderately impaired throughout the Cispus River watershed, with headwater subwatersheds and smaller drainages containing a mix of both conditions. None of the subwatersheds are rated as impaired. It is important to note that in many subwatersheds rated as moderately impaired, stream channels originate above the treeline and limited riparian vegetation is a natural condition (e.g., the headwaters of the Muddy Fork and Adams Creek on the flanks of Mt. Adams). Many of the functional riparian subwatersheds are located in the eastern portion of the watershed in wilderness, where several subwatersheds are rated functional for all three watershed processes. Conditions become more unfavorable (moderately impaired) as you move downstream. However, even in the upper-most mainstem

Cispus (40101) and the Muddy Fork Cispus (40401, 40402), there are moderately impaired subwatersheds with respect to riparian condition.

Riparian conditions in the NF Cispus and mainstem Cispus subwatersheds (40901-40904) are primarily moderately impaired, except for the Swede-Irish Creeks subwatershed (40901), which is rated functional. Riparian ratings for the subwatersheds containing important fish habitat reaches of the mainstem Cispus River (50301, 50302, 50602) are also primarily moderately impaired.

9.7.3.2 Predicted Future Trends

9.7.3.2.1 Hydrology

Nearly all of the land area in the Cispus River watershed lies within GPNF, and is managed by the USFS. Wetland area in the uplands of the Cispus River is limited. Hydrologically mature forest cover in these subwatersheds is generally higher than in other areas of the region (averaging 60%) and road densities are low to moderate (28 subwatersheds <3 mi/sq mi). Due to the high percentage of public land ownership, forest cover within these subwatersheds is predicted to generally mature and improve. Based on this information, hydrologic conditions are predicted to trend stable or improve gradually over the next 20 years.

Other streams referred to in the LFA include Greenhorn Creek (50401), Iron Creek (50501-50503), Orr Creek (40702), and Woods Creek (50601) (Wade 2000). Orr and Greenhorn Creeks are headwaters tributaries, and are characterized by functional hydrologic conditions. The subwatersheds in the Iron Creek drainage and the Woods Creek subwatershed are characterized by moderately impaired hydrologic conditions. All of these subwatersheds have moderate to high road densities (3.0-4.4 mi/sq mi), and three out of four of these subwatersheds have moderately high stream crossing densities. Given the high road densities and the public land ownership, hydrologic conditions in these subwatersheds will probably remain constant or improve gradually over the next 20 years.

9.7.3.2.2 Sediment

Timber harvesting will continue, but due to public ownership it will be relatively modest into the foreseeable future, and impacts will be mitigated by improved forestry and road management practices. Impacts resulting from recreational uses, however, are likely to increase with growing population pressures. Considering these circumstances, the trend in sediment conditions is expected to remain relatively constant or to slightly improve over the next 20 years.

9.7.3.2.3 Riparian Condition

Given the large proportion of public land ownership throughout the Cispus River watershed, and the assumption that the trend for hydrologic recovery in these subwatersheds will also benefit riparian conditions, the predicted trend is for general improvement over the next 20 years. The generally low streamside road densities in the Cispus watershed indicate generally good potential for riparian recovery.

9.7.4 Upper Cowlitz

The Upper Cowlitz River watershed is located in the eastern half of WRIA 26, in the northeast portion of the region. The watershed is comprised of 54 subwatersheds covering a total of approximately 364,000 acres (564 sq mi). The northern portion of the watershed lies within Mt. Rainier National Park and the Tatoosh Wilderness Area, and the eastern portion comprises the Goat Rocks Wilderness. The remainder of the Upper Cowlitz River Watershed lies within the GPNF. Principal tributaries in the watershed include the Muddy and Clear Forks of the Cowlitz River, the Ohanapecosh River, Silver Creek, and Skate Creek. The entire drainage is located upstream of the Cowlitz Falls Dam. Currently, the system of dams blocks all natural upstream passage and downstream fish migration. Migrants are currently transported around the Dams.

The Upper Cowlitz River watershed is primarily a high elevation system, with only 16% lying in the rain-on-snow zone. Mature forest cover in these subwatersheds averages 70% and the average road density is moderate in general (3 mi/sq mi), although there are six subwatersheds with densities greater than 5 mi/sq mi. Natural erodability within the watershed is low. Thirty-four subwatersheds are higher elevation headwaters. Twelve subwatersheds are moderate size mainstem rivers, including the Ohanapecosh River and the lower Clear and Muddy Forks of the Cowlitz, which flow through higher elevation volcanic rocks with low natural erodability levels. Seven subwatersheds are large mainstem rivers such as the Cowlitz mainstem, with low/moderate natural erodability levels. One subwatershed, Siler Creek (30701), is classified as a lowland, rain dominated, and small tributary stream.

9.7.4.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Upper Cowlitz River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 9-7. A reference map showing the location of each subwatershed in the basin is presented in Figure 9-34. Maps of the distribution of local and watershed level IWA results are displayed in Figure 9-35. The majority of subwatersheds are functional to moderately impaired at the local level for all three watershed processes, although eight are impaired with respect to hydrology, one is impaired for sediment and one is impaired with respect to riparian conditions. Functional hydrology, sediment, and riparian conditions occur mostly in headwaters and medium-sized tributaries of the Upper Cowlitz originating in the wilderness areas and Mt. Rainier National Park, concentrated above the Cowlitz-Muddy Fork confluence (20201). Results for watershed level conditions are generally similar.

Table 9-7. IWA results for the Upper Cowlitz River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
10101	F	F	F	F	F	none
10102	F	M	F	F	F	10101, 10103
10103	F	F	F	F	F	none
10201	M	F	M	M	F	none
10202	M	F	M	M	F	none
10203	F	F	F	F	F	10201, 10202
10204	F	F	F	F	F	none
10205	F	M	F	F	F	10201, 10202, 10203, 10204
10206	F	F	F	F	F	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205,
10301	F	M	F	F	M	none
10302	M	M	F	F	F	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10303, 10304, 10305, 10306, 10307
10303	F	F	F	F	F	10301, 10304, 10305, 10306, 10307
10304	F	F	F	F	F	none
10305	F	F	F	F	F	none
10306	F	F	F	F	F	10304, 10305
10307	F	M	F	F	M	none
10401	M	M	I	M	M	none
10402	M	I	M	M	I	none
10403	F	F	M	F	F	none
10404	F	F	M	M	F	10401, 10402, 10403
10405	F	F	F	M	F	10401, 10402, 10403, 10404
20101	F	F	F	F	M	none
20102	F	M	M	F	M	none
20201	M	M	M	F	M	20102
20202	F	M	F	F	M	none
20301	M	M	M	M	M	none
20302	F	M	M	F	M	20301
20401	F	F	M	F	F	none
20402	M	F	F	M	F	none
20403	F	M	M	F	F	20401, 20402
20501	F	F	M	F	F	20502, 20503, 20504
20502	F	M	F	F	M	none
20503	F	F	M	F	F	none
20504	F	M	F	F	M	none
20601	I	M	M	F	F	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403
20602	I	M	M	I	M	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30101	F	M	M	F	M	30102
30102	F	M	M	F	M	none
30201	I	M	M	I	M	none
30202	F	M	F	M	M	30201
30301	F	M	M	F	F	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202
30302	F	M	M	F	F	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202, 30301
30303	F	M	M	F	M	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202, 30301, 30302
30401	M	M	M	F	M	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202, 30301, 30302, 30303
30402	F	F	M	F	M	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202, 30301, 30302, 30303, 30401
30501	I	M	M	I	M	none
30502	M	M	M	M	M	none
30503	I	M	M	I	M	30504

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
30504	M	F	M	I	M	30502
30505	I	M	M	I	M	none
30506	M	M	M	I	M	30501, 30502, 30503, 30504, 30505
30601	I	M	M	I	M	none
30602	I	M	M	F	M	10101, 10102, 10103, 10201, 10202, 10203, 10204, 10205, 10206, 10301, 10302, 10303, 10304, 10305, 10306, 10307, 10401, 10402, 10403, 10404, 10405, 20101, 20102, 20201, 20202, 20301, 20302, 20401, 20402, 20403, 20501, 20502, 20503, 20504, 20601, 20602, 30101, 30102, 30201, 30202, 30301, 30302, 30303, 30401, 30402, 30501, 30502, 30503, 30504, 30505, 30506, 30601, 30602, 30701,
30701	M	M	M	M	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800040#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

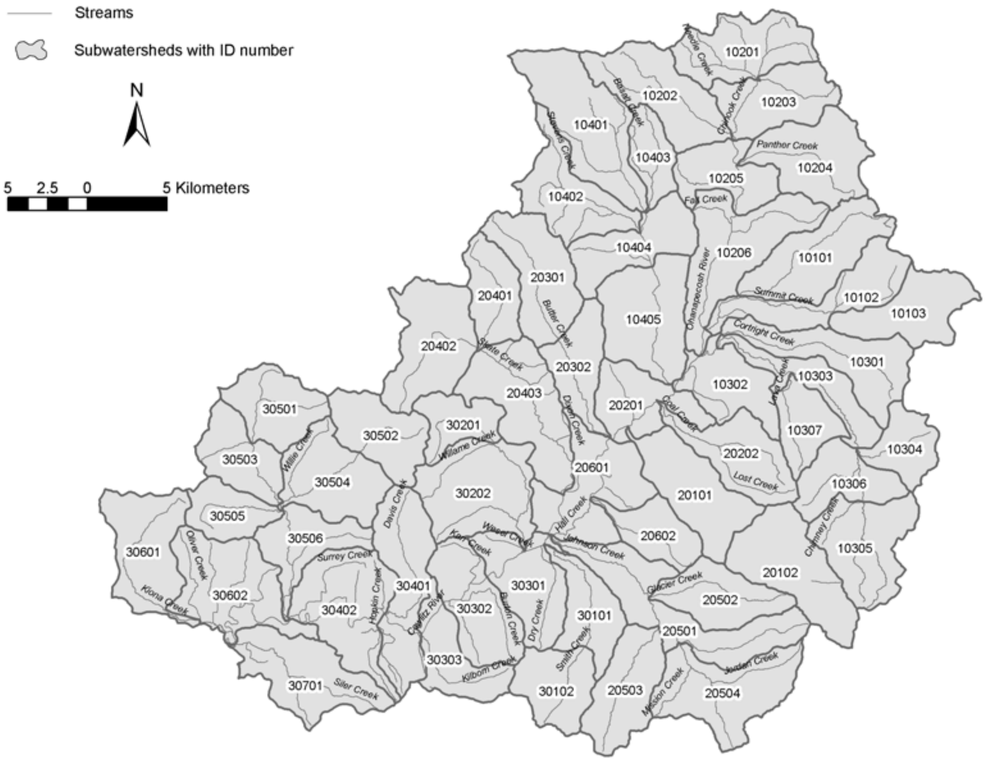


Figure 9-34. Map of the upper Cowlitz basin showing the location of the IWA subwatersheds

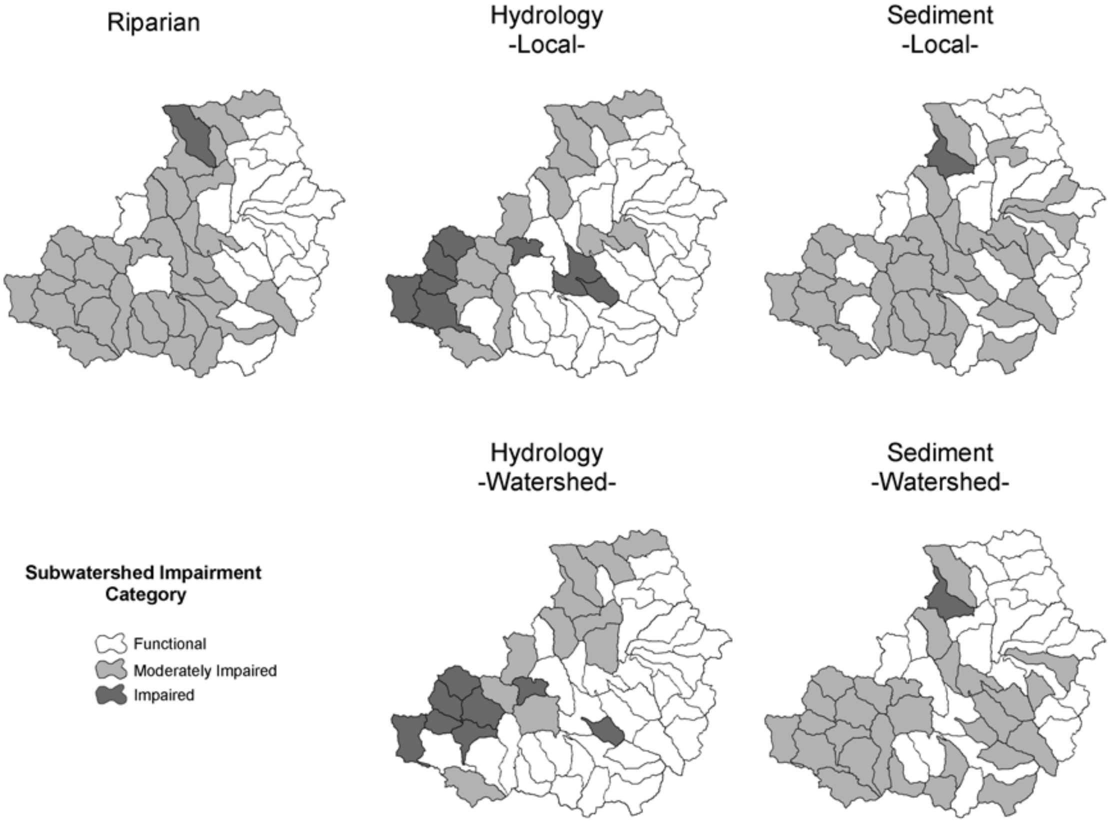


Figure 9-35. IWA subwatershed impairment ratings by category for the Upper Cowlitz basin

9.7.4.1.1 Hydrology

Almost all of the land area in the upper Cowlitz watershed lies within National Forest, National Park, or in designated wilderness area. The percentage of watershed lying in a rain-on-snow zone is low (16%), but could have some impact, especially in the higher elevation subwatersheds, such as the Ohanapecosh River.

Local hydrologic conditions across the Upper Cowlitz River watershed range from functional to impaired, with functional subwatersheds located in most headwaters areas and along the mainstem of the Upper Cowlitz River (30301-30303) downstream of and including the Smith Creek (30101, 30102) and Johnson Creek (20501-20504) drainages. Moderately impaired subwatersheds include the Muddy Fork drainage (10401-10405), Willame Creek (30201, 30202), the Cowlitz downstream of the Cowlitz-Ohanapecosh confluence (10302, 20201), and a few headwater tributary subwatersheds of the Ohanapecosh River (10201, 10202) and Skate Creek (20402). Most of these impaired conditions are buffered by headwater tributaries and by the upstream influences along the Cowlitz mainstem. Impaired areas include the Silver (30501, 30503, 30505) and Kiona Creek (30601) drainages in the southwest portion of the watershed.

The relatively intact local hydrologic conditions in the Upper Cowlitz headwaters appear to buffer hydrologic conditions in the mainstem subwatersheds at the watershed level.

9.7.4.1.2 Sediment

Functional sediment conditions at both the local and watershed levels can be found in headwaters subwatersheds, especially in the eastern portion of the watershed. However, the sediment conditions trend towards moderately impaired on a downstream gradient towards the mainstem Cowlitz at the lower end of the watershed. All of the subwatersheds in the Upper Cowlitz watershed have low natural erodability ratings, averaging 16 on a scale of 0-126. This suggests that these subwatersheds would not be large sources of sediment impacts under disturbed conditions. Except for the Silver Creek drainage, road densities and streamside road densities in these subwatersheds are also relatively low.

9.7.4.1.3 Riparian

Riparian conditions are rated functional to moderately impaired throughout the Upper Cowlitz River watershed. Most of the functional riparian subwatersheds are located in the eastern portion of the watershed, where many subwatersheds are rated functional for all three watershed processes. The majority of headwaters subwatersheds in this portion of the watershed are rated functional. Conditions become more unfavorable (moderately impaired) moving downstream. However, even in the upper-most reaches of the Ohanapecosh River (10201, 10202) and Skate Creek (20401), there are moderately impaired subwatersheds with respect to riparian condition.

9.7.4.2 Predicted Future Trends

9.7.4.2.1 Hydrology

Due to the high percentage of public land ownership, especially protected land, forest cover within these subwatersheds is predicted to generally mature and improve. Wetland area in the uplands of the upper Cowlitz River is limited. Based on this information, hydrologic conditions are predicted to trend stable or improve gradually over the next 20 years.

9.7.4.2.2 Sediment

Given the high percentage of public land ownership in these subwatersheds, and the relatively low level of current impacts, the trend in sediment conditions is expected to remain relatively constant or to slightly improve over the next 20 years.

9.7.4.2.3 Riparian Condition

Based on the assumption that the trend for hydrologic recovery in these subwatersheds will also benefit riparian conditions, the predicted trend is for general improvement over the next 20 years.

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Volume II, Chapter 10
Kalama Subbasin

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10.0 Kalama Subbasin

10.1 Subbasin Description

10.1.1 Topography & Geology

The Kalama River subbasin is a 205 square mile watershed extending from the southwest slopes of Mount St. Helens to the Columbia River, where it enters at RM 73.1. The watershed is bordered by the Toutle and Coweeman basins to the north and the NF Lewis basin to the south. The headwaters are in Skamania County although 99% of the basin lies within Cowlitz County.

The elevation ranges from sea level at the Columbia River to near 8000 feet on Mount St. Helens. Past eruptions of Mount St. Helens and associated lahars have shaped the landscape of the basin over the past 20,000 years. The lahars left unconsolidated deposits creating slope stability concerns in the steep upper watershed (USFS 1996a).

The lower basin is low gradient, with tidal influence extending up to RM 2.8. Lower Kalama Falls at RM 10 blocked most anadromous fish access except for summer steelhead until it was laddered in 1936. Only summer steelhead and some spring chinook are now passed above the falls. The river courses through a narrow V-shaped valley above RM 10. Passage to all anadromous fish is blocked by a falls at RM 35. The upper watershed tributaries have steep gradients only accessible to anadromous fish in the lowest reaches (Wade 2000).

10.1.2 Climate

The Kalama basin experiences a maritime climate with cool, wet winters and dry, warm summers. Mean annual precipitation is 68 inches at the Kalama Falls Hatchery and is over 120 inches in the upper subbasin (WRCC 2003). The bulk of the precipitation occurs from the first of October through March.

10.1.3 Land Use/Land Cover

Most of the basin is forested and nearly the entire basin is managed for commercial timber production (96%). Only 1.3% is non-commercial forest and 1.5% is cropland. Areas along the lower river have experienced industrial and residential development, resulting in channelization of the lower river. Population density and development in the watershed are low. The year 2000 population was approximately 5,300 persons (LCFRB 2001). The town of Kalama, located near the mouth, is the only urban area in the basin. A portion of the upper basin is located within the Mount St. Helens National Volcanic Monument. National Monument land is managed primarily for natural resource protection and tourism. A breakdown of land ownership and land cover in the Kalama basin is presented in Figure 10-1 and Figure 10-2. Figure 10-3 displays the pattern of landownership for the basin. Figure 10-4 displays the pattern of land cover / land-use.

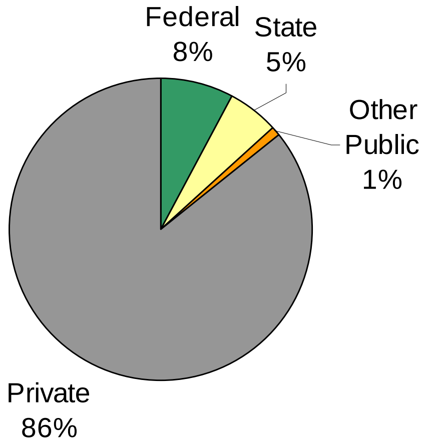


Figure 10-1. Kalama subbasin land ownership

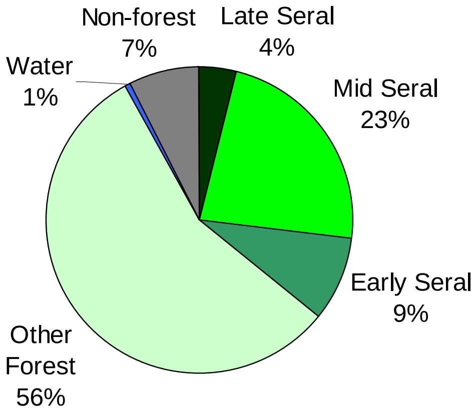


Figure 10-2. Kalama subbasin land cover

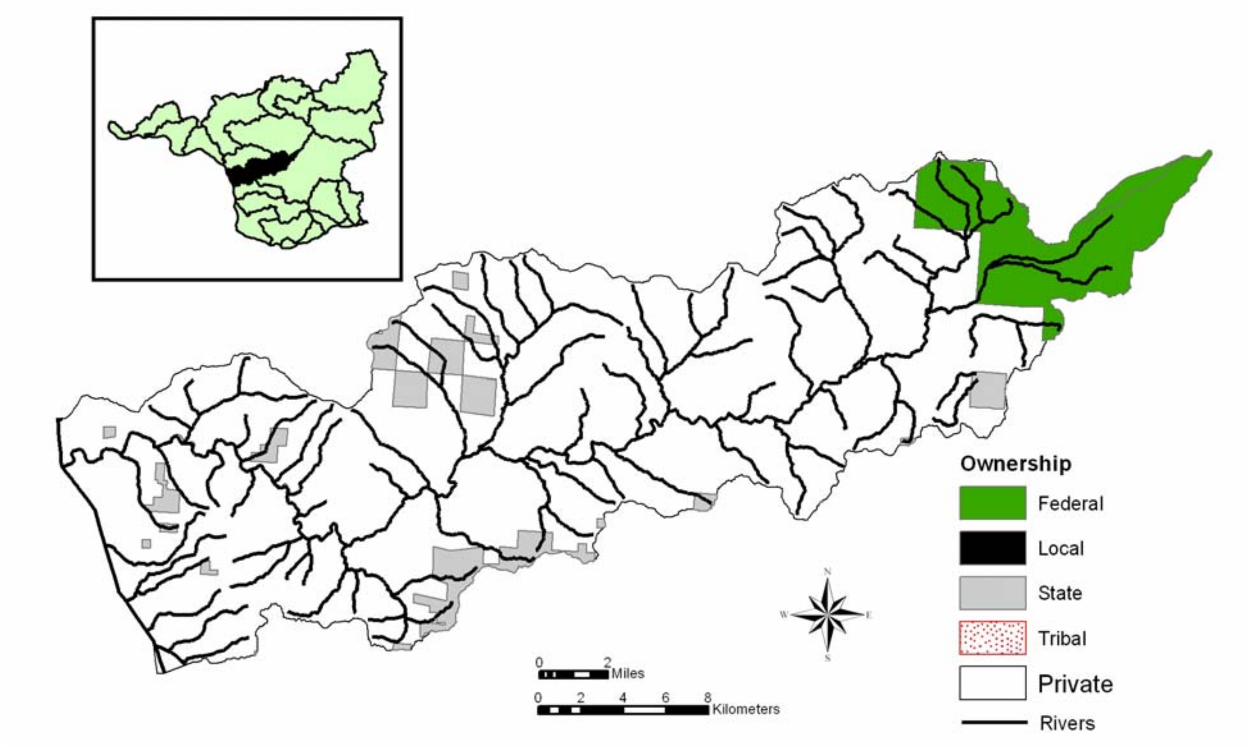


Figure 10-3. Landownership within the Kalama basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

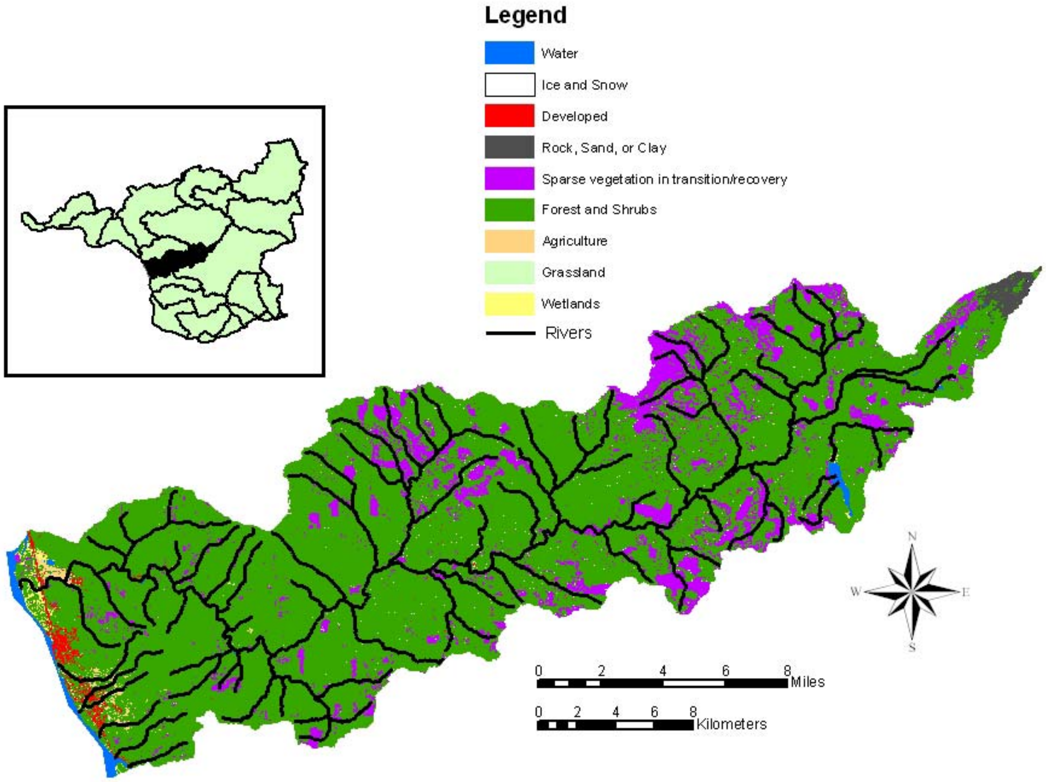
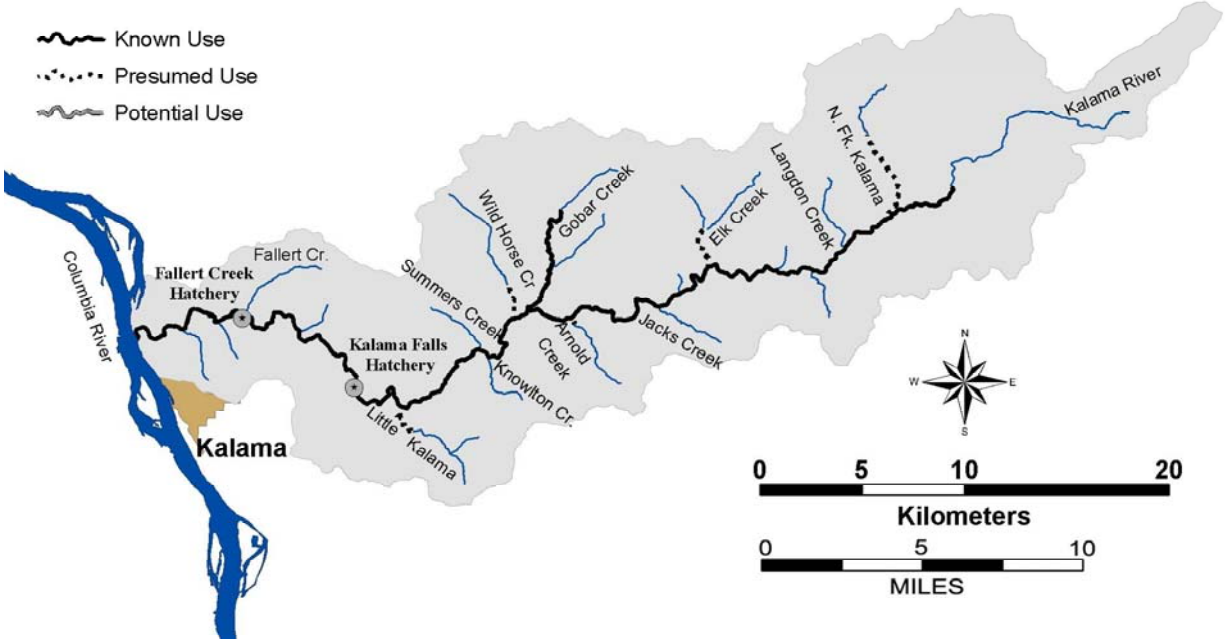


Figure 10-4. Land cover within the Kalama basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

10.2 Focal Fish Species

10.2.1 Spring Chinook—Kalama Subbasin

ESA: Threatened 1999	SASSI: Depressed 2002



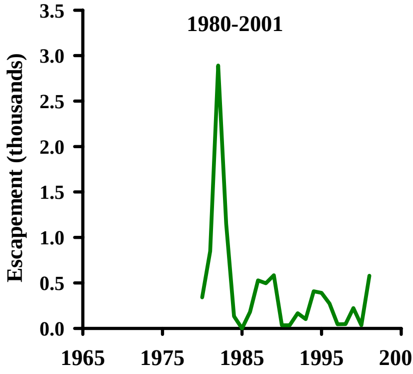
Distribution

- Currently, natural spawning is concentrated in the mainstem Kalama between the Kalama Falls (RM 10.5) and Fallert Creek (Lower Kalama) hatcheries (RM 4.8)
- Some spring chinook are passed above Lower Kalama Falls; spawners have been observed up to upper Kalama Falls (RM 36.8)

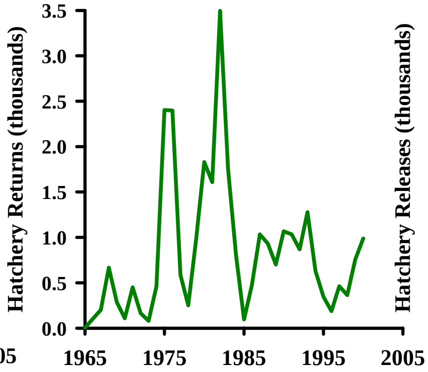
Life History

- Spring chinook enter the Kalama River from March through July
- Spawning in the Kalama River occurs between late August and early October, with peak activity in September
- Age ranges from 2-year old jacks to 6-year old adults, with 4- and 5-year olds usually the dominant age class (averages are 48.3% and 38.1%, respectively)
- Fry emerge between November and March, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts

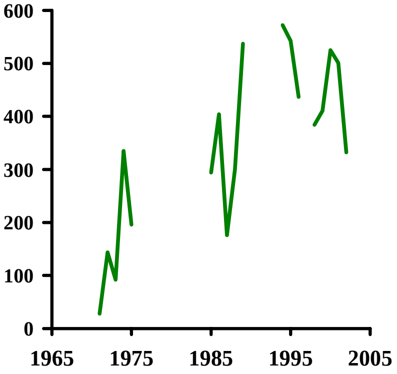
Spring chinook spawner escapement estimates for the Kalama River, 1980-2001



Spring Chinook Kalama Hatchery rack counts, 1965-2001



Spring Chinook hatchery releases on the Kalama River, 1967-2002



Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit
- The Kalama spring chinook stock designated based on distinct spawning distribution, spawning timing, and genetic composition
- Genetic analysis of Fallert Creek (Lower Kalama) Hatchery spring chinook in 1990 indicated they are genetically similar to, but distinct from, Cowlitz Hatchery and Lewis spring chinook and significantly different from other Columbia Basin spring chinook stocks

Abundance

- Reports of considerable historical numbers of spring chinook in the Kalama have not been verified
- By the 1950s, only remnant (<100) spring chinook runs existed on the Kalama
- Kalama River spawning escapements from 1980-2001 ranged from 0 to 2,892 (average 444)
- Hatchery strays account for most spring chinook spawning in the Kalama River

Productivity & Persistence

- NMFS Status Assessment for the Kalama River indicated a 0.56 risk of 90% decline in 25 years and a 0.82 risk of 90% decline in 50 years; the risk of extinction in 50 years was not calculated
- Smolt density model predicted natural production potential for the Kalama River below Kalama Falls of 111,192 smolts plus 465,160 smolts above Kalama Falls
- Juvenile production from natural spawning is presumed to be low

Hatchery

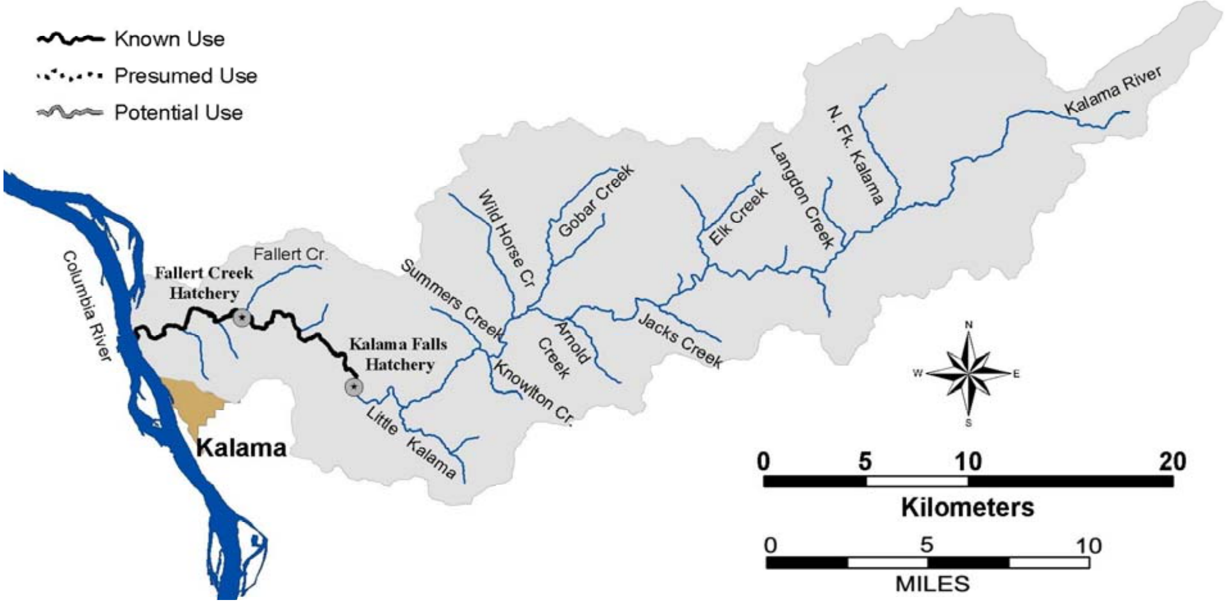
- Fallert Creek (Lower Kalama) Hatchery (RM 4.8) was completed in 1895; Kalama Falls Hatchery (RM 10.5) was completed in 1959; spring chinook have also been reared at Gobar Pond (~4 miles up Gobar Creek); hatchery brood stock is mostly native Kalama stocks with some Cowlitz sock transfers occuring
- Adult returns above hatchery brood stock needs are released above Lower Kalama Falls
- Hatchery releases of spring chinook in the Kalama began in the 1960s; total spring chinook releases into the Kalama Basin from 1967-2002 averaged 378,280
- In 2002 releases into the Kalama from Kalama Falls and Fallert Creek Hatcheries totaled 332,200

Harvest

- Kalama spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial and sport fisheries
- CWT data analysis of the 1989-1994 brood Fallert Creek indicates that 32% of the Kalama spring chinook were harvested and 68% escaped to spawn
- Fishery recoveries of the 1989-1994 brook Cowlitz River Hatchery spring chinook: Kalama sport (52%), British Columbia (17%), Alaska (10%), Washington Coast (9%), Columbia River (6%), and Oregon coast (6%)
- Mainstem Columbia River Harvest of Kalama spring chinook was very low after 1977 when April and May spring chinook seasons were eliminated to protect upper Columbia and Snake wild spring chiook.
- Mainstem Columbia harvest of Kalama River Hatchery spring chinook increased in 2001-2002 when selective fisheries on adipose marked hatchery fish enabled mainstem spring fishing in April (and in May, 2002) again
- Sport harvest in the Kalama River averaged 1,900 spring chinook annually from 1980-1994, reduced to less than 100 from 1995-1999, and has increased to 400 from 2000-2002
- Tributary harvest is managed to attain the Kalama hatchery adult broodstock escapement goal

10.2.2 Fall Chinook—Kalama Subbasin

ESA: Threatened 1999 **SASSI: Healthy 2002**



Distribution

- In the Kalama River, spawning primarily occurs in the mainstem between Kalama Falls Hatchery and the I-5 Bridge (11miles); Lower Kalama Falls (10.5) is a natural barrier to upstream migration; surplus hatchery chinook are released above the falls

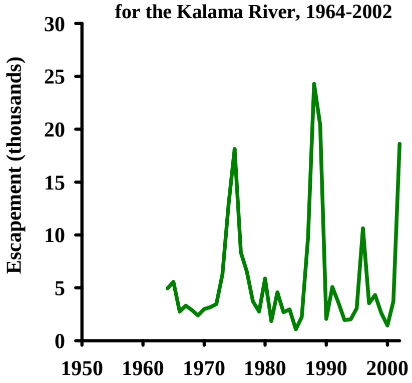
Life History

- Fall chinook upstream migration in the Columbia River occurs in mid August to mid September, partly depending on early rainfall; peak entry into the Kalama is late August to early September
- Spawning in the Kalama River occurs between late September and October; the peak is usually around mid-October
- Age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4
- Fry emerge around early March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the late spring/summer as sub-yearlings
- Kalama fall chinook display early migration and spawning characteristics of tule fall chinook but ocean distribution is typically farther north than most tule stocks (similar to Cowlitz fall chinook)

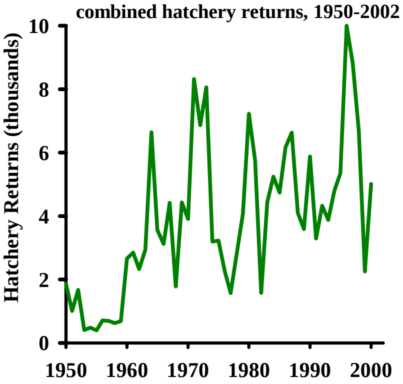
Diversity

- The Kalama fall chinook stock designated based on distinct spawning distribution
- Genetic analysis of Kalama River Hatchery fall chinook determined they were significantly different from most other lower Columbia River tule fall chinook stocks, and most similar to Cowlitz Hatchery fall chinook

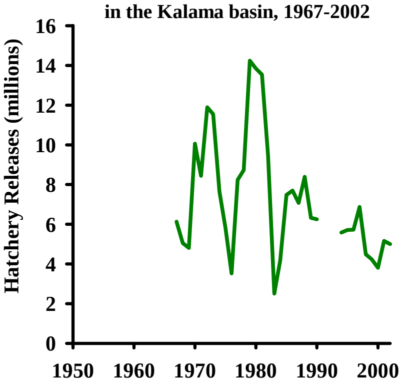
Fall chinook spawner escapement estimates for the Kalama River, 1964-2002



Fall chinook Fallert Cr. and Kalama Falls combined hatchery returns, 1950-2002



Fall chinook releases from hatcheries in the Kalama basin, 1967-2002



Abundance

- In 1936, fall chinook escapement to the Kalama River was 20,000: 13,000 were collected at the hatchery and 7,000 were allowed to spawn naturally
- Kalama River spawning escapements from 1964-2001 ranged from 1,055 to 24,297 (average 5,514)
- Hatchery production accounts for most fall chinook returning to the Kalama River
- Kalama River WDFW interim escapement goal is 2,000 fish; the goal is commonly met
- A significant portion of the natural spawners are hatchery produced fish

Productivity & Persistence

- NMFS Status Assessment for the Kalama River indicated a 0.21 risk of 90% decline in 25 years and a 0.25 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.03
- Smolt density model predicted natural production potential for the Kalama River above Kalama falls of 162,000 fingerlings; below Kalama Falls the model predicts production potential of 428,670 fingerlings
- WDFW concluded that a natural spawning escapement of 24,549 in 1988 only produced an estimated 522,312-964,439 juvenile fall chinook in 1989

Hatchery

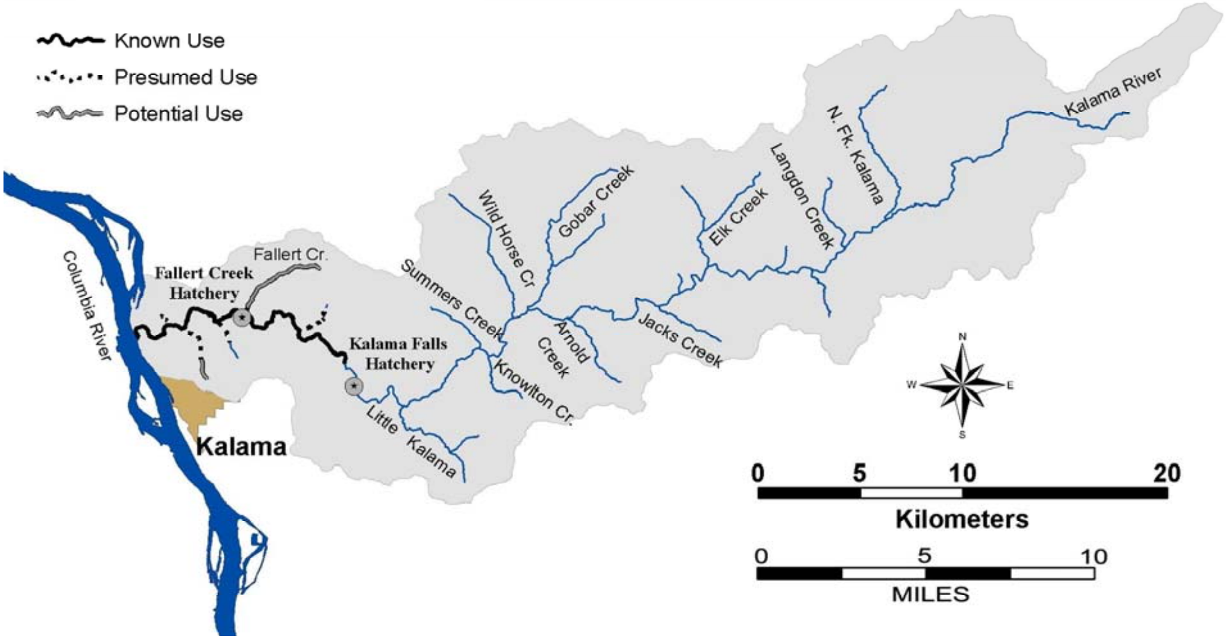
- Lower Kalama (Fallert Creek) Hatchery (RM 4.8) was completed in 1895 (the oldest hatchery in the Columbia basin); Kalama Falls Hatchery (RM 10.5) was completed in 1959
- Hatchery releases of fall chinook in the Kalama began in 1895; hatchery releases are displayed for 1967-2002
- The current hatchery program releases 5.1 million juvenile fall chinook per year into the Kalama River, 2.5 million from Fallert Creek and 2.6 million from Kalama Falls
- Hatchery adult rack returns have ranged from 1,000 to 8,000 since 1960
- Kalama Falls hatchery released upriver bright chinook salmon beginning in the 1970s as an egg bank for Snake River wild fall chinook; the last release was in 1984; a natural run of upriver brights was not established in the Kalama

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Kalama chinook are important contributors to the lower Columbia estuary (Buoy 10) sport fishery, the Columbia River September commercial fishery, and tributary sport fishing in the Kalama
- Columbia River mainstem and Washington/Oregon ocean fisheries harvest is constrained by ESA harvest limitations (49%) on Coweeman wild fall chinook
- Total annual harvest is dependent on management response to annual abundance in PSC (U.S/Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- CWT data analysis of the 1992-1994 brood years indicates a total Kalama fall chinook harvest rate of 32%, with 68% accounted for in escapement
- Fishery CWT recoveries of 1992-94 brood indicate the majority of the Kalama fall chinook stock harvest occurred in British Columbia (36%), Alaska (38%), Washington ocean (6%), and Columbia River (14%) fisheries
- Kalama River tributary sport harvest of fall chinook averaged 895 adults during 1979-86

10.2.3 Coho—Kalama Subbasin

ESA: Candidate 1995	SASSI: Unknown 2002

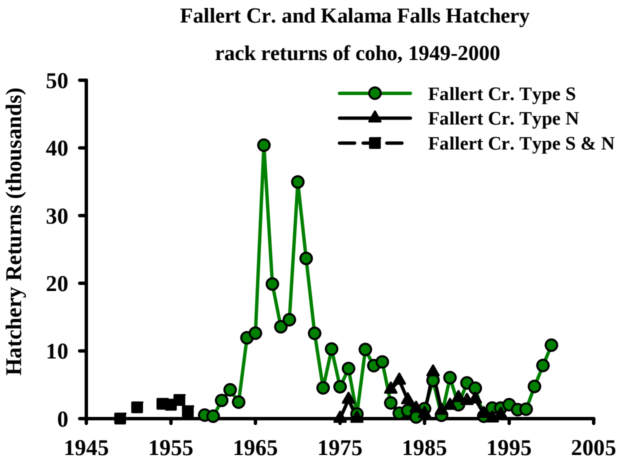


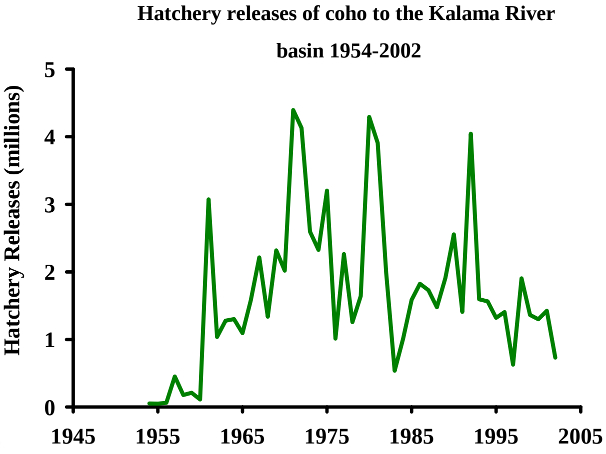
Distribution

- Managers refer to early coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning area is generally limited to accessible tributaries below Kalama Falls (RM 10)
- A fish ladder was installed at Kalama Falls in 1936, providing access above the falls; however, a 1951 WDF survey indicated most fish were distributed below the falls

Life History

- Adults enter the Kalama River from early September through February (early stock primarily from mid-August through September and late stock primarily from late September to November)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring


Fallert Cr. and Kalama Falls Hatchery rack returns of coho, 1949-2000


Hatchery releases of coho to the Kalama River basin 1954-2002

Diversity

- Late stock coho (or Type N) were historically produced in the Kalama basin with spawning occurring from late November into March
- Early stock coho (or Type S) were historically produced in the Kalama basin with spawning occurring from October to mid November
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Kalama River wild coho run is a fraction of its historical size
- An escapement survey in the late 1930s observed 1,422 coho in the Kalama
- In 1951, WDF estimated coho escapement to the basin was 3,000; both early and late coho were present
- Hatchery production accounts for most coho returning to the Kalama River

Productivity & Persistence

- Natural coho production is presumed to be very low
- Electrofishing for juveniles in the Little Kalama River (a major tributary downstream of Kalama Falls) in 1994 and 1995 showed no coho but good numbers of steelhead

Hatchery

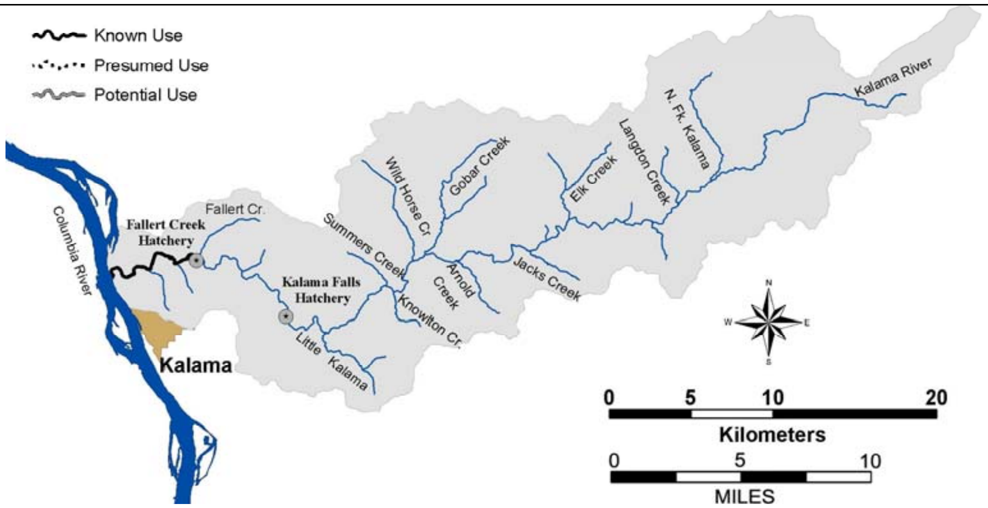
- Fallert Creek Hatchery (completed in 1895) is located about RM 4.3 and the Kalama Falls Hatchery (completed in 1959) is located at RM 10.0
- Coho have been planted in the Kalama basin since 1942; releases were increased substantially in 1967
- The coho program at the two Kalama hatchery complexes was greatly reduced in recent years because of federal funding cuts; the remaining coho program is about 700,000 smolts released annually, split evenly between early stock (reared at Fallert Creek) and late stock (reared at Kalama Falls)

Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- Natural produced lower Columbia River coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early coho, but late coho harvest can also be substantial
- An average of 1,272 coho (1979-1986) were harvested annually in the Kalama River sport fishery
- CWT data analysis of the 1995-97 Fallert Creek Hatchery early coho indicates 30% were captured in a fishery and 70% were accounted for in escapement
- CWT data analysis of 1995-97 brood Kalama Falls Hatchery late coho indicates 76% were captured in a fishery and 24% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 brood Kalama early coho are distributed between Columbia River (49%), Washington Ocean (42%), and Oregon ocean (9%) sampling areas
- Fishery CWT recoveries of Kalama late coho are distributed between Columbia River (58%), Washington ocean (32%), and Oregon ocean (10%) sampling areas

10.2.4 Chum—Kalama Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Chum spawning habitat is limited to the mainstem Kalama, between Modrow Bridge (RM 2.4) and Lower Kalama Falls (RM 10)

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- No hatchery releases of chum have occurred in the Kalama basin

Abundance

- In 1951 estimated chum escapement to the Kalama River was 600

Productivity & Persistence

- Current juvenile production is assumed to be low

Hatchery

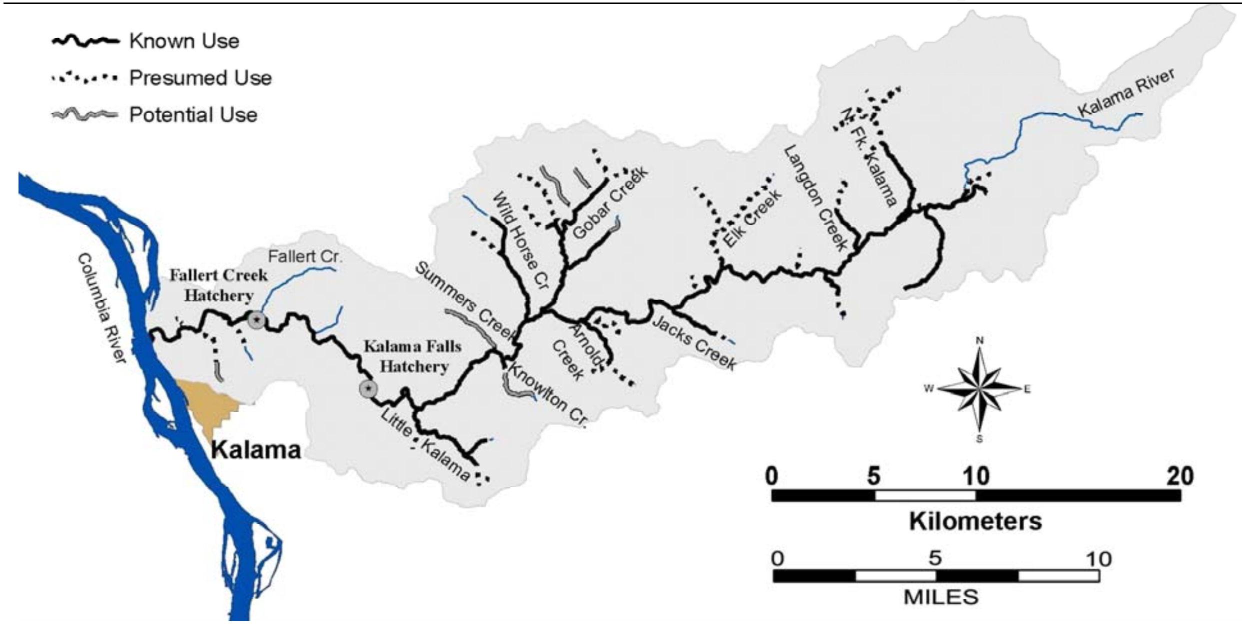
- The Fallert Creek (Lower Kalama) Hatchery and the Kalama Falls Hatchery do not produce/release chum salmon; chum salmon releases into the Kalama basin from other hatcheries have not been documented

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries

10.2.5 Summer Steelhead—Kalama Subbasin

ESA: Threatened 1998 **SASSI: Depressed 2002**



Distribution

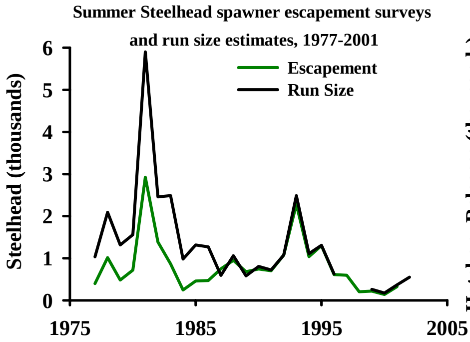
- Spawning occurs above Lower Kalama Falls in the mainstem and NF Kalama River and throughout many tributaries, including Gobar, Elk, Fossil, and Wild Horse Creeks
- A 35ft falls at RM 36.8 blocks all upstream migration

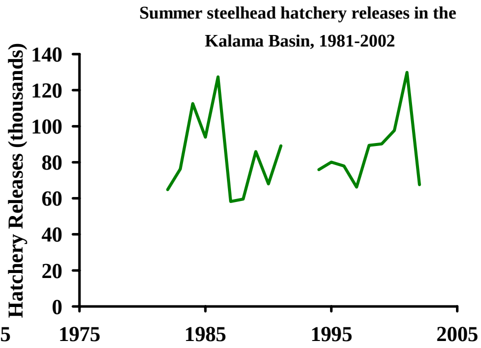
Life History

- Adult migration timing for Kalama summer steelhead is from early June through October
- Spawning timing on the Kalama is generally from mid-January through April, with peak spawning in February
- Thirteen age classes have been observed; dominant age class is 2.2 (average 64.1%)
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; emigration occurs from March to June, with peak migration from mid-April to mid-May

Diversity

- Stock designated based on distinct spawning distribution and early run timing
- Estimated 40% of returning naturally produced adults had at least one hatchery parent; however, wild stock has retained genetic traits of considerable adaptive value relative to the transplanted hatchery stock (Hulett and Leider 1989)
- Conversely, electrophoretic examination of a specific genetic marker suggests that the genetic integrity of wild populations may be at risk because of inbreeding with hatchery stocks (Milner et al. 1980)
- After the1980 Mt. St. Helens eruption, straying Cowlitz River steelhead spawned with native Kalama stocks
- Kalama summer and winter steelhead have been observed spawning, therefore runs are not always reproductively separate


Summer Steelhead spawner escapement surveys and run size estimates, 1977-2001


Summer steelhead hatchery releases in the Kalama Basin, 1981-2002

Abundance

- In 1936-37 steelhead were documented in the Kalama River during escapement surveys
- Wild summer steelhead run size in the 1950s was estimated to be less than 1,500 fish
- Escapement counts from 1977-2001 ranged from 140 to 2,926; run size estimates from 1977-1999 ranged from 582 to 5,903 summer steelhead
- Escapement goal for the Kalama is 1,000 wild adult steelhead; goal has not been met since 1995

Productivity & Persistence

- NMFS Status Assessment indicated a 0.22 risk of 90% decline in 25 years and a 0.42 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.01
- WDW estimated potential summer and winter steelhead smolt production was 34,850; naturally-produced steelhead smolts migrating annually from 1978-1984 ranged from 11,175 to 46,659

Hatchery

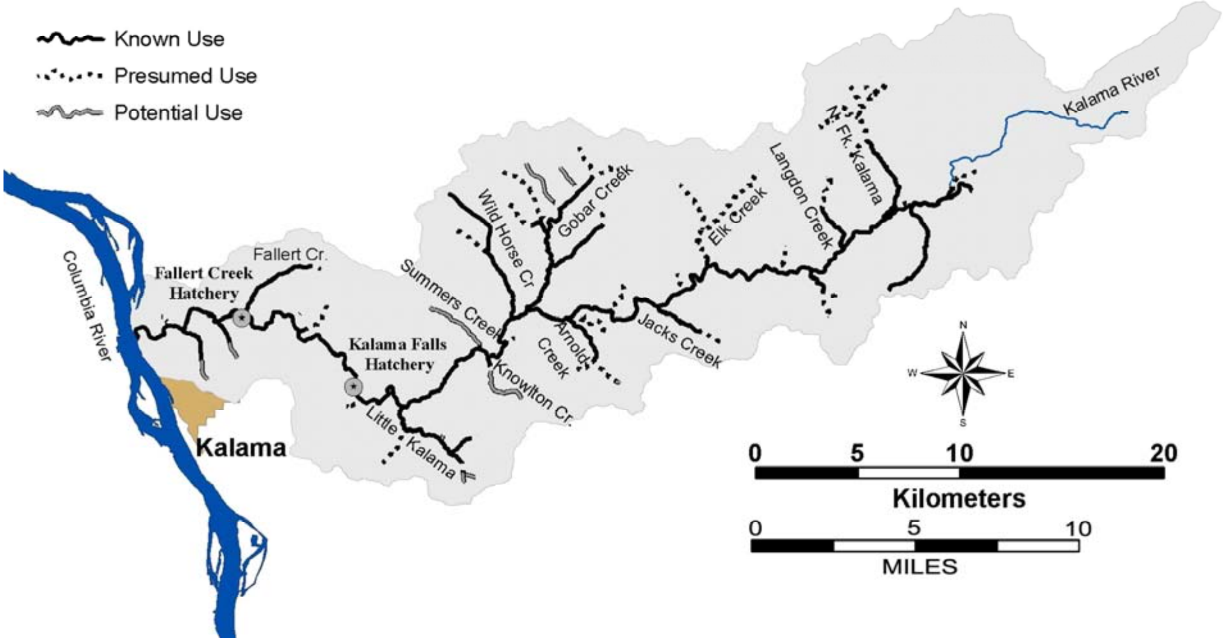
- Two hatcheries in the Kalama basin: Fallert Creek (Lower Kalama) Hatchery (RM 4.3) and Kalama Falls Salmon Hatchery (RM 10); neither hatchery produces summer steelhead
- Gobar Pond, located about 4 miles up Gobar Creek (RM 19.5), is used as a steelhead acclimation pond for 1-2 months prior to release
- Summer steelhead from Beaver Creek and Skamania Hatcheries have been transferred to Gobar Pond as yearlings; steelhead acclimated at Gobar Pond have been released directly to Gobar Creek or trucked and released directly into the Kalama River; release data are displayed from 1981-2002
- Kalama research estimates success of hatchery fish producing adult offspring was only 12% that of wild fish
- Hatchery summer steelhead usually comprise 70-80% of the spawning escapement

Harvest

- No directed commercial fisheries target Kalama summer steelhead; incidental mortality currently occurs during the Columbia River fall commercial fisheries and summer sport fisheries
- Wild summer steelhead sport harvest in the Kalama River from 1977-1999 ranged from 5 to 2,978; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild Kalama steelhead in the mainstem Columbia River and in the Kalama River

10.2.6 Winter Steelhead—Kalama Subbasin

ESA: Threatened 1998 **SASSI: Healthy 2002**



Distribution

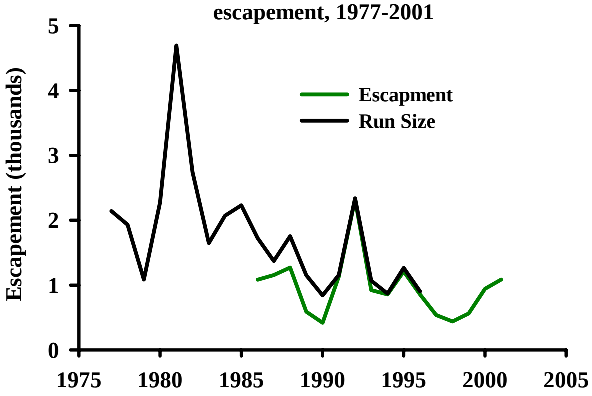
- Spawning occurs in the mainstem Kalama River and Gobar, Elk, and Fossil Creeks
- A 35 ft falls at RM 36.8 blocks all upstream migration

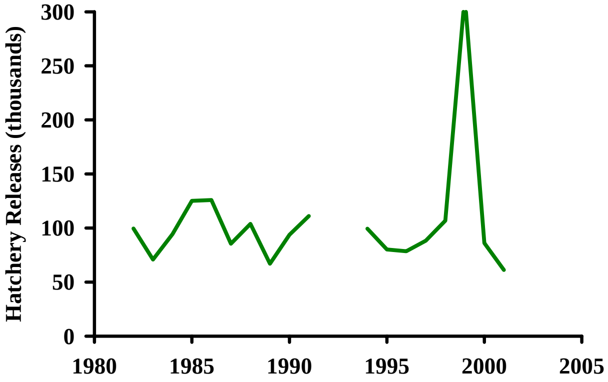
Life History

- Adult migration timing for Kalama winter steelhead is from November through April
- Spawning timing on the Kalama is generally from early January to early June
- Age composition data for Kalama River winter steelhead indicate that the dominant age classes are age 2.2 and 2.3 (50.1 and 30.5%, respectively)
- Wild steelhead fry on the Kalama emerge from April through early July; juveniles generally rear in fresh water for two years; juvenile emigration occurs from March through June, with peak migration from mid-April to mid-May

Diversity

- Kalama winter steelhead stock designated based on distinct spawning distribution and late run timing
- Level of wild stock interbreeding with hatchery brood stock from the Beaver Creek Hatchery, Chambers Creek, and the Cowlitz and Elochoman Rivers is unknown
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead have spawned with native Kalama stocks
- Kalama summer and winter steelhead have been observed spawning, therefore runs are not reproductively separate
- Genetic sampling of juvenile Kalama steelhead in 1994 was inconclusive because the sample was likely mixed winter and summer steelhead


Wild winter steelhead total spawning escapement, 1977-2001


Winter steelhead hatchery releases in the Kalama River Basin, 1982-2001

Abundance

- In 1936, 37 steelhead were documented in the Kalama River during escapement surveys
- Total escapement counts from 1977-2001 ranged from 371 to 2,322; run size estimates for 1977-1999 have ranged from 842 to 4,691
- Escapement goal for the Kalama River is 1,000 wild adult steelhead
- In 1997, the Kalama River had the only winter steelhead stock designated as healthy in the lower Columbia ESU

Productivity & Persistence

- NMFS Status Assessment indicated a 0.0 risk of 90% decline in 25 years and a 0.07 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.0
- Washington Department of Wildlife estimated potential summer and winter steelhead smolt production was 34,850; the number of naturally-produced steelhead smolts migrating annually from 1978-1984 ranged from 11,175 to 46,659

Hatchery

- Two hatcheries in the Kalama basin: Fallert Creek (Lower Kalama) Hatchery (RM 4.3) and Kalama Falls Salmon Hatchery (RM 10); neither hatchery produces winter steelhead
- Gobar Pond, located about 4 miles up Gobar Creek (RM 19.5), is used as a steelhead acclimation pond for 1-2 months prior to release
- Hatchery winter steelhead have been planted in the Kalama basin as early as 1938; consistent releases began in 1955; hatchery winter steelhead are transferred to Gobar Pond as yearlings; steelhead acclimated at Gobar Pond are released directly to Gobar Creek or trucked and released directly into the Kalama River; the Cowlitz and Beaver Creek Hatcheries have released steelhead smolts directly to the Kalama without acclimation; release data are displayed from 1982-2001
- There is some contribution to natural production from hatchery winter steelhead spawning in the Kalama River basin

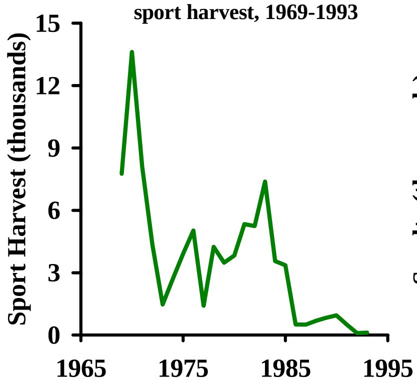
Harvest

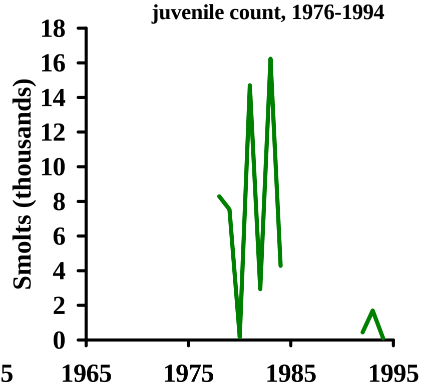
- No directed commercial or tribal fisheries target Kalama winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Kalama River basin

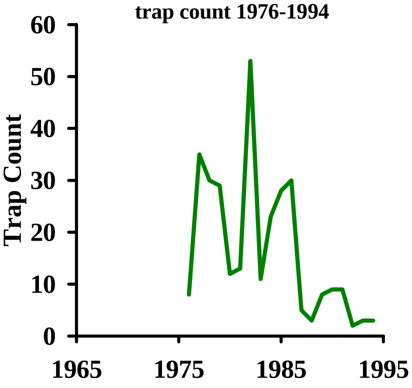
- Wild winter steelhead sport harvest in the Kalama River from 1977-1999 ranged from 4 to 2,162 (average 610); since 1990, regulations limit harvest to hatchery fish only
- ESA limits fishery impact of wild winter steelhead in the mainstem Colubia River and in the Kalama River

10.2.7 Cutthroat Trout—Kalama River Subbasin

ESA: Not Listed **SASSI: Depressed 2000**


Kalama coastal cutthroat trout sport harvest, 1969-1993


Kalama coastal cutthroat trout juvenile count, 1976-1994


Kalama coastal cutthroat trout trap count 1976-1994

Distribution

- Anadromous, fluvial and resident forms are present
- Anadromous cutthroat are found in the mainstem Kalama and tributaries below Kalama Falls (RM 10)
- Fluvial and resident fish are present throughout the basin

Life History

- Anadromous, fluvial, and resident life history forms are all present in the basin.
- Anadromous forms enter the watershed from July through December and spawn from December through June.
- Fluvial and resident fish spawn from February through June.

Diversity

- Distinct stock complex based on the geographic distribution of their spawning grounds.
- Genetic sampling has indicated that Kalama River cutthroat are genetically distinct from other lower Columbia River populations

Abundance

- Declining trends in adult counts, smolt estimates, and sport catch data
- Kalama Falls fishway counts ranged from 8 to 53 cutthroat, and averaged 25 fish from 1976 to 1986
- From 1987 to 1995, counts ranged from 2 to 9 fish per year, and averaged 5
- Estimate of smolts produced above Kalama Falls from 1978 through 1984 ranged from 163 to 16,229 with a yearly average of 7,737.
- From 1992 to 1994, the range dropped to 106 to 1667 with an average of 749 smolts
- Average yearly catch of cutthroat from lower Columbia River sport creel census data averaged 4985 fish from 1969-1985, but only 521 fish from 1986-1993
- Wild cutthroat must now be released in the Kalama River sport fisheries
- No population size data for resident forms

Productivity & Persistence

- Kalama anadromous cutthroat productivity decreased in the 1990s, similar to other salmonids

Hatchery

- There is no hatchery production of cutthroat trout in the Kalama River basin.
- Hatchery-produced chinook, coho and steelhead are released into the Kalama River and tributaries.

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Kalama River
- Wild (unmarked) cutthroat trout must be released in Columbia River and Kalama River sport fisheries

10.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quality and quantity is an important impact for all species, particularly for chum. Loss of estuary habitat quality and quantity is also important, particularly for chum and winter steelhead. The combination of tributary and estuary habitat factors account for 82% and 63% of the relative impact to chum and winter steelhead, respectively.
- Harvest has a large relative impact on fall and spring chinook and coho and moderate impact on winter and summer steelhead. Harvest effects on chum are minimal.
- Hatchery impacts are substantial for coho and fall and spring chinook, and are minimal for steelhead and chum.
- Predation impacts are moderate for winter and summer steelhead, but appear less important for coho, chum, and fall and spring chinook.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

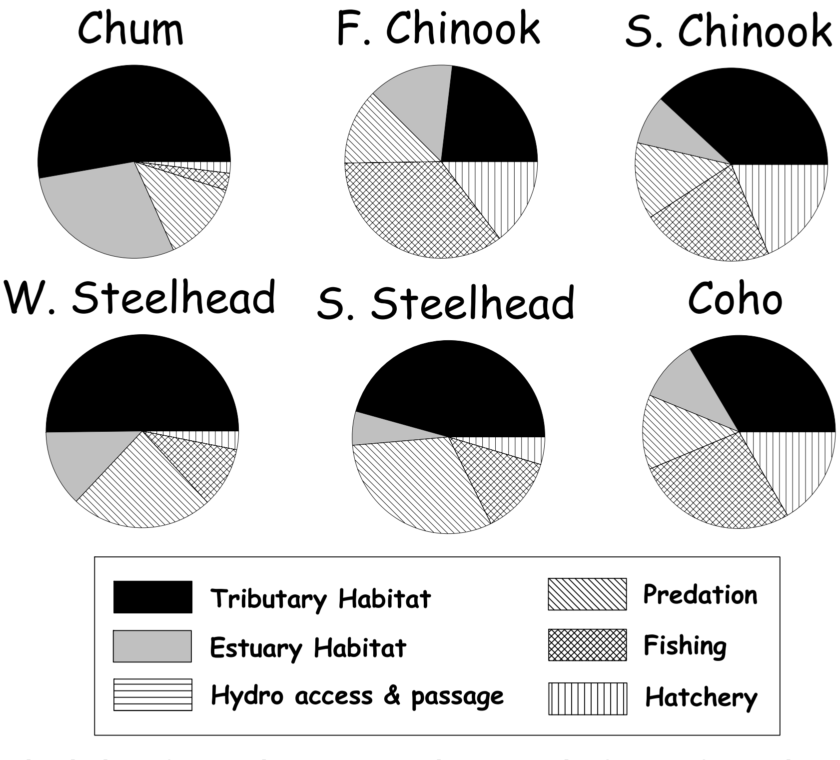


Figure 10-5. Relative index of potentially manageable mortality factors for each species in the Kalama subbasin.

10.4 Hatchery Program

The Kalama River basin has two hatchery facilities: the Lower Kalama (Fallert Creek) Hatchery at RM 4.8 was completed in 1895, and the Kalama Falls Hatchery at RM 10.5 was completed in 1959. Gobar Pond is a rearing and acclimation site on Gobar Creek, a tributary upstream of Kalama Falls Hatchery. Production goals for the entire hatchery complex are 5 million fall chinook, 500,000 spring chinook, 350,000 early run coho smolts, 350,000 late run coho smolts, 45,000 Kalama “wild” late winter steelhead smolts, 45,000 early winter steelhead smolts, 60,000 Kalama “wild” summer steelhead smolts, and 30,000 Skamania stock summer steelhead smolts (Figure 10-6). The winter and summer steelhead programs were adjusted in 1998 and 1999, respectively, to use only “wild” (adipose-present) steelhead broodstock entering the hatchery adult collection facility. The goals of the new steelhead programs are to enhance recreational harvest opportunity and to serve as a risk management tool, maintaining wild broodstock in case of a catastrophic event that negatively effects the natural population. The other hatchery programs continue to support harvest as part of the hydrosystem mitigation.

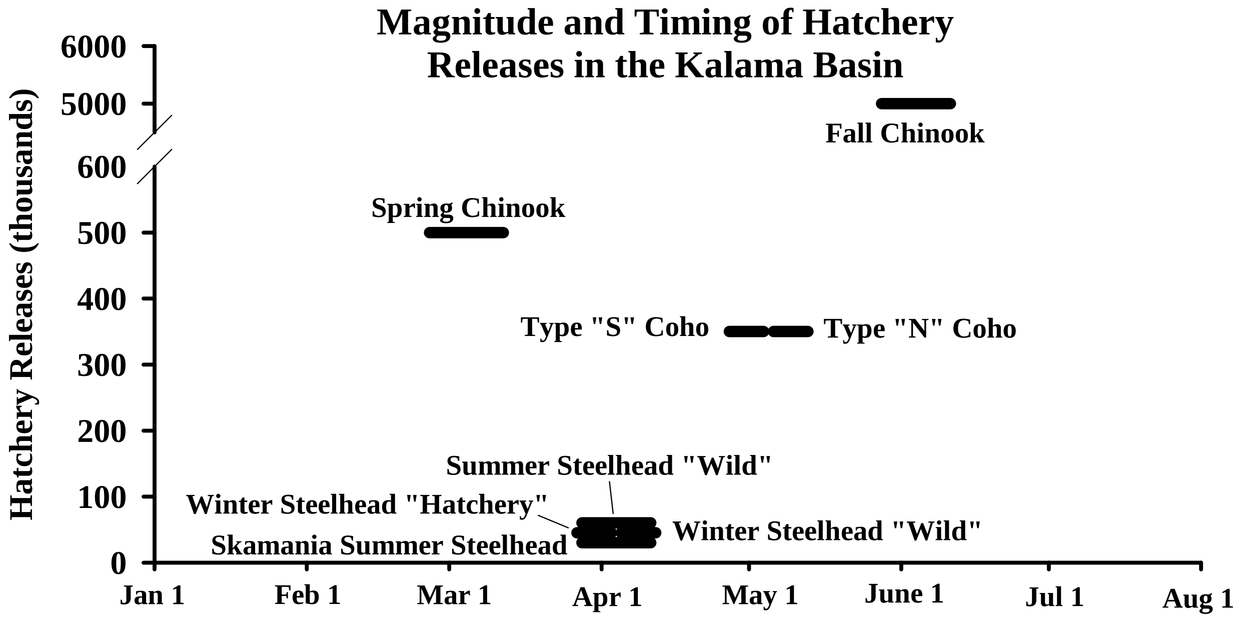


Figure 10-6. Magnitude and timing of hatchery releases in the Kalama River basin by species, based on 2003 brood production goals.

Genetics—Historically, fall chinook broodstock have been almost exclusively obtained from Kalama native fall chinook. Outside transfers have been extremely rare, low in numbers, and have not occurred since 1981. Kalama hatchery fall chinook have been a common donor for several other lower Columbia hatchery programs. Genetic analysis of Kalama River Hatchery fall chinook indicated that they were significantly different from most other lower Columbia River tule fall chinook stocks and were most similar to Cowlitz Hatchery fall chinook.

Broodstock for the spring chinook hatchery program is almost entirely from native Kalama fish, although Cowlitz spring chinook have been used to some degree. Genetic analysis of Kalama Falls Hatchery spring chinook in 1990 indicated that they are genetically similar to, but distinct from, Cowlitz Hatchery and Lewis River spring chinook and are significantly different from other lower Columbia River spring chinook stocks.

Broodstock for the early- and late-run coho salmon hatchery programs comes from adults returning to the hatchery. In years when insufficient numbers of adults have escaped to the hatchery to satisfy broodstock needs, early- and late-run coho eggs have been obtained from Toutle (early stock) or Cowlitz (late stock) hatcheries.

Broodstock for the former summer and winter steelhead hatchery programs in the Kalama basin likely came from a mixture of lower Columbia River steelhead stocks. Wild summer and winter steelhead were present in the basin prior to release of Cowlitz River and Beaver Creek Hatchery stocks, which began as early as 1938. In the late 1980s, an estimated 40% of returning naturally produced adults had at least one hatchery parent; however, the wild stock appears to have retained genetic traits of adaptive value relative to the transplanted hatchery stocks. Broodstock for the current “wild” summer and winter steelhead hatchery programs come from naturally spawned steelhead that voluntarily enter the Kalama Falls Hatchery trap. No adipose fin-clipped or dorsal fin-stubbed adults are used for broodstock in these programs. The goal for both summer and winter steelhead is to develop a wild broodstock to supplement natural production and provide for harvest. Broodstock for hatchery stock early winter steelhead are obtained from returns to Kalama Falls Hatchery and the hatchery stock summer steelhead is obtained from Skamania Hatchery. Neither winter nor summer hatchery stock steelhead are passed above Kalama Falls Hatchery to the steelhead natural spawning habitat.

Interactions—Hatchery production accounts for the majority of fall chinook returning to the Kalama River. A weir is placed annually in the lower river to collect broodstock for the hatchery program. Hatchery and natural production are not distinguishable by external marking. A portion of the return is collected for hatchery broodstock and a portion is passed above the weir to spawn naturally. The number of natural spawners is usually dependent on the total returns, after egg-take requirements are met (Figure 10-7). Juvenile fall chinook may compete with other juvenile salmonids for food and space. This competition is likely minimized by releasing fall chinook smolts that are ready to emigrate. Also, hatchery and wild fish interactions are less likely for fall chinook released from the Fallert Creek Hatchery than for releases from the Kalama Falls Hatchery, because the emigration distance within the basin is shorter.

Hatchery strays from the Kalama Hatchery program account for most spring chinook spawning in the Kalama River; wild fish abundance is generally low (Figure 10-7). Juvenile production from natural spawning is presumed to be low. Spring chinook juveniles may compete with other salmonids for food and space. However, release is timed for smolting, which should minimize time in the watershed and minimize interactions with wild juveniles.

Hatchery production accounts for most coho salmon returning to the Kalama River (Figure 10-7). Juvenile production from natural spawning is presumed to be low. Because few adult wild coho are present, the potential for interaction between wild/hatchery coho adults is likely low. Competition from hatchery coho smolts on other juvenile salmonids is a concern in the Kalama River basin. However, because smolts are released volitionally after smoltification and migrate out of the basin rapidly, competition with other salmonids in the Kalama River is likely minimized. Hatchery coho smolts rarely residualize (0.002%) so there is little concern about ongoing competition with resident fish. Additionally, significant predation by coho smolts on juvenile fall chinook may be occurring, as has been documented in the Lewis River.

Historically, a significant portion of natural steelhead spawners in the Kalama River were hatchery-produced (70-80%) and hatchery and wild fish may have competed for suitable spawning sites. There is less opportunity for early winter hatchery steelhead and wild winter steelhead adults to interact because of spawn time differences, however there is more potential for summer hatchery steelhead to interact with wild winter steelhead because there is potential for overlap in the spawn time. Genetic mixing is still minimized by spatial and temporal segregation; further, hatchery steelhead are not passed upstream of Kalama Falls.

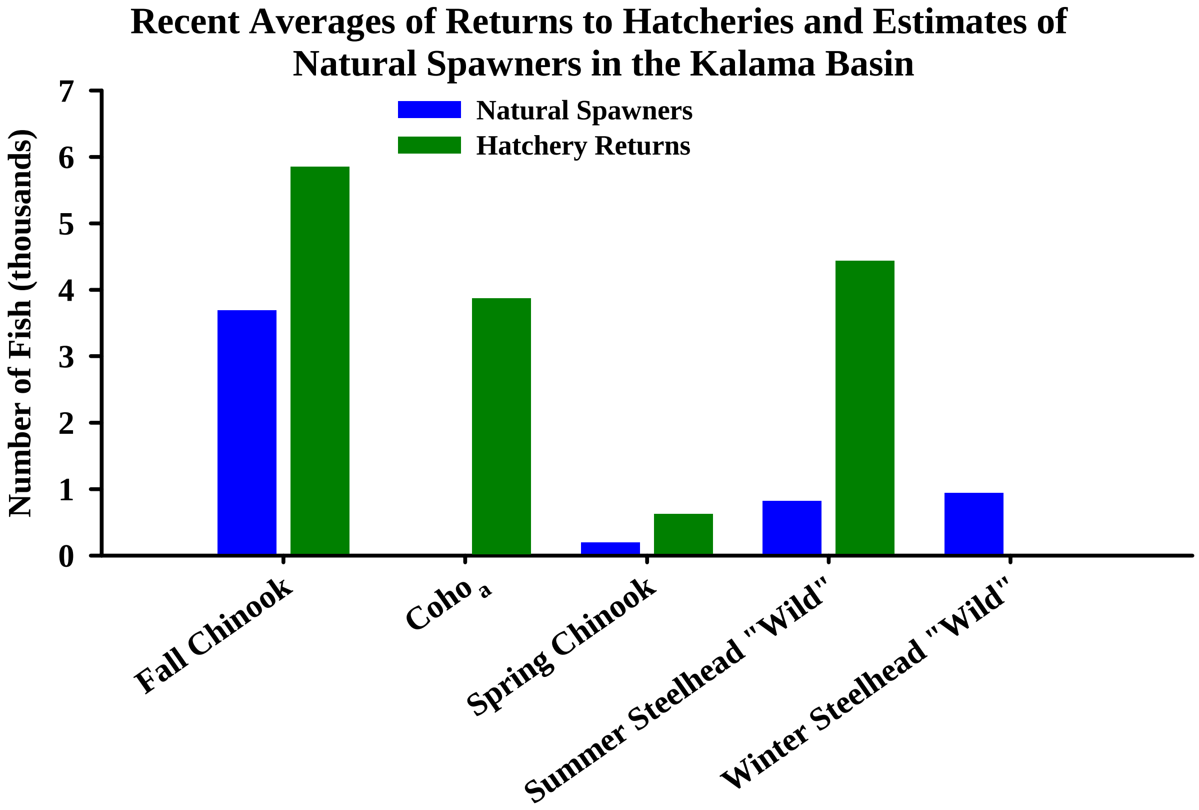


Figure 10-7. Recent average hatchery returns and estimates of natural spawning escapement in the Kalama River basin by species.

Note: The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present, except for Kalama wild summer steelhead, which represents the 1988–99 average. Calculation of each average utilized a minimum of 5 years of data, except for Kalama wild winter steelhead, which only includes 2000 escapement data.

[a] A natural stock for this species and basin has not been identified based on populations in WDFW's 2002 SASSI report; to date, escapement data are not available.

Research on the Kalama indicates that the success of hatchery summer steelhead producing adult offspring was approximately 12% that of wild fish. With the former steelhead hatchery programs, the potential existed for competition from hatchery summer and winter steelhead smolts on other salmonids in the system for food and space but competition was likely minimal because steelhead were released as rapidly emigrating smolts, and relatively few summer and winter steelhead were released annually. As the new “wild” steelhead hatchery programs continue, as described above, wild/hatchery fish interactions will be difficult to define as the distinction between hatchery and wild fish becomes unclear.

One unexpected benefit from the steelhead programs is the data generated on coastal cutthroat trout, a candidate species for ESA listing. Various life stages of cutthroat trout are captured during adult and smolt trapping operations, which provide valuable data on run timing, size, sex, spawner abundance, and smolt production levels.

Water Quality/Disease—Most water for the Kalama River Hatchery complex comes directly from the Kalama River. A seasonal creek regarded as pathogen-free, is also used for incubation and early rearing. All water quality parameters are monitored under the hatchery's NPDES permit. A third pathogen-free water source was recently developed as a supplement and emergency backup for incubation and early rearing. Fungus is controlled during the incubation stage by a 1,667-ppm drip of formalin for 15 minutes daily. Egg mortalities are removed by hand picking. Disease monitoring is continuous, and the area fish health specialist visits monthly and advises on disease treatments. Fish are checked by the area fish health specialist before release.

Mixed Harvest—The purpose of the Kalama River Hatchery complex fall chinook program is to provide harvest opportunities to mitigate for fall chinook salmon lost as a result of hydroelectric development in the lower Columbia River basin. Historically, exploitation rates of hatchery and wild fall chinook likely were similar. Fall chinook are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1992–1994 brood years of Kalama Hatchery fall chinook indicate a 32% exploitation rate on fall chinook; 68% of the adult return was accounted for in escapement. Exploitation of wild fish during the same period likely was similar. Current hatchery and wild fall chinook harvest rates remain similar and are constrained by ESA harvest limitations.

A goal of the spring chinook hatchery program at the complex is to provide harvest opportunities to mitigate for spring chinook salmon lost as a result of hydroelectric development. All hatchery smolts are adipose fin-clipped to allow for selective harvest. Historically, exploitation rates of hatchery and wild spring chinook likely were similar. Spring chinook are an important target species in Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years from the Fallert Creek Hatchery indicate a 32% exploitation rate on spring chinook; 68% of the adult return was accounted for in escapement. Most of the harvest occurred in the Kalama River sport fishery. Exploitation of wild fish during the same period likely was similar. In recent years, selective fisheries in the mainstem Columbia and in the Kalama have increased harvest of Kalama River hatchery spring chinook while maintaining low rates on wild fish; the mainstem spring chinook sport fishery was re-opened in April–May (since closure after 1977) because of the ability to selectively harvest hatchery fish and release wild fish. The lower Columbia River commercial fishery has also been extended into late March under selective fishery regulations.

The purpose of the coho salmon program at the Kalama River Hatchery complex is to produce lower Columbia River late (Type-N) and early (Type-S) coho that will contribute to the Pacific Ocean and Columbia River basin commercial and sport fisheries while providing adequate escapement for hatchery broodstock. All hatchery smolts are adipose fin-clipped to allow for selective harvest. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. Ocean and Columbia River combined harvest of Columbia River-produced coho ranged from 70% to over 90% during 1970–1983. Ocean fisheries were limited beginning in the mid-1980s and Columbia River commercial fisheries were temporally adjusted in the early 1990s to protect several wild coho stocks. Columbia River coho exploitation rates during 1997 and 1998 averaged 48.8%. With the advent of selective sport fisheries for adipose-fin clipped fish in 1998, exploitation of wild coho is much lower than in 1997-1998, while hatchery fish can be harvested at a higher rate. Kalama wild coho are beneficiaries of ESA harvest constraints for Oregon coastal natural coho in ocean fisheries and for Oregon lower Columbia natural coho in Columbia River fisheries

A goal of the summer and winter steelhead hatchery programs at the Kalama complex is to mitigate for summer and winter steelhead lost as a result of Columbia River basin hydroelectric development. Fisheries that may benefit from these programs include lower Columbia and Kalama River sport fisheries, although no patterns of adult returns have been established for the new "wild" broodstock programs. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead likely were similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and Washington tributaries became selective during 1986–1992 (except the Toutle in 1994). Current selective harvest regulations in the lower Columbia and tributary sport fisheries have targeted hatchery steelhead and limited harvest of wild winter and summer steelhead to less than 10% (6% in the Kalama River fishery). A harvest management plan for these hatchery programs is being developed, pending consultation between WDFW and NOAA Fisheries.

Passage—Adult collection facilities at the Kalama Falls Hatchery consist of a step and pool ladder system; adults volitionally enter the trap. Captured adults are transferred via tanker truck to sorting ponds and held for broodstock collection. Returning adult salmonids that do not enter the hatchery ladder system encounter lower Kalama Falls just upstream of the hatchery; the falls block migration of most salmonids, although steelhead are able to negotiate the falls under certain water conditions. Captured spring chinook that exceed broodstock needs are released above lower Kalama Falls to utilize spawning habitat between lower and upper Kalama Falls. Summer and winter steelhead beyond broodstock needs are returned to the river below lower Kalama Falls to provide for recreational harvest opportunities until mid-November and February 1, respectively. After those dates, excess fish are utilized for local food banks or landlocked lake fisheries. A weir is placed in the lower Kalama River in the fall to capture fall chinook broodstock. A significant portion of the fall chinook return is passed above the weir to naturally spawn. Coho and steelhead are small enough to pass through the weir and continue upstream migration.

Supplementation—The new "wild" summer and winter steelhead hatchery programs have as their primary goal the development of a wild broodstock program to return adults to the sport fishery and serve as a risk management tool, maintaining wild broodstock in case of a catastrophic event that negatively effects the natural population. Only native Kalama wild broodstock is being used for these programs. The programs are being monitored and evaluated intensely to identify potential risks to natural production.

10.5 Fish Habitat Conditions

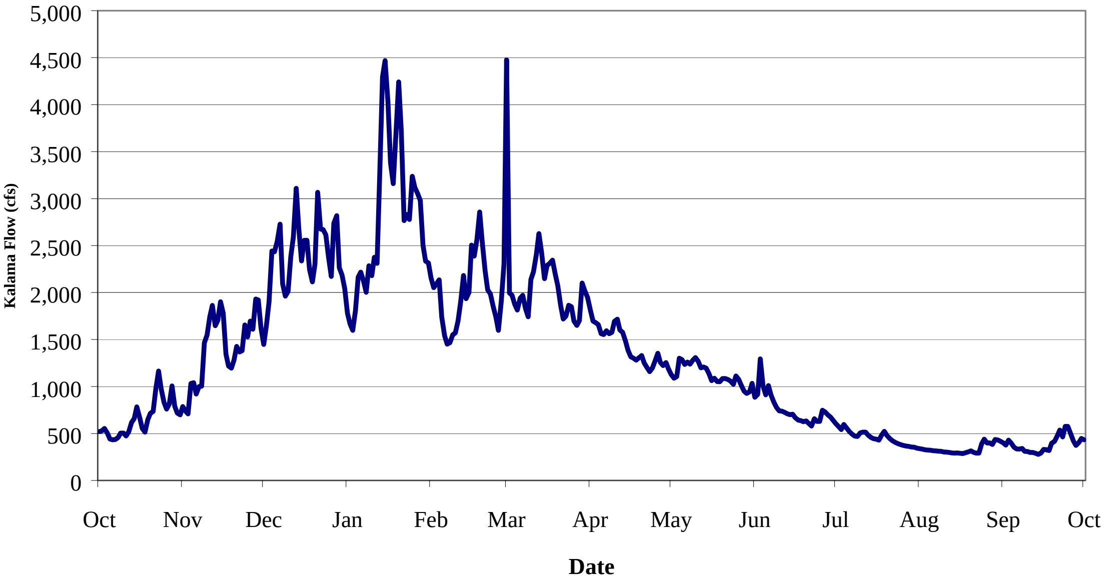
10.5.1 Passage Obstructions

Accumulation of sediments at the mouth has created a wide shallow channel that is believed to cause passage problems for migrating fish, especially at low tide. The shallow flow increases susceptibility to predation and elevated water temperatures. The lower Kalama River Hatchery presents a partial barrier to migration up Hatchery (Fallert) Creek during low flows. Culverts, mouth sediment accumulations, and log jams on several tributary creeks are also thought to create potential barriers (Wade 2000).

10.5.2 Stream Flow

Stream flow in the subbasin is a direct result of rainfall, since only a small portion of the basin is above the usual snowline. Peak flows generally correspond with mid-winter rains. Summer low flow typically occurs in August (mean of 306 cubic feet per second [cfs]) and high flows occur in December or January (mean of 2,157 cfs and 2,152 cfs, respectively) (WDW 1990). Mean annual flow from 1953-67 was 1,219 cfs.

Figure 10-8. Kalama River hydrograph (1966-1975). Values are daily mean flows. The Kalama



exhibits a fall through spring rainfall dominated regime, with flows typically falling below 300 cfs in late summer. Data is from USGS Stream Gage #14223500; Kalama River Below Italian Cr. near Kalama, Wash.

Most private timberland was logged in the 1970s and early 1980s, including riparian areas. These activities, combined with splash dam log transport, poor road construction, and inadequate culverts, served to alter hydrologic and sediment transport processes and limit anadromous fish habitat (Wade 2000). The February 1996 flood caused 39 landslides.

Generation of increased overland flow may occur due to the extensive road network and past vegetation removal due to logging, though this process is assumed to be recovering as a result of logging reductions and improved road building and maintenance. Using vegetation and road conditions, the USFS noted a potential 10% increase of peak flow volumes (compared to undisturbed conditions) in six of eight subbasins (USFS 1996a).

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 17 of 18 subwatersheds (7th field) are “impaired” with regards to runoff conditions. Only the highest headwater subwatershed receives a “moderately impaired” rating. High road densities and young forest stands are the primary causes of hydrologic impairment. These conditions create a risk of increased peak flow volumes.

An IFIM study conducted in 1999 on the mainstem by the WDOE found that flows were below optimal for coho and chinook spawning in October, and below optimal for juvenile rearing from mid-June to mid-October (Caldwell 1999). Concern over low flows also exist in Langdon Creek, NF Kalama, Jack Creek, and Wold Creek, where accumulation of coarse sediments at the mouth may increase the potential for subsurface flow and therefore increase the risk of stranding juvenile fish.

Consumptive water use in the subbasin is estimated to increase from the current 308 million gallons per year (mgy) to 523 mgy by 2020. However, current and predicted future surface and groundwater use is believed to have a relatively insignificant impact on stream flows

(LCFRB 2001). The Limiting Factors Analysis, on the other hand, suggested that water withdrawal development in the lower basin could be a potential future problem (Wade 2000).

10.5.3 Water Quality

Portions of the lower 10 miles of the Kalama and Hatchery (Fallert) Creek are listed on the state's 303(d) list of impaired water bodies due to exceedance of water temperature standards (WDOE 1998). Of particular concern are elevated temperatures that are believed to occur at the mouth, where sediment accumulations have created a wide, shallow channel. This may present problems for fish migrating during summer low flows. A 1994 water temperature survey by WDFW indicated no temperature exceedances during summer low flow on segments of the middle Kalama. Stream temperatures are not considered a problem on the National Forest portion of the basin except for on Fossil Creek where temperatures have been measured as high as 23°C (USFS 1996).

Nutrient levels may be low in the upper river (above the falls) due to low steelhead escapement levels and consequent low levels of carcass-derived nutrients. However, carcass supplementation programs have been conducted and may be alleviating nutrient deficiencies (Wade 2000).

10.5.4 Key Habitat

A few tributaries to the Kalama have low pool frequencies, which may crowd rearing juveniles into existing pools (WDFW 1998). However, in general, pool availability in most of the basin is considered adequate (Wade 2000).

Few off-channel locations exist on the lower river due to channelization, and 1994 surveys indicated few off-channel habitats in the middle river as well (WDFW 1998). The lack of off-channel areas could potentially limit overwintering habitat for coho, steelhead, and spring chinook.

10.5.5 Substrate & Sediment

Surveys conducted by WDFW in 1994, as well as prior data, indicate ongoing concerns with substrate fines throughout the basin. There are also concerns with the accumulation of excessive coarse sediment at the mouths of some tributaries, especially Langdon Creek and the NF Kalama (Wade 2000).

Production of sediment from the subbasin is influenced by highly erodible soils, vegetation removal from logging, and high road densities. The total road density is 5.75 miles/square mile. The Middle Kalama basin, from RM 17 to 32 has a road density of 6.4 miles/square miles (WDFW 1998). National Forest lands in the basin have an average road density of 4.0 miles/square mile and are highly fragmented, with an average of 2.6 road crossings per stream mile. Areas of natural soil instability also exist throughout the basin. The February 1996 floods triggered at least 39 slides in the basin (USFS 1996).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results show that about half of the basin is either "impaired" or "moderately impaired" with regards to sediment supply. The bulk of the impaired subwatersheds are in the middle elevations. These areas are in private commercial timber production and have high road densities.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

10.5.6 Woody Debris

Abundance of in-stream LWD is thought to be low throughout the basin, although some large pieces are evident in the mainstem, often as part of log jams. Contributing to these low levels was the practice of removing in-stream wood, which occurred during the heavy logging years of the 1970s and 80s (WDFW 1998). Removal of LWD for firewood is a potential current problem. Lewis County GIS data rates over 87% of the riparian habitat as lacking vegetation and consisting primarily of deciduous species, suggesting low LWD recruitment potential (Wade 2000).

10.5.7 Channel Stability

Bank stability is generally considered good throughout the basin. Problems exist on the mainstem just upstream and downstream of Spencer Creek (RM 2.2) but it is unknown whether it is a natural or human induced process. The Watershed Recovery Inventory Project (WDFW 1997) identified mass wasting problems along Hatchery Creek, Wild horse Creek, Gobar Creek, NF Kalama, Lakeview Peak Creek, and Langdon Creek. A large slide on the NF Kalama is stabilizing, however a large slide in the headwaters of Lakeview Peak Creek may be a concern until the feature stabilizes (Wade 2000).

10.5.8 Riparian Function

Most of the watershed, including riparian forests, was logged in the late 1960s through the early 1980s. According to an analysis by Lewis County GIS of 1994 and 1996 aerial photos, riparian forests on 85 of the 97.25 miles of anadromous stream channels are lacking riparian vegetation and/or contain mostly deciduous species (Wade 2000).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 17 of 18 subwatersheds are rated as “moderately impaired” for riparian conditions, and only the uppermost headwater subwatershed is rated as “functional”. Impaired riparian conditions are related to past timber harvests (1960s to 1980s), stream adjacent roads, and development along the lower river.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

10.5.9 Floodplain Function

Nearly all of the lower floodplain has been disconnected from the river due to dikes, I-5, and development on the Port of Kalama property (Wade 2000).

10.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Kalama River fall chinook, spring chinook, winter steelhead, summer steelhead, chum, and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

10.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Kalama River subbasin for summer steelhead, winter steelhead, fall chinook, spring chinook, chum, and coho. For all modeled populations, productivity has decreased by 62-90% from historical levels, with chum and spring chinook declining the most (Table 10-1). Adult abundance trends show similar declines (Figure 10-9). Model results indicate that adult abundance of Kalama fall chinook, coho, winter steelhead and summer steelhead has declined by 43-63% from historical levels. Spring chinook and chum, however, have had the most severe declines in adult abundance, with current estimates at only 8% of historical levels. Species diversity (as measured by the diversity index) has remained constant for both fall chinook and summer steelhead (Table 10-1). However, diversity has declined by 9-21% for spring chinook, chum and winter steelhead, and by 63% for coho (Table 10-1).

Estimates of current smolt productivity have decreased from historical estimates in all populations (Table 10-1). Smolt productivity has declined most for winter steelhead and least for chum. However, in the case of chum, this seems counter-intuitive due to the fact that chum adult abundance has declined the most out of the six species. However, this relatively higher smolt productivity is merely an artifact of the way the EDT model calculates productivity. That is, the higher productivity of chum smolts is because Kalama chum now have many less trajectories (life history pathways) that are viable (those that result in return spawners); but the few trajectories that remain have higher productivities than historical trajectories (many of which were only marginally viable). Smolt abundance has decreased by 31-46% for fall chinook, winter steelhead, and summer steelhead, and by 70-83% for spring chinook, chum, and coho (Table 10-1).

Model results indicate that restoration of properly functioning habitat conditions (PFC) would benefit all species (Table 10-1). The most dramatic increase in adult abundance with restoration to PFC would be for chum and coho. Current coho abundance would increase by approximately 113% and current chum abundance by approximately 272%. Smolt numbers are also estimated to increase dramatically for all species, especially for coho, which shows a 343% increase in smolt abundance with restoration of PFC.

Table 10-1. Kalama subbasin— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	1,581	2,367	2,760	3.3	6.9	8.7	1.00	1.00	1.00	248,620	371,277	463,354	398	772	959
Spring Chinook	413	756	4,862	1.8	3.1	17.2	0.79	1.00	1.00	87,930	175,350	286,925	327	601	809
Chum	1,615	6,014	20,637	2.0	6.5	9.7	0.84	1.00	1.00	901,866	2,573,274	4,323,376	703	997	1,147
Coho	484	1,033	1,306	3.8	8.7	12.5	0.37	1.00	1.00	5,192	23,024	30,151	84	194	283
Winter Steelhead	445	614	885	4.0	9.2	17.2	0.91	0.98	1.00	8,032	10,980	13,309	71	167	265
Summer Steelhead	788	953	1,209	4.5	8.2	13.2	0.99	0.99	0.99	14,657	17,583	21,378	83	150	231

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

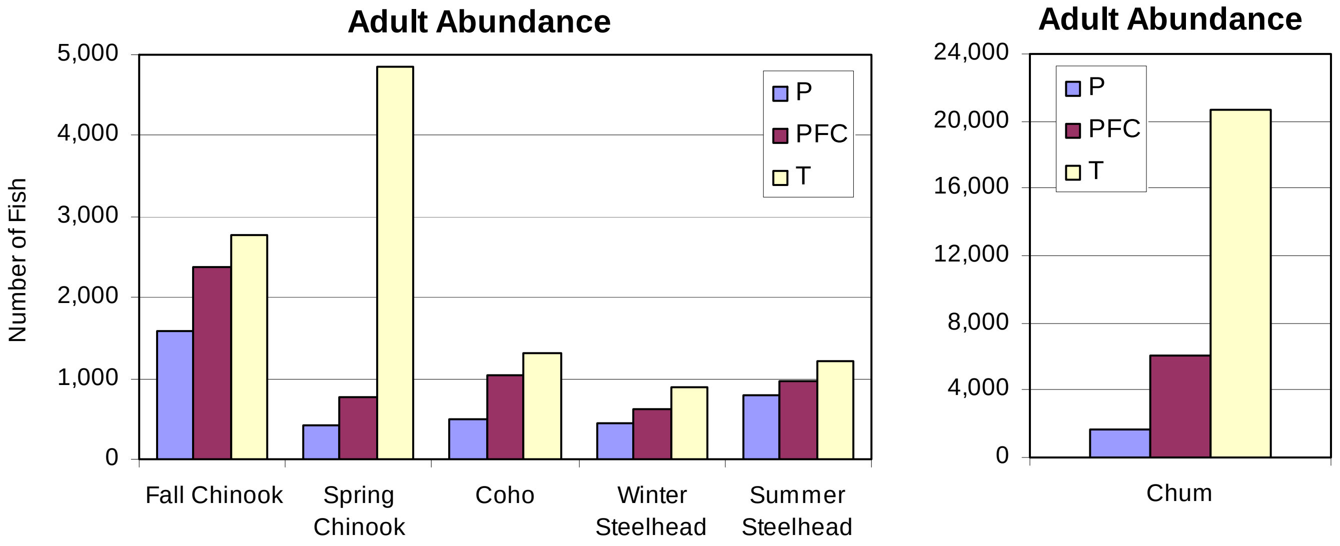


Figure 10-9. Adult abundance of Kalama fall chinook, spring chinook, coho, winter steelhead, summer steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

10.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Summer steelhead have the greatest distribution of the Kalama subbasin populations. Only summer steelhead are believed to have regularly passed upstream of the Lower Kalama Falls at RM 10 prior to the installation of a fish ladder. The Upper Kalama River Falls at RM 35 is the upstream limit. Winter steelhead, fall chinook, spring chinook, and coho occupy the mainstem and small tributaries downstream of the lower falls. Chum historically occupied the lowest few reaches of the mainstem but their numbers are currently very low. See Figure 10-10 for a map of EDT reaches within the Kalama subbasin.

High priority reaches for summer steelhead are located in the headwaters (Kalama 17-20) and the middle mainstem (Kalama 6) (Figure 10-11). The headwater and headwater tributary areas represent important spawning reaches, while the middle mainstem is particularly important for summer adult holding and parr rearing. These important reaches, except for Kalama 6, show a combined preservation and restoration habitat recovery emphasis (Figure 10-11). Kalama 6 has, by far, the highest preservation potential of any summer steelhead reach.

High priority reaches for winter steelhead also include the middle mainstem (Kalama 6 and 8-10), but due to their slightly more downstream distribution, important reaches also include portions of the lower river (Kalama 4 and 5) (Figure 10-12). The lower reaches show a habitat restoration emphasis, while the middle reaches show a combined preservation and restoration habitat recovery emphasis (Figure 10-12).

High priority reaches are similar for fall chinook (Figure 10-13), chum (Figure 10-14), and coho (Figure 10-15). These reaches are primarily located in the lower sections of the river (Kalama 2-5 and Kalama 1 tidal). For both fall chinook and chum, these reaches have either a habitat preservation emphasis or a combined preservation and restoration emphasis. However, for coho, these same reaches have a strong restoration potential only.

For spring chinook, important reaches are found throughout the middle and upper sections of the subbasin (Kalama 8-18) (Figure 10-16). All these reaches, except for Kalama 8 and 18, have a habitat preservation emphasis. Kalama 8 and 18 show a combined preservation and restoration habitat recovery emphasis (Figure 10-16).

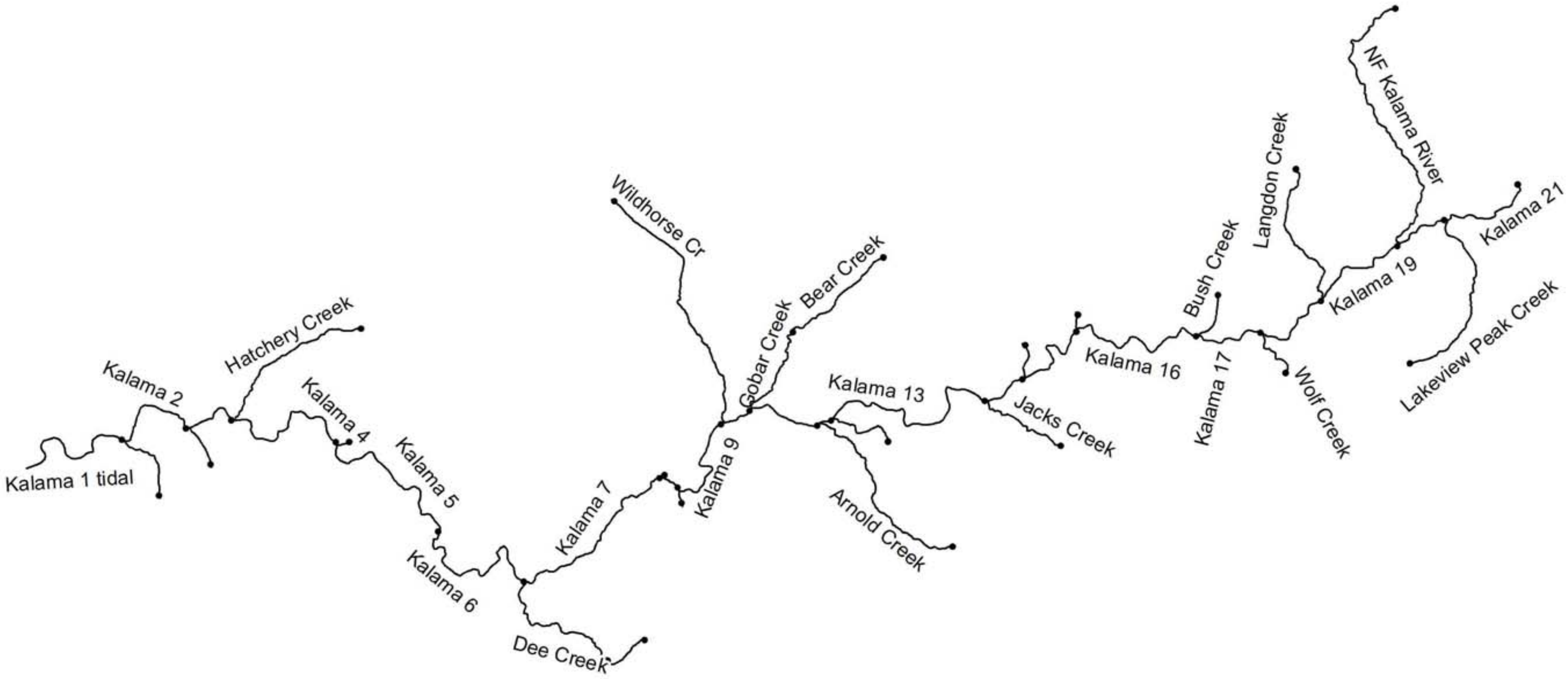


Figure 10-10. Kalama subbasin EDT reaches. Some reaches not labeled for clarity.

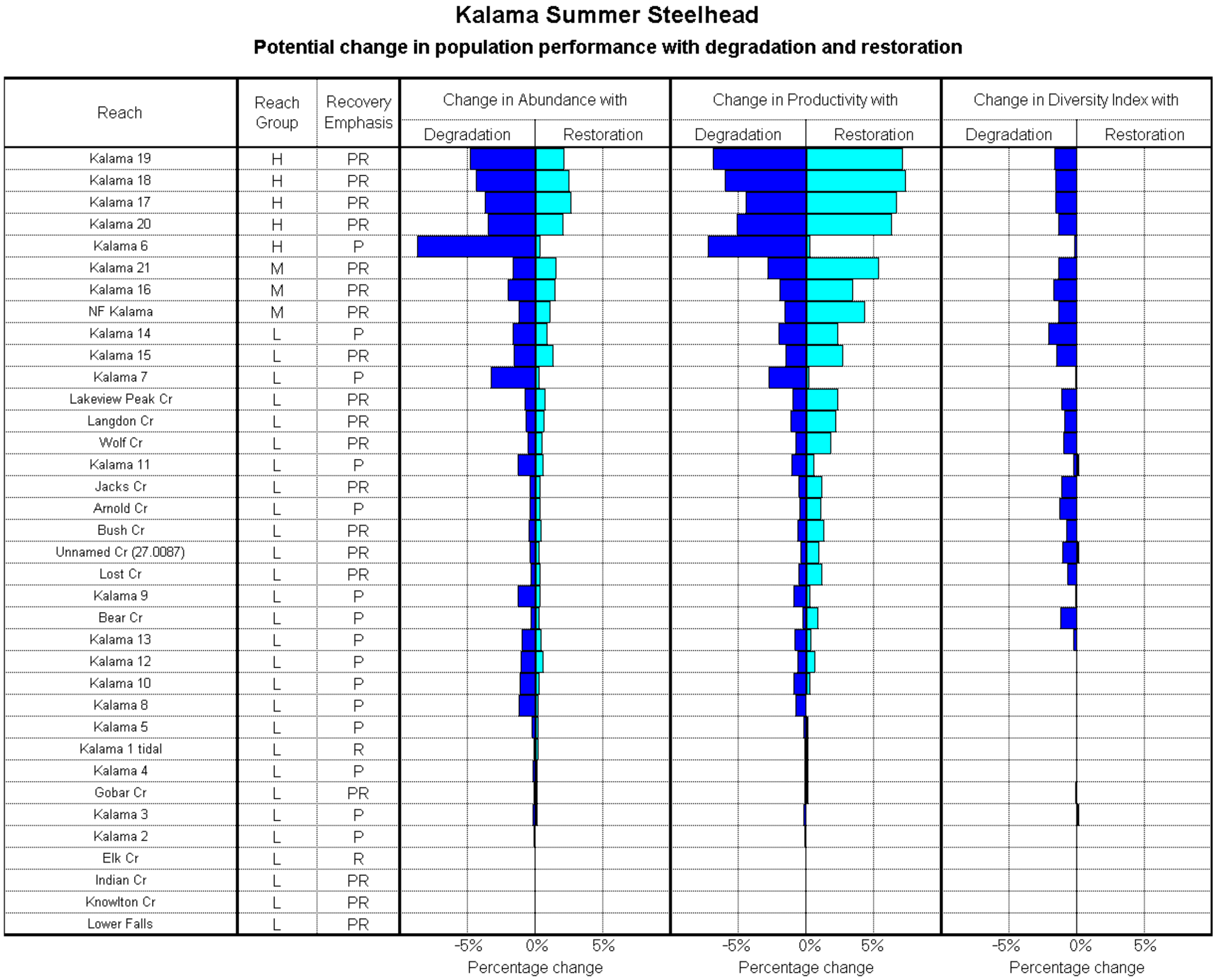
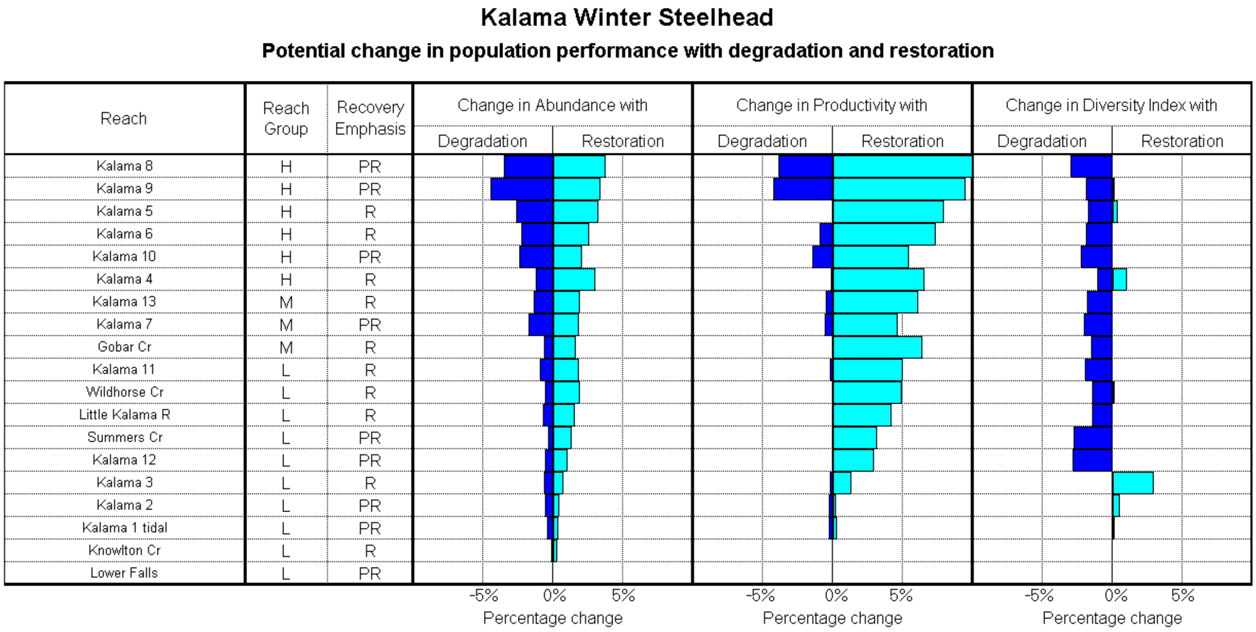
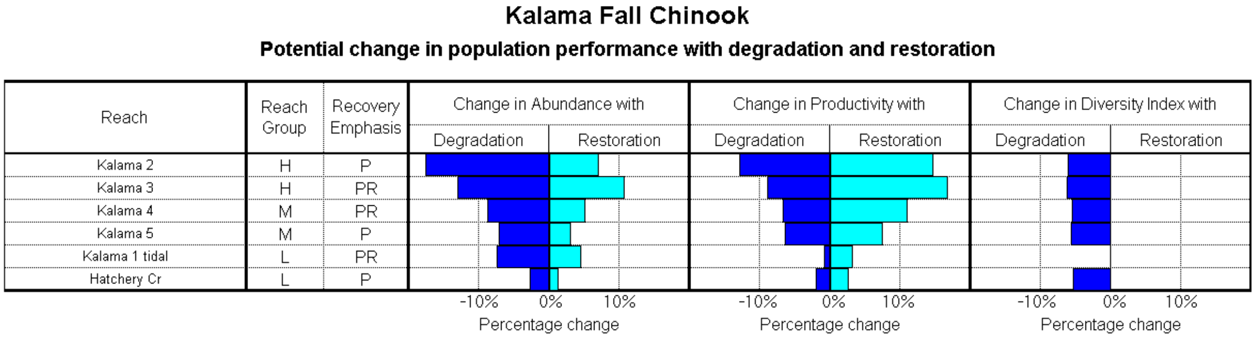


Figure 10-11. Kalama subbasin summer steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



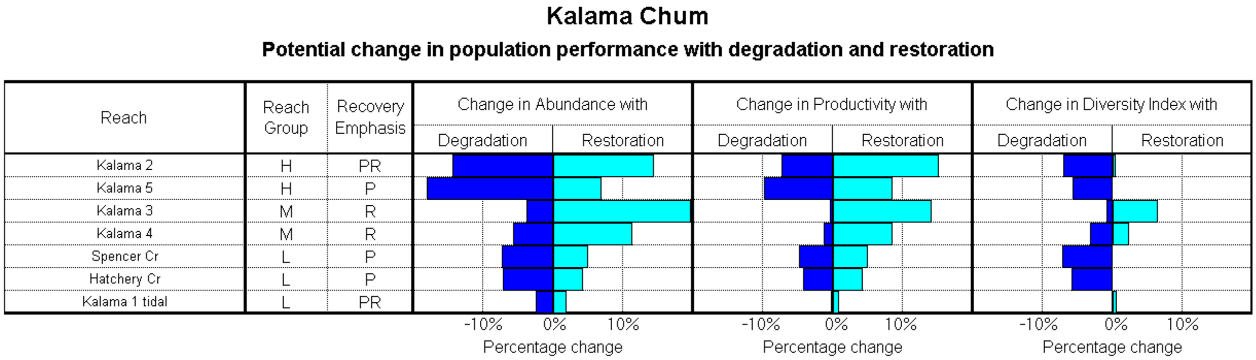
Reach	Reach Group	Recovery Emphasis
Kalama 8	H	PR
Kalama 9	H	PR
Kalama 5	H	R
Kalama 6	H	R
Kalama 10	H	PR
Kalama 4	H	R
Kalama 13	M	R
Kalama 7	M	PR
Gobar Cr	M	R
Kalama 11	L	R
Wildhorse Cr	L	R
Little Kalama R	L	R
Summers Cr	L	PR
Kalama 12	L	PR
Kalama 3	L	R
Kalama 2	L	PR
Kalama 1 tidal	L	PR
Knowlton Cr	L	R
Lower Falls	L	PR

Figure 10-12. Kalama subbasin winter steelhead ladder diagram.



Reach	Reach Group	Recovery Emphasis
Kalama 2	H	P
Kalama 3	H	PR
Kalama 4	M	PR
Kalama 5	M	P
Kalama 1 tidal	L	PR
Hatchery Cr	L	P

Figure 10-13. Kalama subbasin fall chinook ladder diagram.



Reach	Reach Group	Recovery Emphasis
Kalama 2	H	PR
Kalama 5	H	P
Kalama 3	M	R
Kalama 4	M	R
Spencer Cr	L	P
Hatchery Cr	L	P
Kalama 1 tidal	L	PR

Figure 10-14. Kalama subbasin chum ladder diagram.

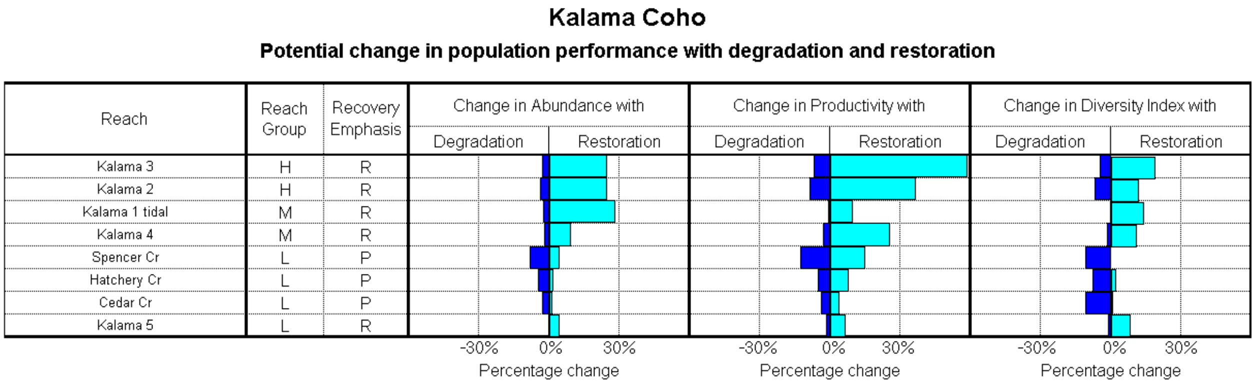


Figure 10-15. Kalama subbasin coho ladder diagram.

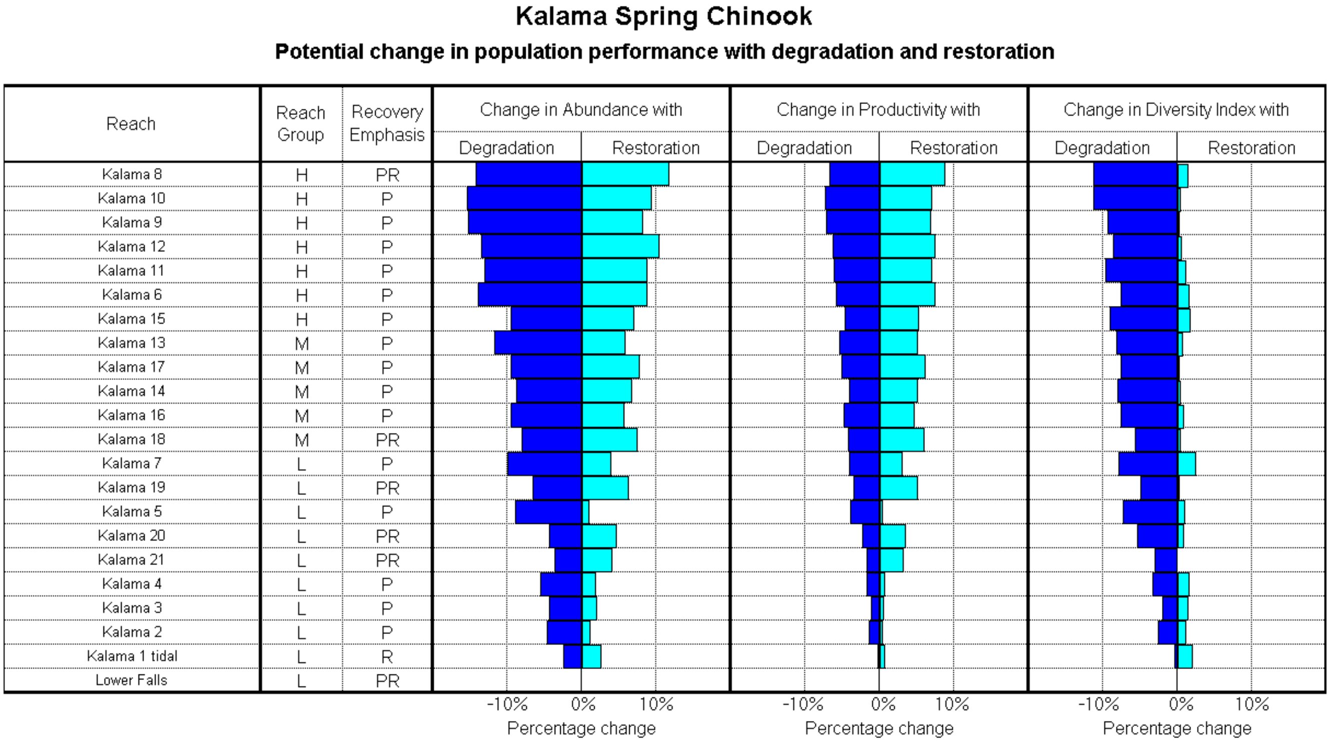


Figure 10-16. Kalama subbasin spring chinook ladder diagram.

10.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The key summer steelhead reaches in the headwaters and headwater tributaries are affected by degraded habitat diversity, sediment, and flow conditions, with lesser impacts due to channel stability and key habitat quantity (Figure 10-17). Degraded conditions affecting habitat diversity are attributable to low instream large wood quantities and young riparian forests. Sediment and flow conditions are related to the intense timber harvests that have occurred in this basin and the associated road network. Many upper basin subwatersheds have over 6 miles of road per square mile. These are some of the highest road densities in the region. Vegetation conditions are also poor, with most of the upper basin forests in stand initiation or early-seral stages. In four out of eight upper subwatersheds assessed in the 1996 Upper Kalama Watershed Analysis (USFS 1996), peak flows were estimated to be elevated over historical levels due to vegetation and road conditions. Channel stability conditions are related to flow alterations and degraded riparian forests. The food resource has been affected by the removal of overhanging tree canopies. Minor predation and competition impacts are related to an ongoing steelhead reproductive success study in the watershed.

Restoration of winter steelhead habitat should focus on the middle mainstem, middle tributaries, and the lower river reaches. The primary degraded attributes in these areas include sediment, habitat diversity, and flow (Figure 10-18). Once again, sediment and flow conditions are related to logging and road densities. Road densities are very high in the middle mainstem and tributary subwatersheds. The Lower Gobar Creek subwatershed has one of the highest road densities of any forested subwatershed in the region, with 7.4 miles of road per square mile. Non-vegetated or shrub vegetated (i.e. stand initiation) forestland makes up 74% of this subwatershed.

High priority reaches for fall chinook (Figure 10-19), chum (Figure 10-20) and coho (Figure 10-21) are similar. As such, so are the restoration priorities, which include impacts from fine sediment, habitat diversity, key habitat, and channel stability. Upper basin logging and road densities contribute to elevated fine sediment levels. A lack of large wood, artificial confinement, and degraded riparian forests contribute to poor channel stability and habitat diversity conditions.

Model results indicate that restoration of spring chinook habitat should focus primarily on improving sediment, habitat diversity, channel stability, and flow issues (Figure 10-22). The cause of these impacts are similar to those mentioned above.

Kalama Summer Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 19	●	⬤							⬤	⬤						●
Kalama 18	●	⬤							⬤	⬤						●
Kalama 17	●	⬤							⬤	⬤						●
Kalama 20	●	⬤							⬤	⬤						●
Kalama 6	•	●							•	•	•			•		+
Kalama 21	●	⬤							⬤	⬤						●
Kalama 16	●	⬤							●	⬤						●
NF Kalama	●	●	•			•			●	⬤	•					✚
Kalama 14	•	⬤							●	⬤						✚
Kalama 15	●	⬤							●	⬤						●
Kalama 7	•	●							•	•						
Lakeview Peak Cr	•	●	•						●	●	•					✛
Langdon Cr	•	●	•						●	⬤	•					✛
Wolf Cr	•	●	•						●	●	•					✛
Kalama 11	•	●		•		•			●		•					
Jacks Cr	•	●	•						●	●	•					
Arnold Cr	•	●	•						●	●	•					
Bush Cr	•	●	•						●	⬤	•					✛
Unnamed Cr (27.0087)	•	●	•						•	●	•					✛
Lost Cr	•	●	•						●	●	•					✛
Kalama 9	•	●		•		•			•	•				•		+
Bear Cr	•	●	•						•	●	•					
Kalama 13	•	●							•	•						
Kalama 12	•	●		•		•			•		•					
Kalama 10	•	●		•		•			•							
Kalama 8	•	●							•							
Kalama 5	•	•		•					•					•		•
Kalama 1 tidal		•		•					•	•						●
Kalama 4	•	•		•					•							
Gobar Cr		•		•					•							
Kalama 3		•														
Kalama 2		•														
Elk Cr		•							•							
Indian Cr																
Knowlton Cr																
Lower Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 10-17. Kalama subbasin summer steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Kalama Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 8	•	⬤	●	•		•			●	⬤				•		╋
Kalama 9	•	⬤	•	•		•			●	⬤				•		╋
Kalama 5	•	●	●	●		•			●	●	╋			●	•	✚
Kalama 6	•	●	●	•		•			●	●	•			•		╋
Kalama 10	•	⬤	•	•		•			●	⬤				•		╋
Kalama 4	•	⬤	●	●		•			●	●				•	•	✚
Kalama 13	•	⬤							●	⬤						✚
Kalama 7	•	●	•	•		•			●	⬤				•		╋
Gobar Cr	•	●	•	•		•			●	●	•					•
Kalama 11	•	●	•	•		•			●	●	•			•		╋
Wildhorse Cr	•	●	•						●	●	•					
Little Kalama R	•	●	•						●	●	•					
Summers Cr	•	●	•						●	⬤	•					╋
Kalama 12	•	●		•					•	●	•					╋
Kalama 3	•	●	•	•					•	•				•	•	●
Kalama 2		•	•	•					•							
Kalama 1 tidal		•		•					•	•						●
Knowlton Cr		•							•							
Lower Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 10-18. Kalama subbasin winter steelhead habitat factor analysis diagram.

Kalama Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 2	●	●	●	•					•	⬤					•	•
Kalama 3	●	⬤	•	•					●	⬤				•	●	●
Kalama 4	●	●	•	•					•	●					•	╋
Kalama 5	●	•	•	•					•	⬤					•	╋
Kalama 1 tidal	•	●		•	•	•			•	•	•			•	•	●
Hatchery Cr	•	•		•					•	●						•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 10-19. Kalama subbasin fall chinook habitat factor analysis diagram.

Kalama Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 2	•	⬤		•					●	●	•				●	•
Kalama 5	•	●		•					•	●	✛				•	✛
Kalama 3	•	⬤		•					●	●					●	⬤
Kalama 4	•	●		•					•	●					●	✛
Spencer Cr		●							•	●						•
Hatchery Cr	•	●							•	•	•					•
Kalama 1 tidal	•	•		•					•							•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 10-20. Kalama subbasin chum habitat factor analysis diagram.

Kalama Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 3	●	⬤	•	•		•			•	●				•	•	⬤
Kalama 2	●	⬤	•	•		•			•	●	•			•	•	✛
Kalama 1 tidal	•	⬤	•	●	•	•			•	•	•			•		⬤
Kalama 4	•	●	•	•					•	•				•	•	●
Spencer Cr	•	●							•	●						●
Hatchery Cr	•	•							•	•						•
Cedar Cr	•	•							•	•						•
Kalama 5	•	●		•					•	•				•		●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 10-21. Kalama subbasin coho habitat factor analysis diagram.

Kalama Spring Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Kalama 8	●	●	●			•			•	⬤						+
Kalama 10	●	⬤	●			•			●	⬤						
Kalama 9	●	●	•			•			•	⬤						
Kalama 12	●	⬤	•			•			●	⬤	•					•
Kalama 11	●	⬤	•			•			●	⬤	•					
Kalama 6	●	●	●			•			•	⬤	•			•		•
Kalama 15	●	●							•	⬤						●
Kalama 13	●	●							•	⬤						+
Kalama 17	●	⬤							●	⬤						•
Kalama 14	●	●							•	⬤						
Kalama 16	●	●							•	⬤						●
Kalama 18	●	⬤							●	⬤						•
Kalama 7	●	●	•						•	⬤						
Kalama 19	●	●							•	⬤						+
Kalama 5		•		•					•					•		•
Kalama 20	●	●							•	⬤						•
Kalama 21	●	●							•	⬤						+
Kalama 4	•	●	•	•		•			•					•		•
Kalama 3	•	●	•	•		•			•					•	•	•
Kalama 2		•	•	•		•										
Kalama 1 tidal	•	●	•	•		•								•	•	•
Lower Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 10-22. Kalama subbasin spring chinook habitat factor analysis diagram.

10.7 Integrated Watershed Assessments

The Kalama watershed has been subdivided into 18 LCFRB recovery planning subwatersheds, 17 of which are part of the Kalama River system while one encompasses small independent tributaries to the Columbia River. The Kalama watershed is comprised primarily of two ecological zones based on rain or snow dominated precipitation. Six subwatersheds are located in the rain-dominated zone, the remainder lie in more snow dominated areas.

Subwatersheds in the Kalama basin can be organized into three groups: upstream mainstem and tributary subwatersheds upstream of and including Elk Creek; lower mainstem subwatersheds between Elk Creek and the Little Kalama River; and the tidally influenced Kalama mainstem and the Little Kalama River including Hatchery Creek.

10.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Kalama River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 10-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 10-23. Maps of the distribution of local and watershed level IWA results are displayed in Figure 10-24. Hydrologic conditions are mostly impaired at the local and watershed levels. Sediment conditions are moderately impaired or functional, and riparian conditions are almost entirely moderately impaired. These results are described in more detail below.

Table 10-2. IWA results for the Kalama watershed.

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
40201	I	M	M	I	M	40101, 40102, 40103, 40202
40202	I	M	M	I	M	40101, 40102, 40103
40301	I	I	M	I	M	40101, 40102, 40103, 40201, 40202, 40302, 40303, 40304
40302	I	M	M	I	M	40101, 40102, 40103, 40201, 40202, 40303, 40304
40303	I	M	M	I	M	40101, 40102, 40103, 40201, 40202
40401	I	F	M	I	M	40101, 40102, 40103, 40201, 40202, 40301, 40302, 40303, 40304, 40402, 40403
40402	I	M	M	I	M	40403
40501	I	M	M	I	M	40101, 40102, 40103, 40201, 40202, 40301, 40302, 40303, 40304, 40401, 40402, 40403, 40502, 40503, 40505
40502	I	F	M	I	M	40101, 40102, 40103, 40201, 40202, 40301, 40302, 40303, 40304, 40401, 40402, 40403, 40503, 40504, 40505
40503	I	F	M	I	M	40101, 40102, 40103, 40201, 40202, 40301, 40302, 40303, 40304, 40401, 40402, 40403
40504	I	F	M	I	F	none
40505	I	M	M	I	M	none
40101	I	F	M	I	M	40102
40102	M	F	F	M	F	none
40103	I	M	M	I	M	none
40304	I	M	M	I	M	none
40403	I	F	M	I	F	none
40601	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

Figure 10-23. Map of the Kalama basin showing the location of the IWA subwatersheds

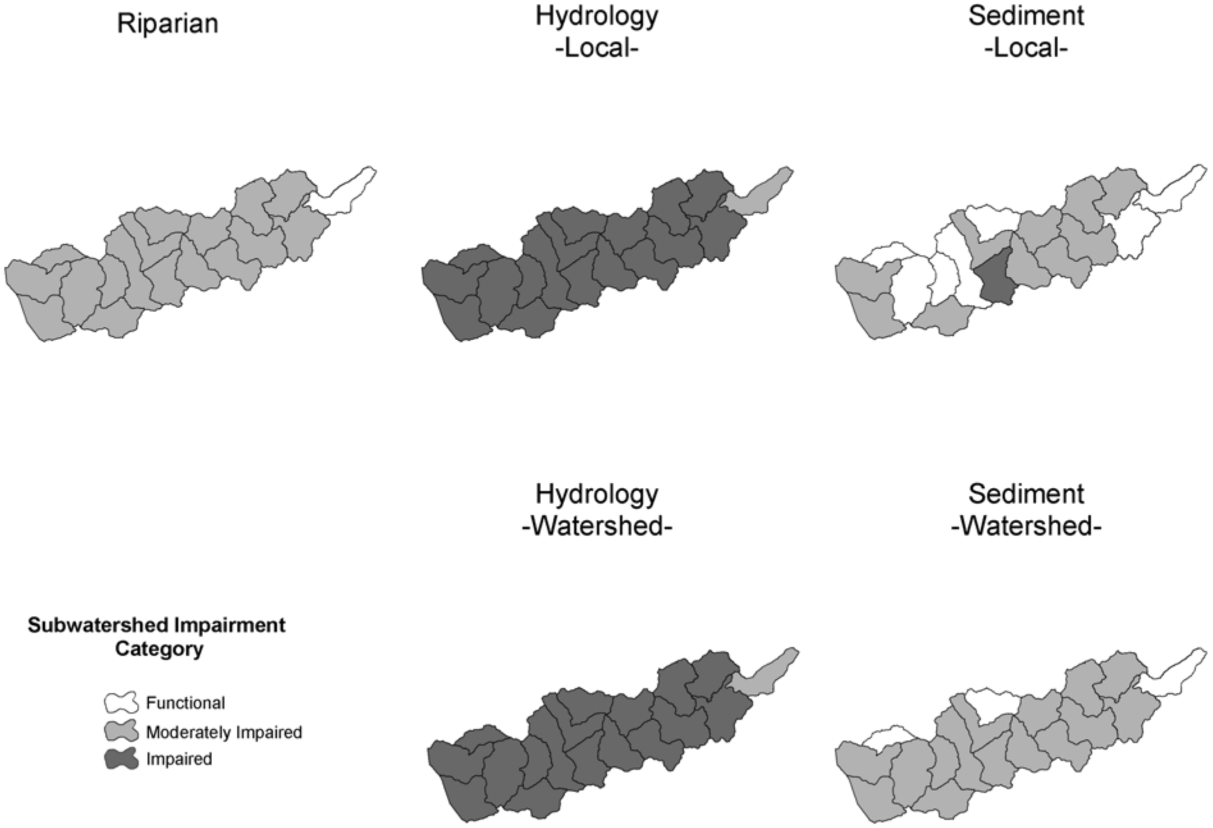


Figure 10-24. IWA subwatershed impairment ratings by category for the Kalama basin.

10.7.1.1 Hydrology

Hydrologic conditions in the upper Kalama mainstem and tributary subwatersheds are uniformly rated as impaired at both local and watershed levels, with the exception of moderately impaired conditions in the Kalama headwaters (40102). Many of the impaired subwatersheds have a high percentage of total area in the rain-on-snow zone (>50%), making them susceptible to an increase in peak runoffs. Mature forest cover in these and contributing subwatersheds is low (~25% on average) and road densities are high, averaging over 6 mi/sq mi.

Hydrologic conditions in the middle mainstem group of subwatersheds are impaired at the local level due to high road densities (averaging 7 mi/sq mi) and only 22% mature forest coverage. These subwatersheds are also all impaired at the watershed level.

The lower Kalama subwatersheds are all rated as impaired for local and watershed level hydrologic conditions. The lower mainstem subwatersheds have some of the highest streamside road densities in the Kalama Basin. The area transitions from predominantly steep terrain in private timber lands to a low lying alluvial valley entering the Columbia River. Agricultural, residential, and commercial development predominate here along the I-5 corridor. The lower reaches of the Kalama River have been channelized and disconnected from the floodplain, which can exacerbate the effects of impaired hydrologic conditions.

10.7.1.2 Sediment Supply

Most current sediment problems are associated with large sediment and bedload deposits caused by past forest practices, including indiscriminate logging around and through streams, the use of splash dams to transport logs, and poor road and culvert construction (WDW 1990). In addition to these land use issues, the eruption of Mt. St. Helens created some debris flows and deposits in headwaters areas that are vulnerable to future erosion. While the natural erodability of the Kalama River watershed is relatively low (ranging from 3 to 21 on a scale of 0-126), the combination of historical and current land uses contribute to widespread impairment in the watershed.

Sediment conditions in the upper mainstem grouping of subwatersheds are generally rated as moderately impaired for sediment at the local level, with functional conditions present in the upper mainstem (40101) and the headwaters (40102). Watershed level sediment conditions reflect upstream influences, with moderately impaired ratings found in all subwatersheds except the headwaters.

Sediment conditions in the middle mainstem grouping of subwatersheds vary at the local level. Sediment conditions are rated as locally functional in the Gobar Creek headwaters (40403), the Kalama mainstem/Wild Horse Creek (40401), and the Kalama mainstem/Sommers Creek (40503). In contrast, conditions in the mainstem Kalama/Arnold Creek (40301) are rated as impaired at the local level. Remaining subwatersheds are rated as moderately impaired. Watershed level sediment conditions indicate the likelihood of strong upstream influences on sediment conditions, with all subwatersheds in this grouping rated as moderately impaired, except for the Gobar Creek headwaters.

The downstream group of subwatersheds are mixed in terms of sediment conditions. Mainstem subwatersheds 40502 and 40501 are rated functional and moderately impaired at the local level, respectively. The Little Kalama drainage (40505) is rated moderately impaired at the local level, while the other lower mainstem tributary, Hatchery Creek (40504), is rated functional. Watershed level conditions in the mainstem are moderately impaired in all subwatersheds, reflecting the influence of sediment conditions in upstream subwatersheds.

10.7.1.3 Riparian Condition

Riparian conditions in the Kalama River watershed are strongly influenced by past land use activities. Most of the watershed, including riparian forests, was logged in the late 1960s through the early 1980s, and many areas are in the early stages of recovery. Recovery in some areas is limited by moderate to high streamside road densities and residential development along the Kalama mainstem. Riparian conditions are rated as moderately impaired throughout the majority of the Kalama River watershed, with functional conditions occurring only in the Kalama River headwaters.

10.7.2 Predicted Future Trends

10.7.2.1 Hydrology

Low levels of public land ownership, low levels of mature forest cover, high road densities, and the likelihood of timber harvest occurring on areas of land coming into rotation suggest that hydrologic conditions will trend stable throughout the Kalama River watershed over the next 20 years. In the upper Kalama mainstem group of subwatersheds, mature forest cover in these and contributing subwatersheds averages only 25%. Road densities are high, averaging over 6 mi/sq mi. Due to the high percentage of active timber lands, high road densities, and low mature forest coverage, the predicted trend is for hydrologic conditions in the upper Kalama mainstem group of subwatersheds to remain in impaired condition over the next 20 years.

Land ownership in the middle mainstem group of subwatersheds is similarly predominated by private timber holdings, with residential and some agricultural development present along the mainstem. Road densities are similarly high, approaching 7 mi/sq mi, and mature forest cover is low, averaging 15%. Given these conditions, and the likelihood that timber harvest activities are likely to continue and road densities are likely to remain high for the foreseeable future, the predicted trend is for hydrologic conditions to remain impaired in these key subwatersheds.

The lower Kalama mainstem group of subwatersheds faces a more complex set of problems than upstream areas. The lower mainstem has been channelized and disconnected from its floodplain, which exacerbates hydrologic impacts caused by conditions in upstream areas of the watershed. Growth pressures in the lower mainstem area are increasing along the I-5 corridor. Given the existing high road densities, the potential for timber harvest on public and private lands, and the potential for future development in low-lying areas, hydrologic conditions in this subwatershed are predicted to remain impaired over the next 20 years, with increasing sources of degradation. It is important to note, however, that while local conditions may continue to degrade, the watershed level hydrologic conditions will be driven by the cumulative conditions in the remainder of the watershed.

10.7.2.2 Sediment

While the natural erodability of the Kalama River watershed is relatively low (ranging from 3 to 21 on a scale of 0-126), the combination of historical and current land uses contribute to widespread impairment in sediment processes in the watershed. State and federal forest practice regulations have led to a reduction of sediment delivery over the past decade, and a general improvement in sediment conditions in the Kalama mainstem. Future trends in sediment conditions throughout the watershed are predicted to be generally stable, with some gradual improvement. High road densities and the likelihood of regular timber harvest rotations will be an ongoing source of sediment loading to stream channels, but these impacts will be reduced in the future as the influence of more effective forestry and road management practices expands.

It is important to note that IWA results do not necessarily represent the influence of catastrophic events on sediment conditions. For example, mass wasting problems identified in Wild Horse Creek (40401) and Gobar Creek (40402) are known to contribute to sediment loading in these drainages and in downstream areas. The low percentage of mature forest coverage (16-35%) and high road densities in these subwatersheds increases the potential for erosion and mass-wasting associated with large rain-on-snow events such as occurred in 1996.

Sediment delivery to the lower Kalama mainstem is dependent upon the cumulative actions in the Kalama watershed as well as channelization and development of the floodplain for agriculture, residential, and industrial uses. The increase growth pressures along the I-5 corridor suggest an upward trend in road density, expansion of urbanization, and reduced agriculture. Sediment delivery to this portion of the watershed is of particular interest because bar formation at the river mouth may present a barrier to fish passage at some times of the year. Sediment conditions in this area of the watershed are predicted to trend towards gradual improvement as conditions improve in upstream areas of the watershed. These gains may be offset if significant development of the floodplain and adjacent areas of the lower river continues to occur.

10.7.2.3 Riparian

Riparian conditions throughout the middle and upper Kalama River watershed are expected to trend towards gradual improvement in most areas over the next 20 years as natural recovery of vegetation progresses. Vegetation recovery may be impeded along the mainstem and adjacent to some tributaries where residential development and streamside roads are present.

The lower Kalama River mainstem and tributaries pose a more complex problem. Almost the entire floodplain of the lower Kalama River has been disconnected from the river by the construction of dikes and levees. Channelization in these downstream subwatersheds limits the potential for riparian recovery. In addition, development pressure along the I-5 corridor is expected to grow. Collectively, these forces are expected to result in a trend towards continuing degradation of riparian vegetation over the next 20 years.

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Volume II, Chapter 11
Lewis River Subbasin—Lower North Fork

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11.0 Lewis River Subbasin—Lower North Fork

11.1 Subbasin Description

11.1.1 Topography & Geology

For the purposes of this assessment, the Lower North Fork Lewis basin extends from the mouth to Merwin Dam, excluding the East Fork Lewis drainage, which is covered in a separate section. Below Merwin Dam, the Lewis River flows generally west/southwest, forming the border of Cowlitz and Clark Counties. The Lewis enters the Columbia at RM 87, a few miles southwest of Woodland, Washington. The Lower Lewis drainage encompasses approximately 65,464 acres (102 mi^2).

The lower 12 miles of the mainstem flow through a broad alluvial valley characterized by agriculture and residential uses. This section is extensively channelized. Tidal influence extends to approximately RM 11. The valley narrows above RM 12 and forms a canyon between the confluence of Cedar Creek (RM 15.7) and Merwin Dam (RM 19.5). The 240-foot high Merwin Dam, completed in 1931, presents a passage barrier to all anadromous fish, blocking up to 80% of the historically available habitat. Major tributaries to the Lower Lewis include the EF Lewis, Johnson Creek, and Cedar Creek. Cedar Creek provides some of the most productive anadromous fish habitat in the North Fork basin.

The Lewis basin has developed from volcanic, glacial, and erosional processes. Mount St. Helens and Mt. Adams have been a source of volcanic material as far back as 400,000 years ago. More recent volcanic activity, including pyroclastic flows and lahars, have given rise to the current landscape. Oversteepened slopes as a result of glaciation, combined with the abundance of ash, pumice, and weathered pyroclastic material, have created a relatively high potential for surface erosion throughout the basin (USFS).

11.1.2 Climate

The climate is typified by mild, wet winters and warm, dry summers. Average annual precipitation is 73 inches at Merwin Dam and 52 inches at Battle Ground, WA (East Fork Lewis) (WRCC 2003). Most of the precipitation falls as rain between November and March.

11.1.3 Land Use/Land Cover

The bulk of the land is forested and a large percentage is managed as commercial forest. Agriculture and residential activities are found in valley bottom areas. Recreation uses and residential development have increased in recent years. The population of the basin is small. The year 2000 population was approximately 14,300 persons (LCFRB 2001). Small rural communities include Chelatchie and Amboy (Cedar Creek drainage). The largest population center is Woodland, which is situated on the lower mainstem. The majority of the basin is forested, except for valley bottom areas, which are dominated by residential and agricultural uses. Stand replacement fires, which burned large portions of the basin between 1902 and 1952, have had lasting effects on basin hydrology, sediment transport, soil conditions, and riparian function. The largest of these was the Yacolt Burn in 1902. Subsequent fires followed in 1927 and 1929. Severe flooding in 1931 and 1934 likely was exacerbated by the effect of the fires on vegetation and soils. A breakdown of land ownership and land cover is included in Figure 11-1 and Figure 11-2. Figure 11-3 displays the pattern of landownership for the basin. Figure 11-4 displays the pattern of land cover / land-use.

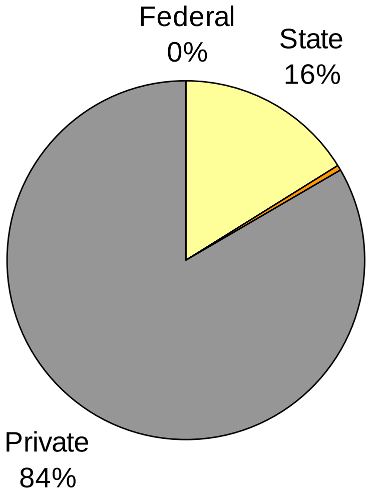


Figure 11-1. Lower North Fork Lewis River basin land ownership

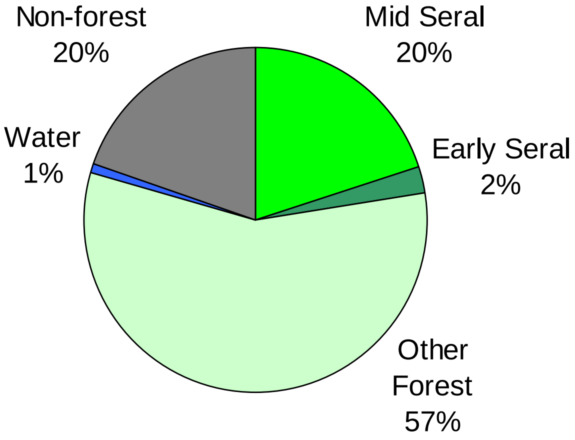


Figure 11-2. Lower North Fork Lewis River basin land cover

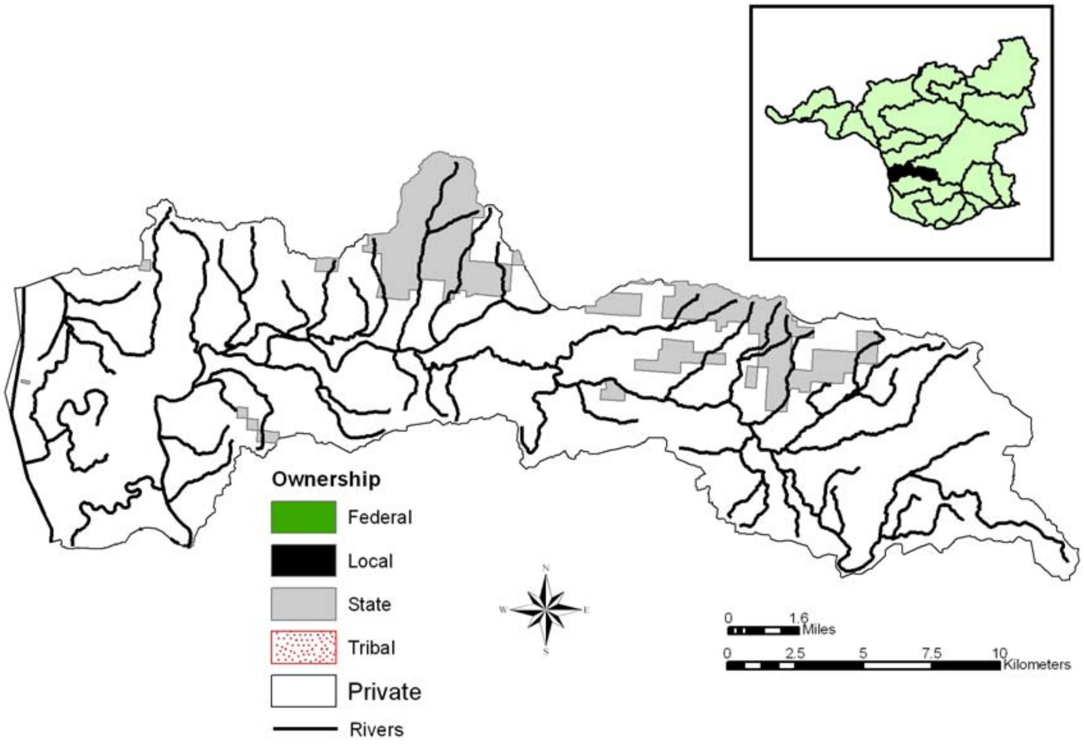


Figure 11-3. Landownership within the Lower North Fork Lewis watershed. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

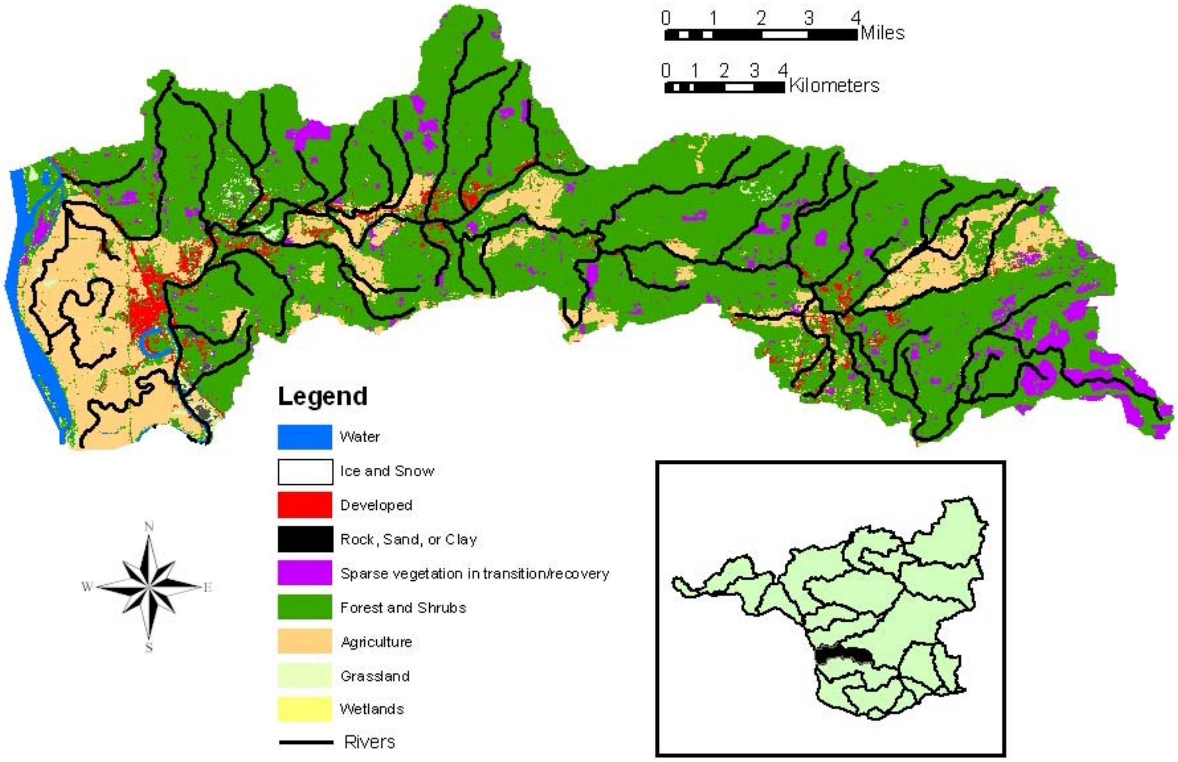
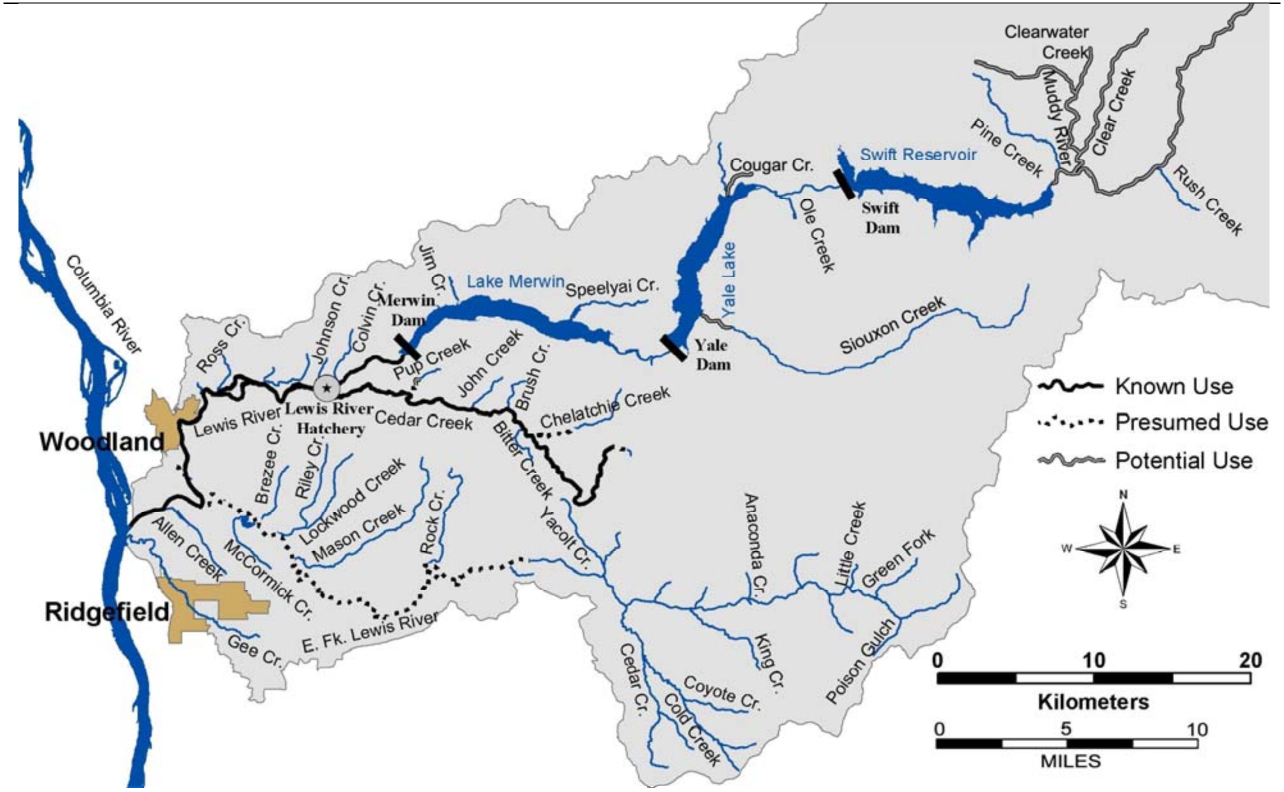


Figure 11-4. Land cover within the Lower North Fork Watershed. Data was obtained from the USGS National Land Cover Dataset (NLCD).

11.2 Focal Fish Species

11.2.1 Spring Chinook—Lewis Subbasin

ESA: Threatened 1999 **SASSI: Depressed 2002**

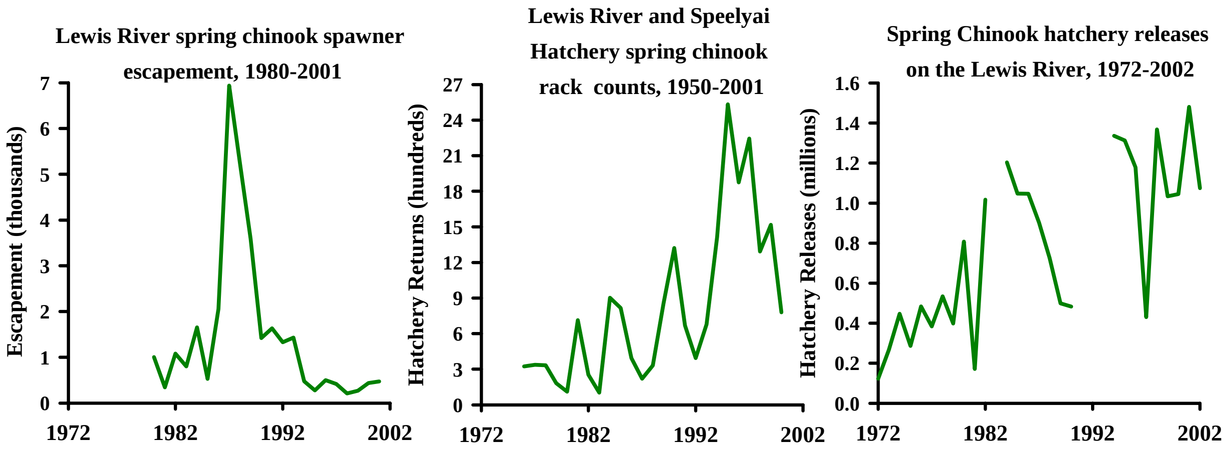


Distribution

- Historically, spring chinook were found primarily in the upper basin; construction of Merwin Dam (RM 19) in 1931 blocked access to most of the spawning areas
- Currently, natural spawning occurs in the North Fork mainstem Lewis River between Merwin Dam and the Lewis River Hatchery (~4 miles)

Life History

- Spring chinook enter the Lewis River from March through June
- Spawning in the Lewis River occurs between late August and early October, with peak activity in mid-September
- Age ranges from 2-year-old jacks to 6-year-old adults, with 4- and 5-year olds usually the dominant age class (averages are 54.5% and 36.8%, respectively)
- Fry emerge between December and January, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts



Lewis River spring chinook spawner escapement, 1980-2001

Lewis River and Speelyai Hatchery spring chinook rack counts, 1950-2001

Spring Chinook hatchery releases on the Lewis River, 1972-2002

Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit (ESU)
- The Lewis spring chinook stock designated based on distinct spawning distribution and spawning timing
- Genetic analysis of the NF Lewis River Hatchery spring chinook determined they were genetically similar to, but different from, Kalama and Cowlitz hatchery spring chinook stocks and significantly different from other Columbia River spring chinook

Abundance

- Reported abundance by WDF and WDF (Smoker et al 1951) indicates that at least 3,000 spring chinook entered the upper Lewis prior to the completion of Merwin Dam in 1932
- By the 1950s, only remnant (<100) spring chinook runs existed on the Lewis
- North Lewis River spawning escapements below Merwin Dam from 1980-2001 ranged from 213 to 6,939
- Native component of the stock may have been extirpated and replaced by introduced hatchery stocks; hatchery strays account for most spring chinook spawning in the North Lewis River

Productivity & Persistence

- NMFS Status Assessment for the Lewis River spring chinook indicated a 0.36 risk of 90% decline in 25 years and a 0.49 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.2
- Juvenile production from natural spawning below Merwin Dam is presumed to be low
- The Current Merwin Dam mitigation goal is to 12,800 spring chinook adults annually

Hatchery

- Lewis River Salmon Hatchery is located about RM 15 (completed in 1930.
- Spring chinook eggs were collected for hatchery production beginning in 1926; spring chinook releases into the Lewis from 1972-1990 averaged 601,184
- The hatchery has reared eggs from outside sources, primarily from the Cowlitz, but a few years in the 1970s there were fish transferred from Klickitat and Carson hatcheries

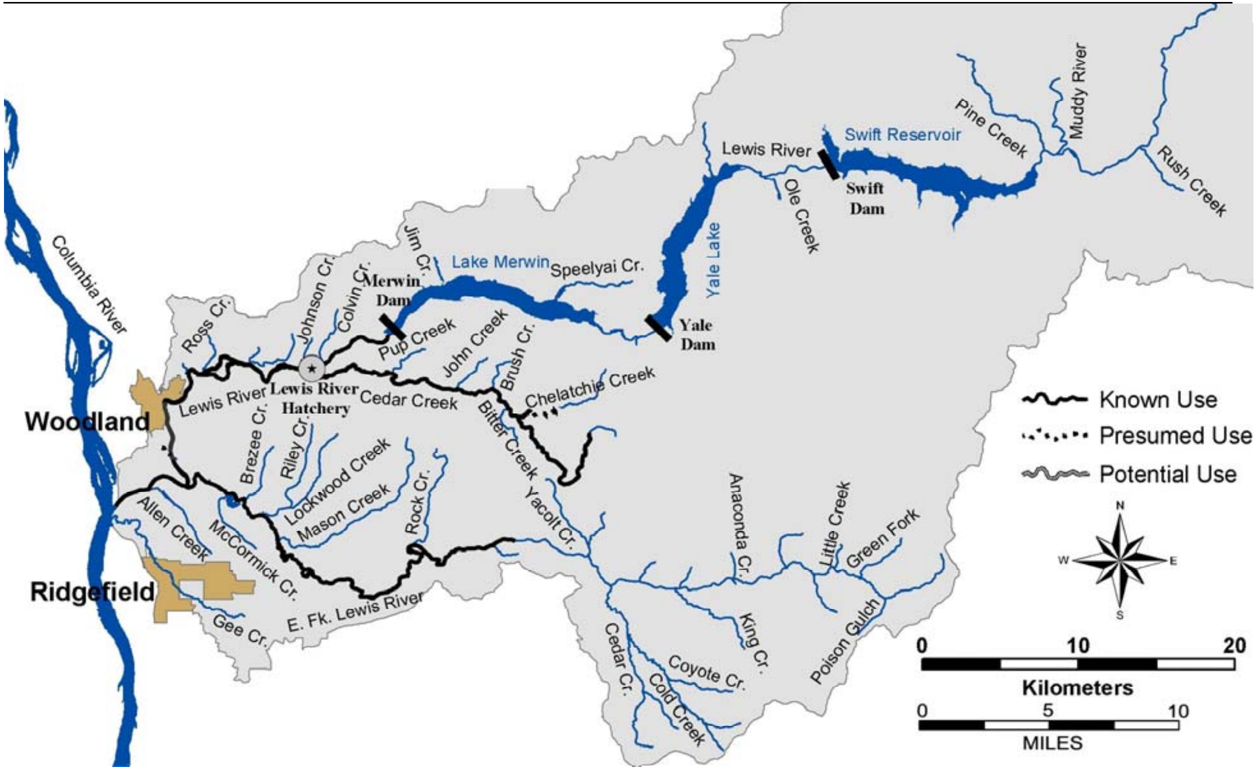
- Spring chinook broodstock return to the Lewis River Hatchery and are also trapped at Merwin Dam; a significant part of the annual return is not trapped and spawns naturally in the river below Merwin Dam

Harvest

- Spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- CWT data analysis of the 1989-1994 brood years indicates that 54% of the Lewis spring chinook were harvested and 46% escaped to spawn
- Fishery recoveries of the 1989-1994 brook Lewis River Hatchery spring chinook: Lewis sport (69%), Alaska (11%), British Columbia (10%), Washington Coast (5%), Columbia River (4%), and Oregon coast (1%)
- Mainstem Columbia River harvest of Lewis spring chinook was substantially reduced after 1977 when April and May spring chinook seasons were eliminated to protect upper Columbia and Snake wild spring chinook.
- Mainstem Columbia harvest of Lewis River Hatchery spring chinook increased during 2001-2002 when selective fisheries for adipose marked hatchery fish enabled mainstem spring fishing in April and in May, 2002)
- Sport harvest in the Lewis River averaged 4,600 from 1980-1994 and 900 during 1995-2002
- Tributary harvest is managed to attain the Lewis hatchery adult broodstock escapement goal

11.2.2 Fall Chinook—Lewis Subbasin

ESA: Threatened 1999	**SASSI: Healthy 2002**



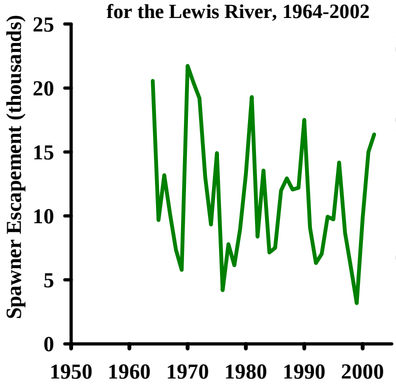
Distribution

- Spawning occurs primarily in the NF Lewis River between Merwin Dam and the Lewis River Salmon Hatchery (~4 miles); some spawning has been observed in Cedar Creek
- Construction of Merwin Dam eliminated approximately half the fall chinook spawning habitat in the North Fork, which historically extended up to the Yale Dam site

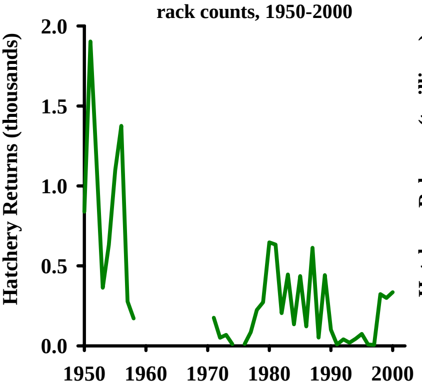
Life History

- Only stock in lower Columbia River to maintain a healthy wild population with negligible hatchery influence
- Lewis River wild fall chinook enter the Columbia River from August through October; they have a broader migration time than other lower Columbia fall chinook stocks
- Lewis River entry occurs in September and October
- Natural spawning in the NF Lewis River occurs between lateOctober and January and peaks in mid-November
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult age of 4 and significant numbers of age 5
- Fry emerge from March to August (peak usually in April), depending on time of egg deposition and water temperature; fry spend the spring/early summer in fresh water, and emigrate in the summer as sub-yearlings

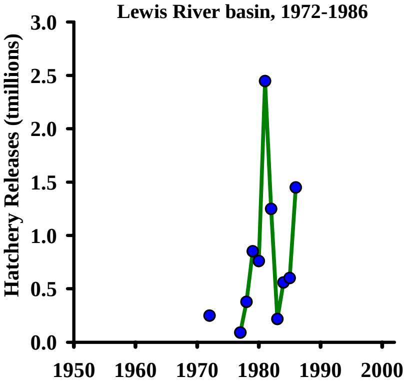
Fall chinook spawner escapement estimates for the Lewis River, 1964-2002



Fall chinook Lewis River Salmon Hatchery rack counts, 1950-2000



Fall chinook hatchery releases in the Lewis River basin, 1972-1986



Diversity

- Late spawners in the North Fork and EF Lewis are considered a lower river wild stock within the Lower Columbia River ESU
- The Lewis River fall chinook stock designated based on distinct spawning timing, spawning distribution, and appearance
- Genetic analysis of NF Lewis River fall chinook in 1990 indicated they are genetically distinct from other Columbia River fall chinook stocks, except EF Lewis and Washougal fall chinook
- Natural escapement to the NF Lewis River comprises about 85% of the lower Columbia River wild fall chinook management stock, the remaining 15% are produced in the EF Lewis and the Sandy River in Oregon

Abundance

- Fall chinook escapement estimates by WDFW in 1951 were 5,000 adults into the Lewis River
- NF Lewis River spawning escapements from 1964-2001 ranged from 3,184 to 21,726 (average 11,232)
- North Fork Lewis escapement goal of 5,700 fish is usually exceeded

Productivity & Persistence

- WDF estimated the number of natural juvenile fall chinook emigrating from the Lewis River during 1977-79 and 1982-87 ranged from 1,540,000 to 4,650,000
- WDF demonstrated a strong relationship between spring flows at Merwin Dam and the number of juvenile fall chinook smolts produced
- Minimum flows for fall chinook spawning and rearing are included in the current hydro operations license
- NMFS Status Assessment for the Lewis River late-fall chinook indicated a 0.05 risk of 90% decline in 25 years, a 0.19 risk of 90% decline in 50 years, and a 0.0 risk of extinction in 50 years

Hatchery

- Lewis River Salmon Hatchery (completed in 1932) is located about RM 15; the Merwin Dam collection facility (completed in 1932) is located about RM 19
- Speelyai Hatchery (completed in 1958) is located on Speelyai Bay in Lake Merwin

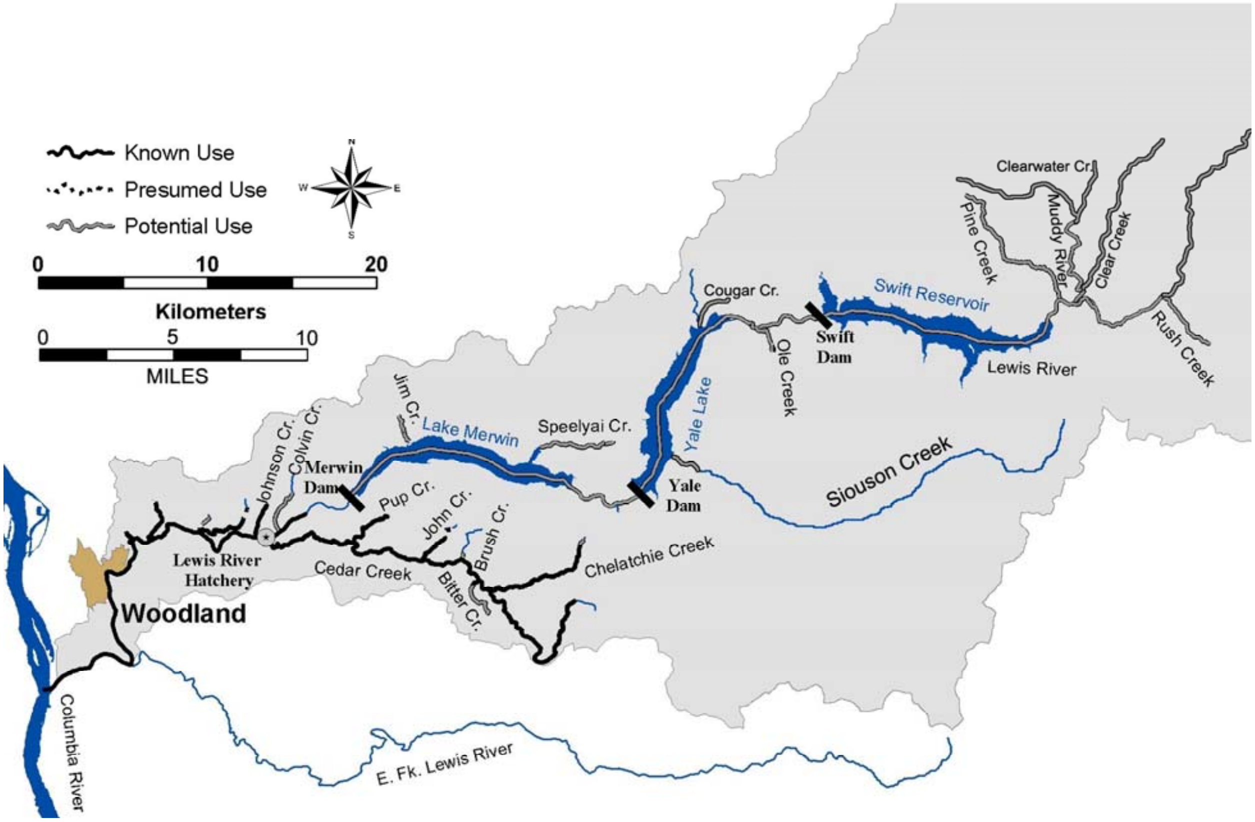
- Merwin Hatchery (completed in 1983) is located about RM 19
- Hatchery releases of fall chinook from the Lewis River Salmon Hatchery began from fish trapped at Merwin Dam collection facility in 1932; annual fall chinook releases ranged from 0 in the late 1960s and early 1970s to 3 million in 1965
- Hatchery releases were discontinued in 1986 to eliminate interactions with a healthy wild fall chinook population

Harvest

- Lewis River wild fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial gill net and sport fisheries
- A portion of the Lewis River wild fall chinook juveniles were captured, marked, and tagged from 1977-80 currently by WDFW and PacifiCor from 1983 to present
- Lewis River wild fall chinook distribute more northerly in the ocean than tule fall chinook, with the primary ocean harvest in British Columbia
- Lewis River wild fall chinook are also an important sport fish in the mainstem Columbia and in the Lewis River
- Lewis River chinook enter the Columbia River over a broader period of time than tule chinook and therefore are harvested in both September and October commercial fisheries
- Harvest is variable dependent on management response to annual abundance in Pacific Salmon Commission (PSC) (US/Canada), Pacific Fisheries Management Council (PFMC) (US ocean), and Columbia River Compact forums
- Total harvest is constrained by ESA limits on Snake and Coweeman wild fall chinook, Pacific Salmon Treaty agreements with Canada, and the Lewis spawning escapement goal
- Columbia River Fisheries are managed to attain a spawning escapement goal of 5,700 adults
- CWT analysis of pre 1991 broods indicate a 49% harvest rate while more recent broods (1991-94) indicate a reduced harvest rate of 28%
- Fishery recoveries of 1977-79 and 1982-84 broods were distributed between Columbia River (45%), British Columbia (31%), Alaska (13%), and Washington/Oregon ocean (10%) sampling areas
- Sport harvest in the mainstem and NF Lewis River averaged 1,400 fall chinook annually from 1980-1998

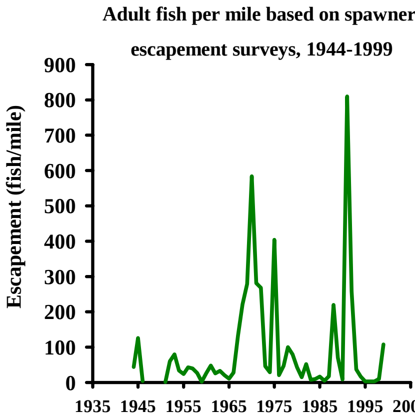
11.2.3 Coho—Lewis Subbasin (North Fork)

ESA: Candidate 1995 **SASSI: Unknown 2002**

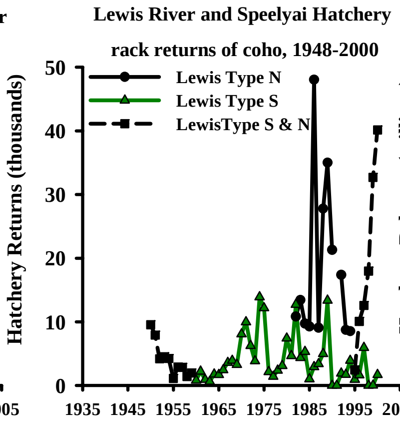


Distribution

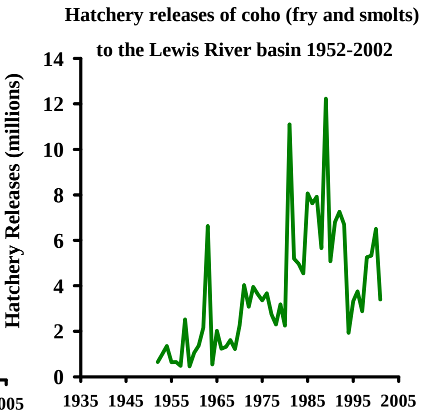
- Managers refer to early coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late coho as Type N due to their ocean distribution generally north of the Columbia River
- Coho historically spawned throughout the basin.
- Natural spawning is thought to occur in most areas accessible to coho; coho currently spawn in the North Lewis tributaries below Merwin Dam including Ross, Cedar, NF and SF Chelatchie, Johnson, and Colvin Creeks; Cedar Creek is the most utilized stream on the mainstem
- Construction of Merwin Dam was completed in 1932; coho adults were trapped and passed above Merwin Dam from 1932-1957; the transportation of coho ended after the completion of Yale Dam (1953) and just prior to completion of Swift Dam (1959)
- As part of the current hydro re-licensing process, reintroduction of coho into habitat upstream of the three dams (Merwin, Yale, and Swift) is being evaluated



Adult fish per mile based on spawner escapement surveys, 1944-1999



Lewis River and Speelyai Hatchery rack returns of coho, 1948-2000



Hatchery releases of coho (fry and smolts) to the Lewis River basin 1952-2002

Life History

- Adults enter the Columbia River from August through January (early stock primarily from mid-August through September and late stock primarily from late September through November)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Late stock coho (or Type N) were historically present in the Lewis basin with spawning occurring from late November into March
- Early stock coho (or Type S) were historically present in the Lewis basin with spawning occurring from late October to November
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance

- Lewis River wild coho run is a fraction of its historical size
- An escapement survey in the late 1930s observed 7,919 coho in the North Fork
- In 1951, WDF estimated coho escapement to the basin was 10,000 fish in the North Fork (primarily early run)
- Escapement surveys from 1944-1999 on the North and South Fork Chelatchie, Johnson, and Cedar Creeks documented a range of 1-584 fish/mile
- Hatchery production accounts for most coho returning to the Lewis River

Productivity & Persistence

- Natural coho production is presumed to be generally low in most tributaries
- A smolt trap at lower Cedar Creek has shown recent year coho production to be fair to good in North and South forks of Chelatchie Creek (tributary of Cedar Creek) and in mainstem Cedar Creek

Hatchery

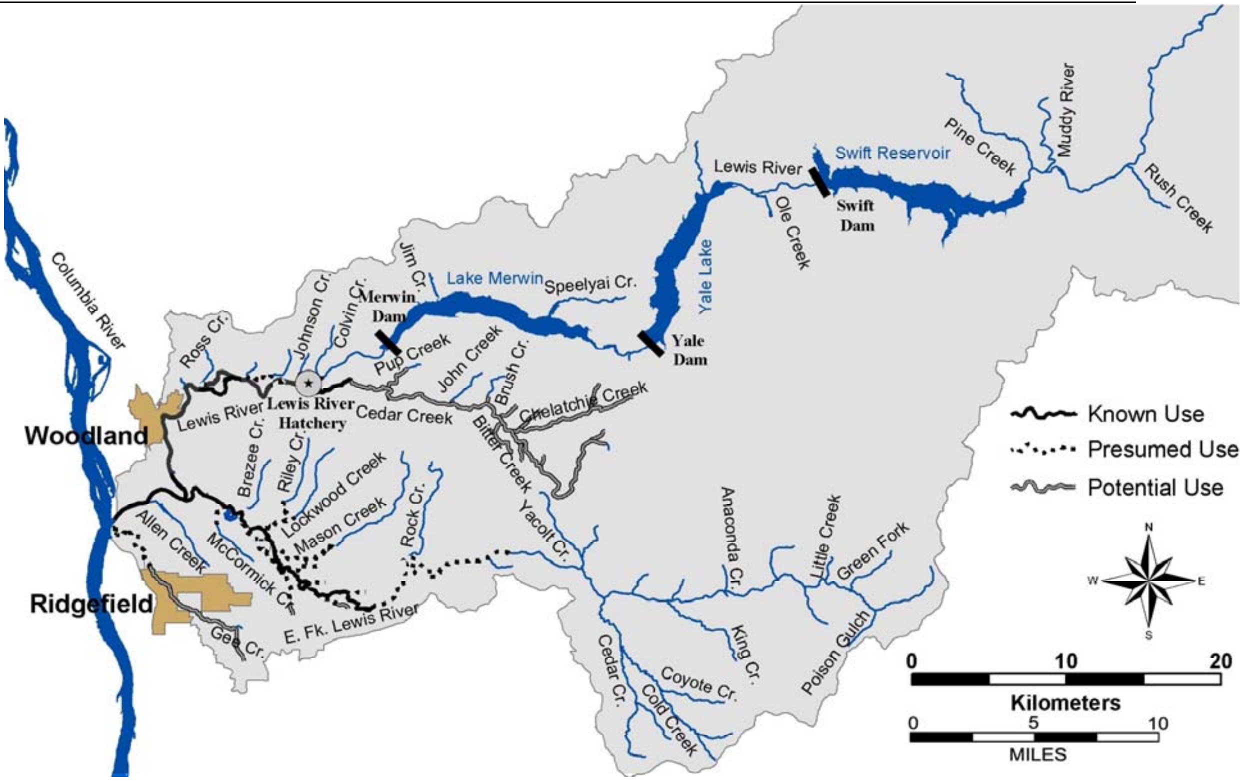
- The Lewis River Hatchery (completed in 1932) is located about RM 13; the Merwin Dam collection facility (completed in 1932) is located about RM 17; Speelyai Hatchery (completed in 1958) is located in Merwin Reservoir at Speelyai Bay; these hatcheries produce early and late stock coho and spring chinook
- Merwin Hatchery (completed in 1983) is located at RM 17 and rears steelhead, trout, and kokanee
- Coho have been planted in the Lewis basin since 1930; extensive hatchery coho releases have occurred since 1967
- The current Lewis and Speelyai hatchery programs include 880,000 early coho and 815,000 late coho smolts reared and released annually

Harvest

- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 3,500 coho (1980-98) were harvested annually in the North Lewis River sport fishery
- CWT data analysis of the 1995-97 brood early coho released from Lewis River hatchery indicates 15% were captured in a fishery and 85% were accounted for in escapement
- CWT data analysis of the 1995-97 late coho released from Lewis River Hatchery indicates 42% were captured in a fishery and 58% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 brood Lewis early coho were distributed between Washington ocean (58%), Columbia River (21%), and Oregon ocean (21%) sampling areas
- Fishery CWT recoveries of 1995-97 brood Lewis late coho were distributed between Columbia River (56%), Washington coast (31%), and Oregon ocean (21%) sampling areas

11.2.4 Chum—Lewis Subbasin

ESA: Threatened 1999	SASSI: NA



Distribution

- Spawning occurs in the lower reaches of the mainstem NF and EF Lewis River.
- Historically, chum salmon were common in the lower Lewis and were reported to ascent to the mainstem above the Merwin Dam site and spawn in the reservoir area
- Chum were also abundant in Cedar Creek, with at least 1,000 annual spawners (Smoker et al 1951)

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts, generally from March to mid-May

Abundance

- 1951 report estimated escapement of approximately 3,000 chum annually in the mainstem Lewis and East Fork and 1,000 in Cedar Creek
- 96 chum observed spawning downstream of Merwin Dam in 1955
- In 1973, spawning population of both the Lewis and Kalama subbasins estimated at only a few hundred fish
- Annually, 3-4 adult chum are captured at the Merwin Dam fish trap

Productivity & Persistence

- Harvest, habitat degradation, and construction of Merwin, Yale, and Swift Dams contributed to decreased productivity
- WDFW consistently observed chum production in the North Lewis in March-May, 1977-1979 during wild chinook seining operations

Hatchery

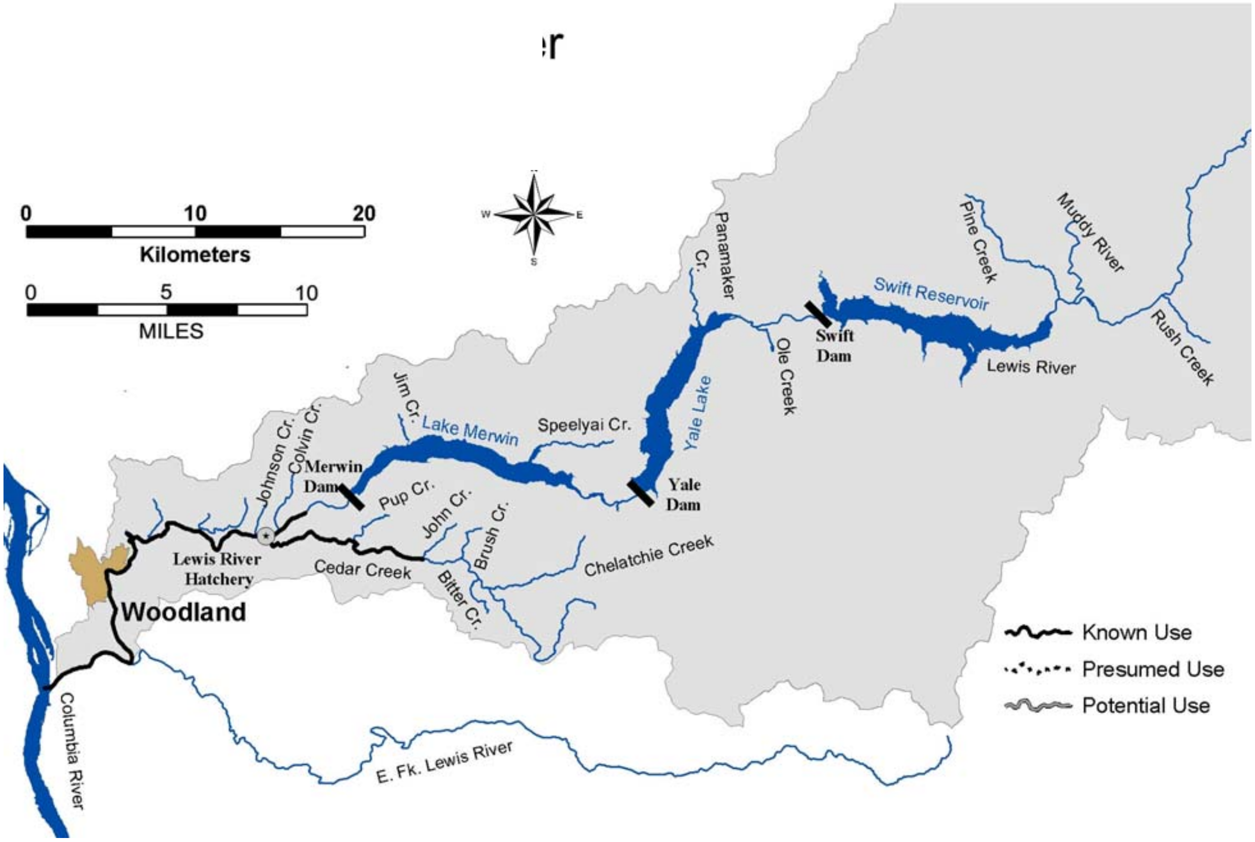
- Chum salmon have not been produced/released in the Lewis River

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less than 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less than 5% of the annual return

11.2.5 Summer Steelhead—Lewis Subbasin (North Fork)

ESA: Threatened 1998 **SASSI: Unknown 2002**

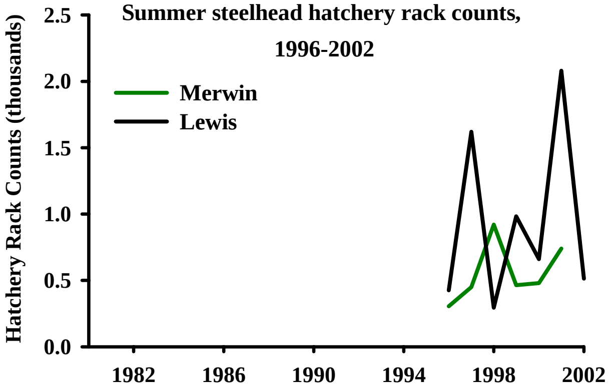


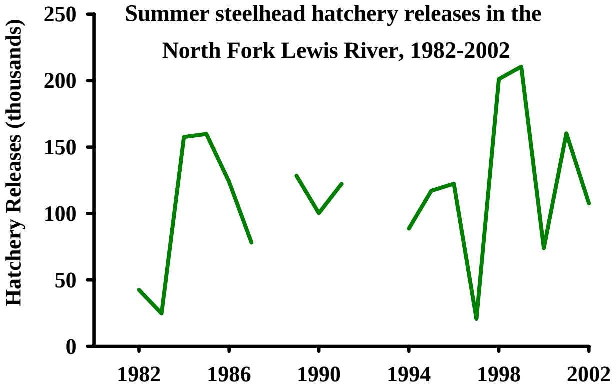
Distribution

- Spawning occurs in the NF Lewis River downstream of Merwin Dam and throughout the tributaries; natural spawning is concentrated in Cedar Creek
- Construction of Merwin Dam in 1929 blocked upstream migration; Most summer steelhead habitat above the Merwin Dam site is contained in Merwin Reservoir tributaries
- Current distribution on the NF Lewis River is from approximately RM 7 to RM 20; a dam located on Cedar Creek was removed in 1946, providing access to habitat throughout this tributary

Life History

- Adult migration timing for NF Lewis River summer steelhead is from May through November
- Spawning timing on the NF Lewis River is generally from early March through early June
- Age composition data are not available for NF Lewis River summer steelhead
- Wild steelhead fry emerge from late April through July; juveniles generally rear in fresh water for two years; juvenile emigration occurs from March to May, with peak migration in early May


Summer steelhead hatchery rack counts, 1996-2002


Summer steelhead hatchery releases in the North Fork Lewis River, 1982-2002

Diversity

- Stock designated based on distinct spawning distribution and run timing
- Progeny from Elochoman, Chambers Creek, Cowlitz, and Skamania Hatcheries have been planted in the Lewis basin; interbreeding among wild and hatchery stocks has not been measured
- After Mt. St. Helens 1980 eruption, straying Cowlitz River steelhead may have spawned with native Lewis River stocks

Abundance

- From 1925-1933, run size was estimated at 4,000 summer steelhead
- In 1936, steelhead were reported in the Lewis River during escapement surveys
- From 1963-1967, run size estimates averaged 6,500 summer steelhead
- Wild summer steelhead escapement to the NF Lewis River was estimated at less than 50 fish in 1984
- Hatchery rack counts for summer steelhead are available from Lewis River and Merwin Hatcheries from 1996-2002
- WDFW indicated that wild summer steelhead account for less than 7% of the total North Fork run

Productivity & Persistence

- Wild fish production is believed to be low

Hatchery

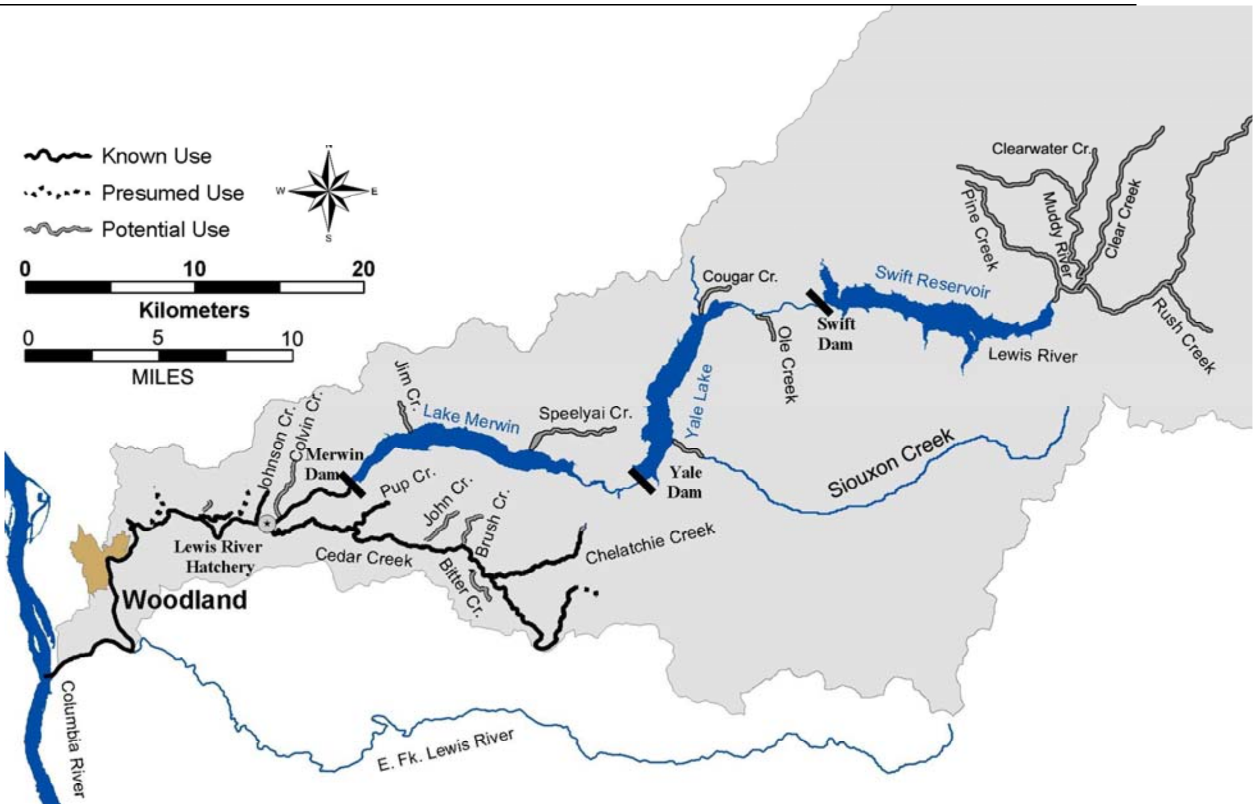
- The Lewis River Hatchery (about 4 miles downstream of Merwin Dam) and Speelyai Hatchery (Speelyai Creek in Merwin Reservoir) do not produce summer steelhead
- In the early 1990s, the Ariel (Merwin) Hatchery (for steelhead and trout) was constructed below Merwin Dam
- A net pen system has been in operation on Merwin Reservoir since 1979; annual average smolt production has been 60,000 summer steelhead; release data are displayed from 1982-2002

Harvest

- No directed fisheries target NF Lewis River summer steelhead; incidental mortality currently occurs during the Columbia River fall commercial and summer sport fisheries
- Summer steelhead sport harvest (wild and hatchery) in the Lewis River basin from 1980-1989 ranged from 3,001 to 8,700; historically, more fish in the sport fishery were caught in the East Fork but currently North Fork harvest exceed West Fork harvest; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild summer steelhead in the mainstem Columbia River and in the Lewis River

11.2.6 Winter Steelhead—Lewis Subbasin (North Fork)

ESA: Threatened 1998 **SASSI: Unknown 2002**

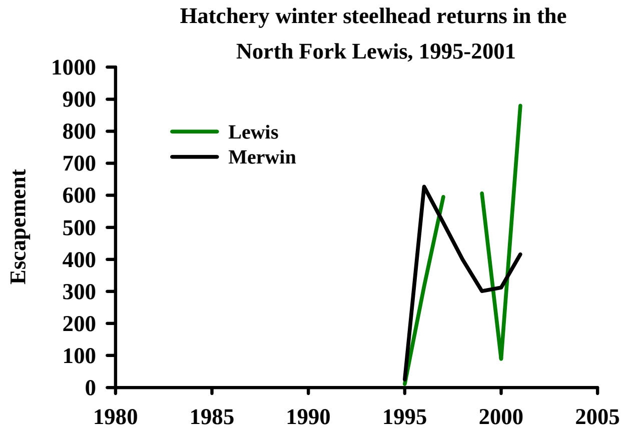


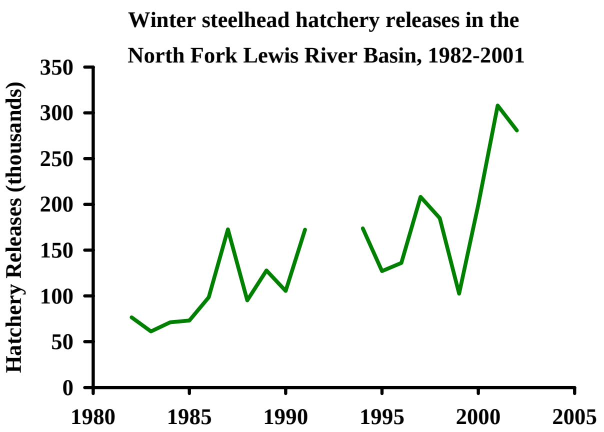
Distribution

- Spawning occurs in the NF Lewis River downstream of Merwin Dam and throughout the tributaries; natural spawning is concentrated in Cedar Creek
- Construction of Merwin Dam in 1929 blocked all upstream migration; approximately 80% of the spawning and rearing habitat are not accessible; a dam located on Cedar Creek was removed in 1946, providing access to habitat throughout this tributary

Life History

- Adult migration timing for NF Lewis winter steelhead is from December through April
- Spawning timing on the NF Lewis is generally from early March to early June
- Limited age composition data for Lewis River winter steelhead suggest that most steelhead are two-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May





Diversity

- Mainstem/NF Lewis winter steelhead stock designated based on distinct spawning distribution and run timing
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead likely spawned with native Lewis stocks
- Allele frequency analysis of NF Lewis winter steelhead in 1996 was unable to determine the distinctiveness of this stock compared to other lower Columbia steelhead stocks

Abundance

- Recent analysis for re-license estimate historical abundance ranging from 5,100-10,000 annually for upper Lewis above Merwin Dam
- In 1936, steelhead were reported in the Lewis River during escapement surveys
- Wild winter steelhead escapement counts for the NF Lewis River are not available
- Escapement goal for the NF Lewis River is 698 wild adult steelhead
- Hatchery origin fish comprise most of the winter steelhead run on the NF Lewis
- WDF estimated that only 6% of the returning winter steelhead in the NF are wild fish

Productivity & Persistence

- Winter steelhead natural production is expected to be low and primarily in Cedar Creek

Hatchery

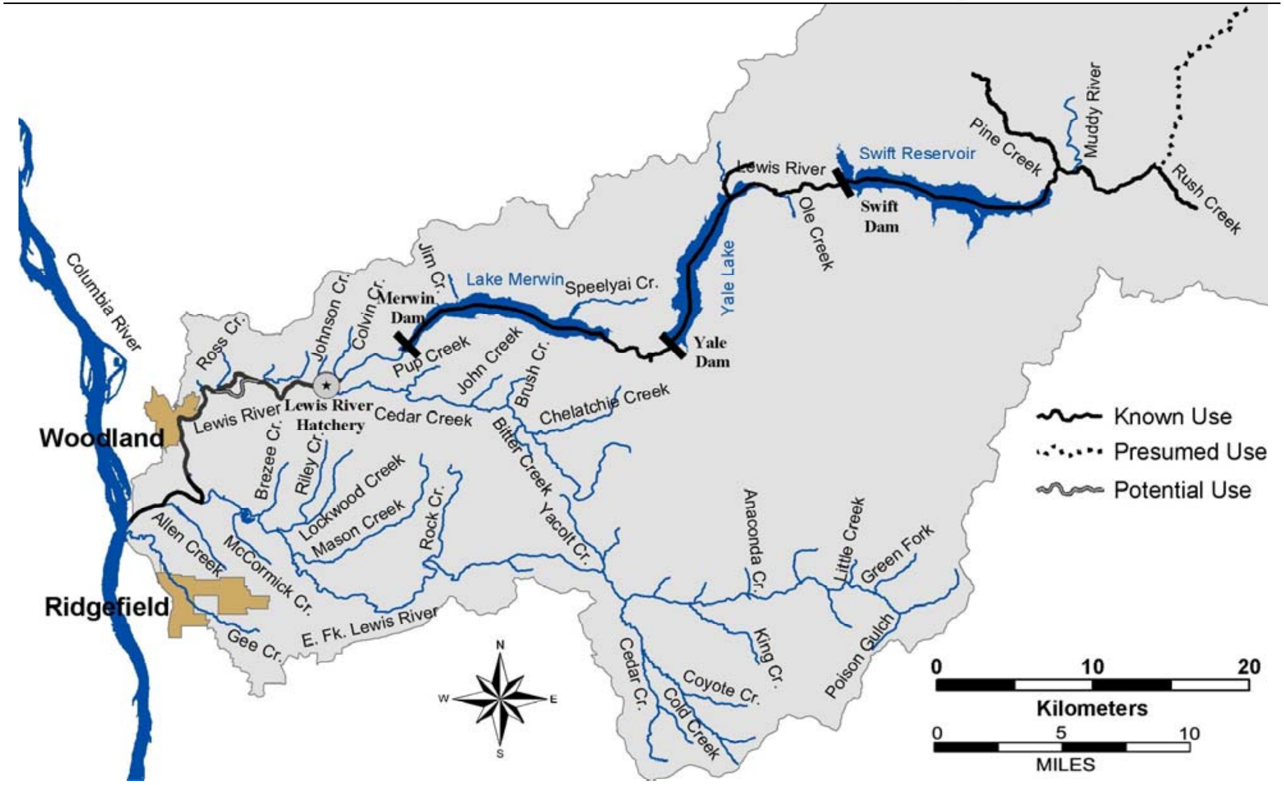
- The Lewis River Hatchery (about 4 miles downstream of Merwin Dam) and Speelyai Hatchery (Speelyai Creek in Merwin Reservoir) do not produce winter steelhead
- The Ariel (Merwin) Hatchery is located below Merwin Dam; the hatchery has been releasing winter steelhead in the Lewis basin since the early 1990s
- A net pen system has been in operation on Merwin Reservoir since 1979; annual average smolt production has been 35,000 winter steelhead; total release data are available from 1982-2001
- Hatchery fish contribute little to natural winter steelhead production in the NF Lewis River

Harvest

- No directed commercial or tribal fisheries target NF Lewis winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Lewis River basin
- Winter steelhead sport harvest (hatchery and wild) in the NF Lewis River averaged 300 fish during the 1960s and 1970s; average annual harvest in the 1980s averaged 1,577; since 1992, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in the Lewis River

11.2.7 Bull Trout—Lewis River Subbasin

ESA: Threatened 1999 **SASSI: Depressed 1998**



Distribution

- The reservoir populations are isolated because there is no upstream passage at the dams

Life History

- Prior to dam construction anadromous and fluvial (rivers) forms were likely present

Diversity

- Genetic sampling in 1995 and 1996 showed that Lewis River bull trout are similar to Columbia River populations
- Swift samples were significantly different from Yale and Merwin samples, indicating that there may have been biological separation of upper and lower Lewis River stocks before construction of Swift Dam in 1958
- Stock designated based on geographic distribution

Abundance

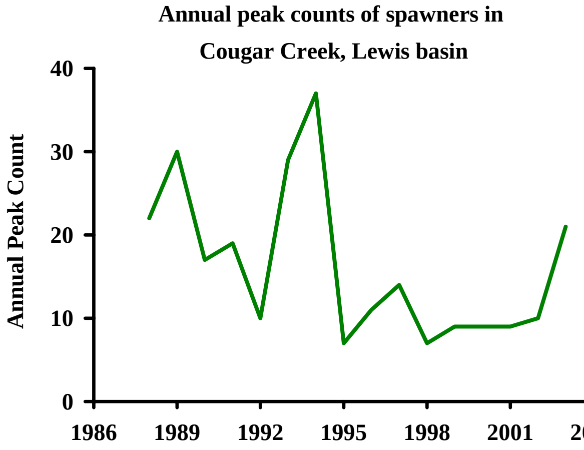
- No information on bull trout abundance in the lower NF Lewis is available

Productivity & Persistence

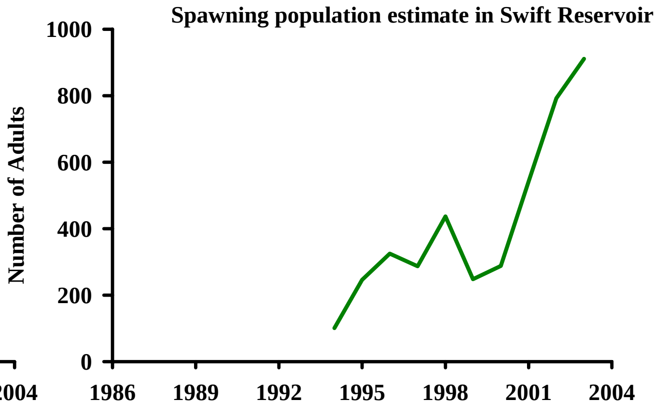
- WDFW (1998) considers Lewis River bull trout to be at moderate risk of extinction

Hatchery

- Three hatcheries exist in the subbasin: two below Merwin Dam, and one on the north shore of Merwin Reservoir. Bull trout are not produced in the hatcheries



Annual peak counts of spawners in Cougar Creek, Lewis basin



Spawning population estimate in Swift Reservoir

Harvest

- Fishing for bull trout has been closed since 1992
- Hooking mortality from catch and release of bull trout in recreational fisheries targeting other species may occur

11.2.8 Cutthroat Trout—Lewis River Subbasin

ESA: Not Listed	**SASSI: Unknown 2000**

Distribution

- Anadromous forms exist in the NF Lewis and its tributaries up to Merwin Dam, which blocks passage
- Adfluvial fish have been observed in Merwin, Yale and Swift Reservoirs
- Resident fish are found in tributaries throughout the North and East Fork basins

Life History

- Anadromous, fluvial, adfluvial and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Fluvial, adfluvial and resident spawn timing is from February through June

Diversity

- Distinct stock based on geographic distribution of spawning areas
- Genetic analysis has shows Lewis River cutthroat to be genetically distinct from other lower Columbia coastal cutthroat collections

Abundance

- Insufficient data exist to identify trends in survival or abundance
- No data describing run size exist
- In 1998, sea-run cutthroat creel survey results showed a catch of only 20 fish
- Fish population surveys in Yale Lake tributaries showed that cutthroat trout was the most abundant salmonid species in those streams
- Cutthroat were the only salmonid found in some small Yale Lake tributaries during sampling in 1996

Hatchery

- Prior to 1999 Merwin Hatchery annually released 25,000 sea-run smolts into the NF Lewis
- The program was discontinued in 1999 due to low creel returns and concerns over potential interaction with wild fish

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest of adipose fin clipped cutthroat occurs in the mainstem Columbia downstream of the Lewis River
- Lewis River wild cutthroat (unmarked fish) must be releases in mainstem Columbia and in Lewis River sport fisheries

11.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- In general, loss of habitat quantity and quality has the highest relative impact on populations in the lower North Fork, while hydrosystem access and passage impacts are greatest for those populations that historically utilized the upper NF Lewis (i.e. winter steelhead and coho). Thus, for populations in the upper NF Lewis basin, the impact of hydrosystem access and passage minimizes the relative importance of all other potentially manageable impact factors.
- Loss of estuary habitat quantity and quality has high relative impacts on chum and moderate impacts on fall chinook and late fall chinook.
- Harvest has relatively high impacts on fall chinook and late fall chinook, while harvest impacts to spring chinook, chum, winter steelhead, and coho are relatively minor.
- Hatchery impacts are high to moderate for late fall chinook, spring chinook, winter steelhead and coho. Hatchery impacts on chum and fall chinook are relatively low.
- Impacts of predation are moderately important to coho, but are relatively minor for all populations.

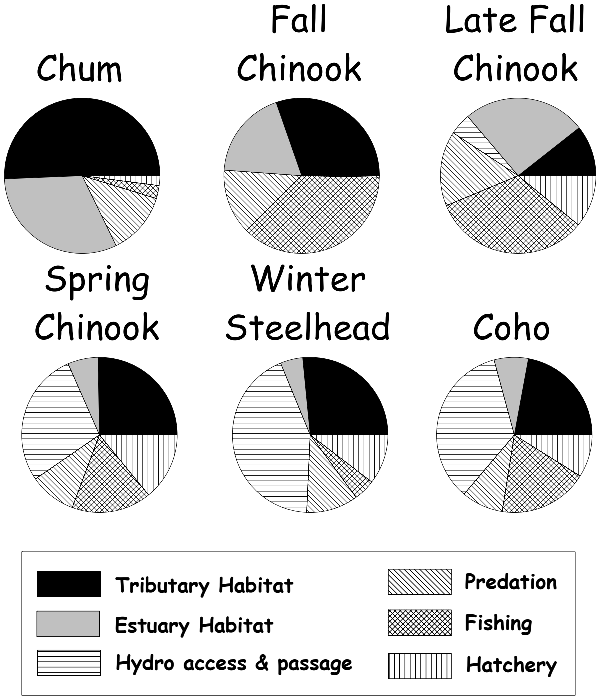


Figure 11-5. Relative index of potentially manageable mortality factors for each species in the North Fork Lewis subbasin.

11.4 Hatchery Programs

The Lewis River basin has multiple hatchery facilities, all located on the NF Lewis River (mainstem). The Lewis River Salmon Hatchery at RM 13, approximately 4 miles downstream of Merwin Dam, was completed in 1932. It has produced fall chinook, spring chinook, early (Type-S) coho, and late (Type-N) coho. The fall chinook hatchery program was discontinued in 1986 to eliminate interactions with a healthy Lewis River wild fall chinook population. Current spring chinook production goals are just over 1 million smolts (Figure 11-6); this includes 900,000 to be released at the hatchery and 150,000 to be transferred to the Fish First Organization Net Pens described below. The collection facility at Merwin Dam was also completed in 1932; adults captured at this facility are enumerated and either transferred to a hatchery for broodstock or released for harvest opportunity or supplementation of natural spawners.

The Speelyai Hatchery on Speelyai Bay in Merwin Reservoir was completed in 1958. It produces spring chinook, 880,000 Type-S, and 815,000 Type-N coho smolts in coordination with the Lewis River Salmon Hatchery (Figure 11-6). Adult spring chinook are captured at the Lewis River and Merwin Hatchery traps, transferred to Speelyai Hatchery for broodstock collection, incubation, and early rearing, and then transferred to the Lewis River Hatchery or Fish First Net Pens for final rearing and release.

The Lewis River net pen system in Merwin Reservoir has been in operation since 1979, serving as a rearing location for hatchery steelhead. A total of 50,000 summer steelhead are transferred to the net pens (from Skamania Hatchery) for release into the NF Lewis.

The Merwin (Ariel) Hatchery below Merwin Dam (at RM 16) was completed in 1983 and produces summer and winter steelhead. Merwin Hatchery steelhead releases into the Lewis River include 175,000 summer steelhead smolts and 100,000 winter steelhead smolts.

Fish First (a volunteer organization) operates spring chinook net pens at RM 10 in the NF Lewis. The annual production goal is 150,000 smolts, which are obtained from the Lewis River Salmon Hatchery production. Fish First volunteers also assist in rearing summer steelhead in the Merwin Reservoir net pens.

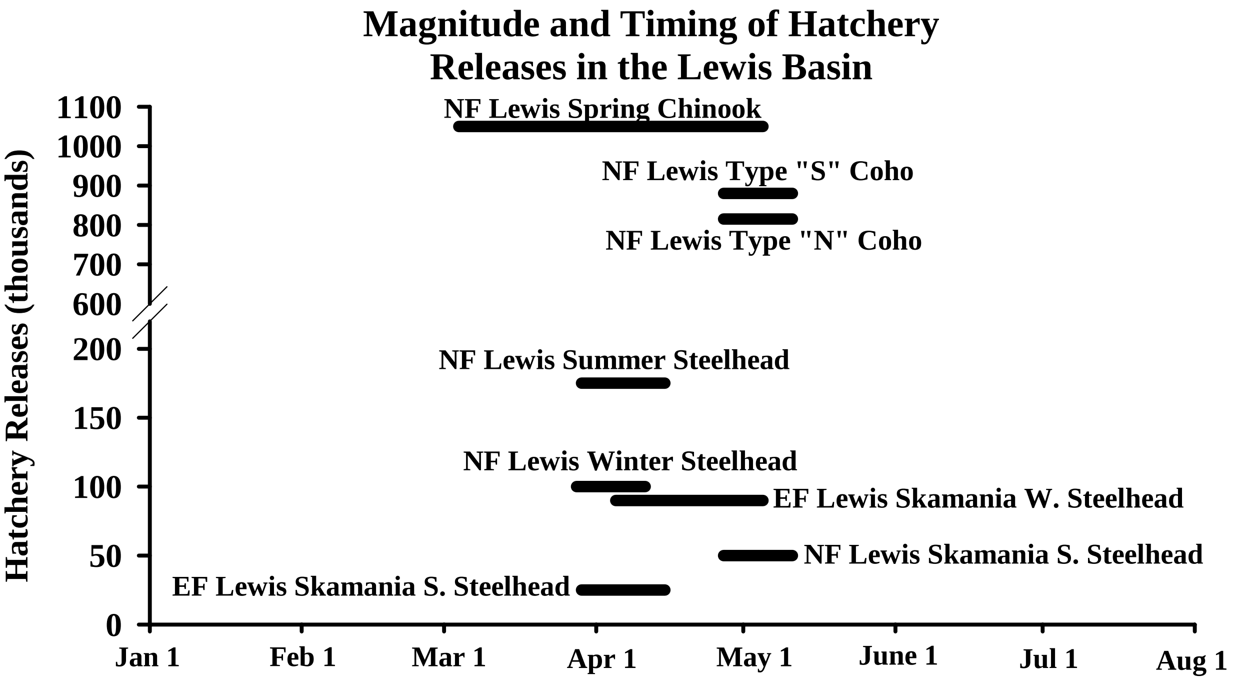


Figure 11-6. Magnitude and timing of hatchery releases in the Lewis River basin by species, based on 2003 brood production goals.

Genetics—Broodstock for the former fall chinook hatchery program likely came from native Lewis River fall chinook and the degree of influence from outside stocks is unknown. Fall chinook hatchery releases ended in 1986; Lewis River fall chinook are the only lower Columbia stock to maintain a healthy wild population with negligible hatchery influence. Genetic analysis in 1990 indicated that NF and EF Lewis River fall chinook were genetically similar and both were distinct from all other lower Columbia River fall chinook stocks.

Broodstock for the spring chinook hatchery program has come from many sources, with most broodstock originating from Cowlitz River spring chinook. Other outside broodstock sources include Carson NFH, Klickitat Hatchery, and Kalama Hatchery. Genetic analysis of NF Lewis River hatchery spring chinook indicated that they were genetically similar to, but separable from, Kalama and Cowlitz hatchery spring chinook stocks and significantly different from other lower Columbia River spring chinook stocks.

Coho broodstock collection comes from adults returning to the Lewis River Salmon Hatchery and the Merwin Hatchery trap facility. WDFW and Fish First have started a small research and enhancement program for wild late coho. This 15,000-smolt and 75,000-fry release program used wild adults collected at the grist mill trap on Cedar Creek.

Broodstock for the winter steelhead hatchery program originated from a mixture of Beaver Creek and Skamania hatchery winter steelhead stocks; Chambers Creek and Cowlitz hatchery stocks also have been released in the basin. Current broodstock collection comes from adults returning to the Lewis River and Merwin hatchery traps. Allele frequency analysis of NF and EF Lewis River winter steelhead was unable to determine the distinctiveness of either stock compared to other lower Columbia River winter steelhead stocks. In recent years, wild late winter steelhead have been collected at Merwin Trap and returned to the Lewis River below Merwin Dam. These wild fish may be used in the future as a brood source for reintroduction of winter steelhead to natural habitats upstream of Swift Dam.

Broodstock for the summer steelhead hatchery program originated from Skamania and Klickitat River crosses; Beaver Creek, Chambers Creek, and Cowlitz River summer steelhead stocks have also been released in the basin. Current broodstock collection comes from adults returning to the Lewis River and Merwin hatchery traps.

Interactions—Hatchery spring chinook account for most spring chinook spawning in the Lewis River (Figure 11-7); juvenile production from natural spawning is presumed to be low. The native component of the spring chinook stock may have been extirpated and replaced by the hatchery stocks so wild and hatchery spring chinook interactions are expected to be minimal. Hatchery spring chinook are released to the Lewis River as smolts; some predation by hatchery-origin smolts may occur on naturally produced salmonids in the system. However, the potential for these interactions is limited to the duration of the smolt emigration. Large releases of hatchery spring chinook smolts may attract additional predators causing increased predation on wild fish, but wild fish may benefit from the presence of large numbers of hatchery fish because wild fish usually have better predator avoidance capabilities. Because the Lewis River fall chinook population represents the majority of fall chinook natural production in the lower Columbia River, any negative interactions with fall chinook are a substantial concern. Additionally, spring chinook are currently part of a proposed reintroduction program in the upper Lewis River basin as part of the basin’s hydrosystem relicensing efforts. Because of these potentially conflicting issues, spring chinook smolt release sites for the reintroduction program are being investigated in locations below the natural production areas for fall chinook to minimize any potential negative interaction between spring chinook smolts and fall chinook juveniles.

Hatchery production accounts for most coho returning to the Lewis River (Figure 11-7). Natural production is presumed to be low, although hatchery coho released above Swift Reservoir have successfully spawned in the upper basin tributaries and wild smolts produced from Cedar Creek have been monitored in recent years. Hatchery coho salmon are released to the Lewis River as smolts; some predation by hatchery-origin smolts may occur on naturally produced salmonids in the system. However, the potential for these interactions is minimized by the limited duration of the smolts’ emigration to the Columbia estuary. As the reintroduction of coho into available habitat in the upper Lewis River is being evaluated through the basin’s hydrosystem relicensing effort, interaction of first generation hatchery fish with hatchery-established natural fish will be an important relationship to monitor. Additionally, coho smolt release sites for the reintroduction program are being investigated in locations below the natural production areas for fall chinook to minimize any potential negative interaction between coho smolts and fall chinook juveniles.

Most NF Lewis River winter steelhead originate from the hatchery program (Figure 11-7); natural production is likely low. Until wild steelhead production is reestablished, interactions between wild and hatchery adult winter steelhead will be low. At Lucia Falls in the EF Lewis River, winter steelhead return data in the late 1970s and early 1980s indicated that the wild portion of the run ranged from 35 to 74%; more recent data (1991-1996) suggests that 49% of spawning winter steelhead were wild fish (LCSCI 1998). Because of the mixture of wild and hatchery fish in the EF Lewis adult return, there is potential for competition for suitable spawning sites, most notably between hatchery summer and wild winter steelhead. Juvenile production levels from winter steelhead natural spawning are unknown. Hatchery winter steelhead smolts may compete with or prey upon other salmonids in the Lewis River; the degree of this risk depends upon the number, size, release time, and stream residence time of the hatchery fish. Interactions between hatchery winter steelhead smolts and other juvenile salmonids are minimized by releasing smolts that migrate through the system quickly, unless smolts residualize. If hatchery winter steelhead and other salmonids occupy the same habitat, the large number of hatchery smolts may provide other salmonids some protection from predators.

Most summer steelhead on the NF Lewis River are of hatchery origin (Figure 11-7) so interactions between wild and hatchery adult summer steelhead are likely minimal. In the EF Lewis River, data in the late 1970s and early 1980s indicated that the portion of wild summer steelhead in the run at Lucia Falls averaged 27%; more recent data (1991-1996) suggests that 30% of spawning summer steelhead were wild fish (LCSCI 1998). Because of the mixture of wild and hatchery fish in the EF Lewis adult return, there is potential for competition between hatchery and wild summer steelhead for suitable spawning sites, but spawning site competition is even more likely between hatchery summer and wild winter steelhead. Juvenile production levels from summer steelhead natural spawning are thought to be moderate. Hatchery summer steelhead smolts may compete with or prey upon other salmonids in the Lewis River; the degree of this risk depends upon the number, size, release time, and stream residence time of the hatchery fish. Interactions between hatchery summer steelhead smolts and other juvenile salmonids are minimized by releasing smolts that migrate through the system quickly, unless smolts residualize. If hatchery summer steelhead and other salmonids occupy the same habitat, the large number of hatchery smolts present may provide other salmonids some protection from predators.

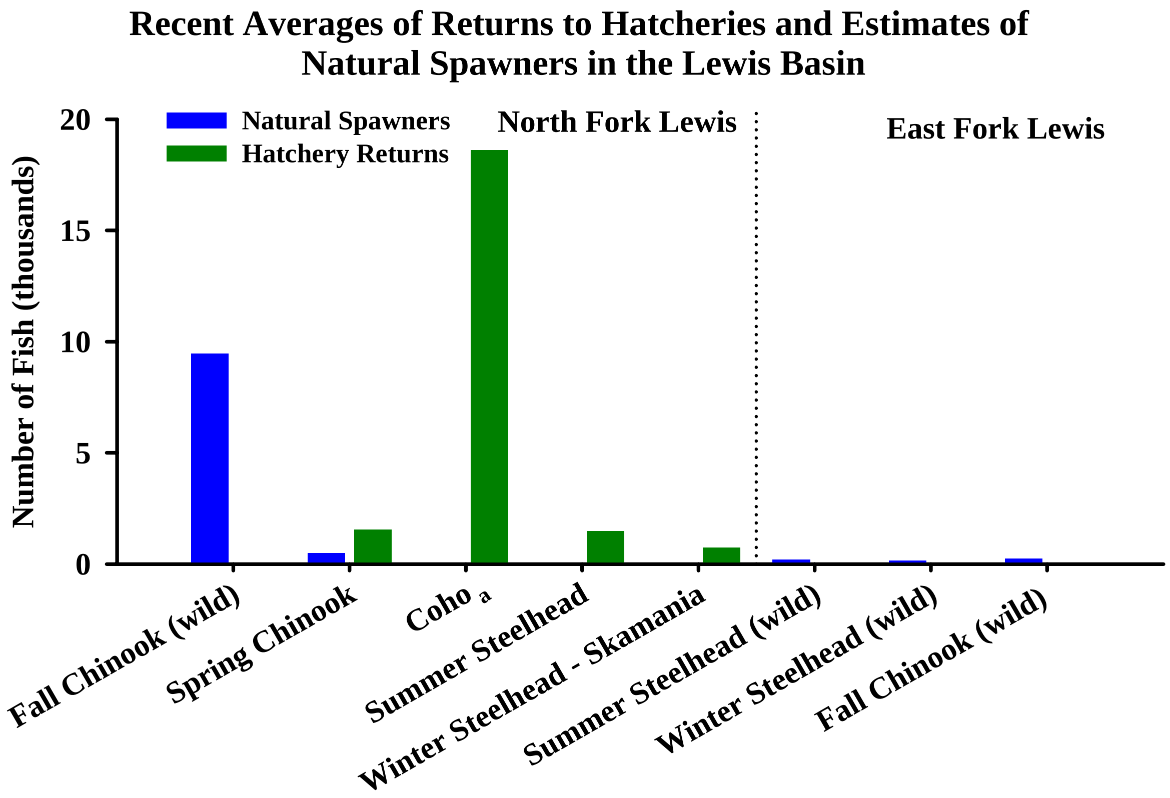


Figure 11-7. Recent average hatchery returns and estimates of natural spawning escapement in the Lewis River basin by species.

The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present. Calculation of each average utilized a minimum of 5 years of data.

[a] A natural stock for this species and basin does not exist based on populations identified in WDFW's 2002 SASSI report; escapement data do not exist.

Water Quality/Disease—Water for the Lewis River Salmon Hatchery comes directly from the Lewis River; this site serves as the primary final rearing site for hatchery spring chinook in the basin. Because the facility is located downstream of multiple hydroelectric generation facilities, influent dissolved gas levels have been a problem. The hatchery is equipped with four degassing towers that are efficient in treating incoming water. Effluent is monitored under the hatchery's NPDES permit. Fish health is monitored continuously by hatchery staff; a fish pathologist visits monthly. The area fish health specialist inspects fish prior to release.

Water for the Speelyai Hatchery comes directly from Speelyai Creek; the facility serves as the primary location for adult broodstock holding and spawning, incubation, and early rearing for the spring chinook hatchery program. Water quality, clarity, and temperature are good; flow to the rearing ponds is about 9,200 gpm. Effluent is monitored under the hatchery's NPDES permit. Adults being held for broodstock collection are inoculated twice with erythromycin. Daily 1-hour standard formalin drip treatments combat fungus problems in the adult holding pond. During the incubation process, eggs are water-hardened in iodophor for viral pathogens; formalin is used to control fungus outbreaks. Disease control procedures are conducted according to the Fish Health Policy. Water for the Merwin Hatchery comes directly from Lake Merwin; water clarity is generally good and water temperatures range from 42-61°F. All water to the hatchery is ozonated and runs through a stripper, entrained gasses are removed, and the water is well-oxygenated. Lake Merwin water is used for adult holding, incubation, and rearing; flow to the rearing ponds is approximately 5,000 gpm. Effluent from the facility is monitored according to the hatchery's NPDES permit. Adults being held for broodstock collection are treated with formalin, hydrogen peroxide, or a combination to control fungus growth. During the incubation process, eggs are water hardened in iodophor for viral pathogens; formalin is used to control fungus outbreaks. Fish health is monitored continuously by hatchery staff; a fish pathologist visits monthly. Disease control procedures during incubation and rearing are conducted according to the Fish Health Policy. The area fish health specialist inspects fish prior to release.

Mixed Harvest—The spring chinook hatchery program at the Lewis River Hatchery complex provides harvest opportunities to mitigate losses resulting from hydroelectric development in the basin. Historically, exploitation rates of hatchery and wild spring chinook likely were similar. Spring chinook are an important target species in Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years of Lewis River spring chinook indicate a 54% exploitation rate; 46% of the adult return was accounted for in escapement. Most of the harvest occurred in the Lewis River sport fishery. Exploitation of wild fish during the same period likely was similar. Currently all spring chinook are externally marked with an adipose fin-clip to allow for selective fisheries. Selective fisheries in the mainstem and tributaries in recent years have increased harvest of Lewis River hatchery spring chinook while maintaining minimal harvest impacts on wild spring chinook. The mainstem Columbia River spring chinook sport fisheries were reopened into April–May (after closure in 1978) as a result of the ability to selectively harvest marked hatchery fish and release wild fish. Lower Columbia commercial fisheries were also extended to late March as a result of selective fishing regulations applied to the commercial fishery.

The purpose of the Lewis River Hatchery complex coho salmon program is to provide harvest opportunities to mitigate for the losses resulting from hydroelectric development in the basin. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. The combined ocean and Columbia

River harvest of Columbia River-produced coho ranged from 70% to over 90% from 1970–83. Ocean fisheries were limited in the mid-1980s and Columbia River commercial fisheries were adjusted in the 1990s to protect several wild coho stocks. Columbia River coho exploitation rates during 1997 and 1998 averaged 48.8%. CWT data analysis of the 1995–1997 brood years of Lewis River Type-S and Lewis River Type-N coho indicate a 15% exploitation rate on early run coho and a 42% exploitation rate on late run coho; 85% and 58% of the adult return was accounted for in escapement for early and late-run coho, respectively. Currently all coho are externally marked with an adipose fin-clip to allow for selective fisheries. With the advent of selective fisheries for hatchery fish, exploitation of wild coho is expected to be extremely low, while hatchery fish can be harvested at a higher rate. Lewis River wild coho benefit from ESA limitations for Oregon Coastal Natural coho in ocean fisheries and for Oregon lower Columbia coho in Columbia River fisheries.

The purpose of the summer and winter steelhead hatchery programs is to provide harvest opportunity to mitigate for fish lost as a result of hydroelectric development in the Lewis River basin, benefiting lower Columbia and Lewis River sport fisheries. Before 1986, exploitation rates of wild and hatchery steelhead likely were similar. However, selective harvest regulations on sport fisheries in the lower Columbia River since 1984 and in the Lewis River since 1992 have targeted hatchery steelhead and limited harvest of wild steelhead. Hatchery steelhead harvest rates are estimated at 70% in the North Lewis and 40% in the EF Lewis, while wild steelhead harvest impacts are estimated at 6 percent in the NF Lewis and 5% in the EF Lewis.

Passage—Adult collection facilities at Lewis River consist of a volunteer ladder with a "V" weir that prevents the escape of captured fish. Because adults are volunteers to the ladder, trap avoidance is possible. Traps are opened at various times of the year to collect fish during the entire length of each run. The Lewis River Hatchery trap is 200'x7'x5' with a flow of 3,500 gpm. Fish that escape the Lewis hatchery trap can encounter Merwin Dam trap, four miles upstream of the Lewis Hatchery. There is no adult passage at Merwin Dam although reintroduction of salmon and steelhead to the upper watershed is planned during the next hydro-license period. No other hatchery facility in the basin has an adult collection system, except a trap at the grist mill on Cedar Creek.

Supplementation—The only purpose of each hatchery program of the Lewis Complex has been to provide harvest opportunity to mitigate for the loss of adult fish resulting from hydroelectric development in the Lewis River basin. However, the new hydro-license is expected to include an integrated hatchery program for harvest and also supplementation to reintroduce natural coho, winter steelhead, and spring chinook to the upper Lewis watershed. The hatcheries will develop appropriate broodstocks for supplementation and provide facilities which will enable both harvest and natural reintroduction goals to be achieved.

11.5 Fish Habitat Conditions

11.5.1 Passage Obstructions

All anadromous passage has been blocked by the 240-ft high Merwin Dam since shortly after its construction in 1931. This facility blocked approximately 80% of the available habitat for steelhead, approximately 50% of the spawning habitat for fall chinook, and virtually eliminated the natural run of spring chinook (WDF 1993, McIssac 1990).

Culvert related passage problems are located on Johnson, Cedar, Beaver, John, Brush, and Unnamed Creeks. Other passage problems exist on Robinson, Ross, and Pup Creeks.

11.5.2 Stream Flow

Mean annual streamflow for the entire Lewis River system is approximately 6,125 cubic feet per second (cfs). Average annual flow measured below Merwin Dam is 4,849 cfs. Flow is dominated by winter rains, though summer flow in the Lower North Fork is slightly augmented by glacier melt in the upper basin. Flow in the lower North Fork is controlled by releases from Merwin Dam according to power needs and licensing agreements between PacifiCorp and the Federal Energy Regulatory Commission (FERC) that have established flow requirements for fish. The terms of new licenses are currently being renegotiated.

Hydropower regulation has altered the hydrograph of the lower mainstem (Figure 11-8). Pre-dam data reveals peaks due to fall/winter rains, winter rain-on-snow, and spring snowmelt. Post-dam data shows less overall flow variation, with a general increase in winter flows due to power needs. Post-dam data shows a decrease in spring snowmelt flows due to reservoir filling in preparation for dry summer conditions, and an increase in fall flows due to reservoir drawdown in preparation for winter rains. The risk of extreme summer low flows that are potentially detrimental to fish in the lower river has been reduced in the post-dam era due to reservoir storage and summer release. The risk of extreme winter peaks has also been reduced, with the tradeoff being the reduction of potentially beneficial large magnitude channel-forming flows.

Modification of flow volumes below Merwin Dam affects channel habitat. Since 1985, the dam operator, PacifiCorp, and the WDF and WDW have studied the relationship between spring flows and fall chinook habitat in the lower Lewis River and evaluated the need to modify spring flow provisions in the licensing agreement. In 1995, Article 49 of the licensing agreement was amended to provide for increased minimum flows of 2,700 cfs in April, May, and June (WDFW 1998). The long-term effects on channel morphology and sediment supply have not been thoroughly investigated.

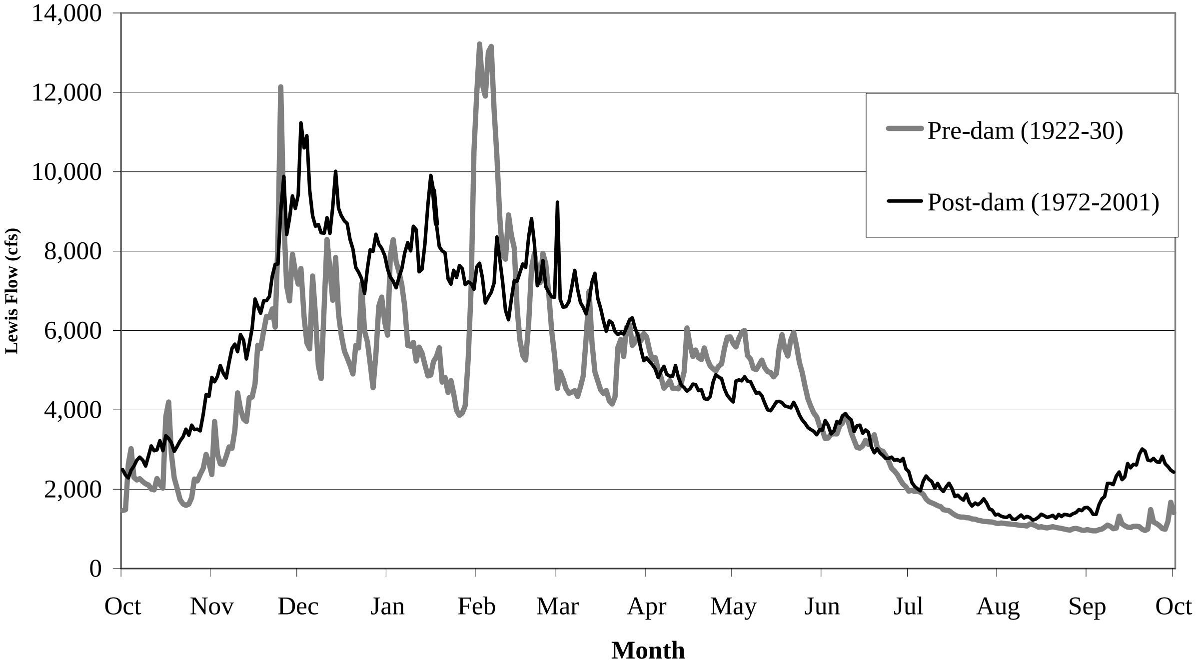


Figure 11-8. Lower Lewis River flow pre- and post-Merwin Dam (1931). Hydro-regulation has decreased flows in the spring and increased flows in the summer and fall. USGS Gage #14220500; Lewis River at Ariel, Wash.

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 9 of the 11 subwatersheds in the lower NF Lewis are "impaired" with regards to runoff conditions. Only one subwatershed, Pup Creek, has "moderately impaired" runoff conditions. Impaired runoff conditions are related to young forest vegetation, high road densities, and watershed imperviousness.

An instream flow analysis on Cedar Creek using the toe-width methodology indicated that sufficient flows for steelhead spawning become limited in June, and juvenile rearing is very limited June through October (Caldwell 1999). The current 672 million gallons per year (mgy) water use is expected to increase by 573 mgy by 2020; however, current and future water use is believed to be insignificant when compared to base flows throughout the year (LCFRB 2001).

11.5.3 Water Quality

Water temperatures at Amboy and at the mouth of Cedar Creek often exceed 61ºF (16ºC) in the summer and sometimes reach 73º-77ºF (23°-25°C) (PacifiCorp 1999 as cited in Wade 2000), potentially impacting steelhead juveniles. High temperatures have been attributed to agriculture, grazing, water withdrawals, surface runoff, residential development, forestry operations, and the construction of illegal dams and diversions throughout the basin. Water quality information is lacking for other lower Lewis tributaries.

11.5.4 Key Habitat

Pool habitat in the mainstem below Merwin Dam is affected by Columbia River backwater in the lower 7 miles and is bedrock controlled by a canyon between RM 15 and

Merwin Dam. The Limiting Factors Analysis TAG expressed concerns about adequate pool habitat on Cedar Creek (above RM 4.4) and North Fork Chelatchie Creek. There is a lack of published data and knowledge of other areas (Wade 2000).

Side channel habitat has been removed from the lower seven miles of the mainstem due to diking. Areas of good side channel habitat exist between RM 7 and RM 15. Information on side channel habitat condition for the upper basin is unavailable (Wade 2000).

11.5.5 Substrate & Sediment

The lower 11 miles of the mainstem is a tidally influenced backwater of the Columbia consisting of fine substrate. Little data exists for the major spawning areas between RM 11 and RM 15. A 1998 spawning gravel survey 0.3 and 0.6 miles below Merwin Dam concluded that sediment had not accumulated in spawning gravel (Stillwater Sciences 1998). The spawning area from RM 15 to the dam is not affected because the dam captures most fine sediment (Wade 2000).

TAG members noted concerns of substrate fines in Cedar Creek (above RM 4.4) and in South Fork Chelatchie Creek. Livestock access and residential development in the Cedar Creek system is seen as a potential source of fine sediments (Wade 2000).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results indicate that 10 of the 11 subwatersheds in the lower NF Lewis basin are “moderately impaired” with regards to sediment supply and one subwatershed is “functional” (lower Cedar Creek). Sediment supply conditions are impaired due to high road densities, stream adjacent roads, and degraded riparian conditions.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

11.5.6 Woody Debris

LWD quantities and recruitment potential in the mainstem and tributaries were considered poor by the Limiting Factors Analysis (LFA) technical advisory group (TAG) (Wade 2000). This has been attributed to logging, stream cleanouts, and poor riparian conditions.

11.5.7 Channel Stability

There are bank stability problems on the mainstem between RM 7 and RM 15, particularly along the golf course (RM 12) and across from Eagle Island. A large slide 2 miles upstream of the hatchery intake on Colvin Creek was the result of a large DNR clear-cut. Sediment input to the stream degraded water quality to the point that hatchery staff removed 1 million eggs to other hatcheries. The LFA TAG noted bank stability problems on Cedar Creek from RM 4.4 to RM 11.2, particularly between Brush Creek (RM 9.3) and one half mile short of Amboy due to past and present land uses in the area. Bank stability concerns were also identified on Amboy, SF Chelatchie, and NF Chelatchie Creeks (Wade 2000).

11.5.8 Riparian Function

The Washington State Conservation Commission conducted an assessment of riparian conditions in the lower basin using 1994 and 1996 aerial photos. Riparian areas with a forested width of less than 75 ft or dominated by hardwoods were categorized as having poor riparian conditions. Poor conditions were identified along the lower mainstem where agricultural and residential uses dominate. River mile 9.9 to 11.7 has large areas of minimal vegetation, often dominated by scotch broom. Conditions improve above RM 15 (Wade 2000).

Poor conditions exist along Robinson, Johnson, and Ross Creeks. Poor conditions also exist between Pup and Chelatchie Creeks on the Cedar, due likely to grazing and residential development. Canopy cover between Amboy and Yacolt on Cedar Creek is considered fair though conditions upstream have been extensively impacted by logging. Conditions on the NF and SF Chelatchie are considered generally poor (Wade 2000).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 8 of the 11 subwatersheds are rated as “moderately impaired” with regards to riparian function; the remainder are rated as “impaired”. Two of the three impaired subwatersheds are located in the lower basin and the other is the Chelatchie Creek basin. Past riparian timber harvesting, roadways, agriculture, and development have degraded riparian forests.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

11.5.9 Floodplain Function

Extensive diking along the lower 7 miles protects farmland and residential uses. It is estimated that greater than 50% of the historical floodplain has been disconnected from the river. Rip-rapped banks between RM 7 and RM 15 protect roads and residential areas. Connections to floodplains and off-channel habitats exist in places (Wade 2000).

11.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to lower Lewis River fall chinook, winter steelhead, chum, and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

11.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the lower North Fork Lewis basin for winter steelhead, fall chinook, chum and coho. Model results indicate current fall chinook productivity is approximately 76% of historical levels (Table 11-1). Winter steelhead, chum, and coho productivities have declined further, to 22%, 29%, and 44% of historical levels, respectively. Current adult abundance values are also sharply lower than historical levels (Figure 11-9). Chum appear to have suffered the greatest decline in abundance, to only 6% of historical estimates. The historical to current change in the diversity index is somewhat less dramatic for all species (Table 11-1). Current chum diversity is estimated at 79% of historical, while fall chinook, coho, and winter steelhead diversity have experienced a 25%, 11% and 50% decrease, respectively.

Model results indicate that current smolt productivities have declined from historical levels for all species (Table 11-1). Similarly, smolt abundance levels have decreased. Current smolt abundance is estimated at 84% of historical levels for fall chinook, 61% for winter steelhead, 38% for coho, and only 16% of historical levels for chum (Table 11-1).

Model results indicate that restoration of PFC conditions would accrue modest to large benefits in adult abundance depending on species. Chum abundance would increase 206%, while coho abundance would increase over 100% (Table 11-1). Smolt abundance levels would also increase if PFC conditions were achieved. Restoration of PFC would have the greatest effect on chum smolt abundance, which would increase 138% from current levels.

Table 11-1. Lower NF Lewis — Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	9,388	10,134	11,200	11.2	12.3	14.7	0.75	0.75	1.00	886,535	918,159	1,047,550	506	539	680
Chum	4,418	13,511	79,061	2.7	6.5	9.3	0.79	1.00	1.00	3,133,646	7,443,617	19,208,380	832	880	987
Coho	2,367	4,771	6,025	5.2	8.9	11.9	0.88	0.99	0.99	54,883	112,226	142,734	121	205	274
Winter Steelhead	367	505	1,161	5.3	12.2	24.7	0.40	0.39	0.80	6,171	8,488	10,142	98	224	253

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

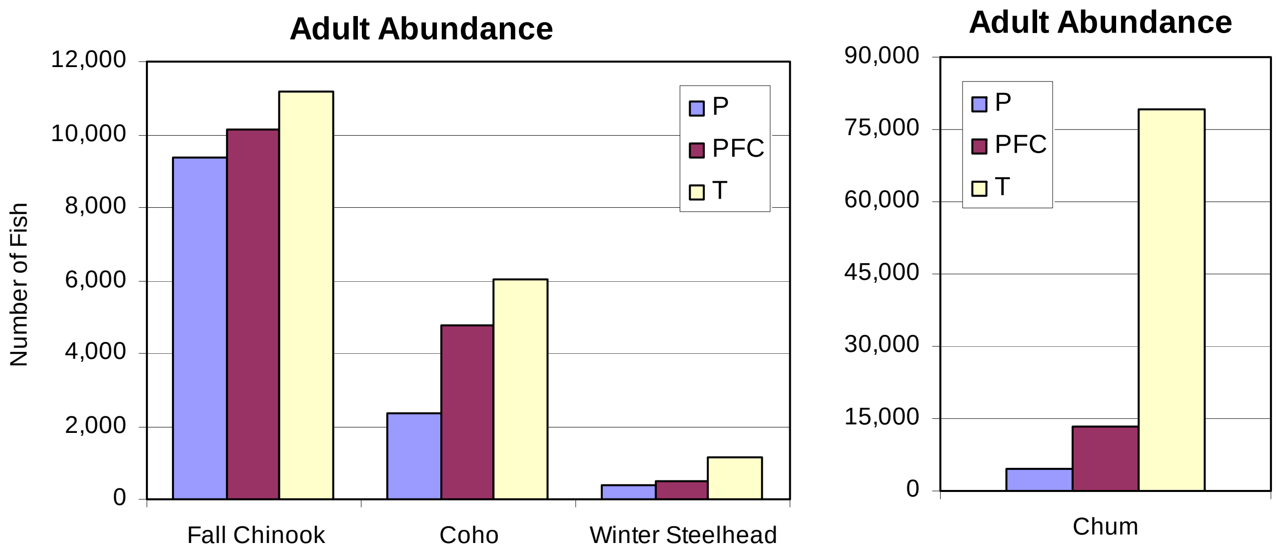


Figure 11-9. Lower NF Lewis— Adult abundance of upper NF Lewis fall chinook, coho, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

11.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Winter steelhead occupy the greatest amount of lower NF Lewis stream reaches, extending up to Merwin Dam on the mainstem and including many reaches within the Cedar Creek system. Fall chinook and chum use primarily just mainstem habitats from the mouth up to Merwin Dam. See Figure 11-10 for a map of EDT reaches within the lower NF Lewis basin.

High priority reaches for winter steelhead consist of Cedar Creek mainstem reaches (Cedar Creek 1a, 1b, 3 and 4) (Figure 11-11). These reaches represent spawning and rearing habitats utilized by this population. The lowest two Cedar Creek reaches (Cedar Creek 1a and 1b) both show a combined preservation and restoration recovery emphasis, while mainstem reaches Cedar Creek 3 and 4 show a preservation emphasis.

Both fall chinook and chum, unlike steelhead, spawn in the Lewis mainstem. Therefore, high priority reaches for chinook include Lewis 3-4 and Lewis 6 (Figure 11-12). All reaches modeled for fall chinook show a strong habitat preservation emphasis. For chum, the high priority reaches include Lewis 6, Lewis 5, and Lewis 4 (Figure 11-13). As with fall chinook, all the reaches modeled show a strong habitat preservation emphasis.

Coho in the lower NF Lewis also have high priority reaches in mainstem areas. Coho high priority reaches are located from Lewis 3 to Lewis 6 (Figure 11-14). All of these reaches, except Lewis 6, have a combined preservation and restoration habitat emphasis. Lewis 6 shows a preservation only emphasis.

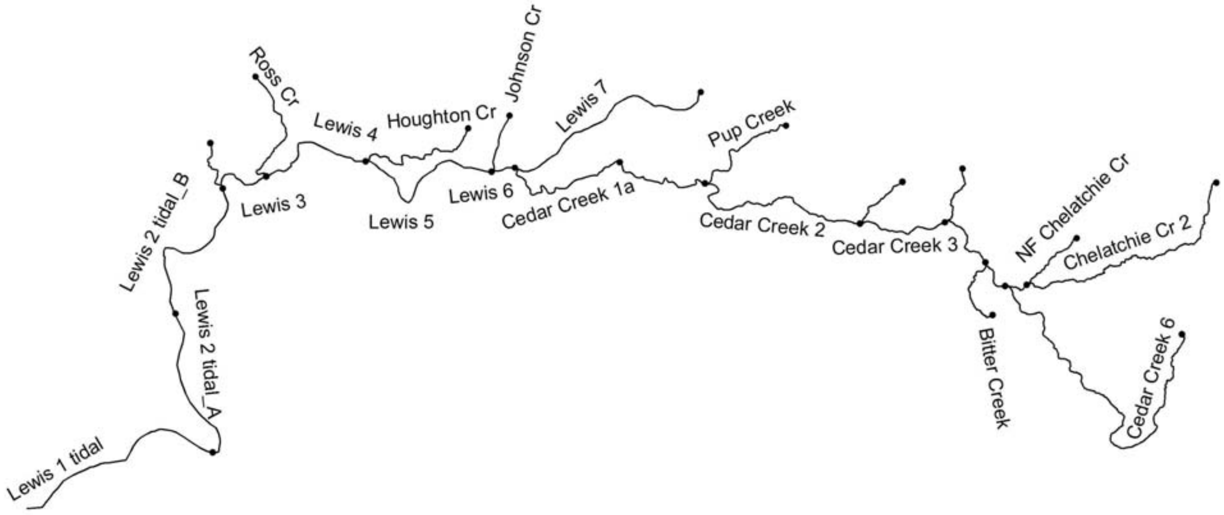
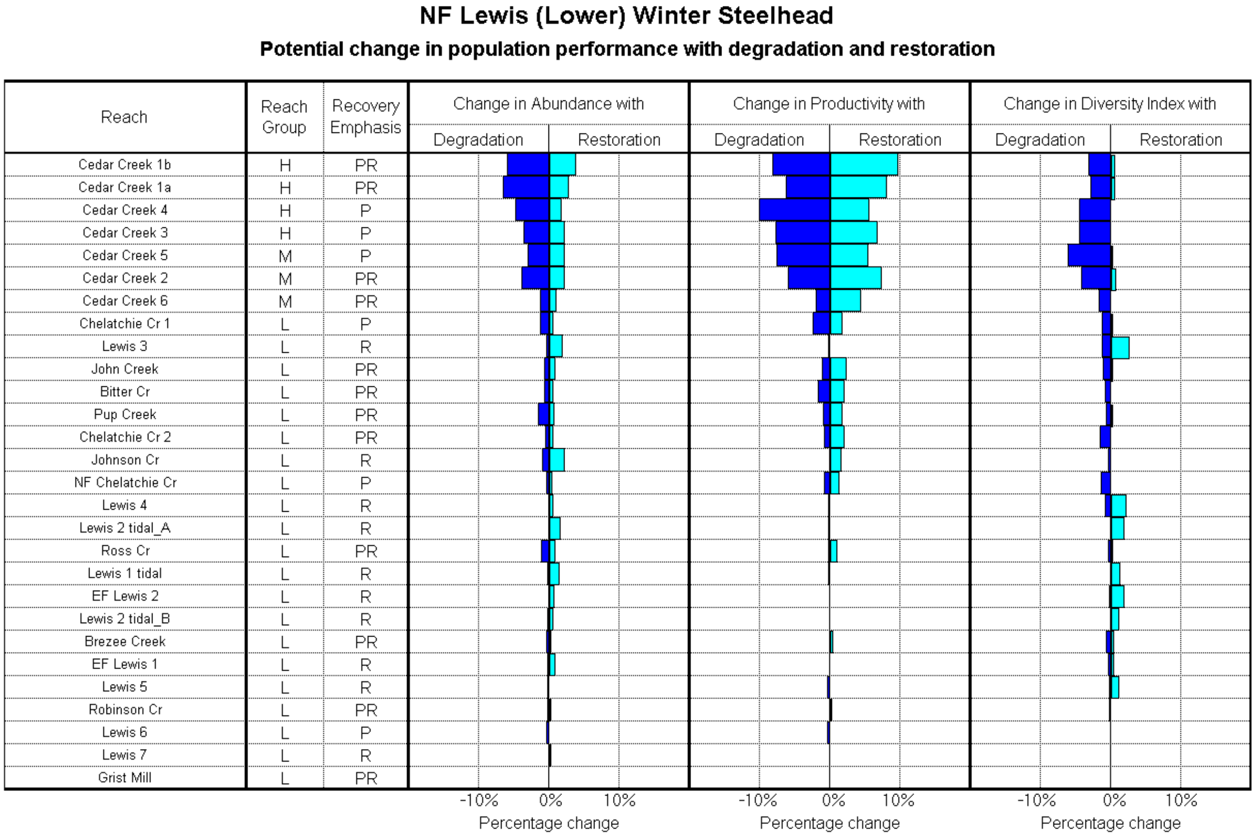
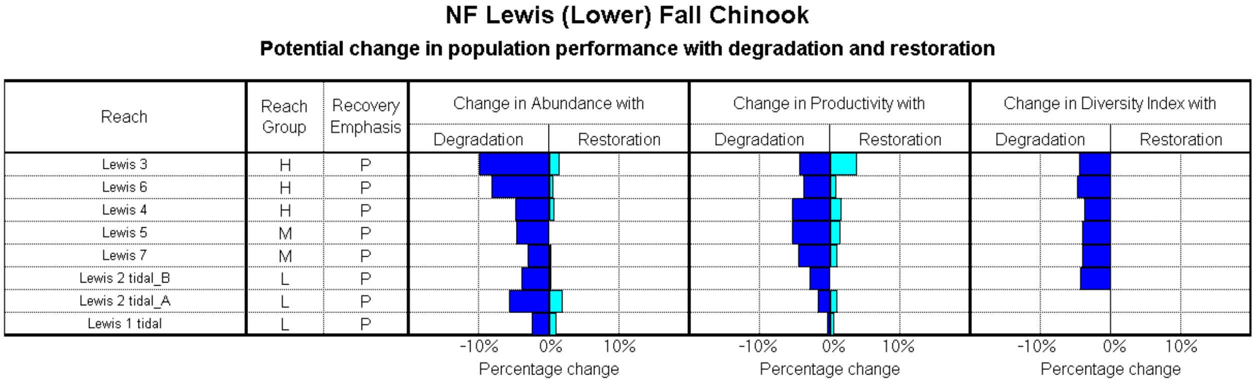


Figure 11-10. Lower North Fork Lewis EDT reaches. Some reaches are not labeled for clarity.



Reach	Reach Group	Recovery Emphasis
Cedar Creek 1b	H	PR
Cedar Creek 1a	H	PR
Cedar Creek 4	H	P
Cedar Creek 3	H	P
Cedar Creek 5	M	P
Cedar Creek 2	M	PR
Cedar Creek 6	M	PR
Chelatchie Cr 1	L	P
Lewis 3	L	R
John Creek	L	PR
Bitter Cr	L	PR
Pup Creek	L	PR
Chelatchie Cr 2	L	PR
Johnson Cr	L	R
NF Chelatchie Cr	L	P
Lewis 4	L	R
Lewis 2 tidal_A	L	R
Ross Cr	L	PR
Lewis 1 tidal	L	R
EF Lewis 2	L	R
Lewis 2 tidal_B	L	R
Brezee Creek	L	PR
EF Lewis 1	L	R
Lewis 5	L	R
Robinson Cr	L	PR
Lewis 6	L	P
Lewis 7	L	R
Grist Mill	L	PR

Figure 11-11. Lower NF Lewis River winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



Reach	Reach Group	Recovery Emphasis
Lewis 3	H	P
Lewis 6	H	P
Lewis 4	H	P
Lewis 5	M	P
Lewis 7	M	P
Lewis 2 tidal_B	L	P
Lewis 2 tidal_A	L	P
Lewis 1 tidal	L	P

Figure 11-12. Lower North Fork Lewis fall chinook ladder diagram.

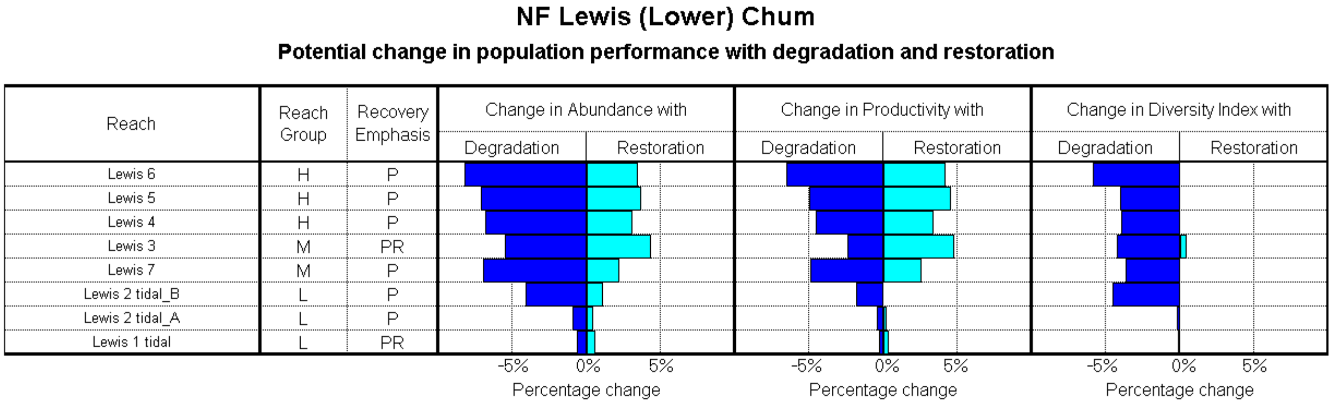


Figure 11-13. North Fork Lewis chum ladder diagram.

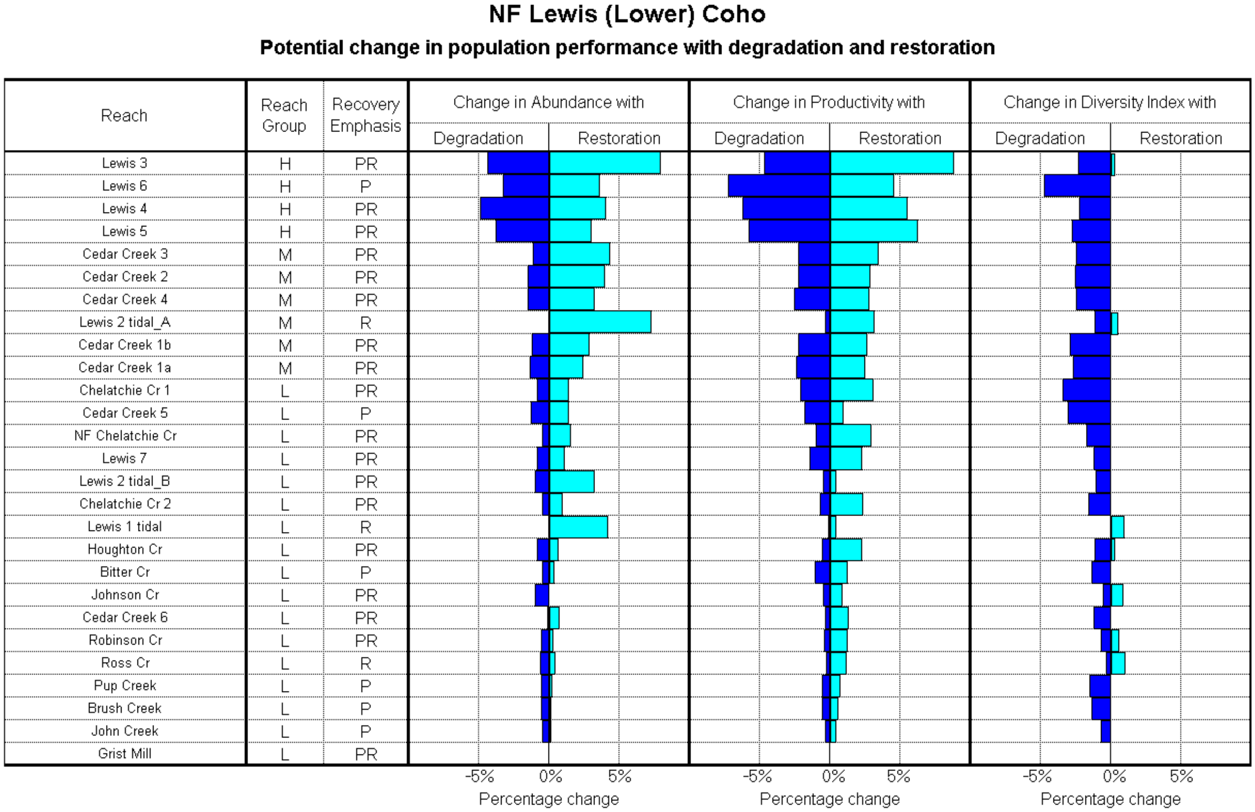


Figure 11-14. North Fork Lewis coho ladder diagram.

11.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The high priority reaches for winter steelhead are in the middle Cedar area. In this area, temperature and habitat diversity have had the greatest impact (Figure 11-15). Lesser impacts are related to sediment, key habitat, and flow. The Limiting Factor Analysis TAG identified middle Cedar Creek as having high gravel embeddedness. Cattle grazing and residential impacts were noted as contributing to degraded fine sediment conditions. Habitat diversity is low due to low LWD levels and degraded riparian zones throughout the Cedar system. Riparian degradation also contributes to high stream temperatures. Riparian zones have been impacted by logging and residential development (Wade 2000).

Fall chinook (Figure 11-16) and chum (Figure 11-17) restoration efforts are best focused on the middle Lewis mainstem (Lewis 3- 7), where sediment, habitat diversity, flow, and harassment have impacted the population. This alluvial channel currently has some of the best side channel habitat available, yet the quantity of these habitats has been reduced considerably since the historical condition. Habitat diversity is degraded due to highly denuded riparian vegetation, invasive plant species, and low LWD quantities. Temperature is a problem due to lack of canopy cover. Channel stability is low due to riparian impacts. Predation impacts are related to the hatchery program and harassment levels are high due to the close proximity to population centers and ease of access.

High priority reaches for coho are located on the lower and middle Lewis mainstem (Lewis 3-5) and Cedar Creek (Cedar Creek 2-4). In these reaches, key habitat and habitat diversity have the greatest impacts (Figure 11-18). Channelization (diking) and degraded riparian zones play the greatest role in these impacts.

Lower NF Lewis Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Cedar Creek 1b	•	●	⬤	●		•		•	●	**+**	•			●		●
Cedar Creek 1a	•	•	⬤	●		•		•	●	**+**	+			●		●
Cedar Creek 4	•	●	●	●		•			●		•			•		•
Cedar Creek 3	●	●	●	●		•			●		•			•		✚
Cedar Creek 5	•	⬤	●	•		•			●		•			•		+
Cedar Creek 2	•	●	⬤	●		•			●	•	•			●		●
Cedar Creek 6	•	●	●	•		•			●	⬤				•		⬤
Chelatchie Cr 1	•	•	•	•		•			•	●				•		+
Lewis 3	•	⬤	+	●		•			•	●				•		⬤
John Creek	•	●	●	•		•			●	⬤						✚
Bitter Cr			●			•			•	⬤	●					+
Pup Creek	•	•	●	•		•			•	●				•		+
Chelatchie Cr 2	•	•	●	•		•			•	●	•			•		•
Johnson Cr	•	⬤	●	•		•			●	⬤	•			•		✚
NF Chelatchie Cr	•	•	•	•		•			•	●	•					+
Lewis 4		●		•		•			•							+
Lewis 2 tidal_A	•	⬤	+	●		•			•	•				•		⬤
Ross Cr	•	•	●	•		•			●	●	•			•		✚
Lewis 1 tidal	•	⬤	+	•		•			•	•				•		⬤
EF Lewis 2	•	●	•	•		•			•	•	•			•		●
Lewis 2 tidal_B	•	●	+	•		•			•	**+**						✚
Brezee Creek		•	•						•	•						+
EF Lewis 1	•	●	•	●		•			•	●	•			•		●
Lewis 5																
Robinson Cr	•	•	•	•					•	●						+
Lewis 6																
Lewis 7		•														+
Grist Mill																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact **+** High Positve Impact ✚

Figure 11-15. Lower NF Lewis winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Lower NF Lewis Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lewis 3	●	●	•	●		•			●	⬤	•			•	●	●
Lewis 6	•	●	•	•		•			•	•	•			•	•	•
Lewis 4	•	●	•	•		•			●	•	•				•	✚
Lewis 5																
Lewis 7	+	•	•	•					•						•	
Lewis 2 tidal_B	•	•		•					•	✚						✚
Lewis 2 tidal_A	●	⬤	+	⬤	•	●			●	•	●			•	•	⬤
Lewis 1 tidal	•	●	+	●	•	•			•	•	•			•	•	●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 11-16. Lower North Fork Lewis fall chinook habitat factor analysis diagram

Lower NF Lewis Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lewis 6	•	●	•	•					●		•				●	✚
Lewis 5	•	●	•	•					●		•				●	✚
Lewis 4	•	●	•	•					●		•				●	+
Lewis 3	•	●	•	•					●	●	•				⬤	⬤
Lewis 7	•	●	•	•					●						●	+
Lewis 2 tidal_B	•	●		•					●	+					•	●
Lewis 2 tidal_A	•	•		•					•		•					•
Lewis 1 tidal	•	•		•					•		•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 11-17. North Fork Lewis chum habitat factor analysis diagram.

Lower NF Lewis Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lewis 3	●	⬤	•	⬤		●			●	⬤	•			•	•	⬤
Lewis 6	•	⬤	•	•		•			•	•	•			•		⬤
Lewis 4	●	●	•	●		●			●	•	•			•	•	⬤
Lewis 5	•	⬤	•	•		•			●	•	•			•	•	⬤
Cedar Creek 3	●	●	●	•		•			●		●			•		●
Cedar Creek 2	●	●	●	●		•			●	•	•			•		⬤
Cedar Creek 4	●	●	●	•		•			●		•			•		●
Lewis 2 tidal_A	●	⬤	+	●	•	●			•	•	•			•		⬤
Cedar Creek 1b	●	●	●	•		•		•	•	+	•			•		●
Cedar Creek 1a	•	●	●	•		•		•	•	+	+			•		●
Chelatchie Cr 1	●	●	•	•		•			•	●	•					●
Cedar Creek 5	•	●	•	•		•			•		•					•
NF Chelatchie Cr	●	•	•	•		•			•	⬤	•					●
Lewis 7		●	•	•		•			•					•		⬤
Lewis 2 tidal_B	●	●	+	●		•			●	✚	•			•		⬤
Chelatchie Cr 2	•	•	•	•		•			•	●	•					●
Lewis 1 tidal	•	⬤	+	●	•	•			•	•	•			•		⬤
Houghton Cr	•	•	•			•			•	•	•					+
Bitter Cr	•	•	•						•	●	•					•
Johnson Cr																
Cedar Creek 6	•	●	•	•					•	●						●
Robinson Cr	•	•							•	•						+
Ross Cr	•	•	•						•	•						╋
Pup Creek	•	•								•						•
Brush Creek		•								•						╋
John Creek	•	•								•						+
Grist Mill																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 11-18. North Fork Lewis coho habitat factor analysis diagram.

11.7 Integrated Watershed Assessment (IWA)

The Lewis River is the centerpiece of WRIA 27, originating in SW Washington's Cascade Mountains, gathering rainfall, snowmelt and glacial runoff from the forested slopes of Mt. Adams and Mt. St. Helens. The river drains a total of 1,043 sq mi (667,742 acres), flowing to the southwest for approximately 93 miles before joining with the Columbia River. For the purposes of the IWA, the Lewis River subbasin is divided into three watersheds: the NF Lewis River—below Merwin Dam, the NF Lewis River—above Merwin Dam, and the EF Lewis River. Thus, the NF Lewis River is divided into two watersheds separated by the Merwin dam at RM 19.

The NF Lewis River below Merwin is composed of ten subwatersheds totaling 64,354 acres. An additional subwatershed associated with an independent tributary to the Columbia River is also discussed within this chapter (Burris Creek, 40602). Note that all composite watershed-level statistics are calculated without the inclusion of Burris Creek.

In addition to approximately 19 miles of mainstem, the watershed includes Cedar Creek, a major tributary system with five subwatersheds totaling 36,000 acres, or roughly 55% of the watershed, as well as several smaller tributaries to the North Fork, such as Robinson Creek, Johnson Creek and Ross Creek. These smaller mainstem tributaries are included within the four subwatersheds that contain segments of the North Fork. The subwatershed immediately below Merwin dam (60504) features a confined channel with banks composed primarily of bedrock and moderately forested slopes. Proceeding downstream, the mainstem becomes less confined, featuring a readily identifiable floodplain, more erodable streambanks and increasing streamside development. The lowest portions of the watershed are almost entirely deforested, heavily developed, and marked by the substantial revetment of the stream channel with dikes, levees and rip rap.

Interpretation of IWA results in the North Fork requires a clear understanding of the implications resulting from the watershed division at Merwin Dam. The four mainstem subwatersheds below Merwin Dam are profoundly influenced by the dams upstream. Total drainage areas for these subwatersheds total in excess of 500,000 acres, while the subwatersheds themselves range from 3,800 – 8,800 acres in size. Total annual discharge is not substantially affected by the dams, but the hydrograph is dramatically altered from its natural condition on seasonal, monthly, weekly and daily timescales. Sediment and large-wood processes are severely retarded by the hydro-system. However, conditions at the watershed level are rated in the IWA as if the watershed indeed terminates at Merwin Dam. That is to say that mainstem areas are influenced by upstream effects only to the base of Merwin Dam. This simplification is a necessity for facilitating the quantitative analysis, but the analysis herein will include a brief discussion of the implications. A partial exception is made for hydrology at the watershed scale, as discussed below.

The watershed is primarily a low-elevation, rainfall-dominated system with relatively low levels of natural erodability as estimated by geologic conditions and slope. However, current conditions feature substantially elevated indices of erodability that are nearly double the background levels. Only 4% of the watershed is in the rain-on-snow zone, almost exclusively in the headwaters of Cedar Creek (subwatershed 60405). However, for the mainstem subwatersheds, roughly 30% of the contributing drainage area is in the rain-on-snow zone when areas above Merwin Dam are included in the analysis. The signature of rain-on-snow events is quite different below major storage dams due to their influence on flood peak flows, episodic sediment input and debris transport. However, the impact of rain-on-snow events is truncated by the storage of peak flows in the reservoirs.

11.7.1.1 Results and Discussion

IWA results were calculated for all subwatersheds in the lower NF Lewis watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in Table 11-2. The local and watershed level results are also shown in Figure 11-19 and Figure 11-20. In general, local hydrologic conditions are impaired and local sediment and riparian conditions are moderately impaired. The results are similar for watershed level conditions, with the exception of hydrology, in which case several watersheds move from impaired to moderately impaired once upstream conditions are considered.

Table 11-2. IWA results for the North Fork Lewis – Below Merwin watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
40602	I	M	I	I	M	60401, 60402, 60403, 60404, 60405, 60406, 60501, 60502, 60503, 60504
60501	I	M	I	M	M	60401, 60402, 60403, 60404, 60405, 60406, 60502, 60503, 60504
60502	I	M	M	M	M	60401, 60402, 60403, 60404, 60405, 60406, 60503, 60504
60503	I	M	M	M	M	60401, 60402, 60403, 60404, 60405, 60406, 60504
60504	I	M	M	M	M	none
60401	I	F	M	I	M	60402, 60403, 60404, 60405, 60406
60403	M	M	M	M	M	none
60402	I	M	M	I	M	60404, 60405, 60406
60404	I	M	M	I	M	60405, 60406
60405	I	M	M	I	M	none
60406	I	M	I	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional
M: Moderately impaired
I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

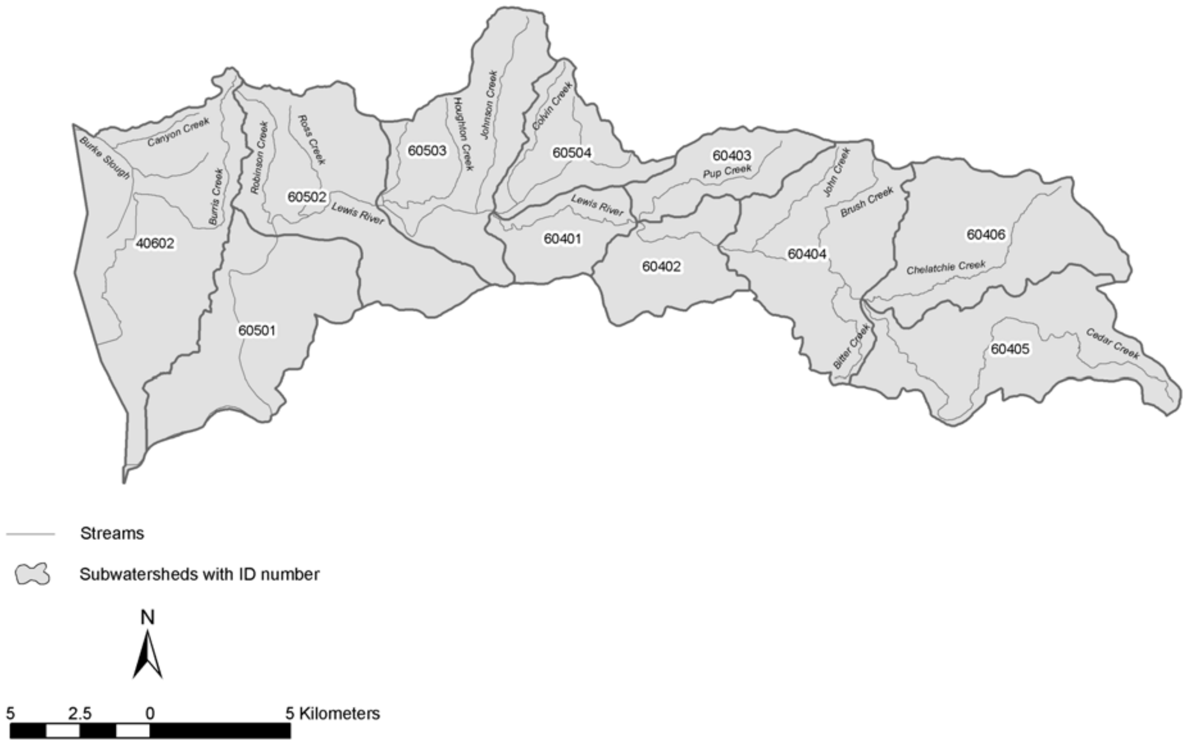


Figure 11-19. Map of the Lower North Fork Lewis Basin showing the location of the IWA subwatersheds.

Figure 11-20. IWA subwatershed impairment ratings by category for the Lower North Fork Lewis Basin.

11.7.1.1.1 Hydrology

Local hydrologic conditions are poor throughout the watershed, with 10 out of 11 subwatersheds falling into the impaired category. Only Pup Creek, a tributary to Cedar Creek, is rated as moderately impaired. It is important to note here that local hydrologic conditions in the IWA are evaluated on the basis of several localized indicators, such as the extent of impervious area, land cover, road density and urban zoning classifications. This intra-watershed approach, while informative regarding local sources of impairment, may overstate the impacts of localized effects for a large river like the Lewis. Conversely, conditions in small tributaries within those subwatersheds are almost exclusively governed by within-subwatershed conditions.

Watershed level conditions are rated as moderately impaired in all mainstem subwatersheds, and impaired in the Cedar Creek drainage and in Burris Creek (40602). Watershed level hydrologic conditions are somewhat better on average than the aggregation of within-watershed upstream effects would suggest, with all mainstem reaches considered only moderately impaired at the watershed scale. The IWA method for hydrology in the lower NF Lewis departs from the standardized method in other watersheds in order to account for the dominant influence of the dams on mainstem hydrology.

The natural hydrograph of the lower mainstem has been altered by hydro-regulation; however, flow releases at certain times of the year are designed to benefit fall chinook. In addition, subwatersheds above Merwin Dam are for the most part hydrologically functional. The lower mainstem subwatersheds therefore receive a moderately impaired rating as opposed to an impaired rating. Recall, however, that several small tributaries to the mainstem are subsumed in these mainstem subwatersheds. The watershed scale analysis does not logically apply to these small, terminal streams that are nearly unaffected by conditions outside the subwatershed. Conditions in these areas are best described by the local, intra-watershed characterization.

For the mainstem sections of subwatersheds 60501, 60502, 60503 and 60504, dam operations are the dominant factor influencing river hydrology. In addition, extensive channel modifications (artificial confinement and bank hardening) in the lower reaches have divorced the mainstem from its floodplain, reducing hydrologic and habitat connectivity while increasing risk of bed scour during high flow events. Wetlands that were once abundant in subwatersheds 60501 and 60502 no longer exist. High proportions of lower mainstem subwatersheds fall within the designated urban growth areas around communities such as Woodland. The two mainstem subwatersheds furthest downstream (60501, 60502) are largely developed, contain only 6% mature forest cover, and contain very small amounts of publicly owned lands (7% and 2% for 60501 and 60502, respectively).

The Cedar Creek drainage is also severely impaired hydrologically but due to different factors. Cedar Creek is dominated by timber activities on private and public lands. Mature forest cover is present over only about 24% of the drainage, with the highest coverage (51%) in the Pup Creek subwatershed. Seventy percent of the Cedar Creek drainage is in commercial timber production, with only 13% of the subwatershed under public ownership. Individual subwatersheds range from 41% designated commercial harvest (60401, lower Cedar Creek) to 95% (60403, Pup Creek).

11.7.1.1.2 Sediment

Local sediment conditions are impaired throughout the watershed with the single exception of subwatershed 60401 in lower Cedar Creek, which is rated functional. Natural erodability is relatively low in all subwatersheds, but conditions relative to the background level are rated moderately impaired to in all cases, with borderline impaired conditions present in some cases. As a low elevation, low gradient, low rain-on-snow proportion watershed, sediment impairment is largely caused by high road density, streamside road density, stream crossing density and impaired riparian conditions including substantial channel modifications. These problems are likely to be exacerbated in subwatersheds where hydrologic and riparian conditions are also impaired, such as Cedar Creek.

Sediment conditions are rated as moderately impaired at the watershed level in all Cedar Creek subwatersheds. Lower Cedar Creek (60401), which is rated locally functional for sediment conditions, is rated moderately impaired at the watershed level due to the influence of degraded areas upstream. All upstream subwatersheds in the Cedar Creek drainage are rated as moderately impaired for sediment.

Extensive channel modifications have starved the river of sediment in some areas while causing local sedimentation from bank erosion in other areas. Natural levels of erodability in the watershed are quite low, but intensive development and associated anthropogenic processes contribute to moderate impairment levels. Mainstem subwatersheds are also profoundly affected by the lack of sediment input from the upper watershed due to the presence of the dams.

11.7.1.1.3 Riparian

Functional riparian subwatershed conditions are entirely absent within the watershed, with three subwatersheds exhibiting substantially impaired conditions, including Chelatchie Creek, Burris Creek and the furthest downstream subwatershed of the mainstem North Fork. The causes are different in each case and tend to reflect the unique conditions in each area. Riparian degradation in the Cedar Creek drainage is related primarily to forest practices on both private and public lands.

The lower mainstem areas (60501, 60502) of the North Fork are characterized in large part by the nearly complete absence of riparian vegetation due to dikes, rip rap and other channel revetments. Denuded streambanks starve the river of organic debris inputs, remove potential sources of LWD, contribute to elevated stream temperatures and promote bank and channel erosion. Greater than 50% of subwatershed 60501 lies in the FEMA floodplain, but the river is largely disconnected from its floodplain by dikes and levees.

Burris Creek suffers many of the same riparian symptoms as the lower North Fork mainstem. Roughly 68% of the subwatershed is contained within the FEMA floodplain with minimal mature forest cover and scant levels of public ownership.

11.7.1.2 Predicted Future Trends

11.7.1.2.1 Hydrology

Absent efforts to remove channel modifications and restore the natural floodplain, mainstem hydrologic conditions are unlikely to improve in the foreseeable future. Small tributaries within mainstem subwatersheds (e.g., Johnson Creek, Houghton Creek, Robinson Creek) are likely to experience further hydrologic degradation due to local-level changes in landscape conditions, including full build-out of areas zoned for growth, higher road densities, and additional impervious surfaces.

Hydrologic conditions in the upper Cedar Creek/Chalatchie Creek drainage are expected to remain relatively stable or to slightly improve as new forest practices regulations begin to have an effect. Lower Cedar Creek subwatersheds (60401) may experience further degradation due to development pressures in areas that are zoned for development but have not been built out.

11.7.1.2.2 Sediment Supply

While localized management actions may improve conditions in smaller tributaries, mainstem sediment processes are likely to remain at moderately impaired levels due to cumulative upstream effects, local development effects, and the impact of hydro-regulation. The mainstem is expected to continue to lack coarse sediments due to the dams and to experience elevated fine sediment due to land use practices. Prospects for localized improvement are better in the upper mainstem subwatersheds (60503 and 60504) due to a much higher percentage of both mature forest cover (27% and 32%, respectively) and percentage of land in public ownership (47% and 42%, respectively) as compared to subwatersheds 60501 and 60502. These lands are managed almost entirely by the WDNR.

In the Cedar Creek drainage, sediment processes are expected to trend towards gradual improvement as improved forestry and road management practices take effect. However, if residential development expands in these areas, sediment conditions could trend towards further degradation.

11.7.1.2.3 Riparian Condition

In the lower mainstem subwatersheds, impaired riparian conditions are likely to persist due to existing streamside road densities, channel alterations, and increasing development pressure. Reconnection of the river with its historical floodplain is likely to be difficult to achieve due to development pressures in urban growth areas, high levels of private ownership, and potential displacement of established land-uses and existing structures.

In the Cedar Creek drainage, forest management on both public and private lands is expected to improve, leading to a gradual improvement in riparian conditions over the next 20 years. Impaired riparian conditions are expected to persist or worsen in lower mainstem subwatersheds due to existing streamside road densities, channel alteration, and increasing development pressures.

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Volume II, Chapter 12
Lewis River Subbasin—Upper North Fork

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12.0 Lewis River Subbasin—Upper North Fork

12.1 Subbasin Description

12.1.1 Topography & Geology

For the purposes of this assessment, the Upper North Fork Lewis is defined as the watershed area contributing to Merwin Dam, which is located at river mile 19.5 on the mainstem Lewis. The Lewis River has its headwaters in Skamania County and flows generally west/southwest, forming the border of Clark and Cowlitz Counties before reaching Merwin Dam. The drainage area is approximately 468,000 acres (731 mi^2) and reaches as high as 12, 270 feet on the summit of Mt. Adams.

Three reservoirs are situated on the mainstem. These are Swift Reservoir (Swift Dam Number 1, RM 47.9), Yale Lake (Yale Dam, RM 34.2), and Lake Merwin (Merwin Dam, RM 19.5). The 240-foot high Merwin Dam, completed in 1931, presents a passage barrier to all anadromous fish, blocking up to 80% of the historically available habitat.

Major tributaries to the Upper Lewis include Canyon Creek, Speelyai Creek (Lake Merwin tributaries), Siouxon Creek, Cougar Creek (Yale Lake tributaries), Swift Creek (Swift Reservoir tributary), Pine Creek, Muddy Creek, and Rush Creek (upper mainstem tributaries).

The Lewis basin has developed from volcanic, glacial, and erosional processes. Mount St. Helens and Mt. Adams have been a source of volcanic material as far back as 400,000 years ago. More recent volcanic activity, including pyroclastic flows and lahars, has given rise to the current landscape. Glaciation has shaped the valleys in upper portions of the basin as recently as 13,000 years ago. Oversteepened slopes as a result of glaciation, combined with the abundance of ash, pumice, and weathered pyroclastic material, have created a relatively high potential for surface erosion throughout the basin.

12.1.2 Climate

The climate is typified by mild, wet winters and warm, dry summers. Average annual precipitation ranges from 73 inches at Merwin Dam to over 115 inches in the upper basin (WRCC 2003). Much of the precipitation falls as snow in the higher elevations, contributing to streamflow from meltwater in dry summer months.

12.1.3 Land Use/Land Cover

The bulk of the land lies within the Gifford Pinchot National Forest. Approximately 70% of the basin is national forest or national monument land, 11% is state land, and the remainder is private, most of it in private industrial forestland ownership. Recreation uses and residential development have increased in recent years. The population of the basin is small, with only small rural communities. The year 2000 population was approximately 14,300 persons (LCFRB 2001). The majority of the basin is heavily forested, except for an area of approximately 30 square miles in the north part of the upper basin that was denuded by the 1980 eruption of Mount St. Helens. Stand replacement fires, which burned large portions of the basin between 1902 and 1952, have had lasting effects on basin hydrology, sediment transport, soil conditions, and riparian function. The largest of these was the Yacolt Burn in 1902. Subsequent fires followed in 1927 and 1929. Severe flooding in 1931 and 1934 likely was exacerbated by the effect of the fires on vegetation and soils. A breakdown of land ownership and land cover in the North Fork basin is given in Figure 12-1 and Figure 12-2. Figure 12-3 displays the pattern of landownership for the basin. Figure 12-4 displays the pattern of land cover / land-use.

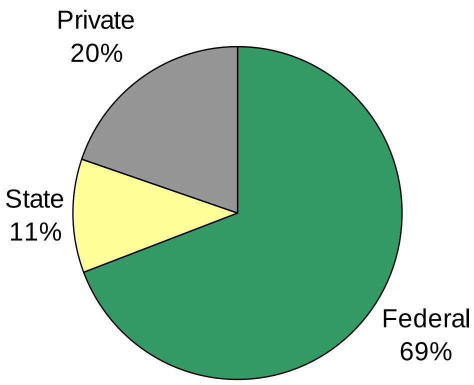


Figure 12-1. Upper North Fork Lewis River basin land ownership

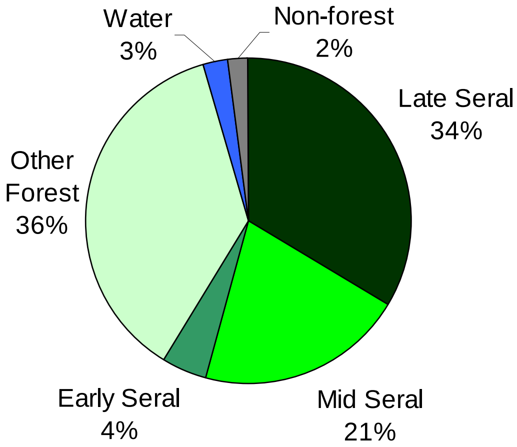


Figure 12-2. Upper North Fork Lewis River basin land cover

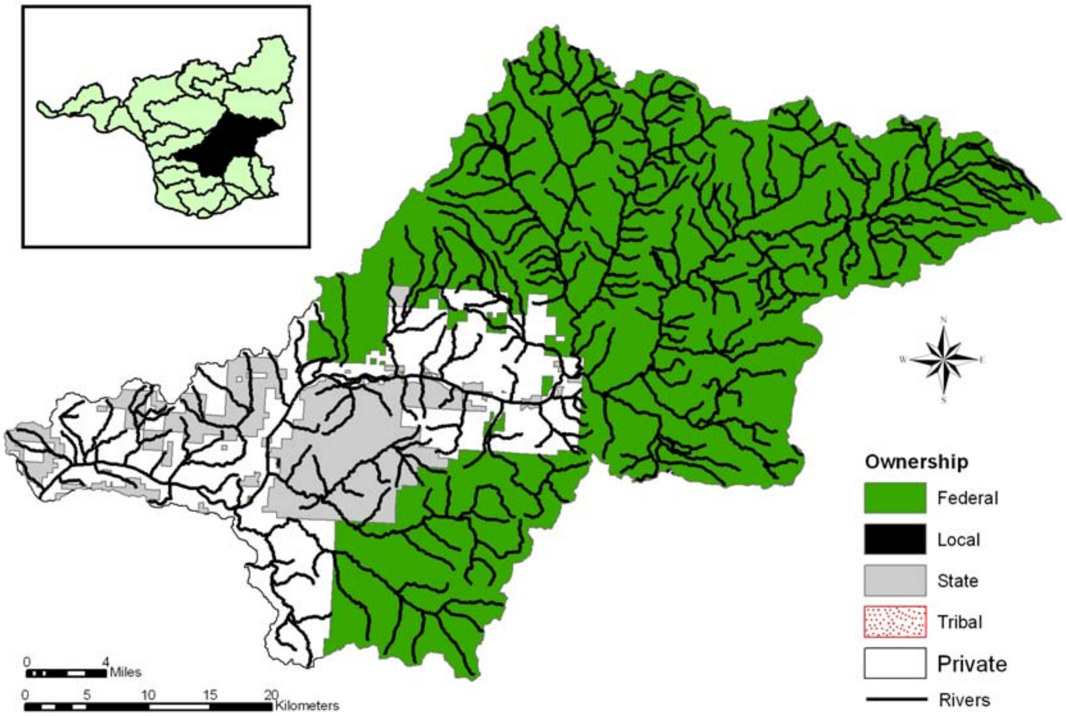


Figure 12-3. Landownership within the upper North Fork Lewis basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

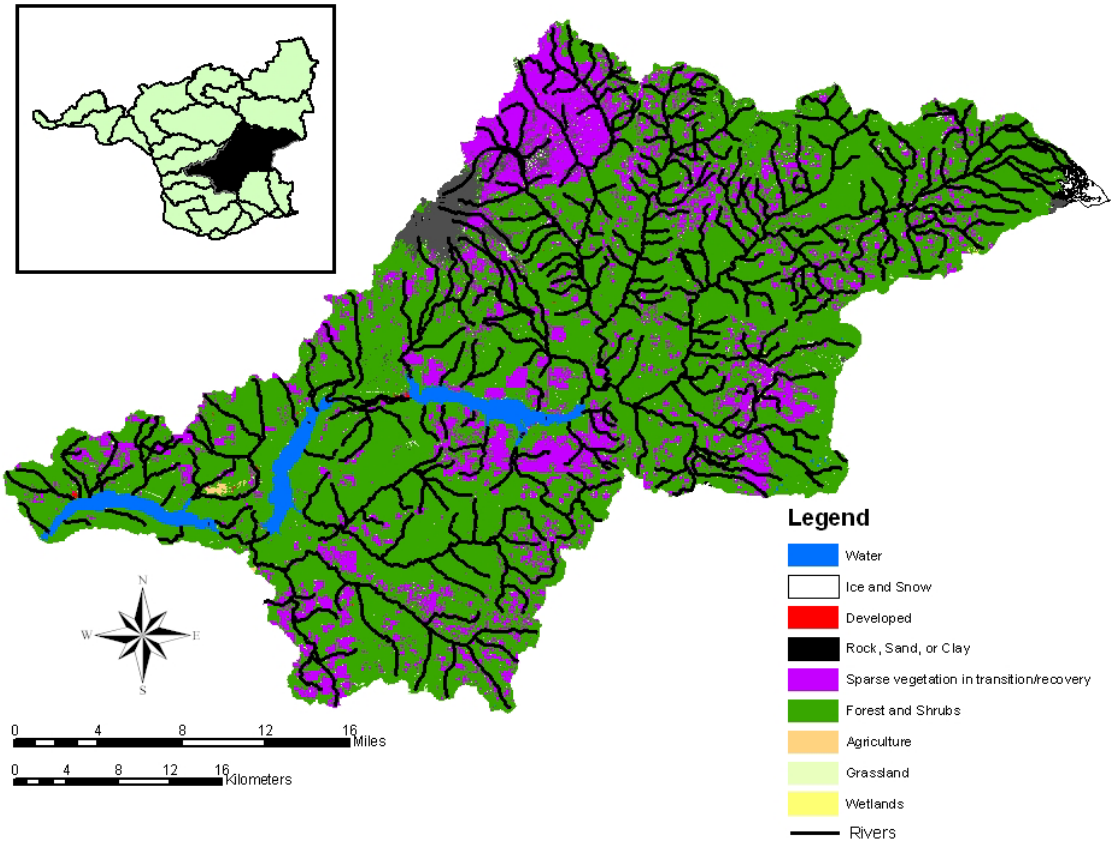
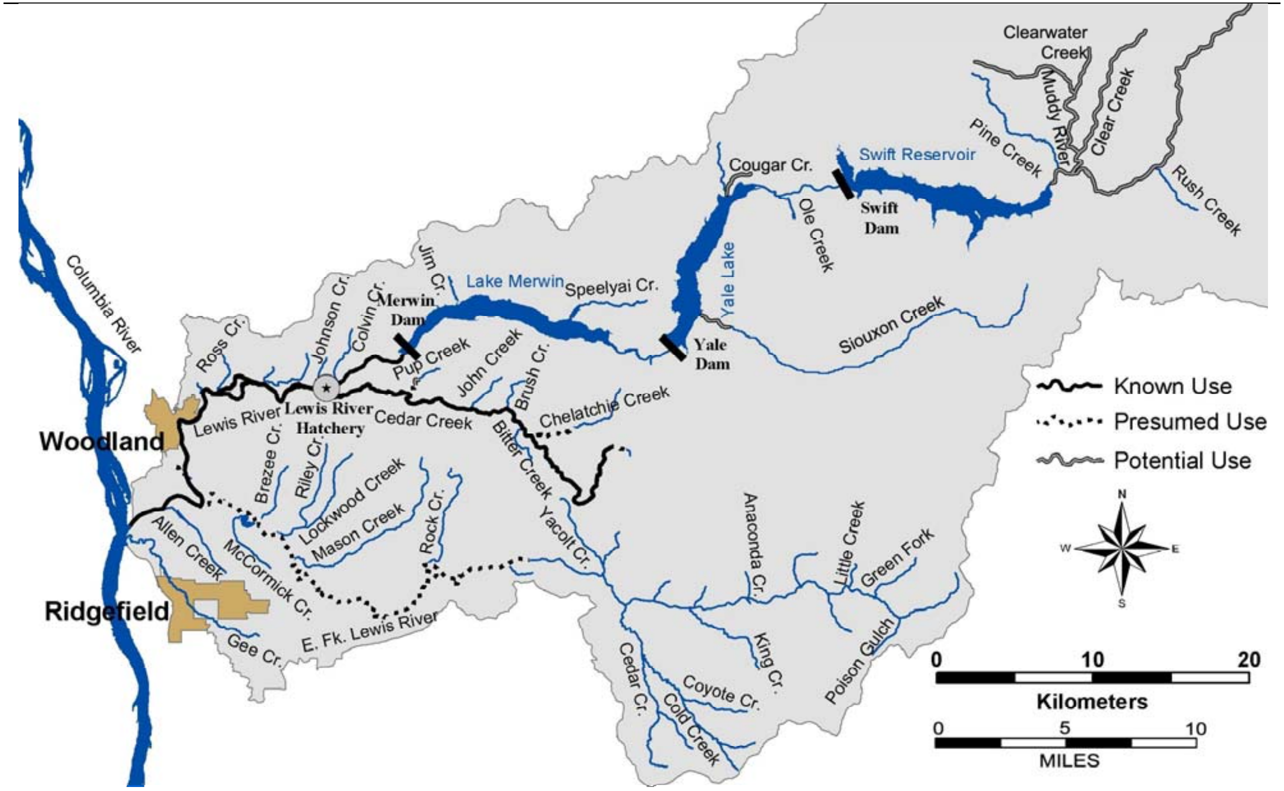


Figure 12-4. Land cover within the upper North Fork Lewis basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

12.2 Focal Fish Species

12.2.1 Spring Chinook—Lewis Subbasin

ESA: Threatened 1999	**SASSI: Depressed 2002**

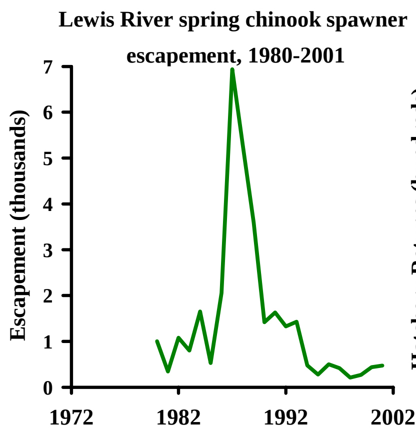


Distribution

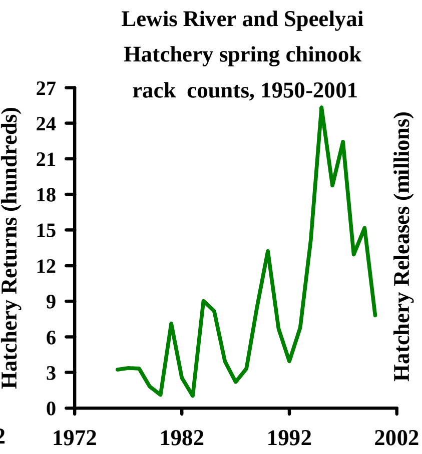
- Historically, spring chinook were found primarily in the upper basin; construction of Merwin Dam (RM 19) in 1931 blocked access to most of the spawning areas
- Currently, natural spawning occurs on the mainstem Lewis between Merwin Dam and the Lewis River Hatchery (~4 miles), but is concentrated in the area immediately below Merwin Dam and Cedar Creek

Life History

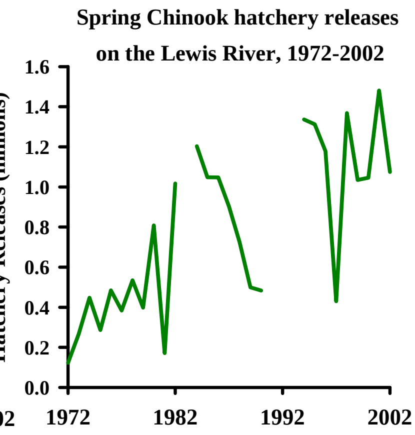
- Spring chinook enter the Lewis River from March through June
- Spawning in the Lewis River occurs between late August and early October, with peak activity in mid-September
- Age ranges from 2-year-old jacks to 6-year-old adults, with 4- and 5-year olds usually the dominant age class (averages are 54.5% and 36.8%, respectively)
- Fry emerge between December and January on the Lewis, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts



Lewis River spring chinook spawner escapement, 1980-2001



Lewis River and Speelyai Hatchery spring chinook rack counts, 1950-2001



Spring Chinook hatchery releases on the Lewis River, 1972-2002

Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit (ESU)
- The Lewis spring chinook stock designated based on distinct spawning distribution and spawning timing
- Genetic analysis of the NF Lewis River Hatchery spring chinook determined they were genetically similar to, but different from, Kalama and Cowlitz hatchery spring chinook stocks and significantly different from other Columbia River spring chinook

Abundance

- Reported abundance by WDF and WDF (Smoker et al 1951) indicates that at least 3,000 spring chinook entered the upper Lewis prior to the completion of Merwin Dam in 1932
- By the 1950s, only remnant (<100) spring chinook runs existed on the Lewis
- Lewis River spawning escapements from 1980-2001 ranged from 213 to 6,939
- Native component of the stock may have been extirpated and replaced by introduced hatchery stocks; hatchery strays account for most spring chinook spawning in the Lewis River

Productivity & Persistence

- NMFS Status Assessment for the Lewis River spring chinook indicated a 0.36 risk of 90% decline in 25 years and a 0.49 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.2
- Juvenile production from natural spawning below Merwin Dam is presumed to be low
- The Current Merwin Dam mitigation goal is to 12,800 spring chinook adults annually

Hatchery

- Lewis River Salmon Hatchery is located about RM 15 (completed in 1930).
- Spring chinook eggs were collected for hatchery production beginning in 1926; spring chinook releases into the Lewis from 1972-1990 averaged 601,184
- The hatchery has reared eggs from outside sources, primarily from the Cowlitz, but a few years in the 1970s there were fish transferred from Klickitat and Carson hatcheries

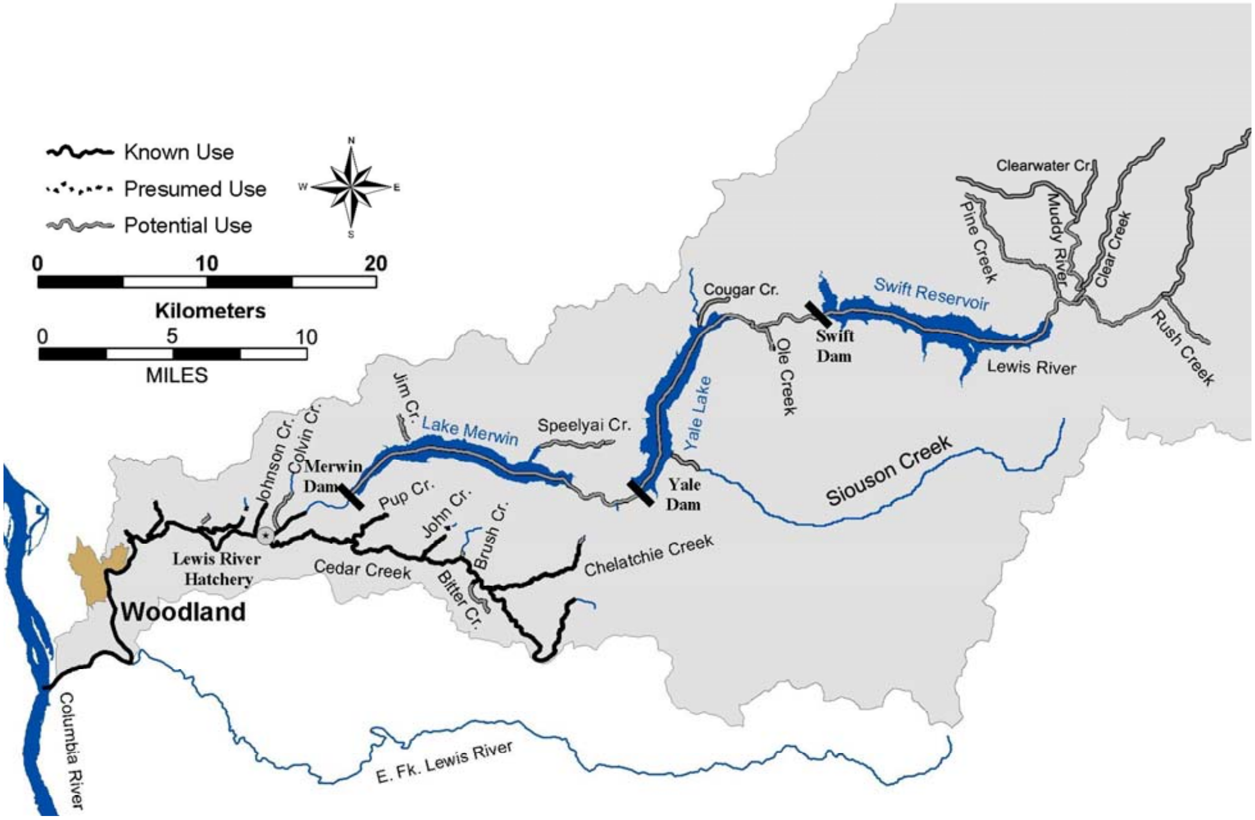
- Spring chinook broodstock return to the Lewis River Hatchery and are also trapped at Merwin Dam; a significant part of the annual return is not trapped and spawns naturally in the river

Harvest

- Spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- CWT data analysis of the 1989-1994 brood years indicates that 54% of the Lewis spring chinook were harvested and 46% escaped to spawn
- Fishery recoveries of the 1989-1994 brook Lewis River Hatchery spring chinook: Lewis sport (69%), Alaska (11%), British Columbia (10%), Washington Coast (5%), Columbia River (4%), and Oregon coast (1%)
- Mainstem Columbia River harvest of Lewis spring chinook was low after 1977 when April and May spring chinook seasons were eliminated to protect upper Columbia and Snake wild spring chinook.
- Mainstem Columbia harvest of Lewis River Hatchery spring chinook increased during 2001-2002 when selective fisheries for adipose marked hatchery fish enabled mainstem spring fishing in April and in May, 2002)
- Sport harvest in the Lewis River averaged 4,600 from 1980-1994 and reduced to 900 averaged during 1995-2002
- Tributary harvest is managed to attain the Lewis hatchery adult broodstock escapement goal

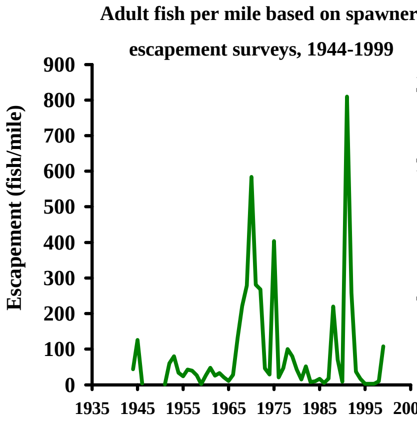
12.2.2 Coho—Lewis Subbasin (North Fork)

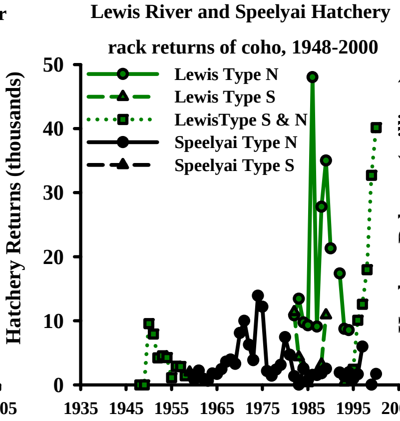
ESA: Candidate 1995 **SASSI: Unknown 2002**

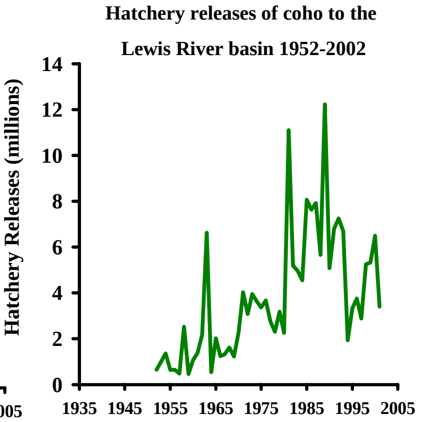


Distribution

- Managers refer to early coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late coho as Type N due to their ocean distribution generally north of the Columbia River
- Coho historically spawned throughout the basin.
- Natural spawning is thought to occur in most areas accessible to coho; coho currently spawn in the North Lewis tributaries below Merwin Dam including Ross, Cedar, NF and SF Chelatchie, Johnson, and Colvin Creeks; Cedar Creek is the most utilized stream on the mainstem
- Construction of Merwin Dam was completed in 1932; coho adults were trapped and passed above Merwin Dam from 1932-1957; the transportation of coho ended after the completion of Yale Dam (1953) and just prior to completion of Swift Dam (1959)
- As part of the current hydro re-licensing process, reintroduction of coho into habitat upstream of the three dams (Merwin, Yale, and Swift) is being evaluated


Adult fish per mile based on spawner escapement surveys, 1944-1999


Lewis River and Speelyai Hatchery rack returns of coho, 1948-2000


Hatchery releases of coho to the Lewis River basin 1952-2002

Life History

- Adults enter the Columbia River from August through January (early stock primarily from mid-August through September and late stock primarily from late September through November)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Late stock coho (or Type N) were historically present in the Lewis basin with spawning occurring from late November into March
- Early stock coho (or Type S) were historically present in the Lewis basin with spawning occurring from late October to November
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance

- Lewis River wild coho run is a fraction of its historical size
- An escapement survey in the late 1930s observed 7,919 coho in the North Fork
- In 1951, WDF estimated coho escapement to the basin was 10,000 fish in the North Fork (primarily early run)
- Escapement surveys from 1944-1999 on the North and South Fork Chelatchie, Johnson, and Cedar Creeks documented a range of 1-584 fish/mile
- Hatchery production accounts for most coho returning to the Lewis River

Productivity & Persistence

- Natural coho production is presumed to be generally low in most tributaries
- A smolt trap at lower Cedar Creek has shown recent year coho production to be fair to good in North and South forks of Chelatchie Creek (tributary of Cedar Creek) and in mainstem Cedar Creek

Hatchery

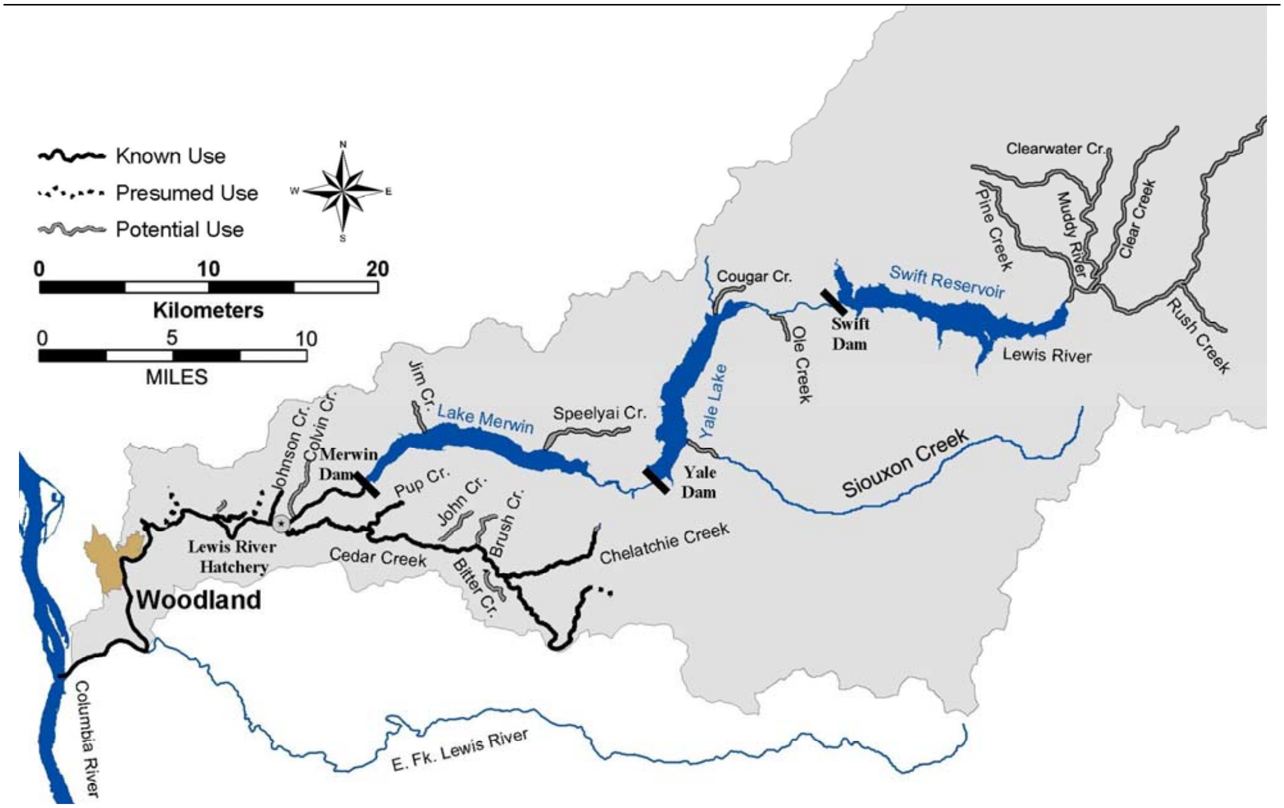
- The Lewis River Hatchery (completed in 1932) is located about RM 13; the Merwin Dam collection facility (completed in 1932) is located about RM 17; Speelyai Hatchery (completed in 1958) is located in Merwin Reservoir at Speelyai Bay; these hatcheries produce early and late stock coho and spring chinook
- Merwin Hatchery (completed in 1983) is located at RM 17 and rears steelhead, trout, and kokanee
- Coho have been planted in the Lewis basin since 1930; extensive hatchery coho releases have occurred since 1967
- The current Lewis and Speelyai hatchery programs include 880,000 early coho and 815,000 late coho smolts reared and released annually

Harvest

- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 3,500 coho (1980-98) were harvested annually in the North Lewis River sport fishery
- CWT data analysis of the 1995-97 brood early coho released from Lewis River hatchery indicates 15% were captured in a fishery and 85% were accounted for in escapement
- CWT data analysis of the 1995-97 late coho released from Lewis River Hatchery indicates 42% were captured in a fishery and 58% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 brood Lewis early coho were distributed between Washington ocean (58%), Columbia River (21%), and Oregon ocean (21%) sampling areas
- Fishery CWT recoveries of 1995-97 brood Lewis late coho were distributed between Columbia River (56%), Washington coast (31%), and Oregon ocean (21%) sampling areas

12.2.3 Winter Steelhead—Lewis Subbasin (North Fork)

ESA: Threatened 1998 **SASSI: Unknown 2002**

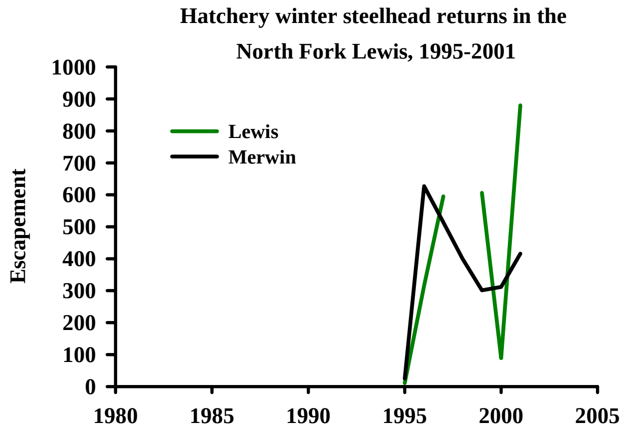


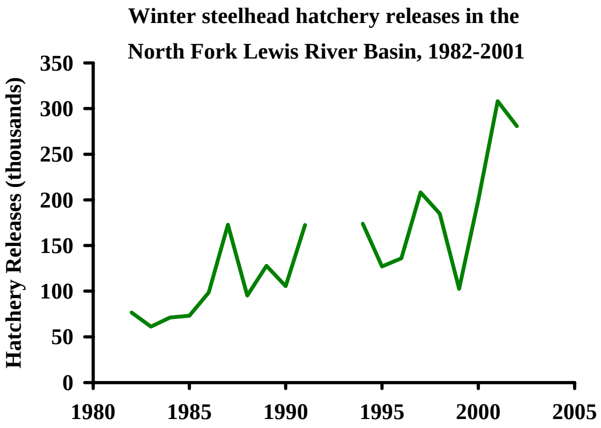
Distribution

- Spawning occurs in the NF Lewis River downstream of Merwin Dam and throughout the tributaries; natural spawning is concentrated in Cedar Creek
- Construction of Merwin Dam in 1929 blocked all upstream migration; approximately 80% of the spawning and rearing habitat are not accessible; a dam located on Cedar Creek was removed in 1946, providing access to habitat throughout this tributary

Life History

- Adult migration timing for NF Lewis winter steelhead is from December through April
- Spawning timing on the NF Lewis is generally from early March to early June
- Limited age composition data for Lewis River winter steelhead suggest that most steelhead are two-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May





Diversity

- Mainstem/NF Lewis winter steelhead stock designated based on distinct spawning distribution and run timing
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead likely spawned with native Lewis stocks
- Allele frequency analysis of NF Lewis winter steelhead in 1996 was unable to determine the distinctiveness of this stock compared to other lower Columbia steelhead stocks

Abundance

- Recent analysis for re-license estimate historical abundance ranging from 5,100-10,000 annually for upper Lewis above Merwin Dam
- In 1936, steelhead were reported in the Lewis River during escapement surveys
- Wild winter steelhead escapement counts for the NF Lewis River are not available
- Escapement goal for the NF Lewis River is 698 wild adult steelhead
- Hatchery origin fish comprise most of the winter steelhead run on the NF Lewis
- WDF estimated that only 6% of the returning winter steelhead in the NF are wild fish

Productivity & Persistence

- Winter steelhead natural production is expected to be low and primarily in Cedar Creek

Hatchery

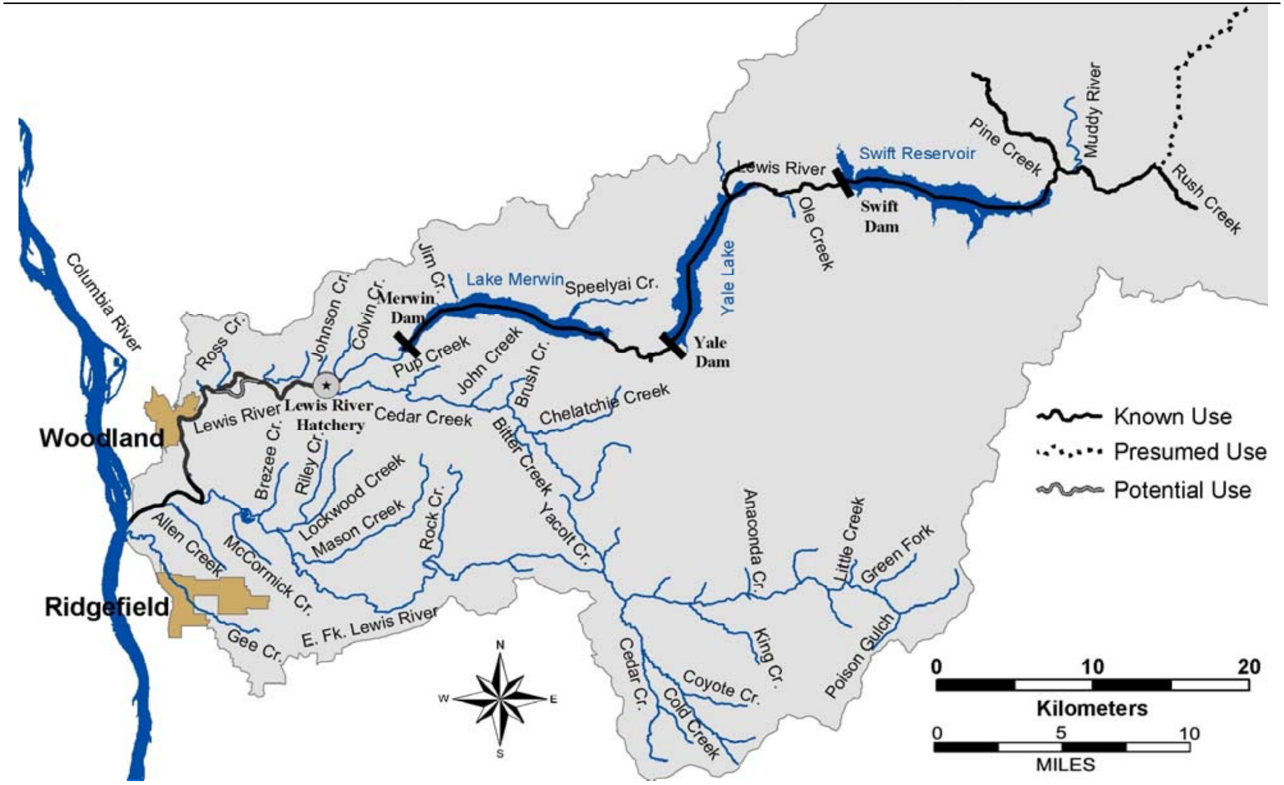
- The Lewis River Hatchery (about 4 miles downstream of Merwin Dam) and Speelyai Hatchery (Speelyai Creek in Merwin Reservoir) do not produce winter steelhead
- The Ariel (Merwin) Hatchery is located below Merwin Dam; the hatchery has been releasing winter steelhead in the Lewis basin since the early 1990s
- A net pen system has been in operation on Merwin Reservoir since 1979; annual average smolt production has been 35,000 winter steelhead; total release data are available from 1982-2001
- Hatchery fish contribute little to natural winter steelhead production in the NF Lewis River

Harvest

- No directed commercial or tribal fisheries target NF Lewis winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Lewis River basin
- Winter steelhead sport harvest (hatchery and wild) in the NF Lewis River averaged 300 fish during the 1960s and 1970s; average annual harvest in the 1980s averaged 1,577; since 1992, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild winter steelhead

12.2.4 *Bull Trout—Lewis River Subbasin*

ESA: Threatened 1999 **SASSI: Depressed 1998**



Distribution

- The reservoir populations are isolated because there is no upstream passage at the dams

Life History

- Prior to dam construction anadromous and fluvial (rivers) forms were likely present

Diversity

- Genetic sampling in 1995 and 1996 showed that Lewis River bull trout are similar to Columbia River populations
- Swift samples were significantly different from Yale and Merwin samples, indicating that there may have been biological separation of upper and lower Lewis River stocks before construction of Swift Dam in 1958
- Stock designated based on geographic distribution

Abundance

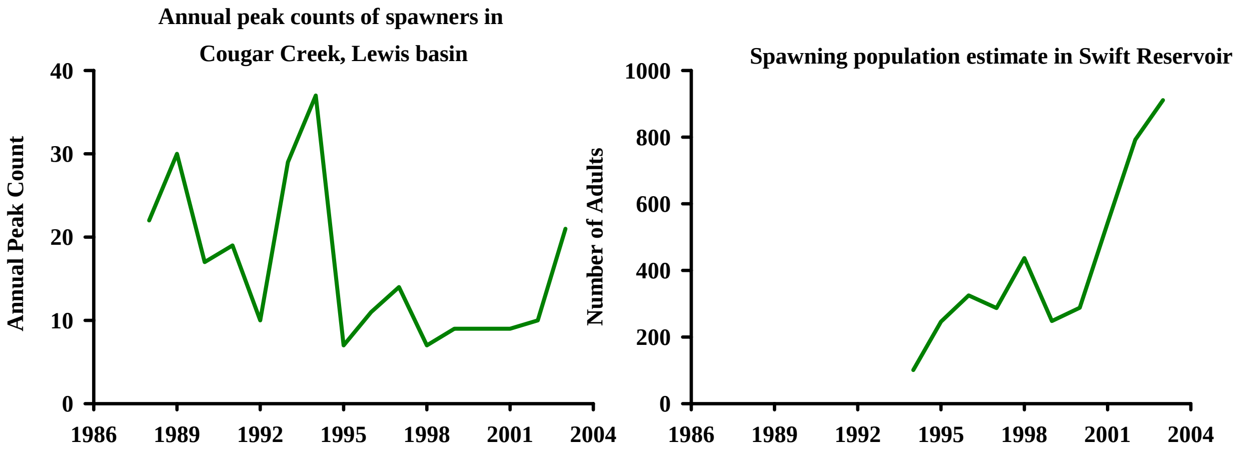
- No information on bull trout abundance in the lower NF Lewis is available

Productivity & Persistence

- WDFW (1998) considers Lewis River bull trout to be at moderate risk of extinction

Hatchery

- Three hatcheries exist in the subbasin: two below Merwin Dam, and one on the north shore of Merwin Reservoir. Bull trout are not produced in the hatcheries



Annual peak counts of spawners in Cougar Creek, Lewis basin

Spawning population estimate in Swift Reservoir

Harvest

- Fishing for bull trout has been closed since 1992
- Hooking mortality from catch and release of bull trout in recreational fisheries targeting other species may occur

12.2.5 Cutthroat Trout—Lewis River Subbasin

ESA: Not Listed	**SASSI: Unknown 2000**

Distribution

- Anadromous forms exist in the NF Lewis and its tributaries up to Merwin Dam, which blocks passage
- Adfluvial fish have been observed in Merwin, Yale and Swift Reservoirs
- Resident fish are found in tributaries throughout the North and East Fork basins

Life History

- Anadromous, fluvial, adfluvial and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Fluvial, adfluvial and resident spawn timing is from February through June

Diversity

- Distinct stock based on geographic distribution of spawning areas
- Genetic analysis has shows Lewis River cutthroat to be genetically distinct from other lower Columbia coastal cutthroat collections

Abundance

- Insufficient data exist to identify trends in survival or abundance
- No data describing run size exist
- In 1998, sea-run cutthroat creel survey results showed a catch of only 20 fish
- Fish population surveys in Yale Lake tributaries showed that cutthroat trout was the most abundant salmonid species in those streams
- Cutthroat were the only salmonid found in some small Yale Lake tributaries during sampling in 1996

Hatchery

- Prior to 1999 Merwin Hatchery annually released 25,000 sea-run smolts into the NF Lewis
- The program was discontinued in 1999 due to low creel returns and concerns over potential interaction with wild fish

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest of adipose fin clipped cutthroat occurs in the mainstem Columbia downstream of the Lewis River
- Lewis River wild cutthroat (unmarked fish) must be releases in mainstem Columbia and in Lewis River sport fisheries

12.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- In general, loss of habitat quantity and quality has the highest relative impact on populations in the lower North Fork, while hydrosystem access and passage impacts are greatest for those populations that historically utilized the upper NF Lewis (i.e. winter steelhead and coho). Thus, for populations in the upper NF Lewis basin, the impact of hydrosystem access and passage minimizes the relative importance of all other potentially manageable impact factors.
- Loss of estuary habitat quantity and quality has high relative impacts on chum and moderate impacts on fall chinook and late fall chinook.
- Harvest has relatively high impacts on fall chinook and late fall chinook, while harvest impacts to spring chinook, chum, winter steelhead, and coho are relatively minor.
- Hatchery impacts are high to moderate for late fall chinook, spring chinook, winter steelhead and coho. Hatchery impacts on chum and fall chinook are relatively low.
- Impacts of predation are moderately important to coho, but are relatively minor for all populations.

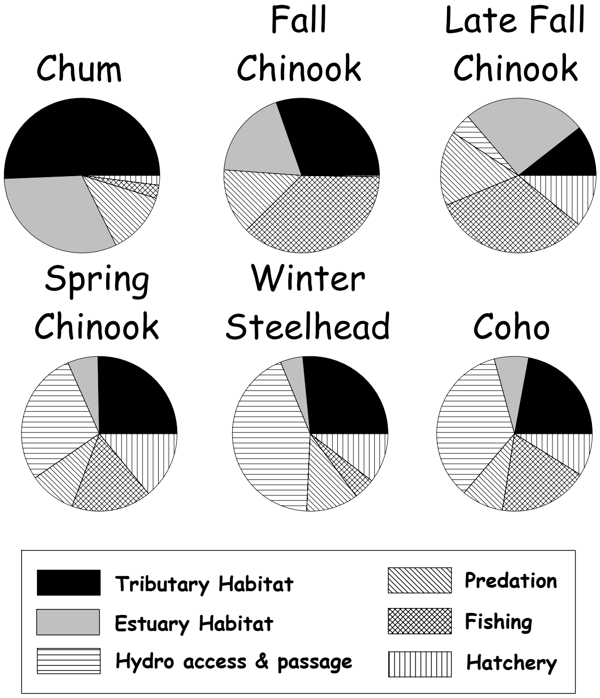


Figure 12-5. Relative index of potentially manageable mortality factors for each species in the North Fork Lewis subbasin.

12.4 Hatchery Discussion

A discussion of hatcheries in the Lewis River basin is included in Vol II, Chapter 10.4.

12.5 Fish Habitat Conditions

12.5.1 Passage Obstructions

The three dams on the mainstem are Merwin Dam (RM 20), Yale Dam (RM 35), and Swift No. 1 (RM 45). Each dam creates its own reservoir with lengths of 14.5, 10.5 and 11.5 miles, respectively. A smaller dam, Swift No. 2, diverts water from the tailrace of Swift No. 1 down a 3.5-mile canal to a power generating facility. On April 21, 2002 the Swift number 2 powerhouse was destroyed by a breach in the power canal. A rebuild of the powerhouse is underway.

All anadromous passage has been blocked by the 240-foot high Merwin Dam since shortly after its construction in 1931. This facility blocked approximately 80% of the available habitat for steelhead, approximately 50% of the spawning habitat for fall chinook, and virtually eliminated the natural run of spring chinook (WDF 1993, McIssac 1990). Over 25 miles of stream habitat was directly inundated by the reservoirs (USFS 1995a).

Bull trout populations that were historically fluvial and/or anadromous are now adfluvial populations isolated in the reservoirs, with limited access to spawning habitat. Bull Trout spawning occurs in tributaries to Swift Reservoir and Yale Lake and there is no upstream passage between reservoirs. Bull trout found in Lake Merwin are believed to have spilled over Yale Dam (Wade 2000). Passage issues for bull trout in the upper North Fork basin have been identified in the Bull Trout Recovery Plan (USFWS 2002). Upstream and downstream passage at Yale Dam and Swift Dam (Number 1 and 2) is considered necessary for Lewis River bull trout recovery (USFWS 2002).

12.5.2 Stream Flow

Average annual stream flow measured below Merwin Dam is 4,849 cfs. Flow is dominated by winter rains, though spring and summer flow in the North Fork is augmented by glacier melt. The annual hydrograph indicates peak flows from winter rain and rain-on-snow events as well as peak flows in the spring due to snowmelt (Figure 12-6). Reservoir levels and flow between reservoirs are largely controlled by releases from the dams.

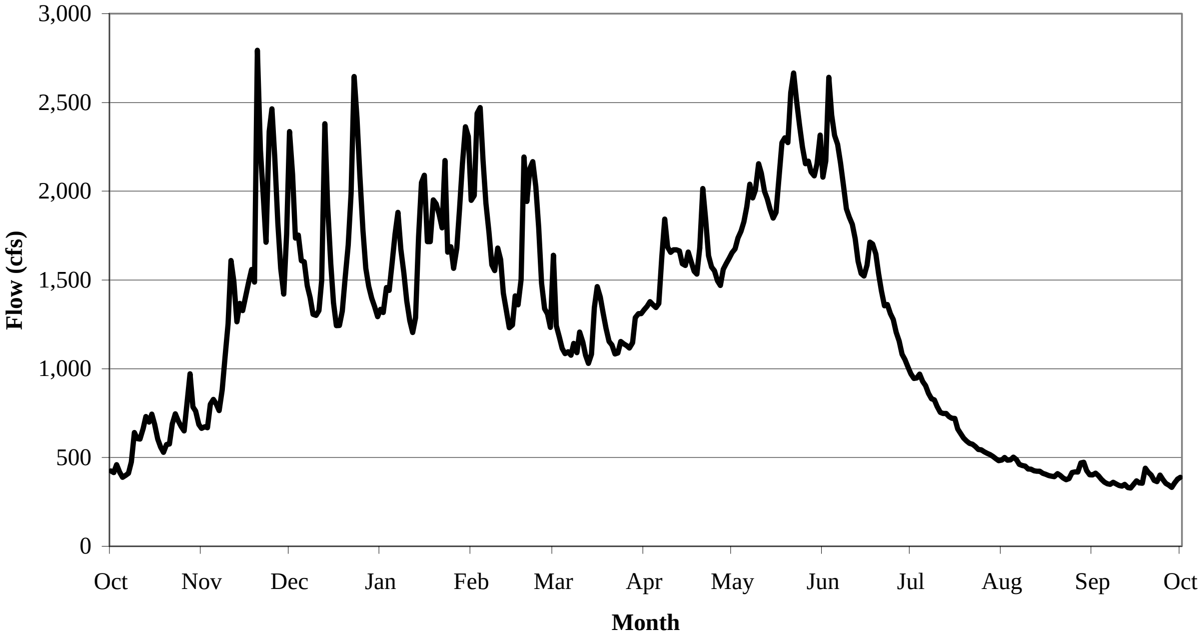


Figure 12-6. Lewis River flow above reservoirs (Lewis River above Muddy Creek) for water years 1961-1970. These data exhibit the double humped hydrograph typical of a winter rain/rain-on-snow and spring snowmelt flow regime. USGS Gage #14216000; Lewis River above Muddy River near Cougar, Wash.

The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that runoff properties are “impaired” in 10 of the 77 subwatersheds (7th field) in the upper Lewis basin. Seven subwatersheds are “moderately impaired” and the remainder are “functional”. Impaired subwatersheds are located primarily in the Canyon Creek drainage (Lake Merwin tributary) and other small Lake Merwin tributaries on the north side of Lake Merwin close to Merwin Dam. These areas are located mostly in private commercial timberland where forests are in young seral stages and road densities are high. Most of the basin that is within the Gifford Pinchot National Forest is in good condition with regards to runoff properties, however, peak flow analyses by the USFS in 1995 and 1996 indicated potential concerns with increases in the 2-year peak flow in lower and middle Pine Creek and middle Swift Reservoir tributaries due to vegetation conditions (USFS 1995b, USFS 1996). Many streams were also characterized as having extended stream channel networks due to roads and road ditches, which can increase peak flow potential. The channel network of lower Pine Creek has increased 48% due to the presence of roads.

The toe-width method was used to estimate low flow impacts on Upper Lewis River tributaries. The resulting values were compared to stream gauge data and spot flow measurements (Caldwell 1999). Results indicate that in Speelyai Creek, flow may be limiting for juvenile rearing June through November, and may be limiting for fall spawning species in the fall. Flows appear to be adequate for summer steelhead and coho spawning. In Canyon Creek, flows are below optimum for fall spawning, except for coho. Flows for coho spawning approach optimal conditions by mid October. In Cougar Creek, flows are also below optimum for fall spawning, except for coho. Flows for salmonid rearing are adequate.

A 1996 PacifiCorp survey in Panamaker (tributary to Cougar Creek), Ole, Rain, and Dog Creeks indicated that these experienced intermittent fall flow, potentially limiting available habitat (Wade 2000).

Total consumptive water use in the basin, estimated at approximately 672 million gallons per year (mgy) is expected to increase by 573 mgy by 2020, however, the use is minor when compared to stream base flows (LCFRB 2001).

12.5.3 Water Quality

In the upper Lewis basin, stream water temperatures have exceeded the state standard of 16ºC in Pine, Siouxon, Canyon, and Quartz Creeks. This is of particular concern in Pine Creek due to the presence of bull trout that require very cold water. High temperatures on the portions of Canyon and Siouxon that lie within state and private land are attributed to lack of stream shade. It is suspected that elevated temperatures in Pine Creek are due to channel widening from timber harvest and vegetation removal as a result of the 1980 Mount St. Helens eruption (USFS 1995b, USFS 1996).

High turbidity levels have been documented in some streams. In November 1994 turbidity was measured at 94 NTUs in the Muddy River, 36 NTUs in the upper mainstem Lewis, and 18 NTUs in Pine Creek (USFS 1995b).

A lack of marine derived nutrients from anadromous salmon carcasses may be a limiting factor in the upper watershed but little information exists on this subject (Wade 2000).

12.5.4 Key Habitat

The USFS has evaluated pool frequency in the upper watershed. Upper Pine Creek, an important Bull Trout spawning stream, has both poor (</=50% desired frequency) and fair (50-99% desired frequency) pool frequency. Tributaries on the south side of Swift Reservoir received a poor pool frequency rating (USFS 1995). Many tributaries to Canyon Creek and Siouxon creek also have a poor rating, potentially impacting cutthroat trout. In the upper watershed above the Alec Creek confluence, approximately 70% of the surveyed reaches received a poor rating and 26% received a rating of fair for pool frequency (USFS 1995b).

The USFS gauges habitat fragmentation by calculating the amount of road crossings over streams per lineal mile of stream segment. Using this approach, the lower Pine Creek basin is classified as having “extreme” fragmentation (>2.26 road crossings/stream mile) and the upper Pine Creek basin has “high” fragmentation (>1.5 road crossings/stream mile). Cougar Creek was not surveyed (USFS 1995b).

12.5.5 Substrate & Sediment

Surface erosion is a particular concern in the northern portion of the upper basin due to highly erodable ash and pumice soils from past eruptions of Mount St. Helens. Mass wasting is also a concern throughout the basin and became particularly evident in the winter 1996 floods that resulted in some large landslides. Portions of the basin have a combination of high road densities, steep slopes, and highly erodable soils that make them especially vulnerable to increased sediment production and transport. These conditions, combined with heavy logging on steep slopes, have increased the potential for sediment production. According to USFS watershed analyses, over 11% of the Pine Creek basin is considered potentially unstable, over 40% of the Cougar Creek basin is considered potentially unstable, and over 27% of the upper watershed (above the Pine Creek confluence) is considered either unstable or potentially unstable (USFS 1995a, USFS 1995b, USFS 1996).

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results show that the subwatersheds with the greatest sediment supply impairments are tributary basins on the northeastern portion of Swift Reservoir and in lower Canyon Creek. Approximately half of the remaining subwatersheds are rated as moderately impaired and the remainder are rated as functional. The functional subwatersheds are clustered primarily in the upper portion of the basin. Impaired sediment supply conditions are related primarily to high road densities on naturally unstable slopes.

As part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP), investigators found that an increase in road densities is associated with declines in status of bull trout. In areas where bull trout populations were strong, road densities averaged 0.45 mi/ mi^2, whereas areas where populations were depressed or absent, road densities averaged 1.36 mi/ mi^2 and 1.71 mi/ mi^2, respectively (Quigley and Arbelbide 1997). The majority of the subwatersheds contributing to bull trout streams have road densities greater than 2 miles/mi^2.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

12.5.6 Woody Debris

LWD concentrations in Pine Creek are low (<40 pieces per mile). Pine Creek also has low recruitment potential due to logging and effects of the 1980 eruption of Mount St. Helens. Surveys in the upper watershed above the Alec Creek confluence indicate that approximately 53 percent of the surveyed reaches had less than 40 pieces per mile (USFS 1995b).

12.5.7 Channel Stability

An aerial photograph analysis conducted by the USFS indicated that reaches of Pine and Swift Creeks have been adjusting to past timber harvest, roading, and the Mount St. Helens eruption. Reaches in Pine Creek increased in width by as much as 210% between 1959 and 1989 and are considered the most sensitive reaches in the area due to highly erodible mudflow deposits. High rates of bank erosion on these streams were also noticed during the analysis (USFS 1996). In 1989, the Upper Lewis mainstem, Quartz Creek, and Pin Creek were still adjusting from past sediment pulses due to 1970s flooding. Several reaches of steams on the south side of the upper mainstem suffer from bank instability and erosion (USFS 1995b).

12.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 42 of the 77 subwatersheds in the upper Lewis basin are moderately impaired with regards to riparian function and the remainder are considered functional. Functional riparian areas are located primarily in the upper mainstem subwatersheds above the Muddy Creek confluence and in Siouxon Creek subwatersheds.

The Regional Ecosystem Assessment Project (REAP) report characterized riparian reserves in the upper Lewis basin as having between 50-80% late successional forest. The portion of the basin between upper Yale Lake and just above Pine Creek has only 22% of stream riparian reserves in late successional stages (USFS 1996). The upper basin (above the Alec Creek confluence) has 46% of stream riparian reserves in late successional stages (USFS 1995b).

Timber harvest has occurred on approximately 36%, 77%, and 23% of the riparian reserves in the upper, middle, and lower Pine Creek basins, respectively (USFS 1996). On Rush Creek, 13% of the riparian area in the upper basin and 23% in the lower basin has been harvested (USFS 1995a).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

12.5.9 Floodplain Function

The Upper Lewis system consists of steep slopes with limited floodplains. Any floodplains along the mainstem would have been inundated by the reservoirs. Other floodplain areas are largely intact.

12.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to upper NF Lewis River spring chinook, coho, and winter steelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

12.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes. Habitat-based assessments were completed in the upper NF Lewis basin for spring chinook, coho, and winter steelhead. There is currently no passage above the dams. Hypothetical survival through the dams and reservoirs was modeled at 100% since the primary objective of the EDT analysis is to assess the relative impact of habitat conditions in the upper basin. This should be taken into consideration when interpreting the numbers presented in the baseline EDT population analysis.

Model results indicate that adult productivity has declined for all species in the upper NF Lewis basin (Table 12-1). Current productivities are between 21% and 44% of historical levels. Adult abundance levels have also declined sharply for all species (Figure 12-7). Spring chinook have seen the greatest decline in adult abundance, with current estimates at only 15% of historical levels. Species diversity (as measured by the diversity index) has decreased from historical estimates for the upper NF Lewis (Table 12-1). Fall chinook and spring chinook diversity is currently at 35% and 30% of historical levels, respectively. Both coho and winter steelhead diversity has declined by 51% and 57%, respectively.

As with adult productivity, smolt productivity has declined for all species in the upper NF Lewis. Current productivity estimates are between 31% and 57% of the historical smolt productivity, depending on species (Table 12-1). Smolt abundance numbers are similarly low, especially for spring and fall chinook (Table 12-1). Current smolt abundance estimates for spring and fall chinook are at 20% and 30% of historical levels, respectively.

Model results indicate that restoration of PFC conditions would have important benefits in all performance parameters for all species (Table 12-1). For adult abundance, restoration of PFC conditions would increase current returns from 30% for winter steelhead to 90% for spring chinook. Similarly, smolt abundance numbers would increase for all species (Table 12-1). Spring chinook would see the greatest increase in smolt numbers with a 74% increase.

Table 12-1. Upper NF Lewis — Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Spring Chinook	1,624	3,079	10,560	4.7	8.0	15.0	0.30	0.44	0.99	66,195	114,944	335,351	176	290	424
Coho	11,526	16,208	23,332	4.7	7.7	21.8	0.48	0.59	0.97	254,912	358,878	345,473	92	150	295
Winter Steelhead	1,952	2,533	4,954	8.0	15.0	24.1	0.42	0.43	0.98	32,330	41,276	73,470	131	240	350

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

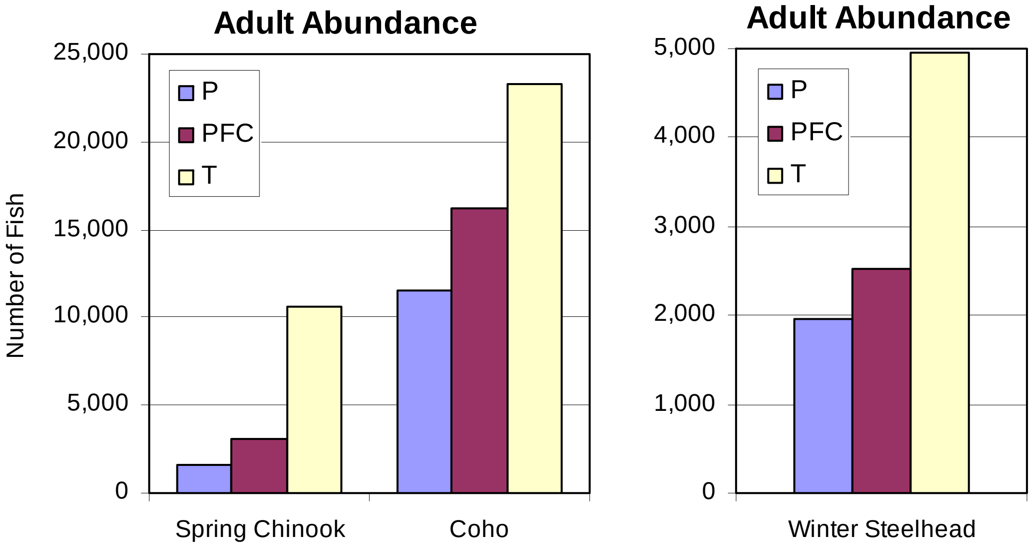


Figure 12-7. Upper NF Lewis— Adult abundance of upper NF Lewis spring chinook, coho and winter steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

12.6.2 Reach Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin. See Figure 12-8 for a map of EDT reaches in the upper NF Lewis Basin.

The reach analysis for the upper NF Lewis was conducted for spring chinook, coho, and winter steelhead. For all species, initial reach analyses showed strong restoration potential in reaches that are now inundated by Merwin, Yale, and Swift Reservoirs. These impoundments flooded approximately 30 stream miles of quality habitat. Due to the impracticality of any restoration measures in the flooded reaches (beside removal of the dams), these reaches were subsequently omitted and analyses run again.

Reaches with a high priority for spring chinook are located in the upper Lewis mainstem (Lewis 18-20, 22, 25 and 27) (Figure 12-9). These areas represent important chinook spawning and rearing habitat and show a combined preservation and restoration habitat recovery emphasis. Lewis 18 appears to be the reach with the highest potential for both preservation and restoration.

Important coho reaches are located in mainstem areas (Lewis 18, 19, 21 and 27) as well as in the tributaries (Diamond Creek, Clearwater Creek, Pepper Creek, and Muddy River among others) (Figure 12-10). These high priority reaches show a mix of recovery emphases. Reaches Lewis 18 and Muddy R1 appear to have the highest restoration potential of any reach modeled for coho. Similarly, reach Lewis 19 has the highest preservation emphasis of any reach modeled for coho.

For winter steelhead, the high priority reaches are similar to those for spring chinook, however, winter steelhead utilize tributary habitat to a greater extent (Figure 12-11). Important mainstem reaches include Lewis 19, 21, and 23-27. Important tributary reaches include areas in Crab Creek, Pine Creek, and Big Creek. The majority of important steelhead reaches show a preservation habitat recovery emphasis, with Lewis 18, Lewis 27, and Crab Creek showing a combined preservation and restoration recovery emphasis.

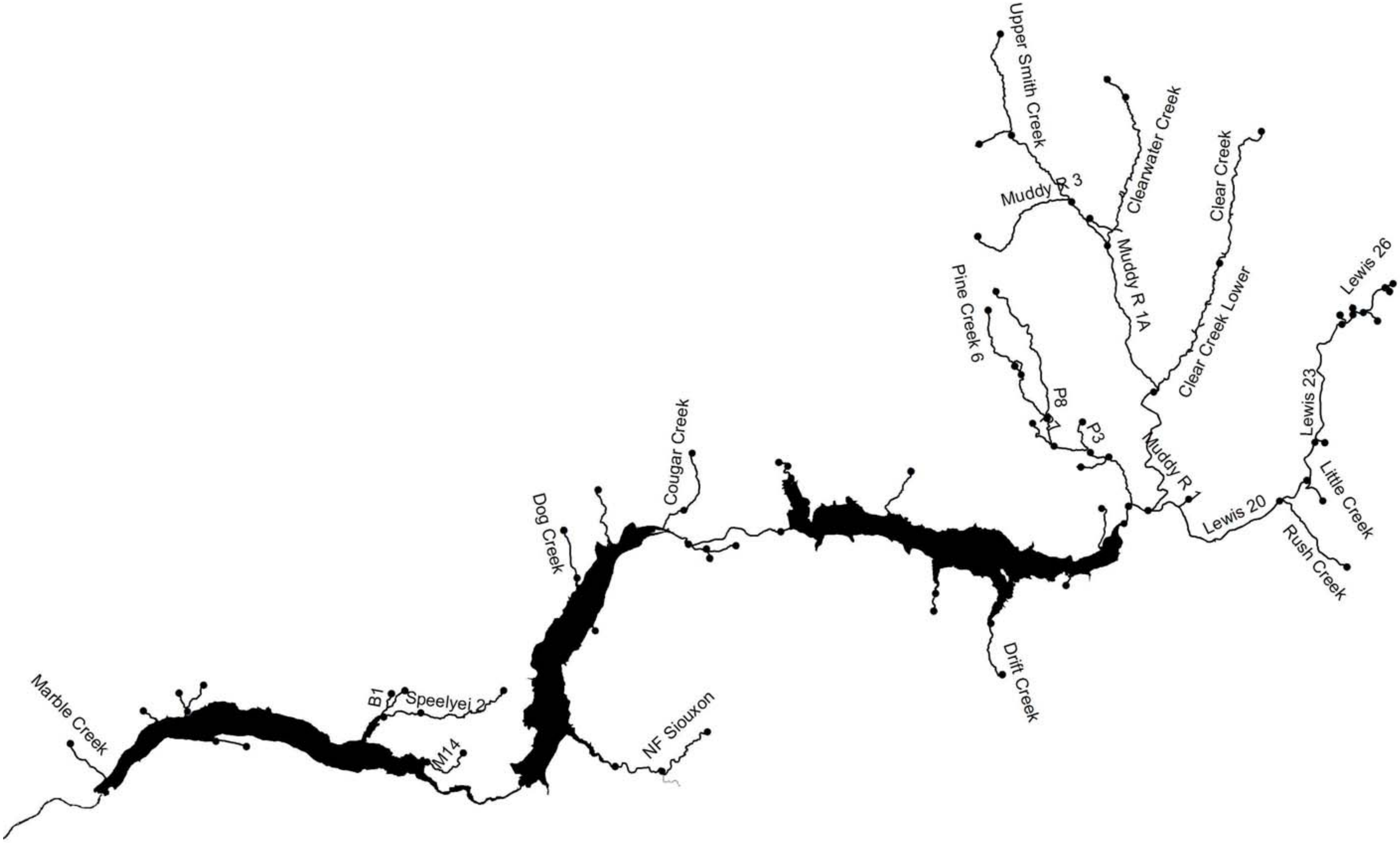


Figure 12-8. Upper North Fork Lewis Basin EDT reaches. Some reaches are not labeled for clarity.

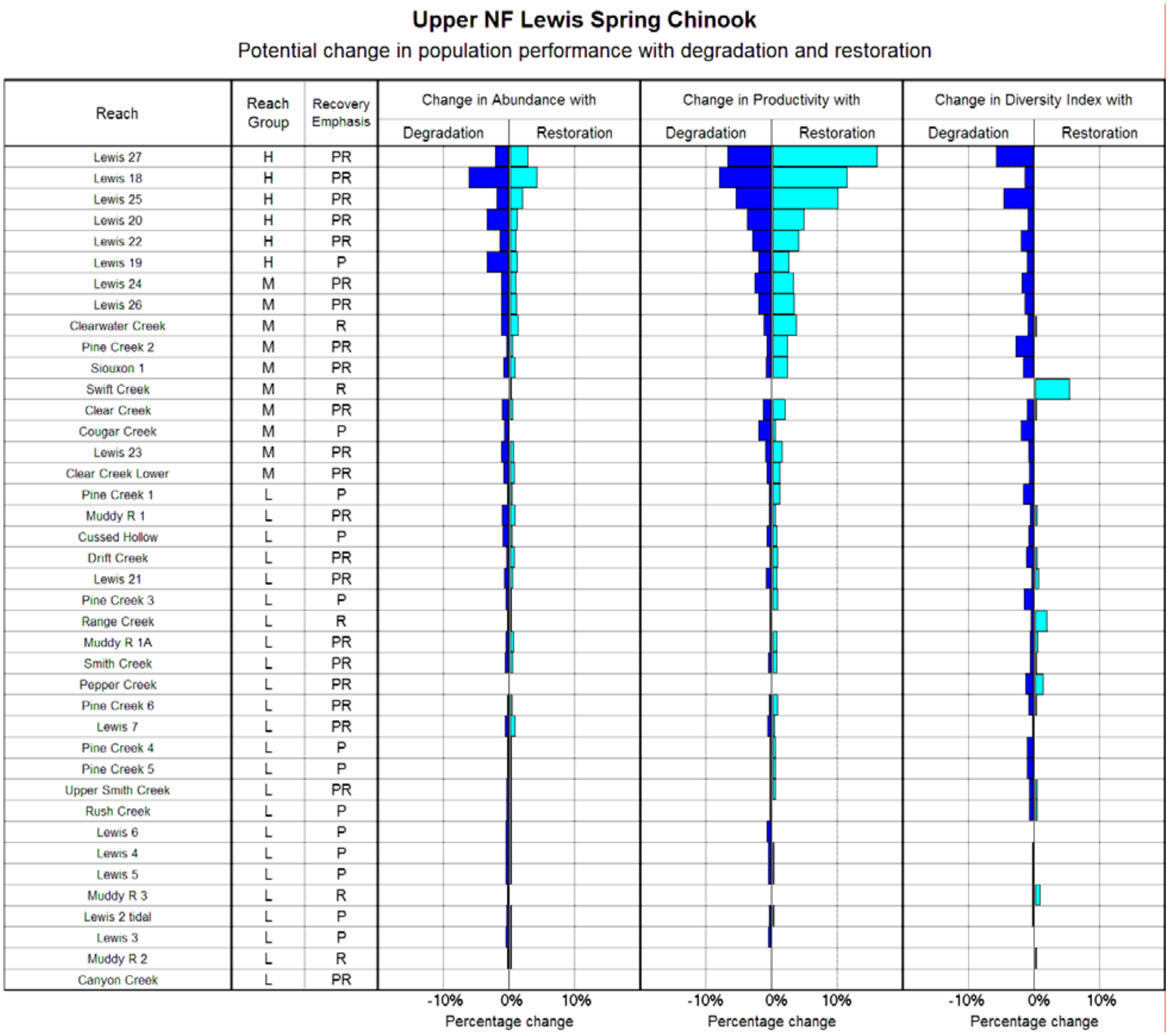


Figure 12-9. Upper NF Lewis spring chinook ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

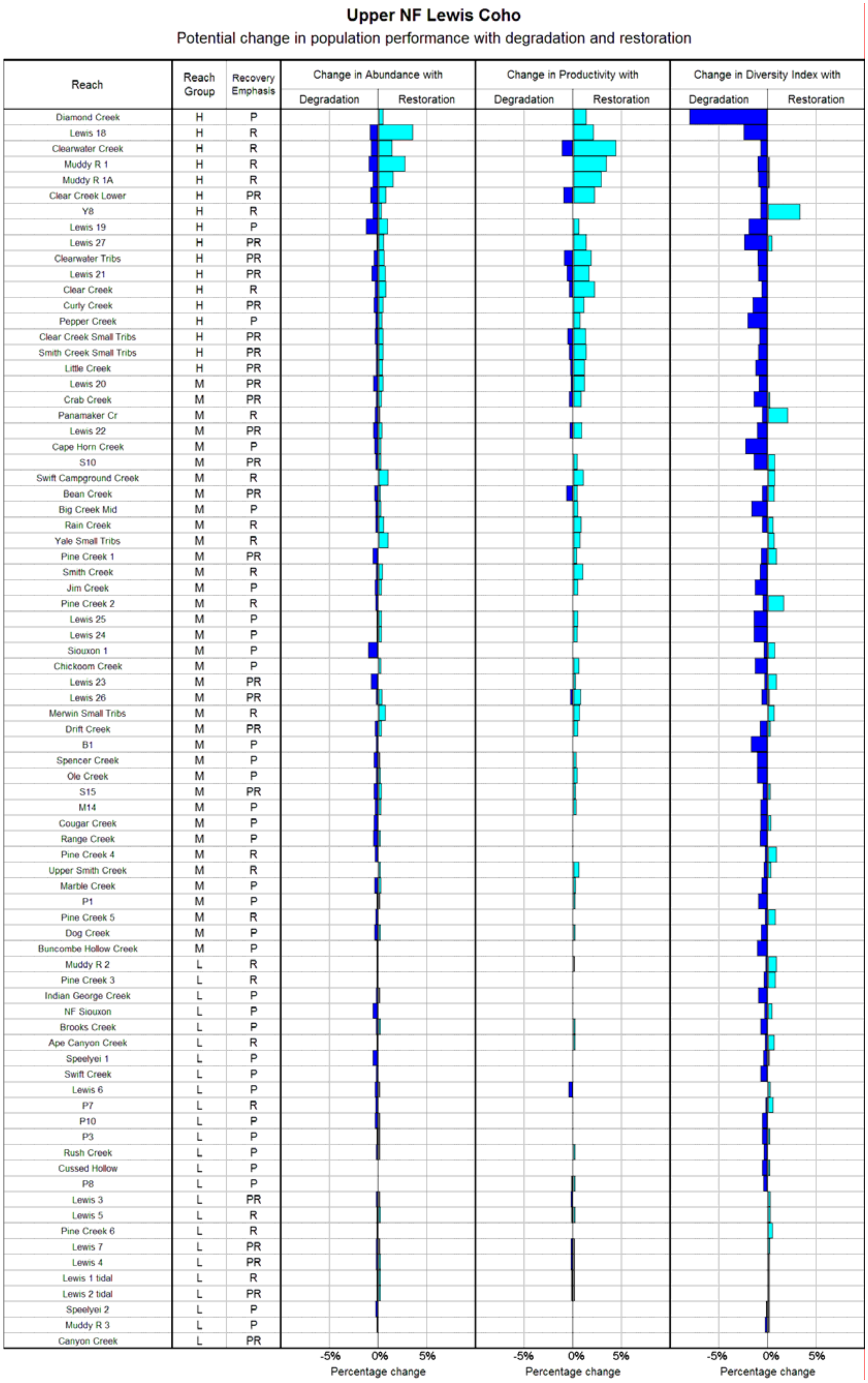


Figure 12-10. Upper NF Lewis coho ladder diagram.

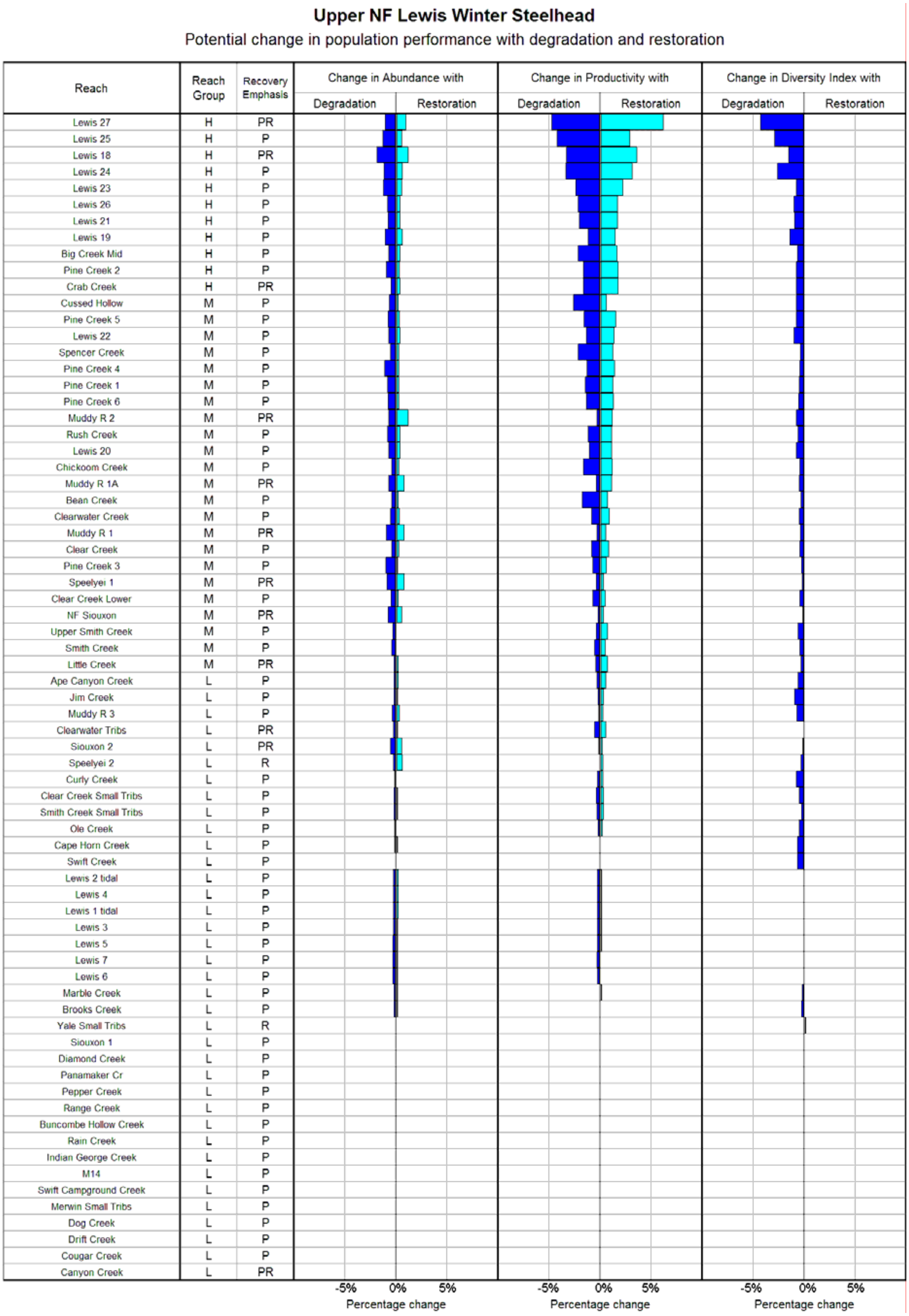


Figure 12-11. Upper Lewis winter steelhead ladder diagram.

12.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

High priority reaches for spring chinook are located in mainstem areas. These reaches have been negatively impacted primarily by alterations to sediment and key habitat, with lesser impacts related to channel stability, habitat diversity, temperature, competition, predation, and food (Figure 12-12). High sediment impacts are related to large floods in the 1970s that delivered pulses of sediment that widened channels and contributed to instability (USFS 1995). These channels are still recovering. Predation impacts are primarily due to the potential for bull trout predation on juvenile spring chinook. Habitat diversity has been reduced due to riparian degradation and low LWD quantities compared to historical levels.

For coho, the high priority reaches appear to be most impacted by sediment, habitat diversity, key habitat, and food (Figure 12-13). Some of these impacts are related to degraded riparian, channel, and hillslope conditions due to the Mount St. Helens eruption. Other impacts are most likely associated with road construction/condition and riparian harvest, as discussed above for spring chinook.

As with spring chinook, high priority winter steelhead reaches are generally located in the mainstem areas. The greatest impacts here are sediment and habitat diversity, with lesser impacts from predation, competition, flow, and food (Figure 12-14). Once again, lingering conditions from the Mount St. Helens eruption, high road densities, and timber harvest are the primary drivers of these impacts (refer to the discussion above for spring chinook). Furthermore, these channels are still recovering from large sediment pulses from 1970s floods, which widened channels and created unstable conditions (USFS 1995). The February 1996 flood further exacerbated sediment conditions. Habitat diversity impacts are related to degraded riparian zones (harvest impacts) and low instream LWD levels.

Upper Lewis Spring Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lewis 27	⬤	⬤	●	●		●			●	⬤	●			•		⬤
Lewis 18	●	⬤	●	⬤		⬤			●	⬤	⬤			•	●	⬤
Lewis 25	⬤	⬤	●	●		●			•	⬤	●			•		⬤
Lewis 20	●	●	●	●		●			•	⬤	●					●
Lewis 22	●	●	•	●		●			•	⬤	•					●
Lewis 19	●	●	•	●		●			•	⬤	●					•
Lewis 24	●	●	•	•		•			•	⬤	•					●
Lewis 26	●	●	●	●		●			•	⬤	●					⬤
Clearwater Creek	•	●	⬤	•		•			•	⬤	•			•		⬤
Pine Creek 2	•	●	•						•	•	•				•	✚
Siouxon 1	●	●	•	•					•	●	•					●
Swift Creek	•	●							•	•	•					•
Clear Creek	•	●		•		•			●	⬤	●					●
Cougar Creek		•								•	+					•
Lewis 23	●	●	•	•		•			•	⬤	•					•
Clear Creek Lower	•	●		•		•			●	⬤	●					●
Pine Creek 1	•	●	•						•	•	•					✛
Muddy R 1	•	●	●	•		•			•	⬤	•			•		✚
Cussed Hollow	•	•	●						•	•						●
Drift Creek	●	●	•						•	●	•					⬤
Lewis 21	•	●	•	•		•			•	⬤	•					•
Pine Creek 3	•	●								•						✛
Range Creek	•	●							•	●	•					
Muddy R 1A	•	●	●	•		•			•	●	•			•		✛
Smith Creek	•	•	●						•	•	•					✛
Pepper Creek																
Pine Creek 6	•	●							•	•	•					✚
Lewis 7		⬤	•	●		•			+		•			•	•	✛
Pine Creek 4	•	●							•	•	•					✛
Pine Creek 5	•	●								•						✛
Upper Smith Creek	•	•	•						•	•						✚
Rush Creek		•								•						•
Lewis 6		•		•												
Lewis 4	•	•	•	•					•						•	•
Lewis 5		•		•					•							
Muddy R 3		•	•							•						+
Lewis 2 tidal		•		•					•	•	•				•	●
Lewis 3		•		•						•						•
Muddy R 2	•	•	•						•	●						+
Lewis 1 tidal																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 12-12. Upper NF Lewis spring chinook habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Upper Lewis Coho

ReachName	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Diamond Creek	●	⬤		•		•			●	⬤	•					•
Lewis 18	●	⬤	•	⬤		⬤			●	⬤	⬤			●	•	⬤
Clearwater Creek	●	⬤	⬤	•		●			●	⬤	⬤			•		⬤
Muddy R 1	●	⬤	⬤	●		⬤			●	⬤	⬤			•	•	✚
Muddy R 1A	●	⬤	●	●		●			●	⬤	●			•		✛
Clear Creek Lower	•	⬤		•		•			●	⬤	⬤			•		⬤
Y8	●	●							•	●	•					•
Lewis 19	●	⬤	•	●		●			•	⬤	●			•		•
Lewis 27	●	⬤		•		•			•	⬤	•			•		⬤
Clearwater Tribs	•	⬤		•		•			●	⬤	●			•		⬤
Lewis 21	●	⬤	•	●		●			•	⬤	●			•		●
Clear Creek	•	⬤		•		•			●	⬤	●			•		⬤
Curly Creek	●	⬤		•		•			•	⬤	●					⬤
Pepper Creek	●	●	•	•		•			•	⬤	•					⬤
Clear Creek Small Tribs	•	●		•		•			●	⬤	●			•		⬤
Smith Creek Small Tribs	•	●		•		•			●	⬤	●			•		⬤
Little Creek	•	●				•			●	⬤	•					●
Lewis 20	•	⬤	•	•		●			•	●	●					•
Crab Creek	•	●	•	•		•			•	⬤	•					●
Panamaker Cr	•	•							•	•						
Lewis 22	•	●		•		•			•	●	•					•
Cape Horn Creek	•	●	•			•			•	•	•					●
S10	●	●							•	●	•					•
Bean Creek	•	●							•	•	•					●
Big Creek Mid	●	●							•	●						●
Rain Creek	●	●	•	•		•			●	⬤	●					⬤
Pine Creek 1																
Smith Creek	•	⬤	•	•		•			•	•	•			•		✛
Jim Creek	•	●	•	•		•			•	⬤	●					●
Pine Creek 2																
Lewis 25	●	●		•		•				●	•					●
Lewis 24	•	●		•		•			•	●	•					●
Siouxon 1																
Chickoom Creek	●	●	•						•	●	•					●
Lewis 23																
Lewis 26	•	●		•		•			•	⬤	•					●
Drift Creek	●	●							•	●	•					●
B1																•
Spencer Creek	•	•							•	•						●
Ole Creek	•	•	•	•		•			•	●	●					●
S15	●	●							•	●	•					•
M14	•	●	•	•		•			•	⬤	●					●
Cougar Creek		•								•						•
Range Creek	●	•							•	●	•					•
Pine Creek 4																
Upper Smith Creek	•	●	•						•	•	•					✚

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 12-13. Upper NF Lewis coho habitat factor analysis diagram. Some low priority reaches are not included for display purposes.

Upper Lewis Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lewis 27	•	⬤	•	⬤		●			●	⬤	●			•		⬤
Lewis 25	•	⬤	•	●		●			•	⬤	●			•		●
Lewis 18	●	⬤	•	⬤		⬤			●	⬤	⬤			●	•	•
Lewis 24	●	⬤	•	●		●			●	⬤	●			•		●
Lewis 23	•	⬤	•	●		●			●	⬤	●			•		●
Lewis 26	•	●	•	●		●			•	⬤	•			•		●
Lewis 21	•	●	•	●		●			•	⬤	•			•		•
Lewis 19	•	⬤	•	●		●			•	⬤	●			•		
Big Creek Mid	•	⬤		•		•			●	⬤	•					⬤
Pine Creek 2	●	●	•	•		•			●	●	•				•	✚
Crab Creek		●	●	•		•			●	⬤	•			•		●
Cussed Hollow		●	•	•		•			●	•	•			•		●
Pine Creek 5	•	●	•	•		•			•	●	•			•	•	✚
Lewis 22	•	●	•	●		●			•	⬤	•			•		•
Spencer Creek																
Pine Creek 4	•	●	•	•		•			•	●	•				•	✚
Pine Creek 1	•	●	•	•		•			•	●	•				•	✚
Pine Creek 6	•	●	•	•		•			•	●	•				•	✚
Muddy R 2	●	⬤	●	●		●			⬤	⬤	●			●	•	✚
Rush Creek																
Lewis 20	•	●	•	●		●			•	⬤	●			•		•
Chickoom Creek	•	●	•	•		•			●	⬤	•			•		●
Muddy R 1A	●	●	●	●		●			●	⬤	●			●	•	✚
Bean Creek		•	•	•		•			●	⬤	•			•		●
Clearwater Creek	•	●	●	•		•			●	⬤	●			●		●
Muddy R 1	●	⬤	●	●		●			●	⬤	●			●	•	✚
Clear Creek	•	●		•		•			●	⬤	●			•		●
Pine Creek 3	•	●		•		•			•	●	•				•	✚
Speelyei 1	•	•		•		•			+	•				•		●
Clear Creek Lower	•	●		•		•			●	⬤	●			•		•
NF Siouxon	●	⬤	●	•		•			●	⬤	•			•		●
Upper Smith Creek	●	⬤	●	•		•			●	⬤	●			•	•	
Smith Creek	●	●	●	•		•			●	●	●			●		✚
Little Creek		●		•		•			•	⬤	•					•
Ape Canyon Creek	•	●	•	•					•	●	•			•		●
Jim Creek	•	•	•	•		•			•	●	•					●
Muddy R 3	•	●	•	•		•			●	⬤	•			•	•	✚
Clearwater Tribs		•		•		•			●	⬤	•			•		•
Siouxon 2																
Speelyei 2																
Curly Creek		•		•					•	⬤	•					•
Clear Creek Small Tribs		•		•		•			•	●	•					•
Smith Creek Small Tribs																
Ole Creek		•		•					•	●	•					
Cape Horn Creek		•	•	•					•	•	•					•
Swift Creek	●	⬤	•	●		•			●	⬤	●					⬤
Lewis 2 tidal		●		•						●					●	●
Lewis 4		•		•						●					●	•
Lewis 1 tidal		●		•						●					●	●

High Impact ⬤ Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 12-14. Upper NF Lewis winter steelhead habitat factor analysis diagram.

12.7 Integrated Watershed Assessment (IWA)

For the purpose of recovery planning, the upper NF Lewis (above Merwin Dam) watershed is composed of 77 planning subwatersheds totaling 468,000 acres. The headwaters of the North Fork flow from the flanks of Mt. Adams, while several large tributaries, including Pine Creek, Smith Creek and Clearwater Creek (the latter two joining to form the Muddy River) flow from the slopes of Mt. St. Helens. The large majority of the upper NF Lewis watershed is under public ownership (80%). The subwatersheds furthest upstream are within the Gifford Pinchot National Forest (GPNF), with lower elevation areas falling under a patchwork of federal, state and private ownership. Most private holdings are in the downstream portion of the watershed. With the exception of hydro-project related facilities and a few small towns (e.g., Cougar) at lower elevations, timber production dominates the landscape, along with the increasing emphasis on non-consumptive forest uses under federal management. The lower watershed features the three reservoirs and four associated hydroelectric projects owned by PacifiCorp and Cowlitz County Public Utility District.

12.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the upper NF Lewis watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 12-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 12-15. Maps of the distribution of local and watershed level IWA results are displayed in Figure 12-16. Conditions for hydrology are mostly functional throughout the basin. Riparian and sediment conditions are mostly moderately impaired, with the remainder rated primarily as functional. In general, conditions deteriorate as one moves from the upper to the lower portion of the basin. The bulk of the heavily degraded subwatersheds are in the Canyon Creek/Fly Creek drainage, and in other portions of the lower watershed.

Table 12-2. Summary of IWA results for the upper NF Lewis River (above Merwin Dam)

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
10101	F	M	M	F	M	none
10102	F	F	F	F	F	none
10201	F	F	F	F	F	10101, 10102
10301	F	M	F	F	M	none
10401	F	F	F	F	F	none
10501	F	M	F	F	F	10502, 10401, 10301, 10201, 10101, 10102
10502	F	M	F	F	M	10401, 10301, 10201, 10101, 10102
10601	F	F	F	F	F	none
10701	F	F	F	F	F	none
10702	F	M	F	F	M	10703, 10701
10703	F	M	F	F	M	10701
10801	F	F	F	F	M	10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
10901	F	M	F	F	M	10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
10902	F	F	F	F	F	10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
11001	F	M	F	F	F	11002
11002	F	F	M	F	F	none
11201	F	F	F	F	F	11202
11202	F	F	M	F	F	none
11301	F	M	F	F	F	11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
11302	F	F	F	F	F	11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
11303	F	F	M	F	F	11304
11304	F	F	M	F	F	none
20101	F	F	M	F	F	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
20102	F	F	M	F	F	20101
20103	F	M	M	F	F	20102, 20101
20201	F	M	M	F	M	none
20202	F	M	M	F	M	20201
20203	F	F	M	F	F	none
20204	F	F	M	F	M	20203, 20202, 20201
20301	F	M	F	F	M	none
20302	F	M	F	F	M	none
20303	F	F	F	F	M	20302, 20301
20401	F	F	F	F	F	20303, 20302, 20301
20402	F	F	F	F	F	20401, 20303, 20302, 20301
20501	F	M	M	F	M	20103, 20102, 20101, 20204, 20203, 20202, 20201
20502	F	F	M	F	F	20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301
30101	F	F	M	F	F	none
30102	F	M	M	F	M	30101
30201	F	M	F	F	M	30202
30202	F	M	M	F	M	none
30301	F	I	M	F	F	30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
30302	F	M	M	F	F	30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
30401	F	M	M	F	M	30402
30402	F	M	F	F	M	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	**Sediment**	**Riparian**	**Hydrology**	**Sediment**	
30501	F	F	M	F	M	30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
30502	F	I	M	F	M	30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
30503	F	M	M	F	M	none
40101	F	M	F	F	M	40102, 40103
40102	M	M	F	M	M	none
40103	M	M	F	M	M	none
40201	F	M	M	F	M	40202, 40101, 40102, 40103
40202	F	F	F	F	M	40101, 40102, 40103
40301	F	M	M	F	M	40302, 40303, 40201, 40202, 40101, 40102, 40103
40302	F	M	F	F	M	40303
40303	F	M	F	F	M	none
40401	M	M	M	M	M	40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
40402	F	M	F	F	M	none
40501	F	M	M	F	M	40301, 40302, 40303, 40201, 40202, 40101, 40102, 40103, 40502, 40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
40502	F	M	M	M	M	40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
40503	I	M	M	M	M	40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
40504	M	F	M	M	F	none
40505	M	F	M	M	F	none
40506	F	F	F	F	F	none
60101	M	M	M	M	M	60102
60102	I	M	M	I	M	none
60103	I	M	M	I	M	none
60201	I	I	M	I	M	60203, 60204, 60205, 60202, 60103, 60101, 60102
60202	I	M	F	I	M	60103, 60101, 60102
60203	I	M	M	I	M	60204
60204	I	M	M	I	M	none
60205	M	M	F	M	M	none
60301	I	M	M	M	M	60306, 60302, 60303, 60304, 40505, 60305, 60201, 60203, 60204, 60205, 60202, 60103, 60101, 60102, 40501, 40301, 40302, 40303, 40201, 40202, 40101, 40102, 40103, 40502, 40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60302	F	F	M	M	M	60303, 60304, 40505, 60305, 60201, 60203, 60204, 60205, 60202, 60103, 60101, 60102, 40501, 40301, 40302, 40303, 40201, 40202, 40101, 40102, 40103, 40502, 40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
60303	M	M	M	M	M	none
60304	M	M	M	M	M	40505, 60305, 60201, 60203, 60204, 60205, 60202, 60103, 60101, 60102, 40501, 40301, 40302, 40303, 40201, 40202, 40101, 40102, 40103, 40502, 40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
60305	I	M	M	F	M	60201, 60203, 60204, 60205, 60202, 60103, 60101, 60102, 40501, 40301, 40302, 40303, 40201, 40202, 40101, 40102, 40103, 40502, 40401, 40503, 40402, 40504, 40506, 30201, 30202, 30501, 30502, 30503, 30401, 30402, 30301, 30302, 30102, 30101, 20502, 20501, 20103, 20102, 20101, 20204, 20203, 20202, 20201, 20402, 20401, 20303, 20302, 20301, 11302, 11201, 11202, 11301, 11303, 11304, 11001, 11002, 10902, 10901, 10801, 10702, 10703, 10701, 10601, 10501, 10502, 10401, 10301, 10201, 10101, 10102
60306	I	F	M	I	F	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

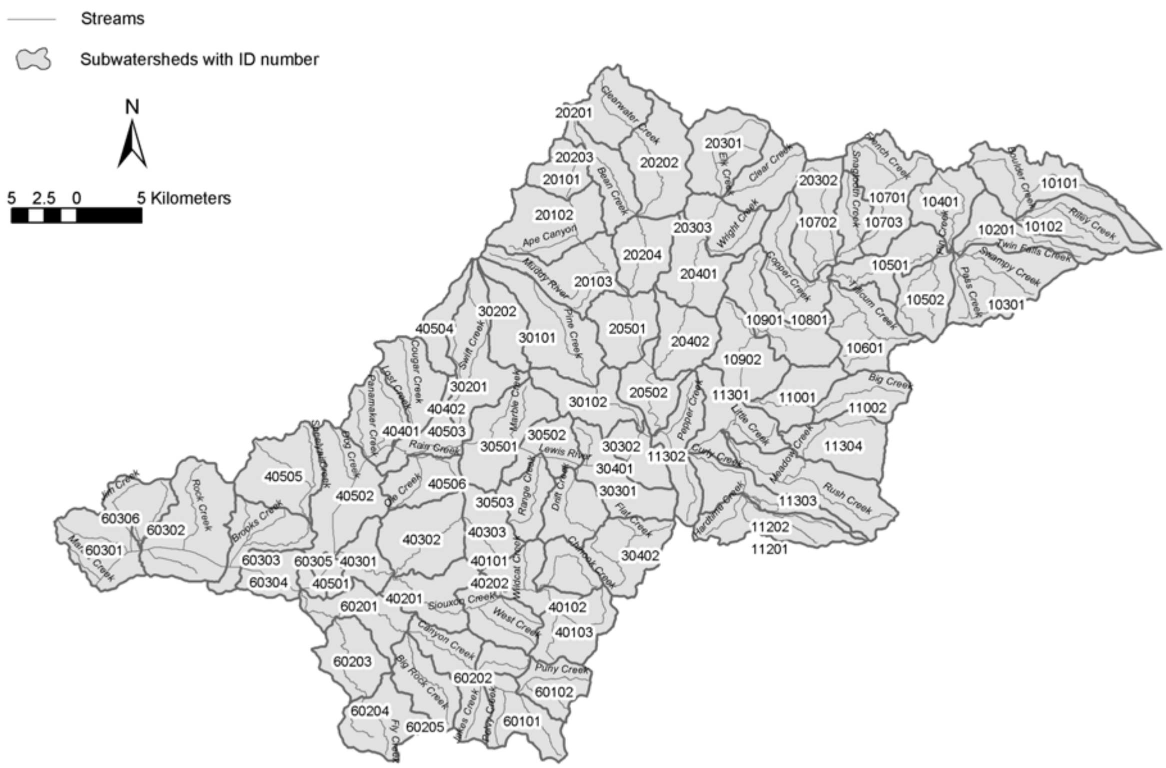


Figure 12-15. Map of the upper North Fork Lewis basin showing the location of the IWA subwatersheds

Figure 12-16. IWA subwatershed impairment ratings by category for the upper North Fork Lewis basin

12.7.1.1 Hydrology

At the local (i.e., within-watershed level) the large majority of subwatersheds in the upper NF Lewis are rated hydrologically functional. Impervious surfaces are nearly absent, as are areas zoned for urban development. Road densities are generally moderate with low densities in the uppermost subwatersheds. Streamside road densities are moderate to high with numerous subwatersheds exceeding 1 mi/stream mi. Thirty-three percent of the watershed is within the rain-on-snow elevation zone, while mature forest covers roughly 54% of the landscape.

Hydrologic conditions are also rated as functional at the watershed level throughout the majority of the watershed. It should be noted, however, that the watershed level IWA hydrologic analysis does not explicitly consider impounded areas as characteristically impaired, but focuses rather on drainage area, land cover, rain-on-snow distribution, etc. It follows that several subwatersheds containing portions of Merwin, Yale and Swift Reservoirs are certainly impaired hydrologically, even if the IWA rating suggests otherwise. The IWA is best used as a descriptor of hydrologic condition as driven by local and watershed level subwatershed process conditions at the subwatershed scale, rather than as a description of instream hydrologic conditions.

In lower portions of the watershed (below the upstream end of Swift Reservoir), public ownership rates are lower but still a relatively robust 60%. Higher levels of hydrologic impairment are in evidence in these lower elevation subwatersheds, on both private and public lands. Seven out of ten hydrologically impaired subwatersheds are located within the Canyon Creek drainage (including Fly Creek), a left-bank tributary to upper Merwin Reservoir that features substantial timber production activities on both public and private lands (60201-205, 60101-103, 60305). The drainage is largely confined with steep banks and numerous smaller tributaries entering through incised hillslopes.

The Siouxon Creek drainage, which empties into Yale Reservoir (series 401xx, 402xx, 403xx), has a high degree of public ownership and currently functional hydrologic conditions. Potentially accessible portions of the Siouxon Creek drainage are thought to have supported substantial numbers of anadromous fish and would likely do so again in the event of anadromous reintroduction into the Yale Reservoir area. In addition, the smaller Ole Creek/Rain Creek drainage (40506) has been identified as a potential site for bull trout restoration for the beleaguered Yale population. This publicly owned subwatershed (WDNR) that drains into the dewatered reach of the mainstem below Swift Dam exhibits functional conditions for all three IWA parameters.

12.7.1.2 Sediment

Moderately impaired sediment and riparian conditions are a reflection of the high levels of timber production within the watershed. Poor road management coupled with clear cutting has exacerbated sediment conditions. In the portions of the watershed flowing from Mt. St. Helens, numerous streams (such as Smith and Pine Creeks) continue to suffer from heavy sediment loads precipitated by the eruption in 1980 (20103, 20501, 20103). Riparian areas throughout these high-elevation reaches were razed by the volcanic debris flow, with the majority of sediment and debris winding up in Swift Reservoir.

The Canyon Creek drainage is largely confined with steep banks and numerous smaller tributaries entering through incised hillslopes. The area has impaired sediment conditions due to human activities, including locally high road densities up to 5 mi/sq mi and stream crossing densities in excess of 5.4 crossings/stream mile in subwatersheds 60201, 60203 and 60204. The proportion of individual Canyon Creek/Fly Creek subwatersheds in the rain-on-snow zone ranges from 15%-93%. Combined with heavily degraded sediment and riparian condition, this area is likely at greatest risk of further degradation within the watershed. However, even in the event of anadromous reintroduction, Canyon Creek would provide limited potential habitat due to impassable, natural falls just upstream of Merwin Reservoir.

Local level sediment conditions in the watershed include 45 subwatersheds with moderately impaired conditions and three with impaired conditions. Impaired and moderately impaired ratings occur throughout the Yale and Merwin portions of the watershed with only isolated pockets of functional conditions. The entire southern half of the watershed (i.e., south of the North Fork reservoirs) from Merwin Dam to the upstream end of Swift Reservoir is rated as impaired or moderately impaired, with the exception of a single subwatershed in the Siouxon drainage (40202), a tributary to Yale Lake, which is rated as functional. This portion of the watershed has experienced high levels of timber harvest, and as a consequence has a higher density of forest roads.

Functional sediment conditions are more prevalent in the upper watershed, upstream of Swift Reservoir. Contiguous concentrations of functional sediment conditions are located along nearly the entire length of Clear Creek (20303, 20401, 20402), Clearwater Creek (20203, 20204), along the mainstem North Fork above Swift (10801, 10902) and in the North Fork headwaters (10201, 10102). Rush Creek, a left bank tributary to the North Fork upstream of Swift Reservoir also has functional sediment conditions. Rush Creek is known for its moderately healthy population of Bull trout.

12.7.1.3 Riparian

Moderately impaired riparian conditions occur in 43 of the 77 subwatersheds, with none rated as impaired. The greatest concentration of functional conditions occur in the upper Lewis mainstem, Clear Creek, and Siouxon Creek drainages. Other functional conditions are scattered throughout the basin. Inadequate stream buffers are primarily related to past timber harvests and stream adjacent roadways. The 1980 Mount St. Helens eruption denuded riparian vegetation in portions of the Pine Creek (series 301xx) and Muddy River (series 201xx, 202xx, 205xx) drainages.

12.7.2 Predicted Future Trends

12.7.2.1 Hydrology

Hydrologic conditions in the watershed are generally good, particularly in areas above Swift Reservoir. The three reservoirs of course do not express functional riverine hydrology, but surrounding watershed processes are generally less impaired than areas downstream of Merwin. The overwhelming majority of lands under federal management hold promise for the protection of functional hydrologic conditions and improvement of impaired areas through continually improving forest management practices. In the event of anadromous reintroduction, key areas above Swift reservoir will form the core spawning and rearing areas within the watershed. These upper watersheds (series 20xxx and 10xxx) benefit from greater than 99% public ownership, primarily as federal forest land. While timber harvest is sure to continue, road and riparian management—coupled with other evolving aspects of the federal forest management program—are likely to produce tangible restoration and protection benefits for key areas such as Clear Creek, Clearwater Creek, Smith Creek, Muddy River, Rush Creek and the mainstem NF Lewis

River. The predicted trend for hydrologic conditions in these watersheds is stable (i.e., functional), with improvement in the landscape level factors that govern hydrologic conditions.

On the north and south sides of Swift Reservoir, many subwatersheds exhibit functional hydrologic conditions and a mixed distribution of private/public ownership. These subwatersheds (series 30xxx) are key candidates for hydrologic protection measures for lands under private ownership. Pine Creek (30101, 30102), for example, is characterized by mixed public/private ownership and is known to support bull trout. Management practices on private timberlands are also likely to improve under the Timber Fish and Wildlife Agreement. However, the likelihood of higher levels of timber harvest on these lands to offset reduced harvest on public lands suggests a trend towards increasing degradation.

Conditions in most of the Yale Reservoir tributary subwatersheds are functional (Siouxon Creek drainage) or moderaly impaired. These subwatersheds are likely to trend stable, with gradual improvement over time as with other largely publicly owned subwatersheds.

The degraded hydrologic conditions in the Canyon Creek-Fly Creek drainage are likely to persist due to a low percentage of mature vegetation, a high percentage within the rain-on-snow zone, steep slopes, and high road densities. The drainage offers limited potential anadromous habitat due to the presence of impassable natural falls at the base of the drainage.

12.7.2.2 Sediment Supply

As with hydrologic conditions, sediment conditions in the upper watershed are likely to improve over the next 20 years under federal forest management. These improvements may prove critical to the success of anadromous reintroduction efforts. The northern flank of the upper watershed (Smith Creek, Pine Creek, Clearwater Creek) will continue to process elevated natural sediment loads as a consequence of the Mt. St. Helens eruption. The long-term prognosis for these areas is quite good following natural recovery of riparian conditions.

Sediment conditions in the lower watershed are predicted to trend towards improvement on publicly owned lands as timber harvest levels decline and the impacts of improved forestry management practices are realized. In contrast, moderately impaired or impaired sediment conditions on private timberlands are likely to trend stable over the next 20 years. Improved forestry and road management practices are expected to improve sediment conditions in general, but these gains may be offset by increased timber harvest on private lands.

12.7.2.3 Riparian Condition

As a predominantly timber-driven watershed, riparian trends in the future will likely closely mimic sediment trends as described above, with progress on publicly owned lands balanced by stable conditions or slight improvements on privately held timber lands. The predicted trend in riparian conditions on public lands is towards improvement, with the trend on private land towards stability with more gradual improvement over time. Some lower-elevation subwatersheds (e.g. lower Speelyai Creek - 60303) may experience increased degradation due to development pressures.

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Volume II, Chapter 13
Lewis River Subbasin—East Fork

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13.0 Lewis River Subbasin—East Fork

13.1 Subbasin Description

13.1.1 Topography & Geology

The East Fork Lewis River has its headwaters in Skamania County and flows generally west, with most of the basin lying within Clark County. It enters the mainstem (North Fork) Lewis at approximately river mile 3.5, about 4,000 feet downstream of the I-5 Bridge. The basin covers an area of approximately 150,635 acres (235 mi^2). The East Fork has its source near Green Lookout Mountain in the Gifford Pinchot National Forest. Elevation ranges from near sea level at the mouth to 4,442 feet. The headwaters are very steep, with narrow valleys, and are dominated by bedrock and boulder substrates. Copper Creek and upper Rock Creek are the two largest tributaries in the upper basin. Lucia Falls at RM 21.3 blocks passage of anadromous fish except steelhead and an occasional chinook and coho. Upstream migration for steelhead was essentially blocked at Sunset Falls (RM 32.7) until 1982 when the falls were notched, lowering the falls from 13.5 to 8 feet; approximately 12% of the steelhead run now spawns above Sunset Falls. Below Lucia Falls, the river flows through a narrow valley, forming a canyon in places, until it opens up around RM 14 into a broad alluvial valley. Stream gradient dramatically drops off within this reach causing large sediment aggradations. Extensive meandering, braiding, and channel shifting occurs in the lower river, particularly between RM 6 and RM 10. Backwater effects from the Columbia extend up to RM 6.

The East Fork Lewis basin has developed from volcanic, glacial, and erosional processes. Glaciation has shaped the valleys in upper portions of the basin as recently as 13,000 years ago. Oversteepened slopes as a result of glaciation, combined with the abundance of ash, pumice, and weathered pyroclastic material, have created a relatively high potential for surface erosion throughout the basin.

13.1.2 Climate

The climate is typified by mild, wet winters and warm, dry summers. Mean annual precipitation is 52 inches at Battle Ground, which is along the lower river (WRCC 2003). Precipitation in the upper basin is considerably greater. Although most of the basin is rainfall dominated, much of the upper basin receives abundant snowfall, with a significant portion of the upper basin in the rain-on-snow zone. The basin is subject to winter freshets and flooding.

13.1.3 Land Use/Land Cover

The bulk of the land is forested and a large percentage is managed as commercial forest. Agricultural and residential activities are found in valley bottom areas. Recreation uses and residential development have increased in recent years. The population in the basin was approximately 24,400 persons in 2000 (LCFRB 2001). Most of the land is private (63%), with about 20% of the basin area lying within the Gifford Pinchot National Forest. Stand replacement fires, which burned large portions of the basin between 1902 and 1952, have had lasting effects on basin hydrology, sediment transport, soil conditions, and riparian function. The largest of these fires was the Yacolt Burn in 1902. Subsequent fires followed in 1927 and 1929. Severe flooding in 1931 and 1934 likely was exacerbated by the effect of the fires on vegetation and soils. A breakdown of land ownership and land cover in the EF Lewis basin is presented in Figure 13-1 and Figure 13-2. Figure 13-3 displays the pattern of landownership for the basin. Figure 13-4 displays the pattern of land cover / land-use.

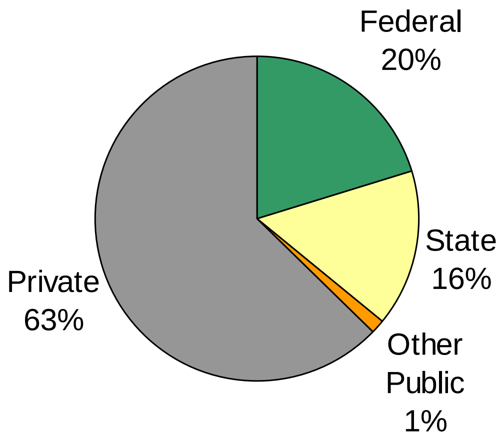


Figure 13-1. East Fork Lewis River basin land ownership

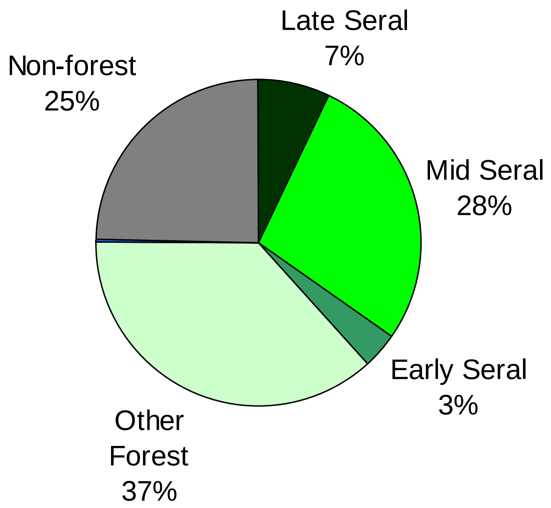


Figure 13-2. East Fork Lewis River basin land cover

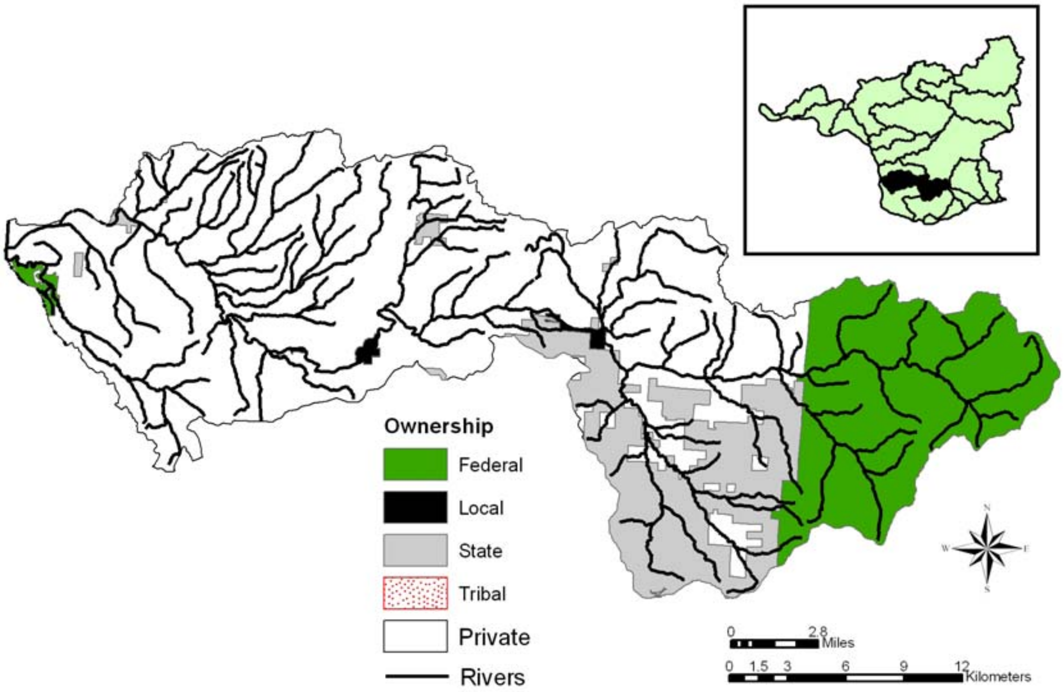


Figure 13-3. Landownership within the East Fork Lewis basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

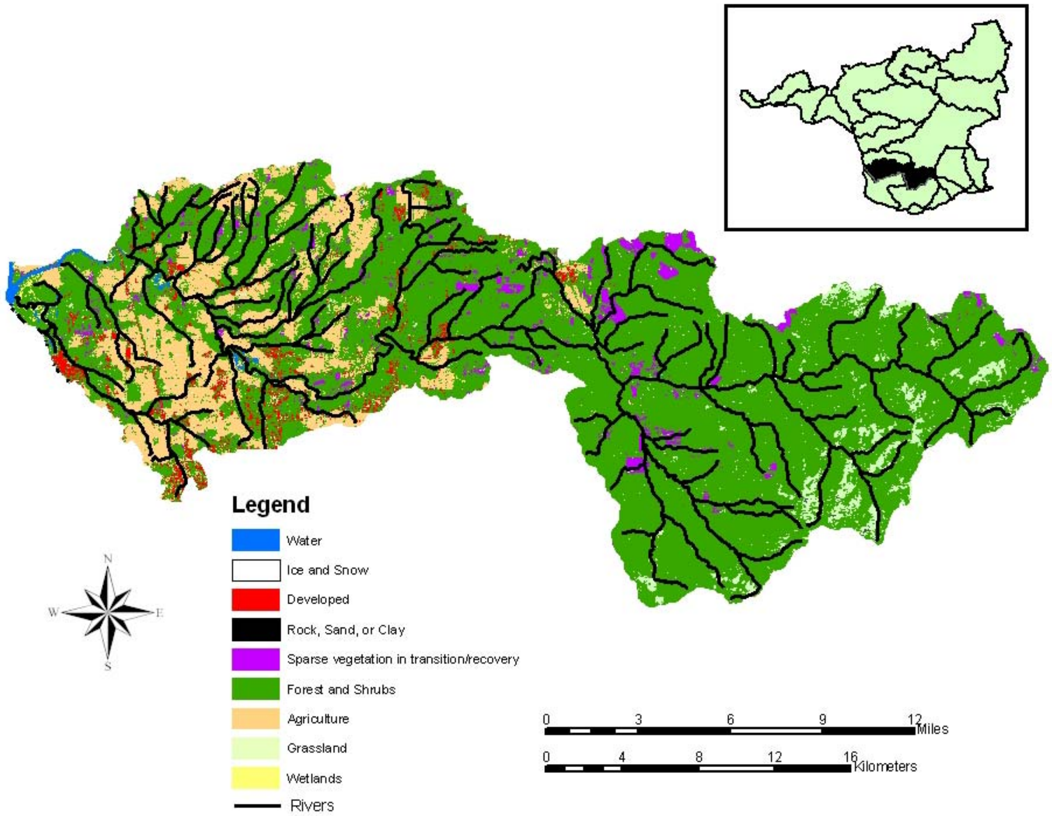
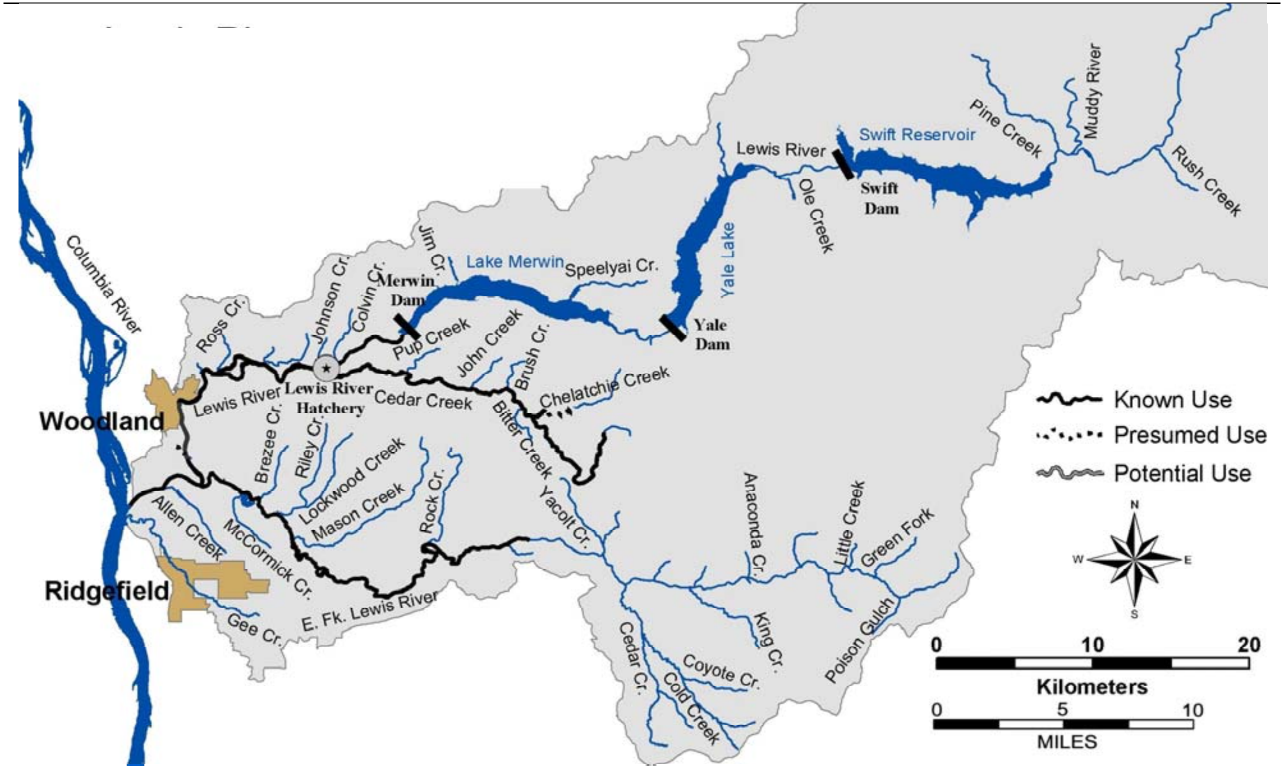


Figure 13-4. Land cover within the East Fork Lewis basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

13.2 Focal Fish Species

13.2.1 Fall Chinook—Lewis Subbasin (East Fork)

ESA: Threatened 1999 **SASSI: Depressed 2002**

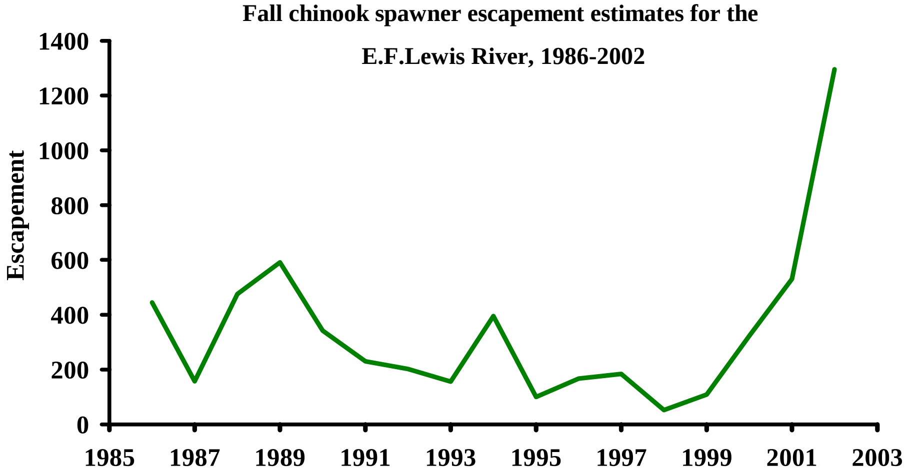


Diversity

- Late spawners in the North Fork and EF Lewis are considered a lower river wild stock within the lower Columbia River ESU
- Early spawners in the EF Lewis are considered lower Columbia tules
- The EF Lewis River fall chinook stock designated based on distinct spawning distribution and timing
- Genetic analysis of EF Lewis River fall chinook indicated they were genetically distinct from other lower Columbia River chinook stocks, except North Lewis River fall chinook

Life History

- Fall chinook enter the Lewis River from August to November, depending on early fall rain
- Natural spawning in the EF Lewis River occurs in two distinct segments: the early segment in October and the late segment from November through January
- Age ranges from 2-year-old jacks to 6-year-old adults, with dominant adult ages of 3, 4, and 5 (averages are 20.5%, 48.5%, and 22.7%, respectively)
- Fry emerge from March to August (peak usually in April), depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings



Distribution

- Spawning occurs primarily from Lewisville Park downstream to Daybreak Feeders (approx. 6 miles); the late spawning segment also spawns in areas upstream of Lewisville Park
- The EF Lewis late spawning fall chinook along with North Lewis and Sandy River late spawning fall chinook comprise the lower Columbia River wild management unit

Abundance

- Fall chinook escapement estimates by WDFW (1951) were about 4,000 into the EF Lewis River
- EF Lewis River spawning escapement from 1986-2001 ranged from 52 to 591 (average 279)

Productivity & Persistence

- NMFS Status Assessment for the EF Lewis River fall chinook indicated a 0.0 risk of 90% decline in 25 years, a 0.06 risk of 90% decline in 50 years, and a 0.0 risk of extinction in 50 years
- The EF Lewis early and late components of natural produced fall chinook have been sustained at low levels with minimal influence from hatchery fish

Hatchery

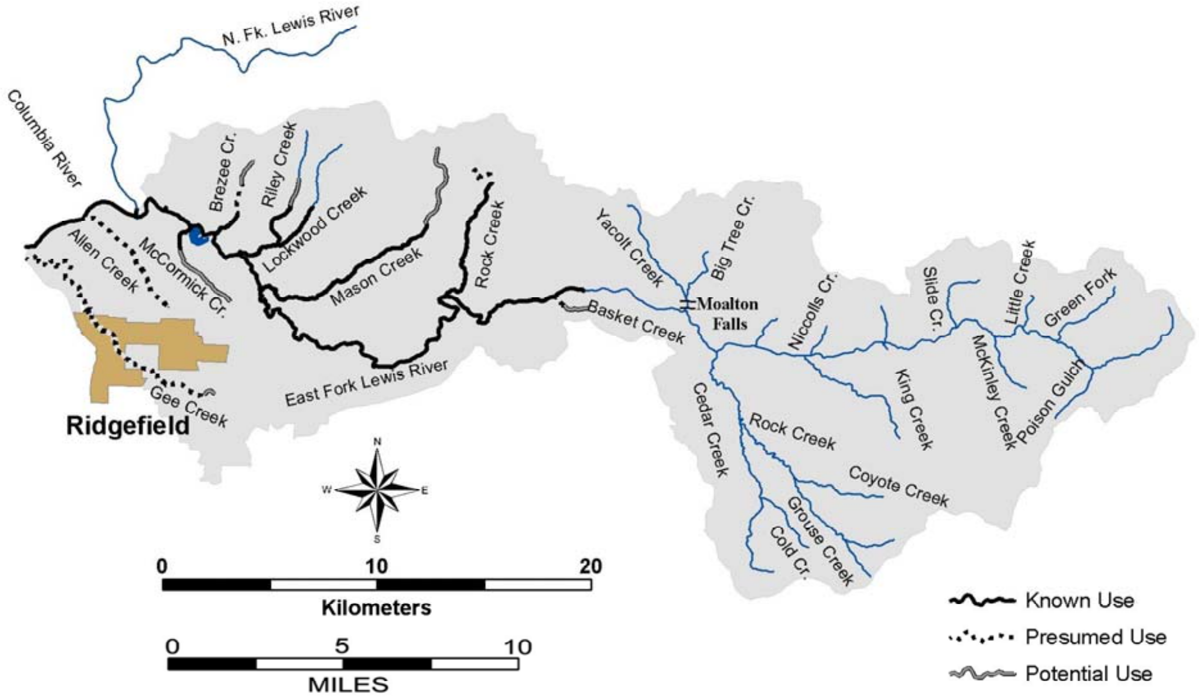
- There are no hatcheries on the EF Lewis River
- Hatchery fish have never been released into the East Fork; hatchery releases of fall chinook in the North Lewis began as early as 1909 and continued through 1985; there may have been some straying of North Lewis hatchery fish to the EF Lewis in past years

Harvest

- East Fork Lewis wild fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial and sport fisheries
- East Fork Lewis late spawning fall chinook migration patterns are likely similar to North Lewis fall chinook and more northerly distributed than other lower Columbia chinook populations, primarily along the coasts of British Columbia and Alaska
- East Fork Lewis early spawning fall chinook migration patterns are likely similar to lower Columbia tule populations, primarily along the coasts of Washington and Southern British Columbia
- Columbia River commercial and sport harvest of late East Fork Lewis fall chinook is constrained by ESA limits on Snake and Coweeman wild fall chinook and the North Lewis spawning escapement goal
- Using North Lewis wild fall chinook as a surrogate for late spawning East Fork Lewis chinook suggests a harvest rate of 49% in the 1980s to early 1990s and a reduced harvest rate of 28% in the mid to late 1990s
- The EF Lewis River is closed to sport fishing for fall chinook

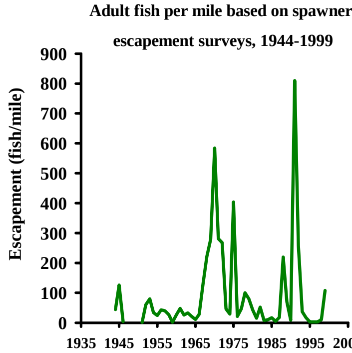
13.2.2 Coho—Lewis Subbasin (East Fork)

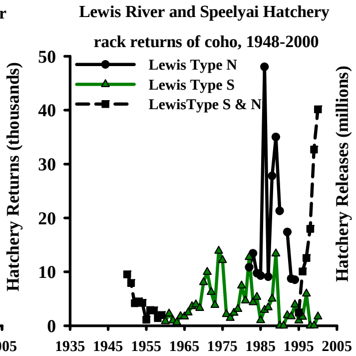
ESA: Candidate 1995 **SASSI: Unknown 2002**

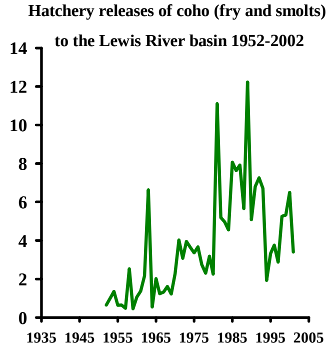


Distribution

- Managers refer to early coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late coho as Type N due to their ocean distribution generally north of the Columbia River
- Coho historically spawned throughout the basin, including headwater tributaries now upstream of dams, such as Muddy River and Pine, Clearwater, and Clear Creeks
- Natural spawning is thought to occur in most areas accessible to coho; coho currently spawn in the North Lewis tributaries below Merwin Dam including Ross, Cedar, North and South Fork Chelatchie, Johnson, and Colvin Creeks; Cedar Creek is the most utilized stream on the mainstem
- On the East Fork, spawning occurs primarily below Lucia Falls (RM 21); Lockwood, Mason, and Rock Creeks are extensively used
- Construction of Merwin Dam was completed in 1932; coho adults were trapped and passed above Merwin Dam from 1932-1957; the transportation of coho ended after the completion of Yale Dam (1953) and just prior to completion of Swift Dam (1959)
- As part of the current hydro re-licensing process, reintroduction of coho into habitat upstream of the three dams (Merwin, Yale, and Swift) is being evaluated


Adult fish per mile based on spawner escapement surveys, 1944-1999


Lewis River and Speelyai Hatchery rack returns of coho, 1948-2000


Hatchery releases of coho (fry and smolts) to the Lewis River basin 1952-2002

Life History

- Adults enter the Columbia River from August through January (early stock primarily from mid-August through September and late stock primarily from late September through November)
- Peak spawning occurs in late October for early stock and December to early January for late stock
- Adults return as 2-year-old jacks (age 1.1) or 3-year-old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Late stock coho (or Type N) were historically present in the Lewis basin with spawning occurring from late November into March
- Early stock coho (or Type S) were historically present in the Lewis basin with spawning occurring from late October to November
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance

- Lewis River wild coho run is a fraction of its historical size
- An escapement survey in the late 1930s observed 7,919 coho in the North Fork and 1,166 coho in the East Fork
- In 1951, WDF estimated coho escapement to the basin was 15,000 fish; 10,000 in the North Fork (primarily early run) and 5,000 in the East Fork (primarily late run)
- Escapement surveys from 1944-1999 on the North and South Fork Chelatchie, Johnson, and Cedar Creeks documented a range of 1-584 fish/mile
- Hatchery production accounts for most coho returning to the Lewis River

Productivity & Persistence

- Natural coho production is presumed to be generally low in most tributaries
- Juvenile sampling in Lockwood Creek in 1994-95 found a low level of coho
- A smolt trap at lower Cedar Creek has shown recent year coho production to be fair to good in North and South forks of Chelatchie Creek (tributary of Cedar Creek) and in mainstem Cedar Creek
- Hatchery coho adults released above Swift Reservoir successfully spawned in upper basin tributaries

Hatchery

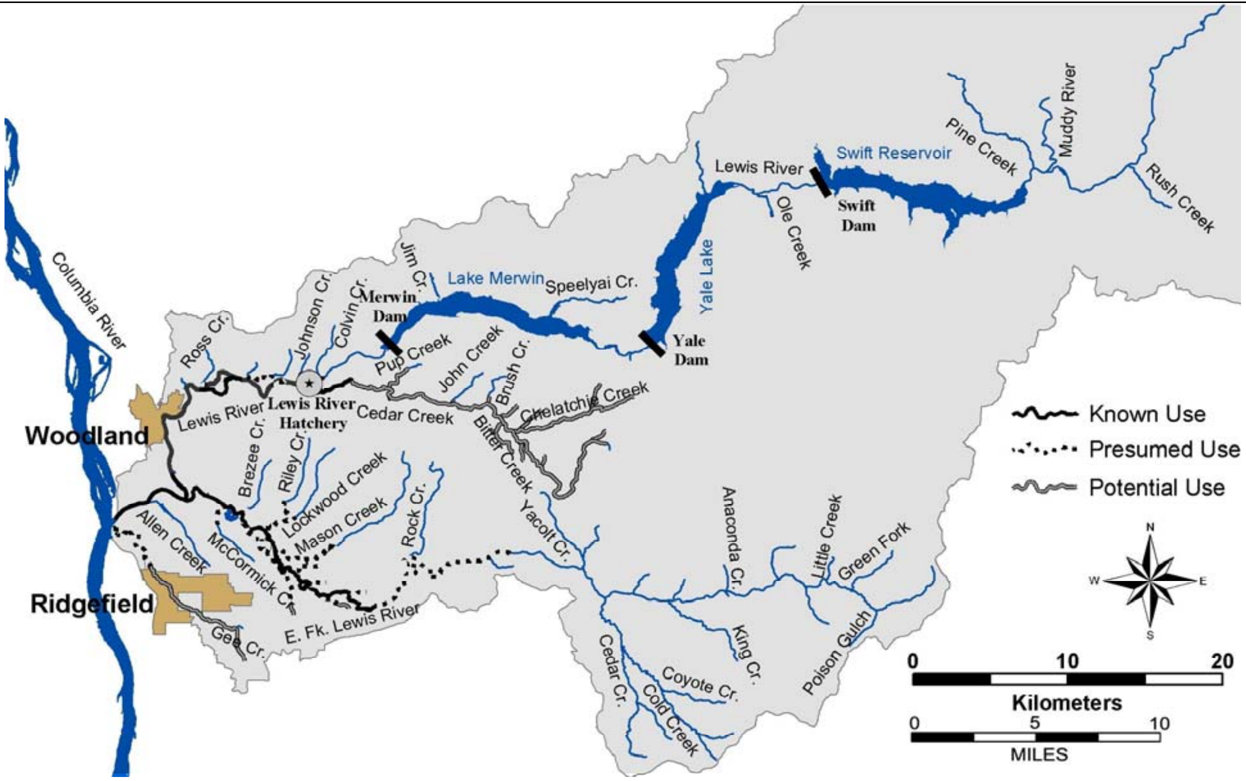
- The Lewis River Hatchery (completed in 1932) is located about RM 13; the Merwin Dam collection facility (completed in 1932) is located about RM 17; Speelyai Hatchery (completed in 1958) is located in Merwin Reservoir at Speelyai Bay; these hatcheries produce early and late stock coho and spring chinook
- Merwin Hatchery (completed in 1983) is located at RM 17 and rears steelhead, trout, and kokanee
- Coho have been planted in the Lewis basin since 1930; extensive hatchery coho releases have occurred since 1967
- The current Lewis and Speelyai hatchery programs include 880,000 early coho and 815,000 late coho smolts reared and released annually

Harvest

- Until recent years, natural produced Columbia River coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River wild coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Natural produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon Coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 3,500 coho (1980-98) were harvested annually in the North Lewis River sport fishery
- An average of 40 coho (1982-1989) were harvested annually in the EF Lewis sport fishery
- CWT data analysis of the 1995-97 brood early coho released from Lewis River hatchery indicates 15% were captured in a fishery and 85% were accounted for in escapement
- CWT data analysis of the 1995-97 late coho released from Lewis River Hatchery indicates 42% were captured in a fishery and 58% were accounted for in escapement
- Fishery CWT recoveries of 1995-97 brood Lewis early coho were distributed between Washington ocean (58%), Columbia River (21%), and Oregon ocean (21%) sampling areas
- Fishery CWT recoveries of 1995-97 brood Lewis late coho were distributed between Columbia River (56%), Washington coast (31%), and Oregon ocean (21%) sampling areas

13.2.3 Chum—Lewis Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Spawning occurs in the lower reaches of the mainstem NF and EF Lewis River.
- Historically, chum salmon were common in the lower Lewis and were reported to ascent to the mainstem above the Merwin Dam site and spawn in the reservoir area
- Chum were also abundant in Cedar Creek, with at least 1,000 annual spawners (Smoker et al 1951)

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts, generally from March to mid-May

Abundance

- 1951 report estimated escapement of approximately 3,000 chum annually in the mainstem Lewis and East Fork and 1,000 in Cedar Creek
- 96 chum observed spawning downstream of Merwin Dam in 1955
- In 1973, spawning population of both the Lewis and Kalama subbasins estimated at only a few hundred fish
- Annually, 3-4 adult chum are captured at the Merwin Dam fish trap

Productivity & Persistence

- Harvest, habitat degradation, and construction of Merwin, Yale, and Swift Dams contributed to decreased productivity
- WDFW consistently observed chum production in the North Lewis in March-May, 1977-1979 during wild chinook seining operations

Hatchery

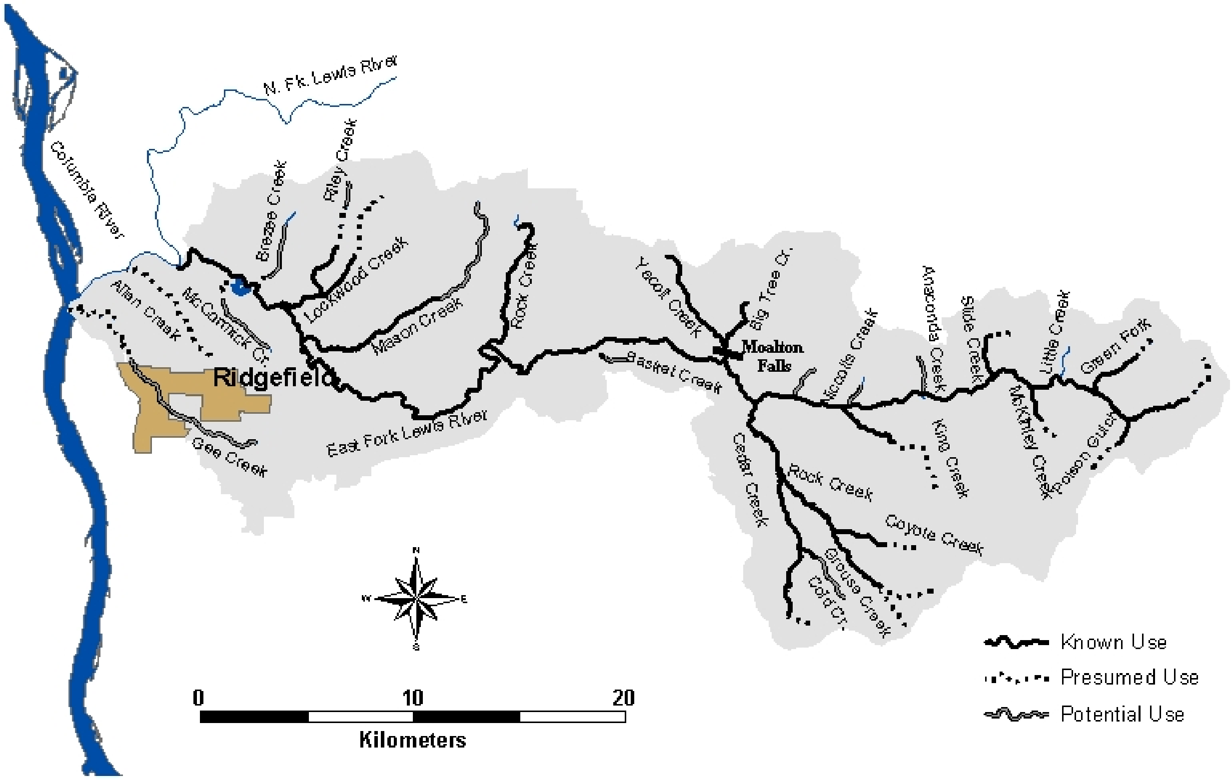
- Chum salmon have not been produced/released in the Lewis River

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less than 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less than 5% of the annual return

13.2.4 Summer Steelhead—Lewis Subbasin (East Fork)

ESA: Threatened 1998 **SASSI: Unknown 2002**

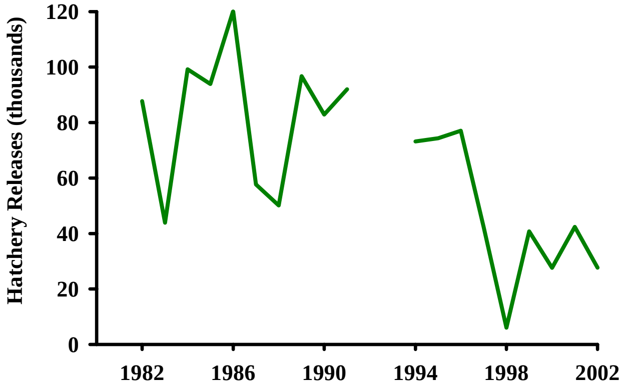


Distribution

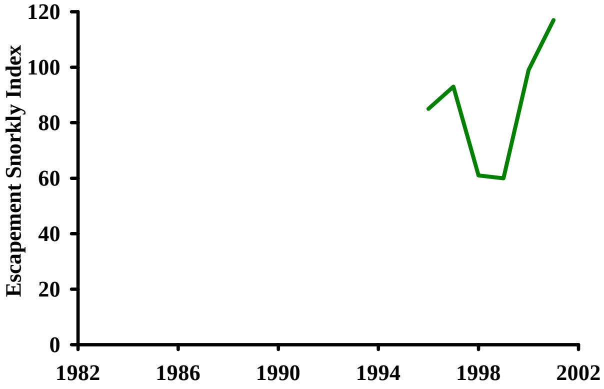
- Spawning occurs in the EF Lewis River as well as Rock Creek and other tributaries; rearing habitat is available throughout most of the basin
- Upstream migration was essentially blocked at Sunset Falls until 1982 when the falls were “notched”, lowering the falls from 13.5 to 8 feet; approximately 12% of the run now spawns above Sunset Falls

Life History

- Adult migration timing for EF Lewis River summer steelhead is from May through November
- Spawning timing on the EF Lewis River is generally from early March through early June
- Age composition data are not available for EF Lewis River summer steelhead
- Wild steelhead fry emerge from late April through July; juveniles generally rear in fresh water for two years; juvenile emigration occurs from March to May, with peak migration in early May



Summer steelhead hatchery releases in the East Fork Lewis River, 1982-2002



Summer steelhead snorkel index counts, 1996-2001

Diversity

- Stock designated based on distinct spawning distribution and early run timing
- Progeny from Elochoman, Chambers Creek, Cowlitz, and Skamania Hatcheries have been planted in the Lewis basin; interbreeding among wild and hatchery stocks has not been measured
- After Mt. St. Helens 1980 eruption, straying Cowlitz River steelhead may have spawned with native Lewis stocks
- Genetic analysis in 1996 provided little information in determining stock distinctiveness

Abundance

- From 1925-1933, run size was estimated at 4,000 summer steelhead
- In 1936, steelhead were reported in the Lewis River during escapement surveys
- From 1963-1967, run size estimates averaged 6,500 summer steelhead
- Wild summer steelhead escapement to the EF Lewis River was estimated at 600 fish in 1984
- Average wild summer steelhead escapement to the EF Lewis River from 1991-1996 was 851
- Snorkel index escapement surveys have been conducted since 1996
- The escapement goal for the EF Lewis River is 814 wild adults

Productivity & Persistence

- Wild fish production is believed to be moderate

Hatchery

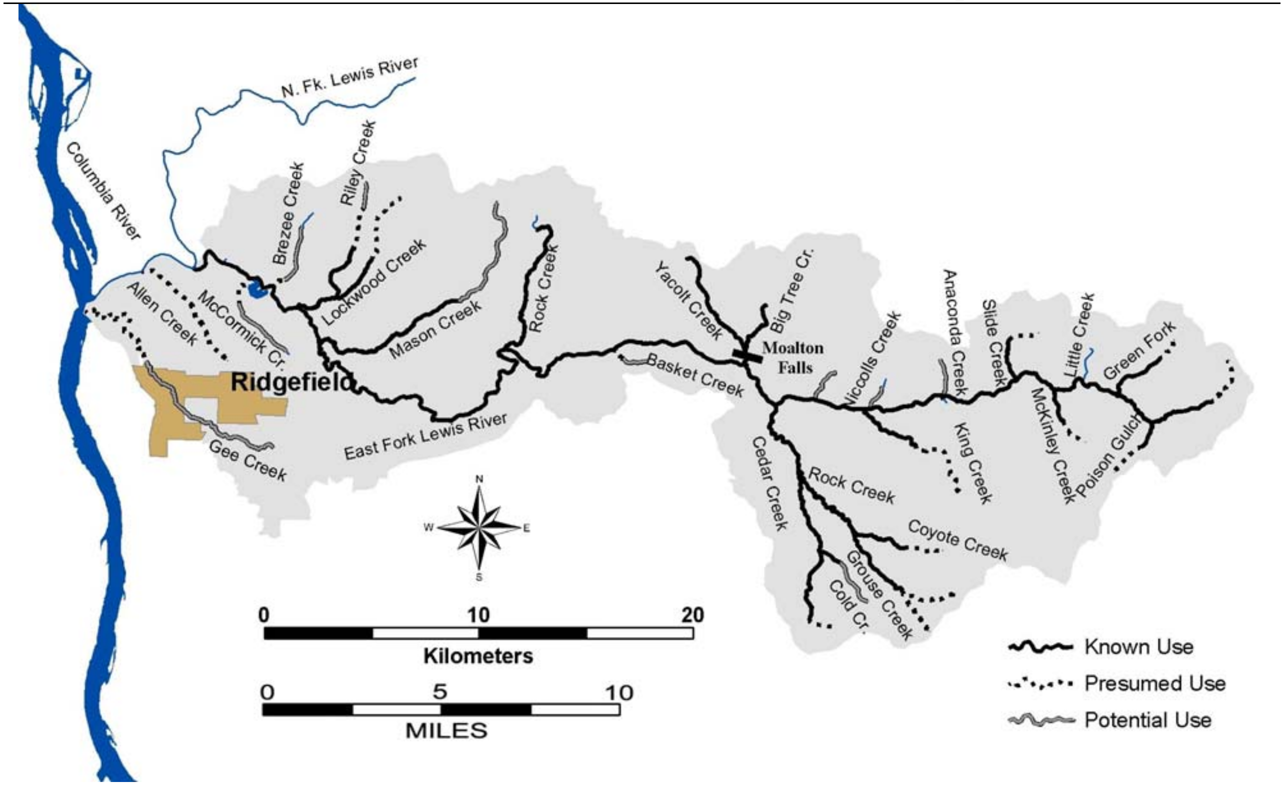
- The Lewis River Hatchery (about 4 miles downstream of Merwin Dam) and Speelyai Hatchery (Speelyai Creek in Merwin Reservoir) do not produce summer steelhead
- A net pen system has been in operation on Merwin Reservoir since 1979; annual average smolt production has been 60,000 summer steelhead; release data are available from 1982-2002; current annual stocking levels in the East Fork are around 40,000 smolts
- The portion of wild summer steelhead in the run at Lucia Falls averaged 27% from 1974-1983
- Recent snorkel surveys indicate hatchery summer steelhead comprise about 70% of the spawning escapement on the EF Lewis River

Harvest

- No directed fisheries target EF Lewis River summer steelhead; incidental mortality currently occurs during the Columbia River fall commercial fisheries and summer sport fisheries
- Summer steelhead sport harvest (wild and hatchery) in the Lewis River basin from 1980-1989 ranged from 3,001 to 8,700; historically, more fish in the sport fishery were caught in the East Fork but currently North Fork harvest exceed East Fork harvest; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild EF Lewis summer steelhead in the mainstem Columbia River and in the EF Lewis River

13.2.5 Winter Steelhead—Lewis Subbasin (East Fork)

ESA: Threatened 1998 **SASSI: Depressed 2002**

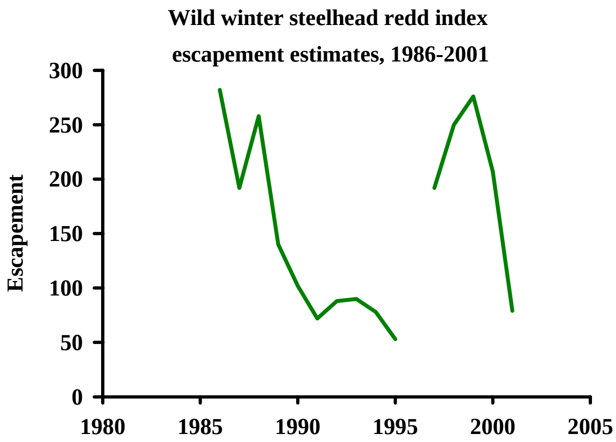


Distribution

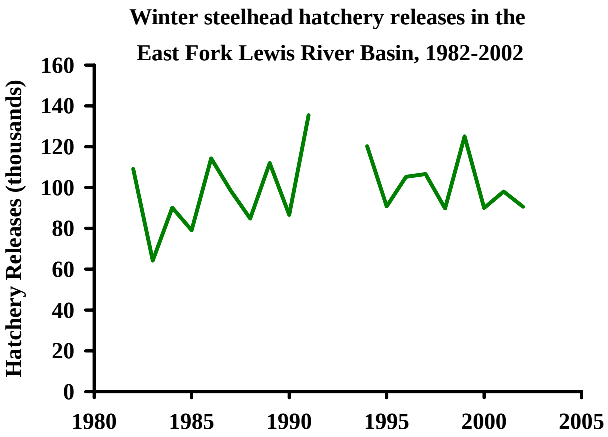
- Spawning occurs in the EF Lewis River as well as Rock Creek and other tributaries; rearing habitat is available throughout most of the basin
- Upstream migration was essentially blocked at Sunset Falls until 1982 when the falls were “notched”, lowering the falls from 13.5 to 8 feet; approximately 12% of the run now spawns above Sunset Falls

Life History

- Adult migration timing for EF Lewis winter steelhead is from December through April
- Spawning timing on the EF Lewis is generally from early March to early June
- Limited age composition data for Lewis River winter steelhead suggest that most steelhead are two-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May



Wild winter steelhead redd index escapement estimates, 1986-2001



Winter steelhead hatchery releases in the East Fork Lewis River Basin, 1982-2002

Diversity

- EF Lewis winter steelhead stock designated based on distinct spawning distribution and late run timing
- Concern with wild stock interbreeding with hatchery brood stock from the Elochoman River, Chambers Creek, and the Cowlitz River
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead likely spawned with native Lewis stocks
- Allele frequency analysis of EF Lewis winter steelhead in 1996 was unable to determine the distinctiveness of the stock compared to other lower Columbia River steelhead stocks

Abundance

- In 1936, steelhead were reported in the Lewis River during escapement surveys
- Historical winter steelhead annual escapement in the Lewis River ranged from 1,000 to 11,000 fish
- Redd index escapement counts from 1986-2001 ranged from 53 to 282 (average 157); a new escapement index was instituted in 1997 and the relationship to the previous index is unknown
- Escapement goal for the EF Lewis River is 875 wild adult steelhead
- The portion of wild winter steelhead at Lucia Falls found in the creel ranged from 35% to 74% from 1974-1983
- Recent data suggests that 51% of spawning steelhead in the East Fork are of hatchery origin

Productivity & Persistence

- NMFS Status Assessment for the EF Lewis River winter steelhead predicted a risk of 1.0 for the risk of 90% decline in both 25 and 50 years; the risk of extinction in 50 years was not applicable
- Winter steelhead natural production is unknown

Hatchery

- There are no hatcheries on the EF Lewis River
- The Ariel (Merwin) Hatchery is located below Merwin Dam the NF Lewis River; the hatchery has been releasing winter steelhead in the Lewis basin since the early 1990s, but does not release steelhead in the EF Lewis

- Annual winter steelhead hatchery smolt releases into the EF Lewis during 1982-2002 have ranged from about 60,000—140,000
- Currently program releases about 90,000 winter steelhead smolts from Skamania Hatchery into the EF Lewis. Hatchery program has changed acclimation sites to the lower East Fork to reduce hatchery/wild interactions in the upper watershed

Harvest

- No directed commercial or tribal fisheries target EF Lewis winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Lewis River basin
- Winter steelhead sport harvest (hatchery and wild) in the Lewis River from 1980-1990 ranged from 2,245 to 6,766 (average 4,385); the portion of this harvest from the East Fork is unknown; since 1992, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in the EF Lewis River

13.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of habitat quantity and quality has the highest relative impact on populations in the EF Lewis.
- Loss of estuary habitat quantity and quality has high relative impacts on chum and moderate impacts on fall chinook and winter steelhead. Impacts to summer steelhead are minor.
- Harvest has relatively high impacts on fall chinook, but impacts to chum, steelhead, and coho are relatively minor.
- Hatchery impacts are high to moderate for summer steelhead and coho, but are low for chum, fall chinook, and winter steelhead.
- Impacts of predation are moderately important to winter and summer steelhead, coho and chum, but are relatively minor for fall chinook.

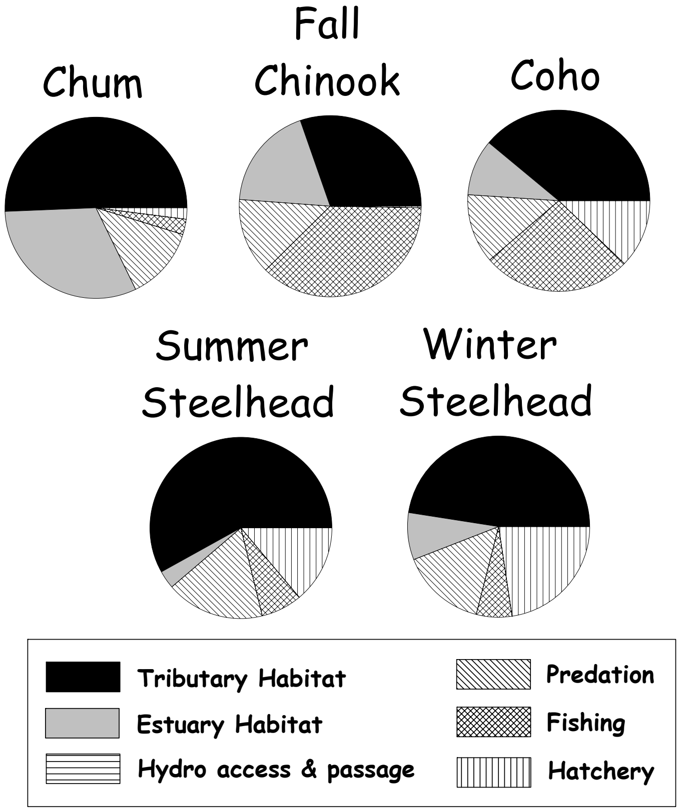


Figure 13-5. Relative index of potentially manageable mortality factors for each species in the East Fork Lewis subbasin.

13.4 Hatchery Programs

Please see Vol II, Chapter 11 for a dicussion of the hatcheries in the Lewis basin.

13.5 Fish Habitat Conditions

13.5.1 Passage Obstructions

No artificial barriers exist on the mainstem of the East Fork Lewis. Lucia Falls at RM 21.3 is believed to block access to anadromous species except for steelhead and an occasional coho. Sunset Falls at RM 32.7 was notched in 1982, allowing for easier passage of this natural feature. Artificial passage obstructions within the watershed include culverts, road crossings, and small dams. More than 10 miles of habitat are believed to be blocked by these obstructions (see Wade 2000 for more details).

13.5.2 Stream Flow

The EF Lewis River watershed is primarily a low to mid-elevation, rain dominated system with extensive rain-on-snow conditions present in the upper reaches. Peak stream flows are generated by fall, winter, and spring rains with flows augmented by snowmelt in the spring and early summer (Figure 13-6).

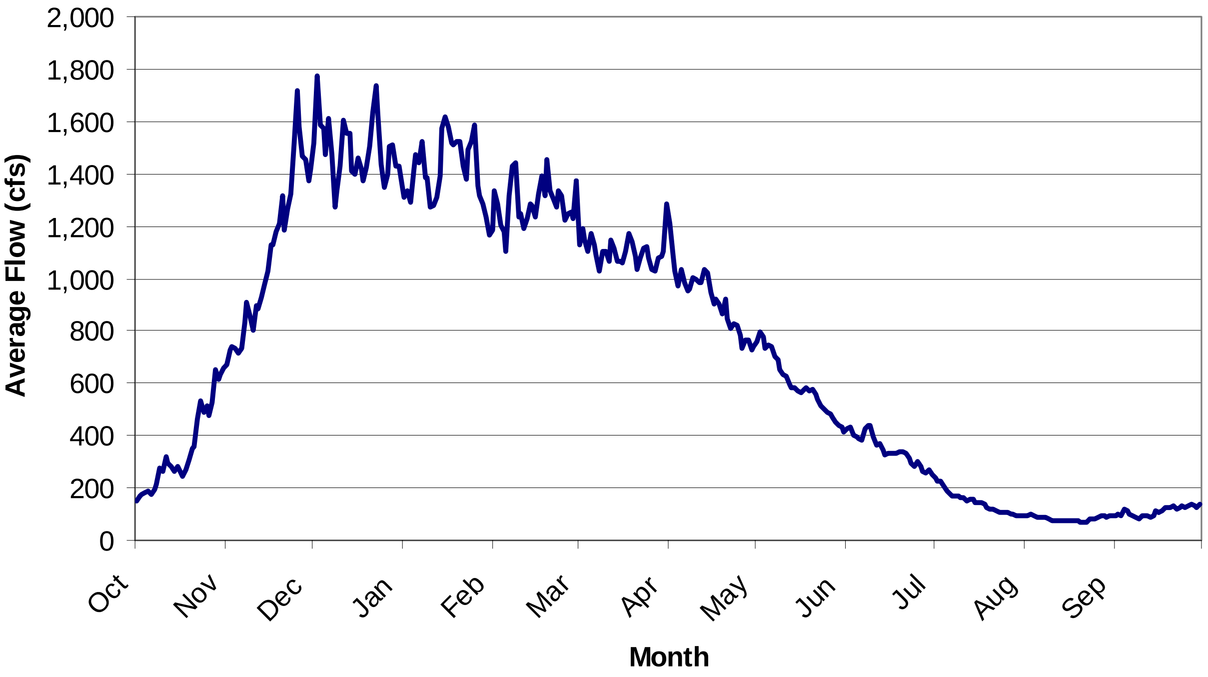


Figure 13-6. Daily average stream flow for the period 1929-2002. USGS Gage #14222500; East Fork Lewis River Near Heisson, WA.

The potential exists for impaired runoff conditions in certain areas due to past fires, the presence of young forest stands, high road densities, and impervious surfaces. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 18 of the 36 subwatersheds (7th field) in the basin are "impaired" with respect to landscape conditions influencing runoff; 14 are rated as "moderately impaired"; and only 4 are considered "functional". The greatest impairments are located in the lower and middle elevation subwatersheds. These subwatersheds are primarily private agricultural, residential, or commercial forest. Runoff conditions improve in the upper watershed, which is predominantly composed of public forest land. In the uppermost, federally managed, portion of the basin, the USFS conducted a peak flow analysis that modeled the effect of vegetation removal on the 2-year peak flow. The Slide Creek, Rock Creek (upper), and Copper Creek basins show susceptibility to flow increases of greater than 10%. These basins show “moderately impaired” conditions according to the IWA. The USFS assessment also indicated that many basins have a significant increase in the length of the channel network due to roads and road ditches, which can also increase peak flows (USFS 1995).

DOE conducted an instream flow study on the EF Lewis and 13 tributaries. The Instream Flow Incremental Methodology (IFIM) was used to model flow-habitat conditions on the mainstem while the toe-width method was used to assess flow-habitat conditions on tributaries. The IFIM results revealed that flows at certain times of the year may be below optimal for fish at various life history stages. Flows for chinook spawning, which starts in October, were only 25% of the optimal flow in October but reached 80% of the optimal flow by November 1. Flows necessary for chinook and steelhead juvenile rearing were only about 30% of optimum in August and September (Caldwell 1999).

Comparing spot flow measurements with flow requirements determined from the Toe-Width method revealed that spawning and rearing habitat was limited for most species in McCormick, Brezee, Lockwood, Mason, and Yacolt Creeks during the fall of 1998. The results in Rock creek suggested insufficient flows for fall spawning but optimum fall rearing conditions (Caldwell 1999).

Based on predictions of future population growth in the basin, total water use is estimated to increase from 10% (2000) to 20% (2020) of late summer flow, assuming full hydraulic continuity between ground water and stream flow. The watershed is near closure for surface water rights and for some existing surface water rights, low flow restrictions are in place in order to protect aquatic biota (LCFRB 2001). The potential for ground and/or surface water withdrawal impacts to salmonids needs further investigation.

13.5.3 Water Quality

The mainstem from the mouth to RM 24.6 was listed on the 1998 WA state 303(d) list of impaired waterbodies due to exceedance of temperature and fecal coliform standards (WDOE 1998). Stream temperatures in the mainstem East Fork commonly exceed the 64°F (18°C) state standard, and occasionally exceed 73.4ºF (23ºC), at locations from Daybreak Park down. In the Ridgefield gravel pits (RM 8), which the stream avulsed into in 1996, temperatures may be warming as a result of large water surface areas within the former gravel pits. Temperature effects in this reach are of particular concern for salmonids (Sweet et al. 2003). USFS monitoring has showed exceedances of the 60.8ºF (16ºC) standard on the mainstem East Fork above and below Sunset Falls as well as on the Green Fork (Wade 2000).

Stream temperatures are also a concern in McCormick Creek, Lockwood Creek and lower Dean Creek. Temperatures in excess of 82.4ºF (28ºC) in lower Dean Creek have been recorded near the outlet of the J.L. Storedahl & Sons - Daybreak gravel mining pits, and conditions are believed to be generally unsuitable for salmonids during the summer (Sweet et al. 2003).

Turbidity is also a concern in portions of the basin. In lower Dean Creek, turbid water has been discharged from the gravel processing ponds owned by J. L. Storedahl and Sons. Measurements associated with the evaluation of a new effluent treatment system, which was implemented in 1999, showed considerable improvements in turbidity levels from pre-project measurements. Recent data from the mainstem East Fork Lewis shows no significant difference in fines between the first riffle above and the first riffle below the Dean Creek confluence (Sweet et al. 2003). Limiting Factors Analysis TAG members noticed turbidity problems in Cedar Creek, potentially from wastewater releases from Larch Mountain Corrections Facility and roads leading to the facility (Wade 2000). An unnamed tributary to the East Fork Lewis, sometimes referred to as Manley Road Creek, has turbidity problems resulting from Teboe processing/mining operations (Donna Hale, personal communication).

Turbidity measurements in lower Rock Creek exceeded state standards in 30% of the samples. Fecal coliform standards were exceeded in 55% of samples and D.O. standards were exceeded 10% of the time. These water quality problems may be due to farming operations (Hutton 1995 as cited in Wade 2000).

Low nutrient levels are assumed to exist in the East Fork Lewis basin due to the lack of sufficient salmonid carcasses as a result of low escapement numbers for most species. However, nutrient enhancement projects have planted numerous carcasses into tributary streams over the past several years (Wade 2000).

13.5.4 Key Habitat

In the lower mainstem, pool abundance and quality are concerns between RM 6 and RM 16.2, partly as a result of the 1996 avulsion of the mainstem into the Ridgfield Pits near RM 8. This avulsion resulted in the abandonment of approximately 3,200 lineal feet of riffle habitat (used primarily for spawning) in exchange for low velocity pool habitat (used primarily for rearing). Portions of the upstream end of the avulsed reach are slowly converting to riffle habitat as the pools fill with coarse sediments (Sweet et al. 2003).

As part of the 2000 Limiting Factors Analysis, the TAG expressed concerns with the availability of suitable pool habitat on the mainstem between lower Rock Creek (RM 16.2) and Sunset Falls (RM 32.7).

USFS surveys in the upper basin, conducted as part of the 1995 watershed analysis, identified substandard pool frequency in approximately 58% of surveyed streams (USFS 1995). Pools suitable for summer steelhead holding exist on the upper mainstem below the Green Fork confluence, though many of these lack adequate cover. Good holding pools are rare on Slide, Green Fork, and the mainstem above Green Fork (USFS 1999).

Historically available side channel habitat has been reduced in the lower river due to draining of wetlands for agricultural uses and conversion to a single thread channel as a result of channel confinement projects (Sweet et al. 2003). Off-channel habitat in the upper basin is sparse and is only accessible during the highest flows (USFS 1999).

13.5.5 Substrate & Sediment

A large portion of sediment delivery in the lower river is from in-channel bed and bank erosion related to channel migration and avulsions. Analysis of historical aerial photos indicates that movement of the channel is a natural process in the lower mainstem alluvial reaches; however, between RM 7 and RM 10, natural rates of channel adjustment have been influenced by the presence of stream-adjacent gravel pits, which have captured the mainstem in a few locations within the past 10 years. These avulsions have altered rates of sediment generation and accumulation. The most notable avulsion occurred near RM 8 in November, 1996, when the mainstem was captured by the abandoned gravel ponds known as the Ridgefield Pits. This avulsion alone abandoned approximately 3,200 feet of riffle habitat. The previous riffle habitat was replaced by pools that are rapidly filling with sediment. In the Ridgefield Pit reach, the former gravel ponds have been filling with fine sediments that are believed to originate primarily from a high sandy bank just upstream of the avulsed reach. In some areas, riffle habitat suitable for spawning is being re-created as the pools fill. Sediment sampling downstream of the Ridgefield Pits in 2001 indicated that fine sediment volumes were less than 10% (Sweet et al. 2003).

Basin-wide sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The results indicate that 28 out of the 36 subwatersheds in the basin are “moderately impaired” with respect to conditions that influence sediment supply. The remainder of the basin was rated as “functional” with respect to sediment supply. Most of the functional subwatersheds were concentrated in the Rock Creek basin (Upper). Sediment supply impairment is related to a number of factors, including primarily naturally unstable slopes and high road densities. The total road density in the basin is 4.13 mi/mi2 (greater then 3 mi/mi2 is considered high by most standards). The upper watershed, dominated by National Forest lands, has a relatively low overall road density of 1.79 mi/mi2. The USFS Watershed Analysis reports an estimated sediment yield due to roads of 400 tons/mi2/year, with 3 out of 23 of the subbasins in the upper watershed (portion primarily in National Forest) having high rates of surface erosion from roads (USFS 1995).

Despite the effects of roads, the Pacific Watershed Institute completed a sediment budget for the upper watershed and determined that the sediment supply is limited, primarily due to most available material having already eroded following early 20th century fires. The lack of supply of gravels may limit spawning habitat in the upper basin. Furthermore, low large woody debris (LWD) concentrations combined with the steep gradient and confinement of most upper basin channels probably results in transport of most gravels out of the upper basin (USFS 1999).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

13.5.6 Woody Debris

LWD recruitment potential is of concern throughout the basin due to past forest fire impacts and harvest of riparian areas. A 1995 aerial photo analysis conducted by the USFS noted that 87% of riparian stands in the upper basin had either young, sparse hardwood stands or were burned in the early part of the century and now contained mature, dense hardwoods, with low to moderate potential for LWD recruitment (USFS 1995). In-stream LWD levels are very low also as a result of salvage logging following large fires in the early 20th century and from removal of log jams in the 1980s that were incorrectly assumed to be fish passage barriers (USFS 1999).

USFS stream surveys in the 1990s found that 92% of the surveyed streams had less than 40 pieces per mile (a poor rating), and at least 98% of the streams surveyed had concentrations of LWD less than 80 pieces per mile (USFS 1995). Limiting Factors Analysis TAG members felt that overall, LWD concentrations in the lower basin were low (Wade 2000).

13.5.7 Channel Stability

Bank stability is a major concern along portions of the lower 14 miles of the mainstem, particularly in areas that have received extensive alteration due to agricultural, residential, and mining development. In the broad alluvial valley between RM 7 and RM 10, dramatic channel adjustments including avulsions and lateral meander migration have occurred since 1858 (Sweet et al. 2003). Current rates of channel adjustment may be altered from their historical condition due to confinement of the river by levees and removal of riparian forests. Recent avulsions into stream-adjacent gravel pits occurred near RM 9 in 1995 and near RM 8 (Ridgefield Pits) in 1996. These adjustments abandoned a combined total of 4,900 feet of spawning habitat and have altered sediment transport dynamics in the lower river. A comprehensive evaluation of the effects of these events can be found in Sweet et al. (2003).

Reconnaisance surveys in 1999 indicated that high stream-adjacent bluffs near Daybreak Park may be contributing large amounts of fine sediment to the river, much of which is collecting in the Ridgefield Pits (Sweet et al. 2003). There are other areas of bank instability near RM 10.5 and RM 11.3. All of these conditions have dramatically altered channel stability and rates of sediment supply in the lower river. In particular, aggradation of sediments in some areas is believed to be causing erosion of lateral banks, therefore increasing width-to-depth ratios.

Bank stability problems in East Fork tributaries include streambank erosion along a segment of Mason Creek, cattle impacts on Rock Creek, and chronic mass wasting sites on upper Rock Creek and upper Lockwood Creek (Wade 2000).

13.5.8 Riparian Function

Riparian conditions in the lower river below RM 10 have been substantially impacted by residential, agricultural, and mining development. This area is believed to have been a gallery-type forest consisting of multiple age classes of willow, alder, ash, and cottonwood, but now consists only of widely dispersed cottonwoods, willow, and ash, with abundant reed canary grass, Himalayan blackberry, and Scotch broom in the disturbed areas. Substantial restoration efforts have involved the planting of thousands of native trees and shrubs in the past few years (Wade 2000).

An analysis of 1996 aerial photos indicated that the majority of the mainstem has lost substantial portions of riparian forest, many having been replaced by lawns. Most of the tributaries also have poor riparian conditions (Wade 2000). Riparian forests in the upper watershed have been altered by fire history, with only 4% of riparian reserves in late-successional stages and a total riparian hardwood composition of 23%. Large segments of the upper mainstem and Copper Creek have canopies that cover less than 50% of the stream channel (USFS 1995).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 8 of the 36 subwatersheds in the basin are “impaired” with respect to riparian function. The remainder fall primarily in the “moderately impaired” category, with only 4 subwatersheds rated as “functional”. The greatest impairments are in the low elevation portions of the basin, which have received the greatest impacts to riparian areas due to agricultural and residential development. Fully functional conditions exist only in a handful of headwaters subwatersheds.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

13.5.9 Floodplain Function

The lower river flows through a broad alluvial valley that has been extensively diked to protect agricultural, residential, and mining activities. Historically, nearly the entire lower river valley bottom was wetlands, with extensive channel braiding from RM 7 to RM 10. By 1937, the mainstem was mostly a single-thread channel with ephemeral floodplain sloughs where the braids once were. This simplification of the channel has reduced a substantial amount of side channel and backwater habitat that was historically used for chum spawning and could provide important overwintering habitat for juvenile coho. Limiting Factors Analysis TAG members estimated that over 50% of the off-channel habitat and wetlands in the historical lower river floodplain have been disconnected from the river (Wade 2000).

13.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to East Fork Lewis River winter steelhead, summer steelhead, fall chinook, chum, and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

13.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the EF Lewis basin for summer steelhead, winter steelhead, fall chinook, chum and coho. Model results indicate an estimated 61- 88% decline in adult productivity for all species compared to historical estimates (Table 13-1). Estimated historical-to-current trends in adult abundance show a decline of 49-90% for all species (Figure 13-7). Fall chinook adult abundance has declined the least, to an estimated 51% of historical levels. Adult abundance of coho, winter and summer steelhead has declined by

75%, 75%, and 79%, respectively. Chum abundance has witnessed the most severe decline. Current estimates of chum abundance are at only 10% of historical levels. Diversity (as measured by the diversity index) has remained relatively constant for fall chinook, chum and summer steelhead (Table 13-1). However, coho and winter steelhead diversity has declined by 29% and 23%, respectively.

Smolt productivity has also declined from historical levels for each species in the EF Lewis basin (Table 13-1). For fall chinook and chum, smolt productivity has decreased by 58% and 43% respectively. For both coho and winter steelhead the decrease was estimated as approximately 80%. Summer steelhead smolt productivity has declined by 72%. Smolt abundance in the EF Lewis has declined most dramatically for chum and coho, with respective 79% and 80% changes from historical levels (Table 13-1). Current fall chinook, winter steelhead, and summer steelhead smolt abundance levels are modeled at approximately half of their historical numbers (Table 13-1).

Model results indicate that restoration of properly functioning habitat conditions (PFC) would achieve significant benefits for all species (Table 13-1). Adult abundance of both chum and coho would increase by more than 200%. Adult returns of fall chinook, winter steelhead, and summer steelhead would increase by more than 60%. Smolt numbers are also estimated to increase dramatically for all species, especially for coho, which shows a 287% increase in smolt abundance with restoration of PFC.

Table 13-1. EF Lewis River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]
Fall Chinook	1,380	2,223	2,690	3.5	7.0	8.8	0.96	1.00	1.00	194,805	323,012	411,593	384	725	913
Chum	4,652	16,540	45,517	2.0	6.7	10.4	0.97	1.00	1.00	2,200,608	6,194,596	10,474,620	641	960	1,122
Coho	1,066	3,306	4,280	2.6	8.8	12.6	0.71	1.00	1.00	20,097	77,730	102,601	56	206	294
Winter Steelhead	631	1,109	2,517	3.7	10.4	29.9	0.77	0.84	1.00	10,560	18,414	22,539	69	188	292
Summer Steelhead	187	338	893	2.6	5.3	17.4	0.94	1.00	1.00	3,500	6,247	8,797	48	97	170

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

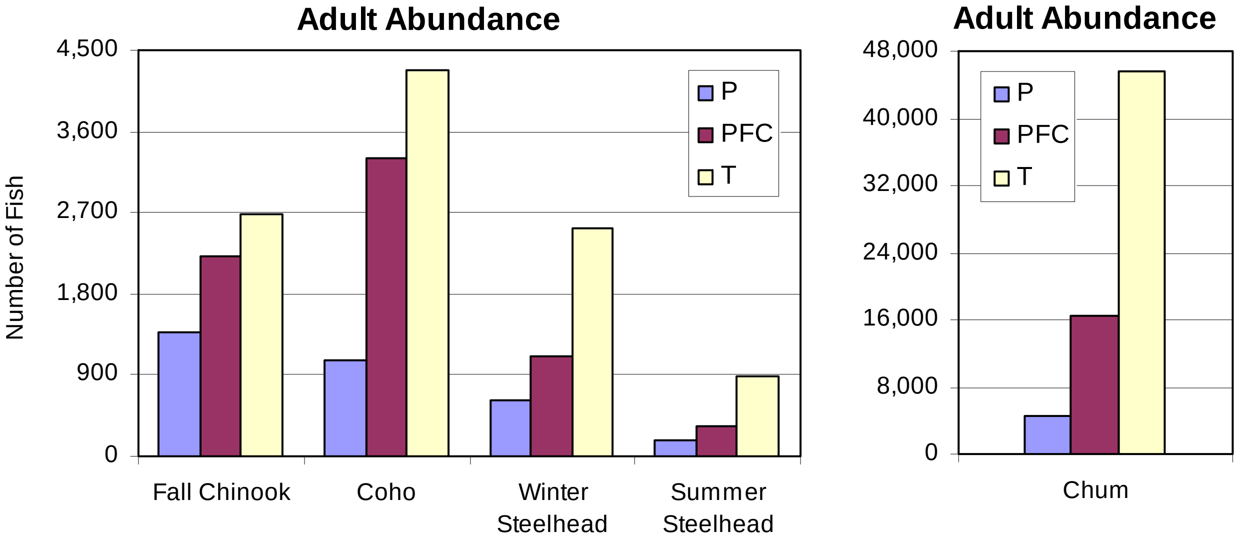


Figure 13-7. Adult abundance of EF Lewis fall chinook, coho, winter steelhead, summer steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

13.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Summer steelhead, which are able to ascend Sunset Falls at RM 32.7, ascend the furthest up the EF Lewis. Winter steelhead, whose distribution stops at Sunset Falls, make greater use of mainstem tributary habitats. Fall chinook distribution ends at Lucia Falls (RM 21.3) and chum distribution ends approximately at lower Rock Creek. See Figure 13-8 for a map of EDT reaches within the EF Lewis basin.

The high priority reaches for winter steelhead are the mainstem reaches (EF Lewis 12 and 13) and reaches in the Rock Creek basin (Rock 1-4) (Figure 13-9). These reaches represent the primary spawning and rearing areas for this population. As such, all of these reaches, except Rock Creek 4, show a preservation emphasis. High priority reaches for summer steelhead are also located in the most productive spawning and rearing reaches of the headwaters (EF Lewis 17-19) and the upper mainstem (EF Lewis 15) (Figure 13-10). These reaches, with the exception of EF Lewis 15, all show a combined preservation and restoration recovery emphasis.

For both fall chinook and chum, the high priority reaches are located lower in the basin. High priority reaches for fall chinook include lower and middle mainstem reaches (EF Lewis 5-7 and 9) (Figure 13-11). Reaches EF Lewis 5-7 show a combined preservation and restoration emphasis, while EF Lewis 9 only has a preservation emphasis. For chum, the high priority reaches are EF Lewis 4-8 (Figure 13-12). All of these reaches, except for EF Lewis 4, have a combined preservation and restoration emphasis.

High priority reaches for coho in the EF Lewis are similar to those for fall chinook. Coho high priority reaches include EF Lewis 5-8 and EF Lewis 10 (Figure 13-13). For coho, all of these reaches have a restoration emphasis, suggesting degradation to key coho habitat in these areas.

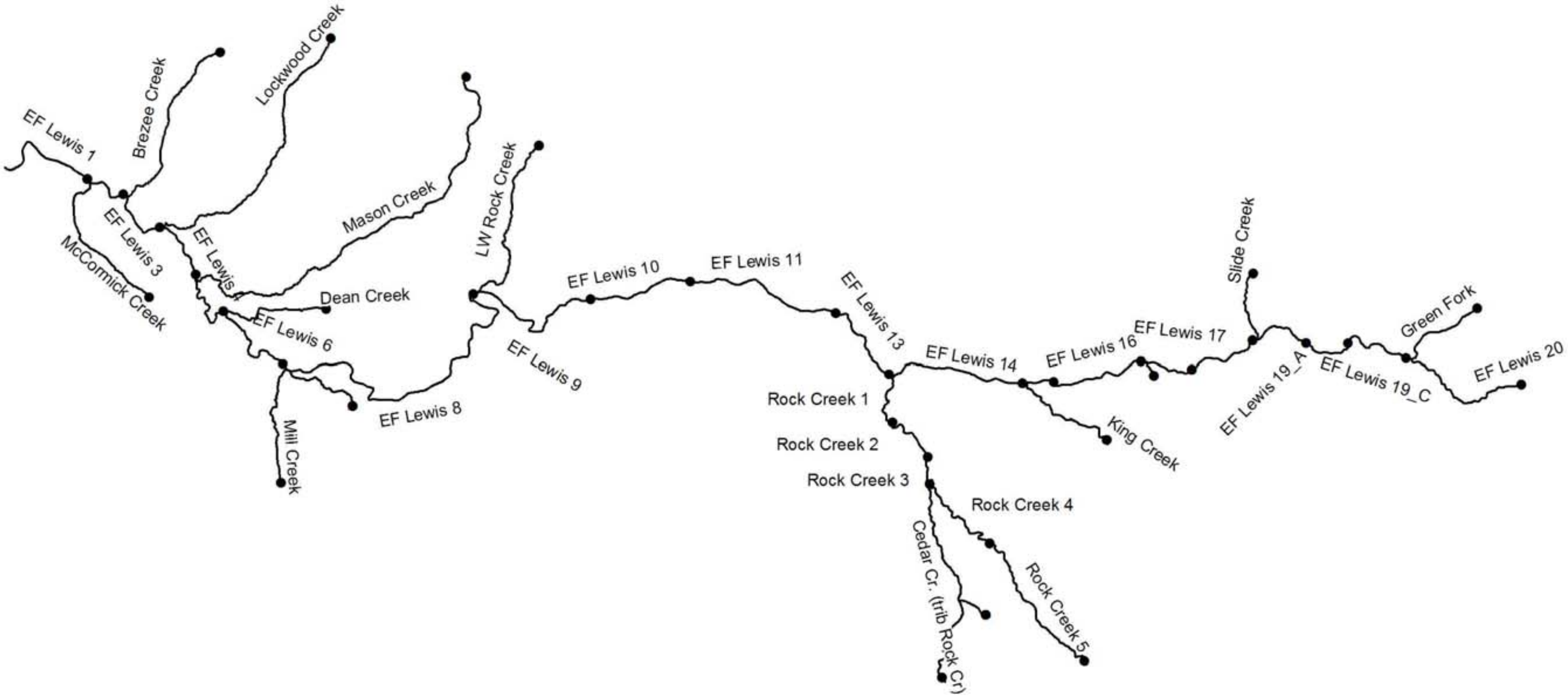
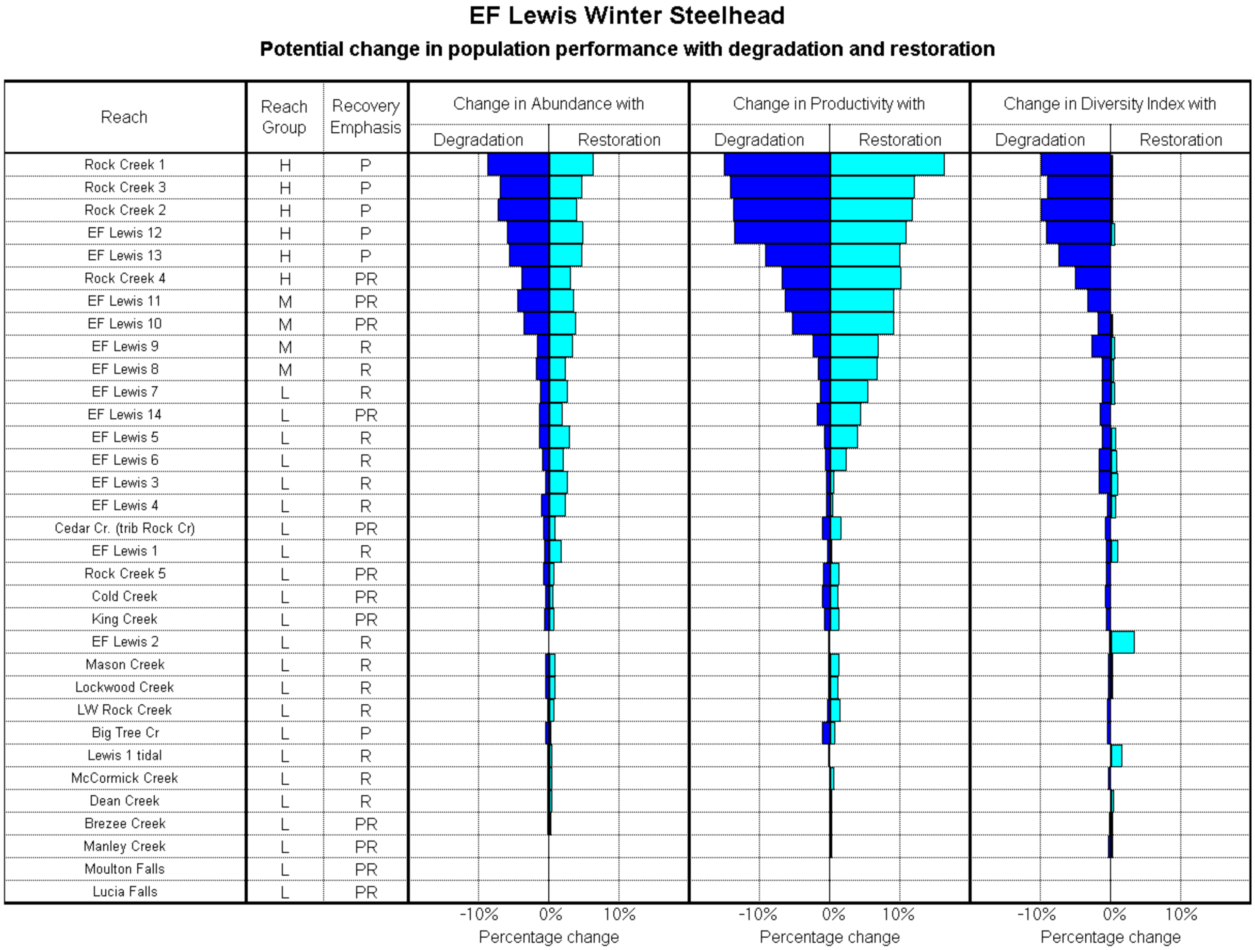
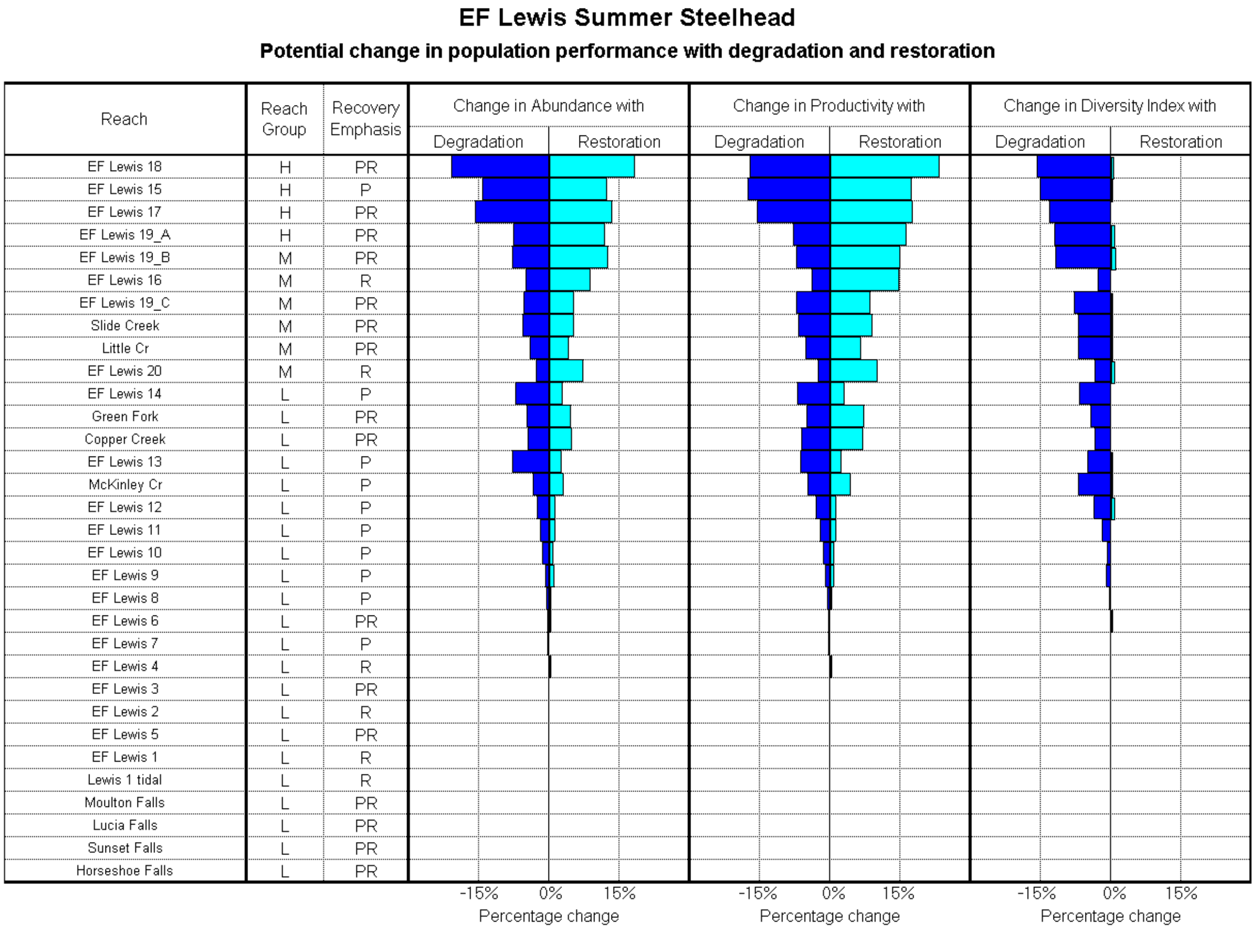


Figure 13-8. EF Lewis EDT reaches. Some reaches are not labeled for clarity.



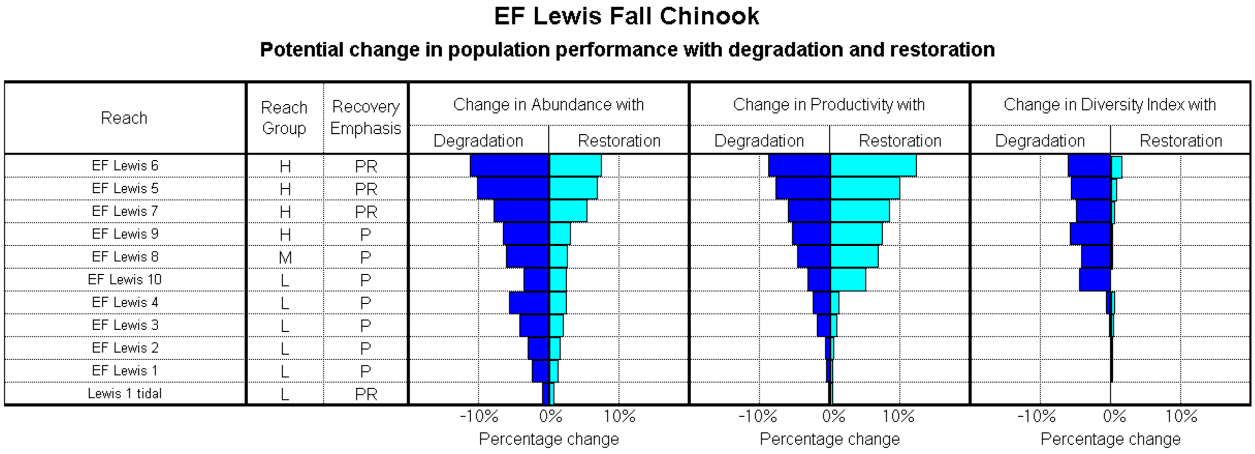
Reach	Reach Group	Recovery Emphasis
Rock Creek 1	H	P
Rock Creek 3	H	P
Rock Creek 2	H	P
EF Lewis 12	H	P
EF Lewis 13	H	P
Rock Creek 4	H	PR
EF Lewis 11	M	PR
EF Lewis 10	M	PR
EF Lewis 9	M	R
EF Lewis 8	M	R
EF Lewis 7	L	R
EF Lewis 14	L	PR
EF Lewis 5	L	R
EF Lewis 6	L	R
EF Lewis 3	L	R
EF Lewis 4	L	R
Cedar Cr. (trib Rock Cr)	L	PR
EF Lewis 1	L	R
Rock Creek 5	L	PR
Cold Creek	L	PR
King Creek	L	PR
EF Lewis 2	L	R
Mason Creek	L	R
Lockwood Creek	L	R
LW Rock Creek	L	R
Big Tree Cr	L	P
Lewis 1 tidal	L	R
McCormick Creek	L	R
Dean Creek	L	R
Brezee Creek	L	PR
Manley Creek	L	PR
Moulton Falls	L	PR
Lucia Falls	L	PR

Figure 13-9. EF Lewis winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.



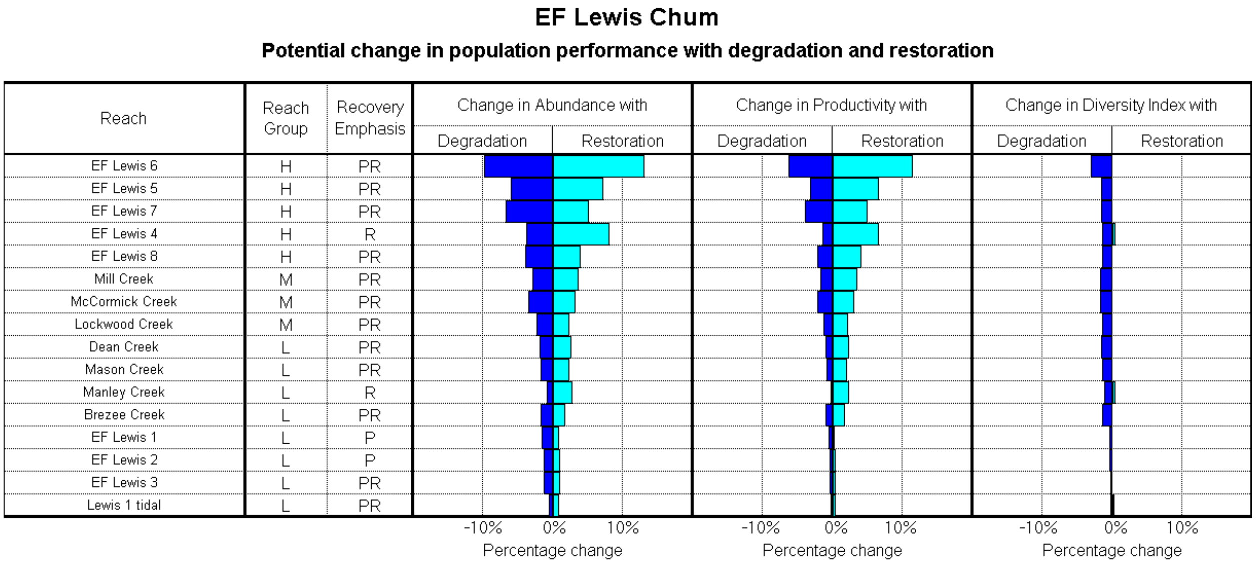
Reach	Reach Group	Recovery Emphasis
EF Lewis 18	H	PR
EF Lewis 15	H	P
EF Lewis 17	H	PR
EF Lewis 19_A	H	PR
EF Lewis 19_B	M	PR
EF Lewis 16	M	R
EF Lewis 19_C	M	PR
Slide Creek	M	PR
Little Cr	M	PR
EF Lewis 20	M	R
EF Lewis 14	L	P
Green Fork	L	PR
Copper Creek	L	PR
EF Lewis 13	L	P
McKinley Cr	L	P
EF Lewis 12	L	P
EF Lewis 11	L	P
EF Lewis 10	L	P
EF Lewis 9	L	P
EF Lewis 8	L	P
EF Lewis 6	L	PR
EF Lewis 7	L	P
EF Lewis 4	L	R
EF Lewis 3	L	PR
EF Lewis 2	L	R
EF Lewis 5	L	PR
EF Lewis 1	L	R
Lewis 1 tidal	L	R
Moulton Falls	L	PR
Lucia Falls	L	PR
Sunset Falls	L	PR
Horseshoe Falls	L	PR

Figure 13-10. East Fork Lewis summer steelhead ladder diagram.



Reach	Reach Group	Recovery Emphasis
EF Lewis 6	H	PR
EF Lewis 5	H	PR
EF Lewis 7	H	PR
EF Lewis 9	H	P
EF Lewis 8	M	P
EF Lewis 10	L	P
EF Lewis 4	L	P
EF Lewis 3	L	P
EF Lewis 2	L	P
EF Lewis 1	L	P
Lewis 1 tidal	L	PR

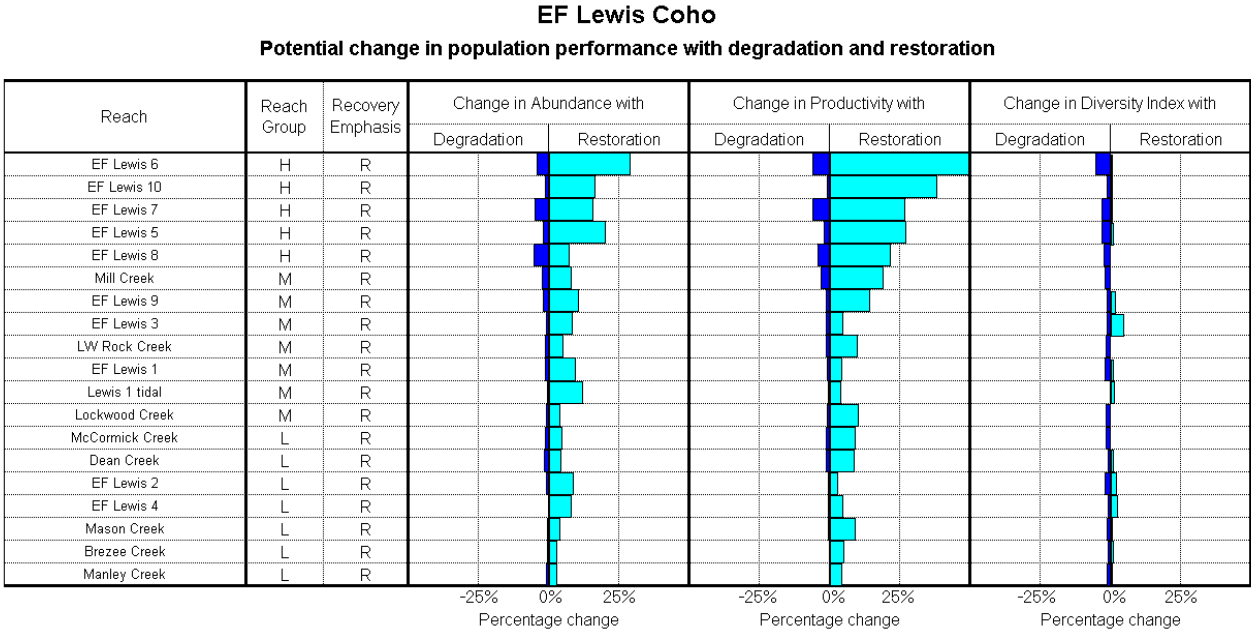
Figure 13-11. East Fork Lewis fall chinook ladder diagram.


EF Lewis Chum

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
EF Lewis 6	H	PR
EF Lewis 5	H	PR
EF Lewis 7	H	PR
EF Lewis 4	H	R
EF Lewis 8	H	PR
Mill Creek	M	PR
McCormick Creek	M	PR
Lockwood Creek	M	PR
Dean Creek	L	PR
Mason Creek	L	PR
Manley Creek	L	R
Brezee Creek	L	PR
EF Lewis 1	L	P
EF Lewis 2	L	P
EF Lewis 3	L	PR
Lewis 1 tidal	L	PR

Figure 13-12. East Fork Lewis chum ladder diagram.


EF Lewis Coho

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
EF Lewis 6	H	R
EF Lewis 10	H	R
EF Lewis 7	H	R
EF Lewis 5	H	R
EF Lewis 8	H	R
Mill Creek	M	R
EF Lewis 9	M	R
EF Lewis 3	M	R
LW Rock Creek	M	R
EF Lewis 1	M	R
Lewis 1 tidal	M	R
Lockwood Creek	M	R
McCormick Creek	L	R
Dean Creek	L	R
EF Lewis 2	L	R
EF Lewis 4	L	R
Mason Creek	L	R
Brezee Creek	L	R
Manley Creek	L	R

Figure 13-13. East Fork Lewis coho ladder diagram.

13.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

As described in the reach analysis section above, the high priority reaches for winter steelhead are in the middle mainstem (EF Lewis 12 and 13) and reaches in the Rock Creek basin (Rock 1-4). In these areas, habitat diversity, sediment, flow, and temperature have had a negative impact on the population (Figure 13-14). Loss of key habitat and channel stability are also important factors. Key habitat has been lost due to recent channel avulsions into streamside gravel pits in the lower and middle mainstem. Sediment impacts are mostly from upriver sources. Habitat diversity impacts stem from degraded riparian zones and low LWD levels.

High priority reaches for summer steelhead are located in upper mainstem reaches that are affected mostly by degraded habitat diversity and flow (Figure 13-15). Sediment, loss of key habitat, and channel stability have also had negative impacts (Figure 13-15). Habitat diversity is low due to degraded riparian zones and low LWD levels. Flow and sediment impacts are related to upper basin forest and road conditions, with some effects still lingering from large fires and floods in the 1920s and 30s. The 1995 USFS watershed analysis (USFS 1995) rated nearly all of the headwater reaches occupied by summer steelhead (except for the Green Fork) as having poor (<40 pieces per mile) LWD abundance. The bulk of these reaches also have riparian canopy openings of greater than 50%. Sediment impacts in the channel below Sunset Falls (EF Lewis 17) and in Green Fork Creek stem largely from past fires and floods (USFS 1995). Flow is affected by hillslope vegetation and road conditions. The 1995 watershed analysis rated 14 of 23 upper basin subwatersheds as being impaired with regards to peak flows.

Important fall chinook reaches are located in the lower mainstem. The greatest impact here is sediment, key habitat, and temperature (Figure 13-16). There is a large influx of sediment from channel sources due to rapid channel migration rates and avulsions into streamside gravel pits. These conditions have served to decrease overall channel stability, increasing bank erosion and downcutting. Low LWD levels, channelization, and degraded riparian forests have contributed to a lack of habitat diversity. Key habitat has been lost due to channelization and channel avulsions. Temperature is impacted by low canopy cover levels and flow is impacted by upper basin conditions mentioned previously for steelhead.

The high priority areas for chum are similar to those for fall chinook. These reaches suffer from similar sediment problems and loss of key habitat (Figure 13-17). However, an additional impact to chum in these areas comes from lack of habitat diversity. These reaches have experienced much channelization (diking) and riparian zone degradation. LWD levels are low in these streams. Residential development and agriculture have altered sediment and flow regimes. Furthermore, the high density of people in the area increases the risk of harassment impacts from anglers and recreationists.

Key restoration areas for coho in the EF Lewis are generally located in middle and lower mainstem sections. In these areas, habitat impacts to coho come from sediment, loss of both key habitat and habitat diversity, and poor channel stability (Figure 13-18). The causes of impacts are similar to those discussed for fall chinook and chum.

EF Lewis Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Rock Creek 1	●	⬤	●	•		•			⬤	⬤	•			•		✛
Rock Creek 3	•	⬤	•			•			●	⬤	•					•
Rock Creek 2	•	⬤	●	•		•			●	●	•			•		●
EF Lewis 12	●	⬤	●	•		•			●	●	•			•		•
EF Lewis 13	●	⬤	●	•		•			●	●	•			•		●
Rock Creek 4	•	⬤	•			•			●	⬤	•					⬤
EF Lewis 11	●	⬤	●	•		•			●	●	•			•		•
EF Lewis 10	●	●	●	•		•			●	●	•			•		•
EF Lewis 9	•	⬤	●	•		•			●	●				•		•
EF Lewis 8	•	•	●	●		•			•	●	•			•		●
EF Lewis 7	•	•	●	●		•			•	●	•			•		⬤
EF Lewis 14	•	●	•	•		•			●	●	•			•		⬤
EF Lewis 5	•	●	●	●		•			•	●	•			•		⬤
EF Lewis 6	•	●	●	●		•			•	●	•			•		⬤
EF Lewis 3	•	●	●	●	•	•			●	•	•			•		⬤
EF Lewis 4	•	●	●	●	•	•			•	●	•			•		⬤
Cedar Cr. (trib Rock Cr)	•	●							•	●						●
EF Lewis 1	•	●	•	●	•	•			•	●	•			•		⬤
Rock Creek 5	•	●							•	●						●
Cold Creek	•	•							•	●						•
King Creek	•	●							•	●						●
EF Lewis 2																
Mason Creek	•	•	•	•					•	●	•			•		✚
Lockwood Creek	•	•	•	•					•	●	•			•		✚
LW Rock Creek	•	•	•	•					•	●	•					✚
Big Tree Cr		•	•						•	⬤	•					+
Lewis 1 tidal		●		•						•						⬤
McCormick Creek		•	•						•	•	•					+
Dean Creek		•	•						•	•				•		✚
Brezee Creek		•	•						•	•						+
Manley Creek		•								•						+
Moulton Falls																
Lucia Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 13-14. EF Lewis winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

EF Lewis Summer Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
EF Lewis 18	●	⬤	●	•		•			⬤	●	•			•		⬤
EF Lewis 15	●	⬤	●	•		•			⬤	●	•			•		•
EF Lewis 17	●	⬤	●	•		•			⬤	●	•			•		●
EF Lewis 19_A	●	⬤				•			⬤	●	•					●
EF Lewis 19_B	●	⬤				•			⬤	●	•					●
EF Lewis 16	●	⬤	•	•		•			●	⬤	•			•		⬤
EF Lewis 19_C	●	●	•	•		•			●	●	●					•
Slide Creek	●	●				•			●	⬤	•					⬤
Little Cr	●	●				•			●	⬤	•					⬤
EF Lewis 20	●	⬤	•			•			●		•					⬤
EF Lewis 14	•	●	•	•		•			●					•		•
Green Fork	•	●				•			●	⬤	•					●
Copper Creek	•	●	•						●	⬤						⬤
EF Lewis 13	•	●	•						•							●
McKinley Cr	●	●							●	⬤	•					⬤
EF Lewis 12	•	●	•						•							
EF Lewis 11	•	●	•						•							
EF Lewis 10	•	•	•						•							
EF Lewis 9	•	•	•	•					•							
EF Lewis 8			•	•												
EF Lewis 6			•	•												•
EF Lewis 7			•													
EF Lewis 4			•	•												•
EF Lewis 3				•												
EF Lewis 2		•		•												
EF Lewis 5																
EF Lewis 1				•												
Lewis 1 tidal		•														
Moulton Falls																
Lucia Falls																
Sunset Falls																
Horseshoe Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 13-15. East Fork Lewis summer steelhead habitat factor analysis diagram.

EF Lewis Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
EF Lewis 6	●	●	⬤	•		•			•	⬤	•			•	•	⬤
EF Lewis 5	●	●	⬤	•		•			•	⬤	•			•	•	⬤
EF Lewis 7	●	•	⬤	•		•			•	⬤	•					●
EF Lewis 9	●	●	●	•					•	●						●
EF Lewis 8	●	•	●	•					•	●	•				•	●
EF Lewis 10	●	•	●						•	⬤	•					●
EF Lewis 4	•	●	•	•	•	•			•	•	•					●
EF Lewis 3	•	●	•	•	•	•			•	•	•					●
EF Lewis 2	•	•	•	•	•	•			•	•	•			•		●
EF Lewis 1	•	•	•	•	•	•			•	•	•			•		●
Lewis 1 tidal	•	•		•		•										•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 13-16. East Fork Lewis fall chinook habitat factor analysis diagram.

EF Lewis Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
EF Lewis 6	●	⬤	●	●					●	⬤	●				●	⬤
EF Lewis 5	●	⬤	•	•					●	⬤	●				●	⬤
EF Lewis 7	●	●	●	•					•	⬤	●				•	•
EF Lewis 4	•	⬤	•	●	•				●	●	•				●	⬤
EF Lewis 8	•	●	•	•					•	●	•				●	●
Mill Creek	•	⬤							•	●	•					✛
McCormick Creek	•	●							•	●	•					✛
Lockwood Creek	•	●							•	•	•					✛
Dean Creek	•	●							•	•	•					✛
Mason Creek	•	●							•	•	•					✛
Manley Creek	•	●							•	•	•				•	✛
Brezee Creek	•	●							•	•	•					✚
EF Lewis 1	•	•	•	•	•				•	•	•					•
EF Lewis 2	•	•		•	•				•	•	•					•
EF Lewis 3	•	•		•					•		•					•
Lewis 1 tidal	•	•		•					•		•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 13-17. East Fork Lewis chum habitat factor analysis diagram.

EF Lewis Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
EF Lewis 6	⬤	⬤	●	●		●			•	⬤	●			•		⬤
EF Lewis 10	●	⬤	●	•		•			•	●	•			•		⬤
EF Lewis 7	●	●	●	●		•			•	⬤	•			•		⬤
EF Lewis 5	●	●	●	●		•			•	●	●			•		⬤
EF Lewis 8	●	●	●	•		•			•	●	•			•		⬤
Mill Creek	●	●	•	•		•			•	⬤	•					●
EF Lewis 9	●	●	•	•		•			•	●						•
EF Lewis 3	•	●	•	•		•			•		•			•		⬤
LW Rock Creek	•	●	•						•	●	•					●
EF Lewis 1	•	●	●	●	•	•			•	•	•			•		⬤
Lewis 1 tidal	•	⬤	+	●		•			•	•	•			•		⬤
Lockwood Creek	•	●	•						•	●	•					●
McCormick Creek	•	●	•						•	●	•					●
Dean Creek	•	●	•						•	●	•					●
EF Lewis 2	•	●	•	●	•	•			•	•	•			•		⬤
EF Lewis 4	•	●	•	•		•			•	•	•			•		⬤
Mason Creek	•	●	•						•	•	•					●
Brezee Creek	•	●	•						•	•	•					•
Manley Creek	•	•	•						•	•	•					•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 13-18. East Fork Lewis coho habitat factor analysis diagram.

13.7 Integrated Watershed Assessment[1]

The East Fork Lewis River is composed of 34 subwatersheds within the East Fork proper, and two independent tributaries, Gee Creek and Allen Canyon Creek. Gee Creek discharges into the Columbia at the Lewis River confluence, whereas Allen Canyon Creek enters the lower Lewis between the East Fork/North Fork split and the Columbia. Lucia Falls marks a transition between high percentages of public ownership in the upper watershed—roughly 66%, with the headwater subwatersheds within the Gifford Pinchot National Forest—and dramatically lower rates of public ownership in the lower river totaling 5%.

13.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the EF Lewis River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 13-1. A reference map showing the location of each subwatershed in the basin is presented in Figure 13-19. Maps of the distribution of local and watershed level IWA results are displayed in Figure 13-20.

Table 13-2. IWA results for the EF Lewis River

Subwatershed[a]	**Local Process Conditions[b]**			**Watershed Level Process Conditions[c]**		**Upstream Subwatersheds[d]**
	Hydrology	**Sediment**	**Riparian**	**Hydrology**	**Sediment**	
50601	M	M	I	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501, 50616, 50605, 50604, 50615, 50614, 50613, 50604, 50603, 50612, 50611, 50608, 50602, 50609, 50607, 50606, 50610
50610	M	M	M	M	M	none
50606	M	M	M	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501, 50616, 50605, 50604, 50615, 50614, 50613, 50604, 50603, 50612, 50611, 50608, 50602, 50609, 50607
50607	M	M	M	M	M	none
50609	I	M	I	I	M	none

---

[1] Because of the complexity and size of the maps that illustrate these watersheds, the figure references in the Integrated Watershed Assessment section refer to maps in a separate file.

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
50602	M	M	M	I	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501, 50616, 50605, 50604, 50615, 50614, 50613, 50604, 50603, 50612, 50611, 50608, 50609, 50607
50608	I	M	I	I	M	none
50611	M	M	M	M	M	none
50612	I	F	M	I	M	50611
50603	I	M	I	I	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501, 50616, 50605, 50604, 50615, 50614, 50613, 50604, 50612, 50611
50613	I	M	M	I	M	none
50614	I	M	I	I	M	none
50615	I	M	M	I	M	none
50604	I	M	M	I	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501, 50616, 50605, 50615
50605	I	M	I	I	M	none
50616	I	M	M	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502, 50501
50501	I	M	M	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505, 50502
50505	I	M	I	I	M	None
50504	I	M	I	I	M	50506
50506	I	M	M	I	M	none
50401	M	F	M	F	F	50405, 50404, 50403, 50402
50402	F	F	M	M	F	50404
50403	I	F	M	I	F	none
50404	M	M	F	M	M	
50405	M	F	M	M	F	

Subwatershed[a]	**Local Process Conditions**[b]			**Watershed Level Process Conditions**[c]		**Upstream Subwatersheds**[d]
	Hydrology	**Sediment**	**Riparian**	**Hydrology**	**Sediment**	
50507	I	M	M	I	M	
50502	M	F	M	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505
	M	F	M	M	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509, 50503, 50502, 50507, 50405, 50404, 50403, 50402, 50401, 50506, 50504, 50505
50503	M	M	M	F	M	50101, 50203, 50201, 50202, 50302, 50301, 50508, 50509
50509	M	M	M	M	M	none
50508	I	M	M	I	M	none
50301	F	M	M	M	M	50302
50302	I	F	M	I	F	none
50202	F	F	F	F	F	none
50201	M	M	M	F	M	50203, 50101
50203	M	M	F	F	M	50101
50101	F	M	F	F	M	none

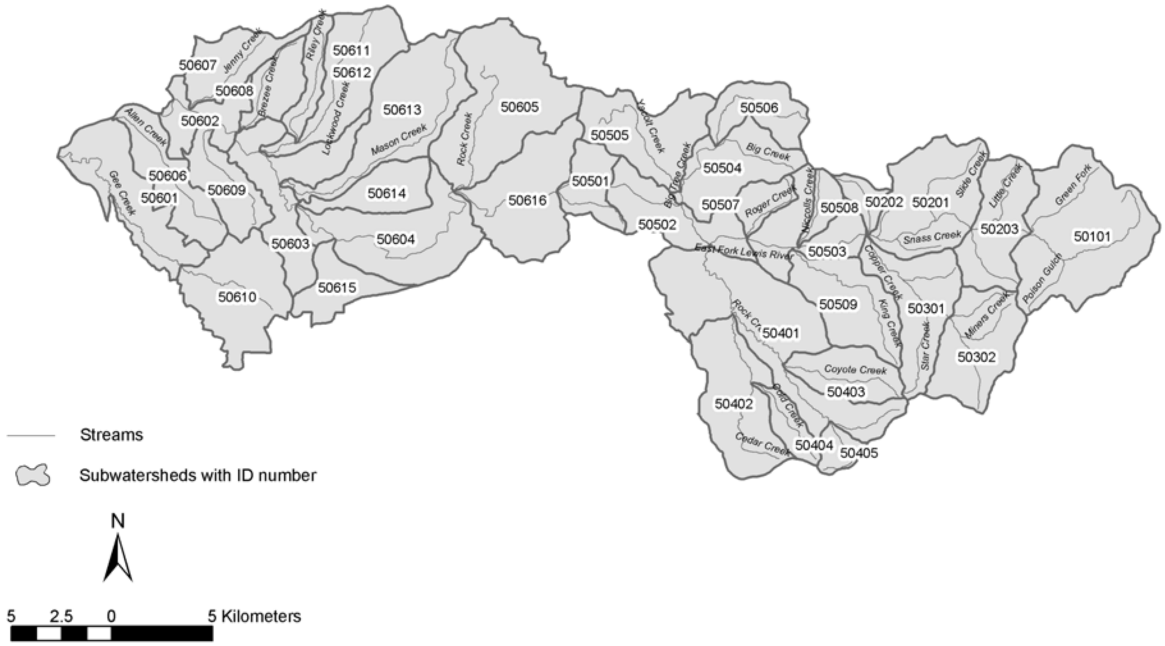


Figure 13-19. Map of the EF Lewis basin showing the location of the IWA subwatersheds

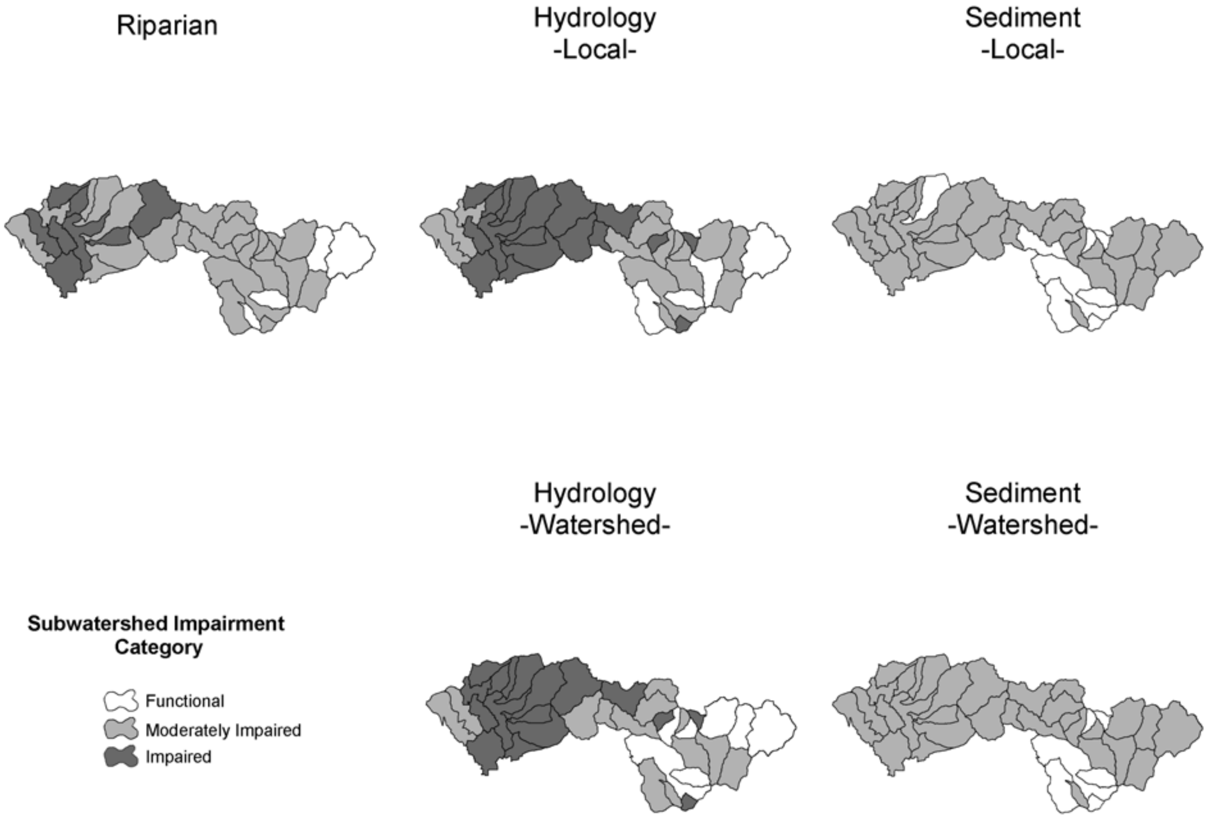


Figure 13-20. IWA subwatershed impairment ratings by category for the EF Lewis basin

13.7.1.1 Hydrology

There is a dramatic difference in hydrologic conditions between the upper and lower watershed. In the lower watershed, local hydrologic conditions are uniformly impaired, with the exception of the independent tributaries (Gee and Allen Canyon Creeks) as well as the mainstem subwatershed furthest downstream (50602).

Subwatersheds above Lucia Falls are for the most part rated moderately impaired at the local level, with the exception of three subwatersheds with more substantial impairment (50202 Anaconda Creek, 50507 Roger Creek, and 50505 Yacolt Creek), and four non-contiguous subwatersheds in the upper basin with functional conditions, including the headwaters of the mainstem (50101), Coyote Creek (50403, a tributary to upper Rock Creek), lower Copper Creek (50301), and Cedar Creek (50402, a tributary to Rock Creek).

Analysis of hydrologic conditions at the watershed scale produces a small number of changes in IWA ratings. For example, two upper mainstem subwatersheds (50201, 50203) earn a functional rating due to the influence of upstream functional conditions.

13.7.1.2 Sediment

Local sediment conditions fall primarily into the moderately impaired category, with no cases of impaired sediment condition and with nearly all functional subwatersheds occurring in the upper basin. Local sediment conditions are moderately impaired throughout the lower watershed, including the mainstem and tributaries Brezee Creek (50611), Lockwood Creek (50602) and Mason Creek (50613).

The change between natural and current erodability is similar for both the upper and lower portions of the basin, and therefore subwatersheds in these areas are rated similarly. However, on an absolute scale, erodability indices are much greater in the lower basin. This is an important distinction: while the IWA method rates sediment conditions as similarly degraded throughout the watershed due to the relative difference between natural and current conditions, the absolute levels remain very low throughout the upper watershed while the lower watershed is in the moderate to high category. Impaired conditions in the lower watershed are not surprising given the extremely low percentage of public ownership, mature forest cover of only 9%, very high road densities ranging from 4.8-7.7 mi/sq mi, and erodable soils.

Whereas rain-on-snow conditions are prevalent in most of the upper watershed, they are generally absent downstream of Lucia Falls. However, due to the stability of soils and much higher level of mature forest cover (57%), rain-on-snow events have less adverse impacts on upper subwatersheds. Road densities in the upper watershed range from 1.9-5.6 mi/sq mi, while stream crossing densities are moderately high.

Watershed level analysis results in few changes to local sediment condition ratings as all but one functional subwatershed are located in terminal areas (i.e., without effects from upstream subwatersheds).

13.7.1.3 Riparian

Riparian conditions are evenly divided in the lower watershed between impaired and moderately impaired categories. Riparian conditions in the upper watershed are for the most part moderately impaired, with localized areas of functional conditions in headwater areas. Riparian impairment in the upper basin is primarily the result of timber harvest and historical stand replacing fires. In the lower watershed, riparian impairment can be attributed to timber harvest, residential development, roadways, and agricultural uses.

13.7.2 Predicted Future Trends

13.7.2.1 Hydrology

In the lower portion of the basin, low levels of public ownership, low levels of mature forest cover, high road densities, and intense development pressure are likely to lead to downward trends in hydrologic conditions. More than 75% of areas zoned for development remain vacant, meaning this area may develop extensively over the next 20 years. As a result, impervious surfaces, road density, and stream crossing density will likely increase.

These trends will apply in low-elevation tributaries, which generally have low forest cover and increasing development. The tributaries to the East Fork—including Brezee, Lockwood, Mason and Mill Creeks, in addition to non-key subwatersheds—likely will become increasingly ‘flashy’, featuring higher, short-duration flows during the rainy season, while also suffering lower base flows during late summer months due to loss of riparian cover, increased watershed imperviousness, higher rates of surface water withdrawal, and depletion of groundwater resources due to withdrawal and reduced infiltration.

Mainstem subwatersheds in the lower East Fork may suffer similar consequences due to development pressure, but hydrologic effects will be substantially governed by conditions further upstream in the upper watershed. Hydrologic continuity has been substantially degraded by the loss of wetlands, gravel mining, and construction of levees. The East Fork avulsion through abandoned gravel pits in the lower river impacted spawning and rearing habitat.

Upper watershed hydrologic conditions are likely to maintain current conditions or gradually improve due to the high percentage of public ownership and low levels of anticipated development. Predicted improvements are based on improved forest management practices on both federal (GPNF) and state (WDNR) lands. Road and road-crossing removal as well as riparian restoration are likely to provide substantial hydrologic benefits.

13.7.2.2 Sediment Supply

As with hydrologic trends, the lower watershed is not likely to experience substantial improvements in sediment conditions in the next 20 years due to development pressures. Furthermore, natural erodability is moderately high (due to geologic conditions) and road densities are unlikely to decrease.

Even with moderate impairment, geology in the upper watershed naturally limits the extent of deleterious, episodic sediment erosion. Sediment processes are likely to improve based on a trend towards improved forest and road management on public lands. Natural regeneration of previously harvested and burned areas will also yield improved sediment supply conditions.

13.7.2.3 Riparian Condition

Upper watershed riparian conditions are represented by a patchwork of functional and moderately impaired subwatersheds. Currently, functional riparian areas are found in only four subwatersheds in the entire basin, all located in the upper reaches of the watershed on publicly owned lands. Forest management by WDNR and the USFS are expected to result in improved riparian conditions.

Moderately impaired to impaired riparian condition ratings are most prevalent along the lower mainstem and tributaries. Historical riparian forests within the mainstem floodplain have been almost entirely removed, limiting LWD recruitment while also reducing channel roughness and stability, which results in higher rates of bank erosion during high flows. Absent restorative measures, episodic levee avulsion and bank erosion events may accelerate in the future. In the lower mainstem and tributary subwatersheds, currently degraded conditions are expected to persist due to existing road densities, channelization, and current land uses.

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Volume II, Chapter 14
Columbia Lower Tributaries Subbasin

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14.0 Columbia Lower Tributaries Subbasin

14.1 Subbasin Description

14.1.1 Topography & Geology

The Columbia Lower Tributaries subbasin contains the stream systems that drain into the Columbia River between the Lewis River and Bonneville Dam, not including the Washougal River watershed, which is considered a separate subbasin. The entire subbasin extends from Columbia River RM 87.5 to RM 142.3 and encompasses approximately 270 mi^2. The subbasin lies within Clark and Skamania Counties and can be divided into two general areas: 1) basins between the Lewis River and the Washougal River (Lake River basin), and 2) basins between the Washougal River and Bonneville Dam (Bonneville Tributaries basin). The Lake River basin lies within the highly urbanized Vancouver, Washington, metropolitan area, and therefore receives tremendous anthropogenic pressures. The Bonneville Tributaries basin consists mostly of small basins draining the steep valley walls of the Columbia River Gorge.

Surface geology in the basin is primarily sedimentary, with volcanic material in headwater areas. Much of the subbasin is underlain by alluvium from catastrophic flooding of the Columbia River during Pleistocene Ice Ages and from more recent floodplain deposits.

14.1.1.1 Lake River

Headwaters of the Lake River basin begin in the low foothills of the southwestern Washington Cascades in Clark County. Lake River drains north from 2,600-acre Vancouver Lake. Major tributaries entering Lake River are Salmon Creek, Whipple Creek, and Flume Creek. Burnt Bridge Creek flows into Vancouver Lake and its watershed is located in the heart of the city of Vancouver. Salmon Creek is the largest tributary to the Lake River basin, with a drainage area of 91 mi^2. Basin elevation ranges from near sea level at the mouth to 1,998 feet in the headwaters of the Salmon Creek basin. Most streams in the basin are low gradient, meandering systems, located within Clark County's flat alluvial plain. Vancouver Lake and Lake River itself are within the historical Columbia River floodplain and are tidally-influenced.

14.1.1.2 Bonneville Tributaries

Streams in the Bonneville Tributaries basin originate on the steep valley walls of the Columbia River Gorge and flow south through Columbia River floodplain terraces before entering the Columbia River. Most of the stream lengths are high gradient and spawning habitat is only available in the lowest reaches. The major streams (from west to east) are Gibbons, Lawton, Duncan, Woodward, Hardy, and Hamilton Creeks. Hamilton Creek has the largest channel length at over 8 miles. Anthropogenic disturbances to these systems are largely related to the transportation corridors that parallel the Columbia River.

14.1.2 Climate

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation ranges from 40 inches at Vancouver to 85 inches at the Skamania Fish Hatchery in the Columbia Gorge. Average annual minimum temperature at Vancouver is 43°F (6°C) and the average annual maximum is 63°F (17°C). The minimum and maximum values at the Skamania Hatchery are 38°F (3°C) and 62°F (17°C), respectively. Winter temperatures seldom fall below freezing, with very little snowfall (WRCC 2003).

14.1.3 Land Use/Land Cover

14.1.3.1 Lake River

Land use in the Lake River basin is predominately urban and rural development, with nearly the entire Burnt Bridge Creek watershed lying within the Vancouver metropolitan area. Historical wetlands and floodplains have been converted to residential, commercial, industrial, and agricultural uses. The upper reaches of the Salmon Creek basin have been impacted by silvacultural activities and rural residential development. Major urban centers in the basin are Vancouver, Orchards, Salmon Creek, Battle Ground, and Ridgefield. The year 2000 population, estimated at 252,000 persons is expected to increase by 267,500 by year 2020 (LCFRB 2001). A breakdown of land ownership and land cover in the Lake River basin is presented in Figure 14-1 and Figure 14-2.Figure 14-3 displays the pattern of landownership for the basin. Figure 14-4 displays the pattern of land cover / land-use.

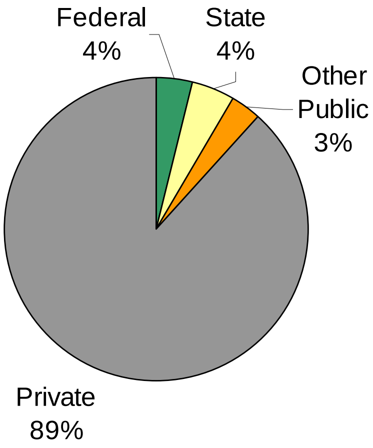


Figure 14-1. Lake River basin land ownership

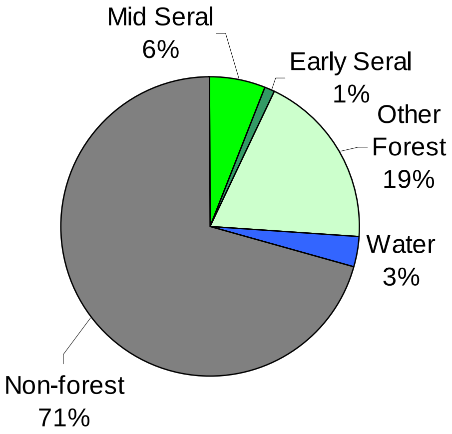


Figure 14-2. Lake River basin land cover

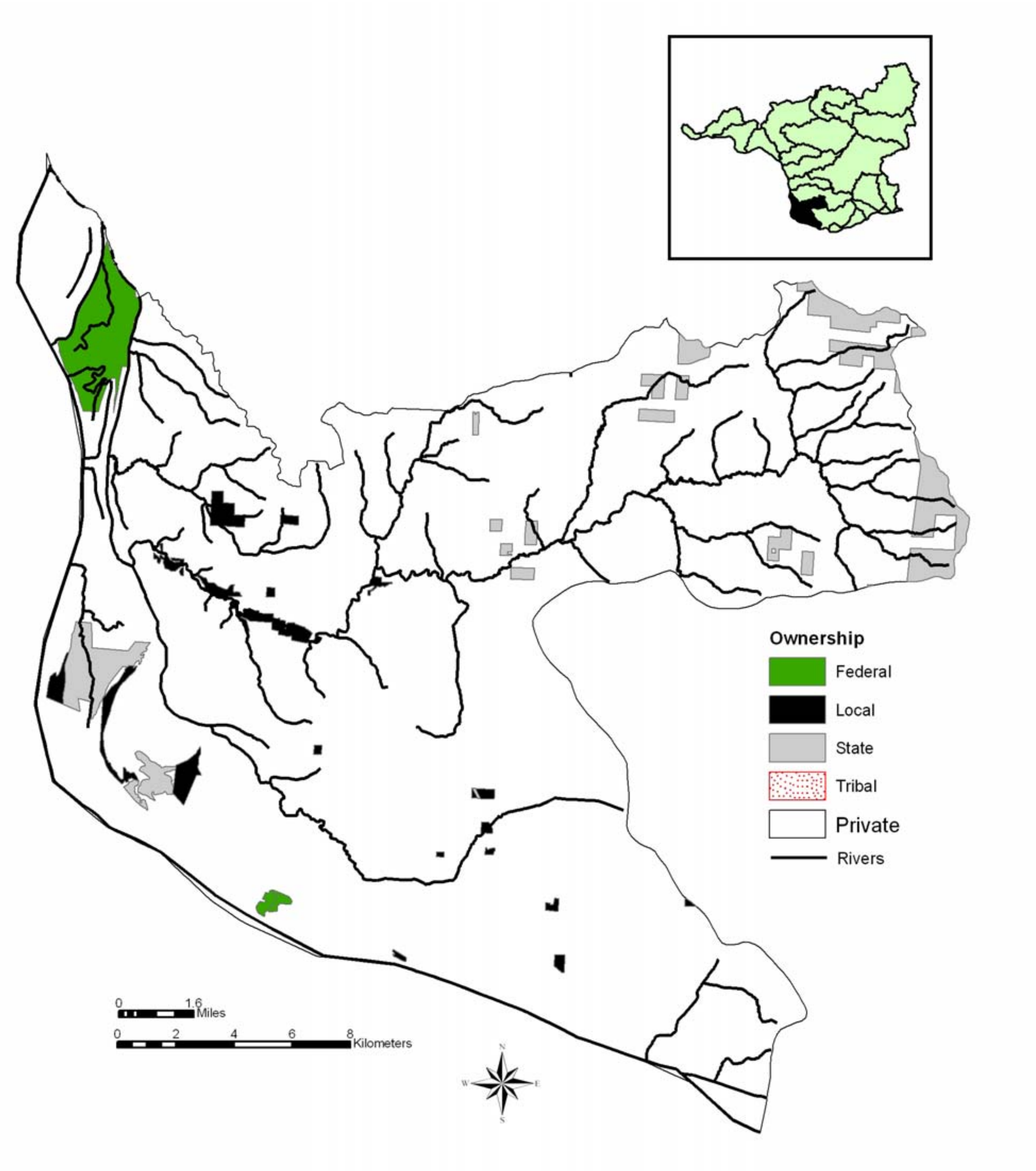


Figure 14-3. Landownership within the Lake River basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

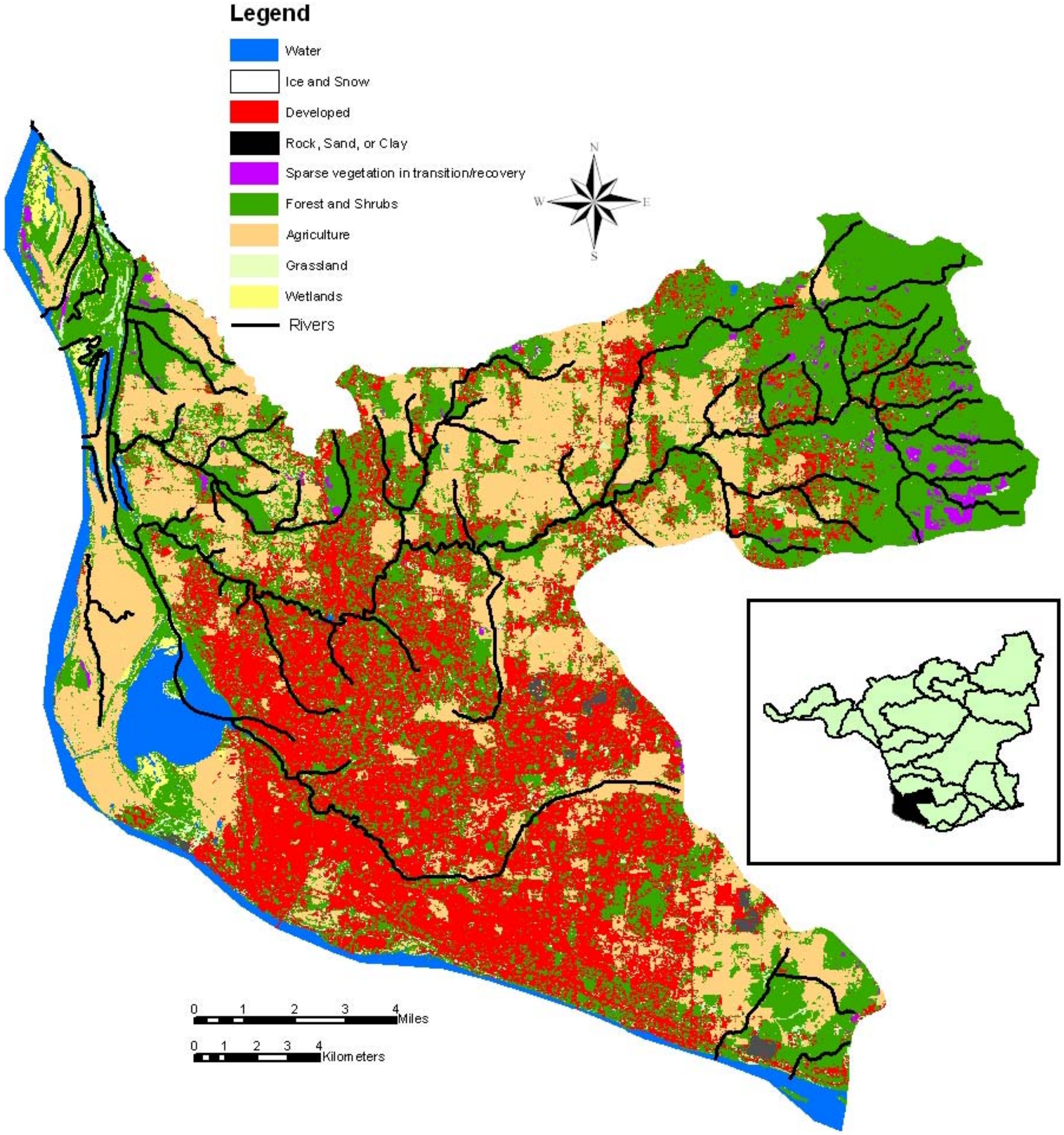


Figure 14-4. Land cover within the Lake River basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

14.1.3.2 Bonneville Tributaries

The Bonneville Tributary watersheds are mostly forested, with a higher degree of residential and agricultural development in the western portion, especially near the town of Washougal. The eastern portion of the basin lies within the Columbia River Gorge National Scenic Area, where land use and development is limited; however, rural residential and industrial uses are located along the Columbia on the lower reaches of some streams. The only population center in the eastern portion of the basin is the town of North Bonneville, situated on the Columbia River just west of Bonneville Dam. The year 2000 population is estimated at approximately 7,000 persons, and is expected to increase to 10,500 by 2020. Bonneville Tributaries land ownership and land cover are illustrated by Figure 14-5 and Figure 14-6.

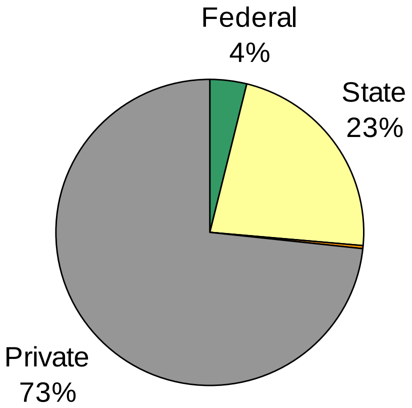


Figure 14-5. Bonneville Tributaries basin land ownership

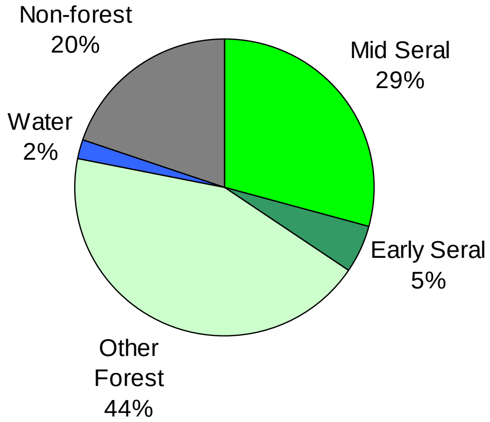


Figure 14-6. Bonneville Tributaries basin land cover

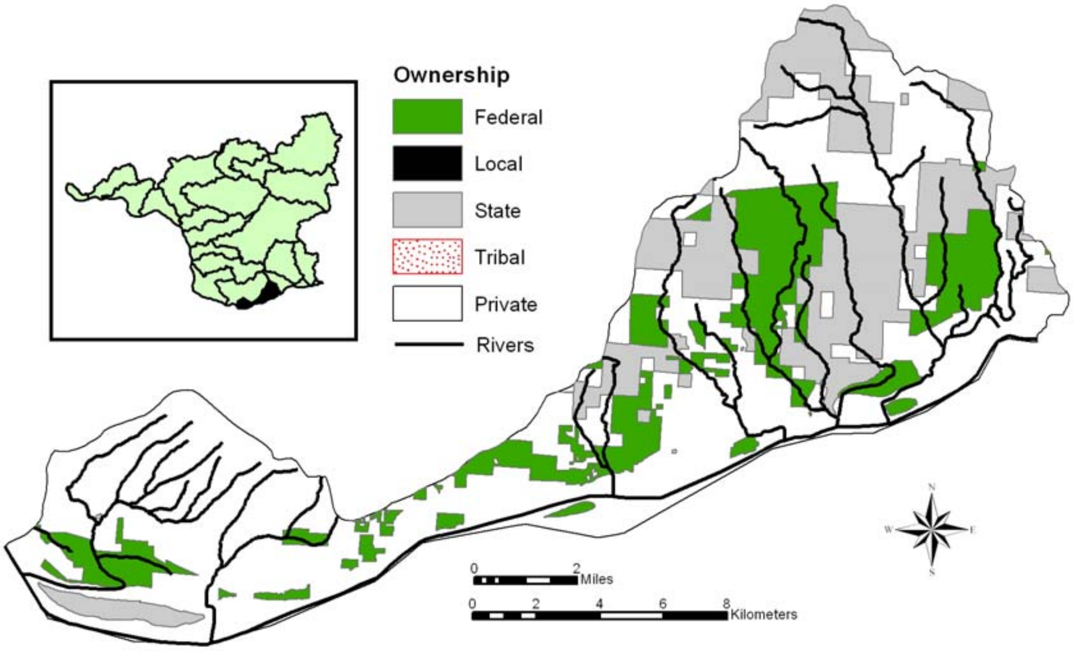


Figure 14-7. Landownership within the Bonneville tributaries basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

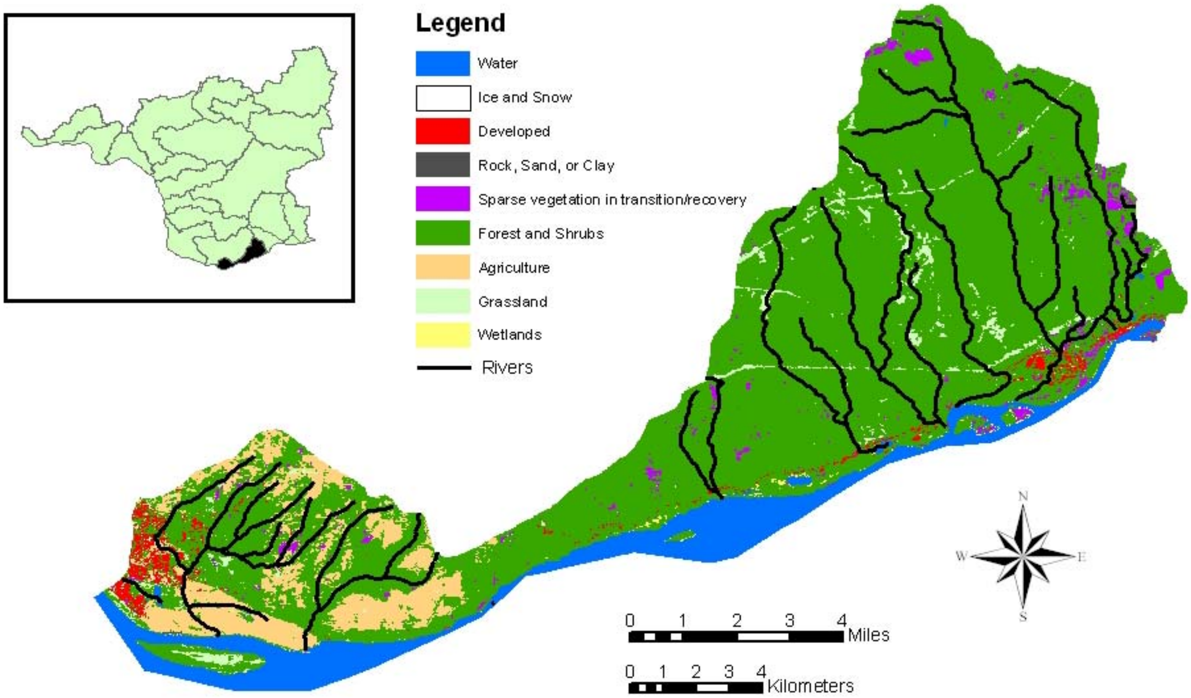
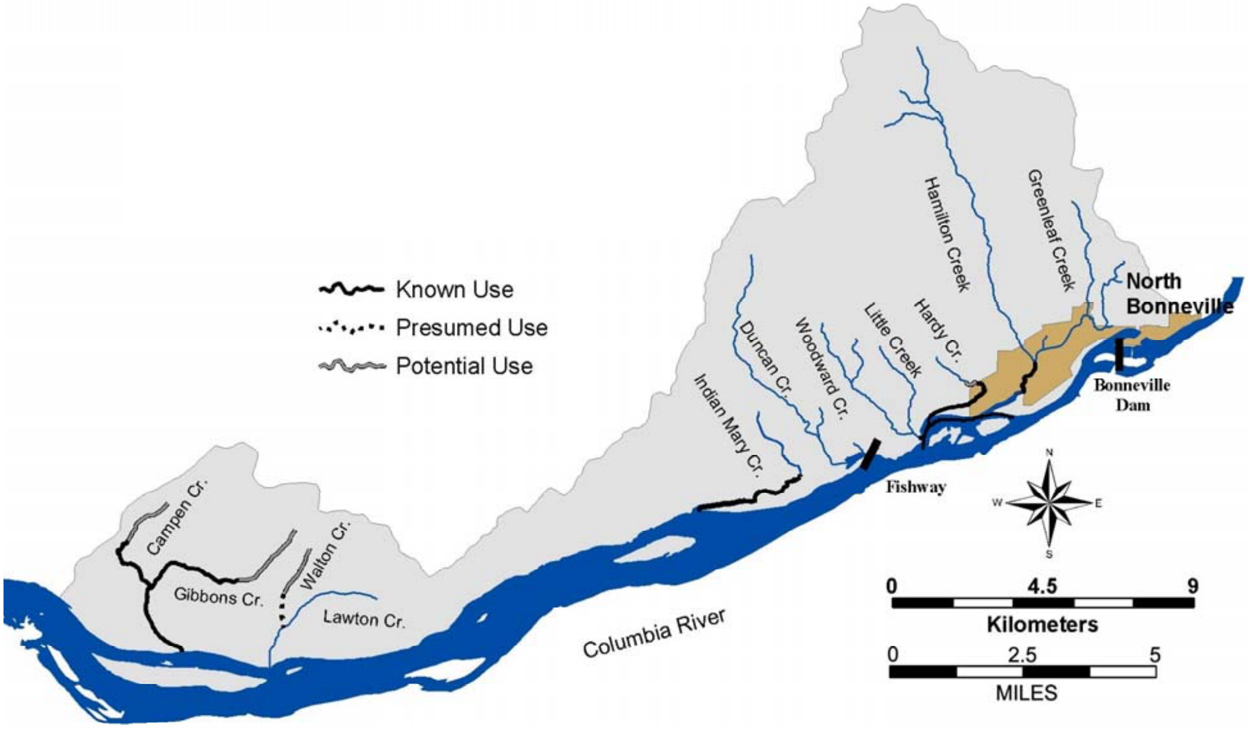


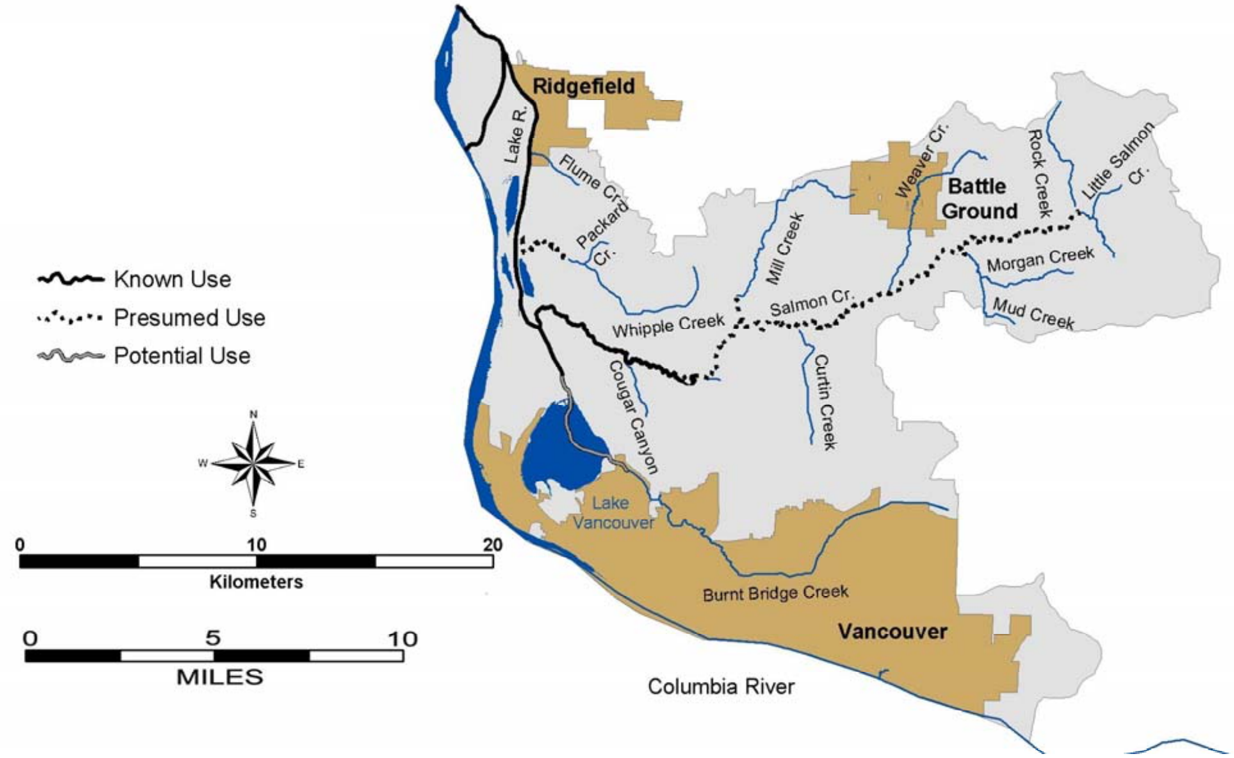
Figure 14-8. Land cover within the Bonneville tributaries basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

14.2 Focal Fish Species

14.2.1 Upriver Bright Fall Chinook—Lower Columbia Tributaries Subbasin

ESA: Threatened 1999 **SASSI: Unknown 2002**





Distribution

- Historical distribution of fall chinook in Salmon Creek was documented in 1951 as the lower 5 miles of creek
- Fall chinook have recently been observed in the mainstem Columbia River from the upper end of Pierce Island to the lower end of Ives Island, along the Washington shore in Hamilton Slough, between the mouths of Duncan and Hardy Creeks, and in the lower reaches of Hardy and Hamilton Creeks; available spawning habitat depends on the spill regime at Bonneville Dam

Life History

- Fall chinook upstream migration in the Columbia River begins in early August or September, depending on early rainfall
- Spawning in the mainstem Columbia River and Bonneville tributaries occurs from mid-October to late November
- Age ranges from 2 year-old jacks to 6 year-old adults, with dominant adult ages of 3 and 4
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings

Diversity

- Early spawning components are considered part of the tule population in the lower Columbia River Evolutionary Significant Unit (ESU)
- Bonneville upriver bright fall chinook stock spawning was discovered in 1994 in the mainstem Columbia immediately below Bonneville Dam; stock origin remains unknown; stock was designated based on distinct spawning distribution
- Allozyme analysis indicate that late bright fall chinook, spawning in the mainstem Columbia below Bonneville Dam, are genetically distinct from other Columbia River bright fall chinook stocks although they resemble Yakima bright fall chinook and upriver bright fall chinook maintained at the Little White Salmon National Fish Hatchery and Bonneville Hatchery

Abundance

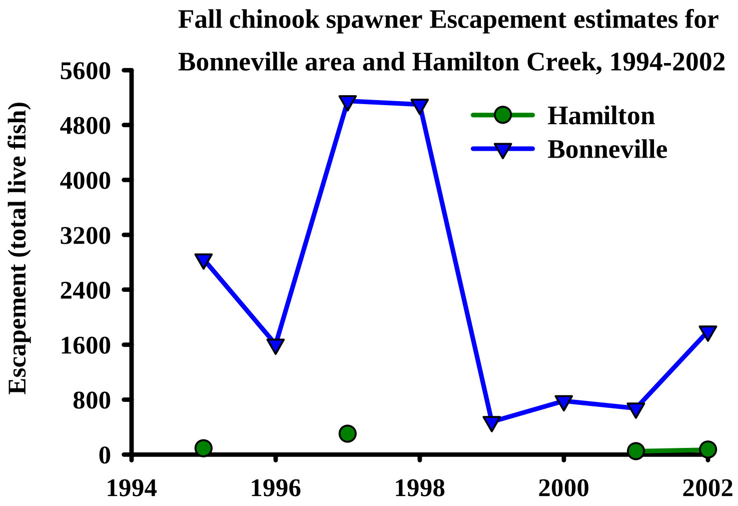
- Escapement surveys in 1936 reported 19 fall chinook spawning in Salmon Creek
- In 1951, fall chinook escapement to Salmon Creek was estimated at 100 fish
- Hamilton Creek spawning escapements from 1995-2001 ranged from 47-300 (average 144)
- Bonneville area spawning escapements from 1994-2001 ranged from 477-5,151 (average 2,143)

Productivity & Persistence

- Productivity data is limited for Bonneville area fall chinook
- Seining operations conducted by the WDFW and ODFW have shown consistent juvenile production from late spawning adults in the mainstem Columbia River below Bonneville Dam

Hatchery

- The Spring Creek National Fish Hatchery near the White Salmon River released, 50,160 fall chinook into Hamilton Creek in 1977

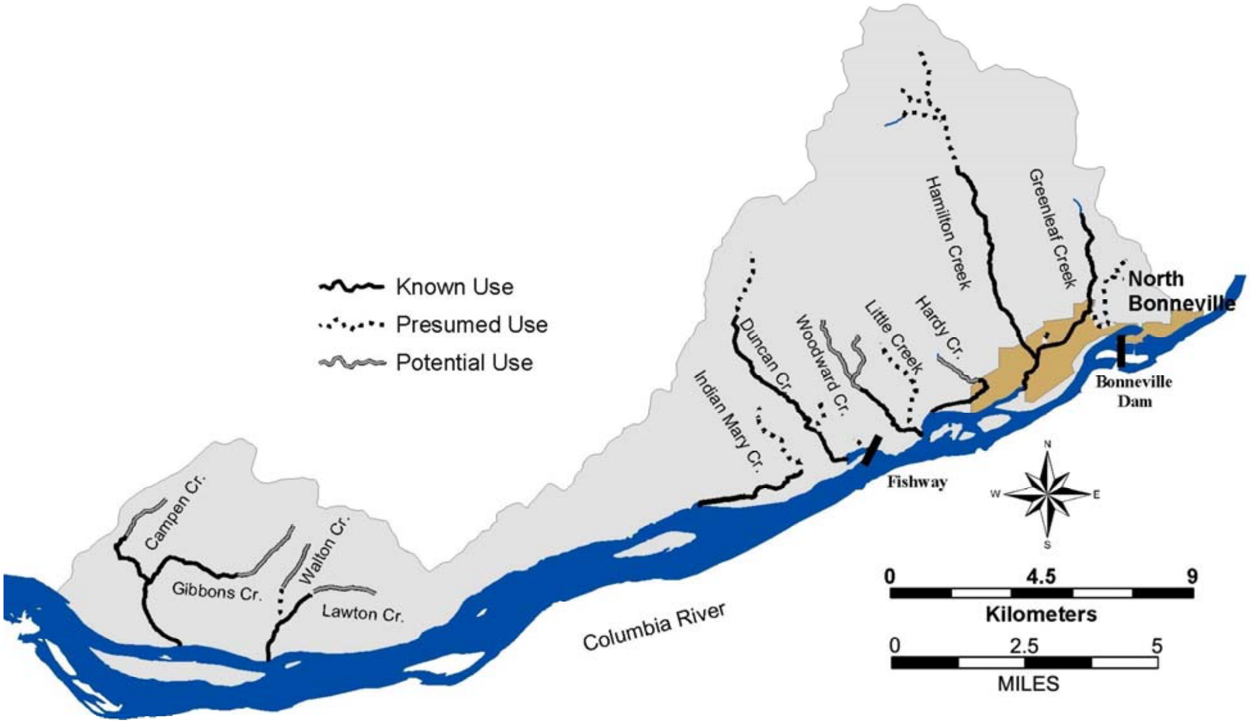


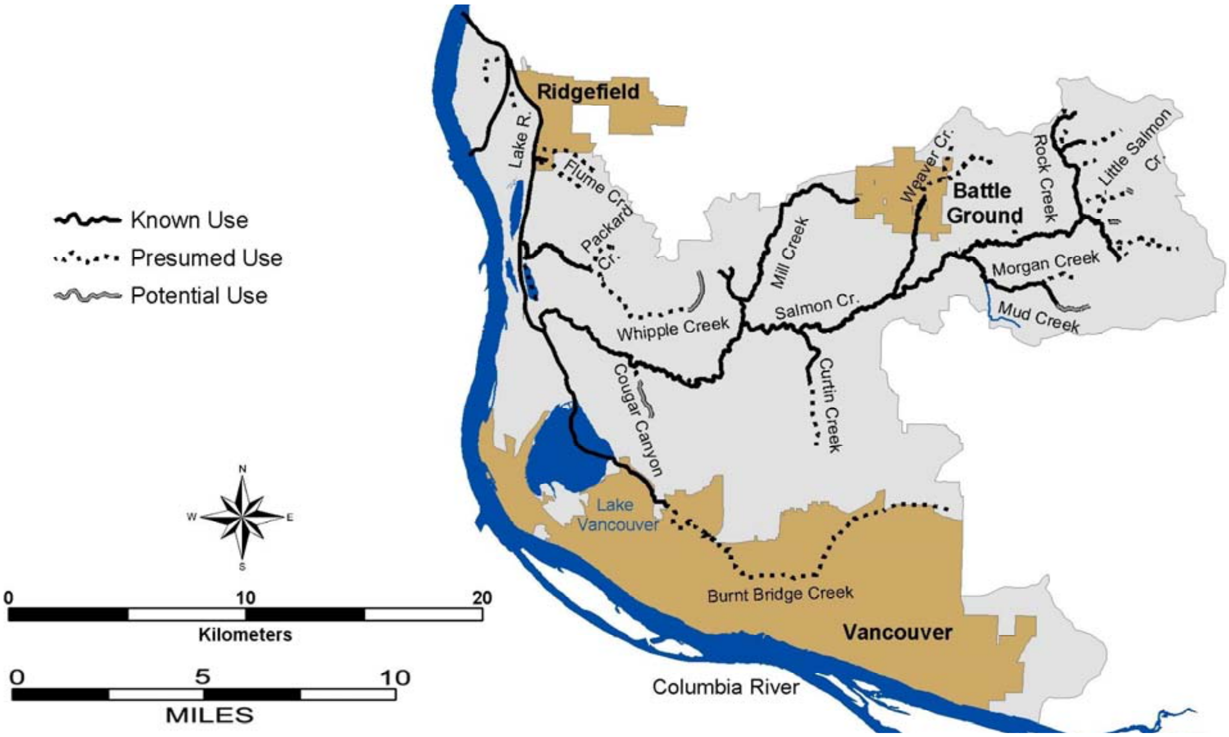
Harvest

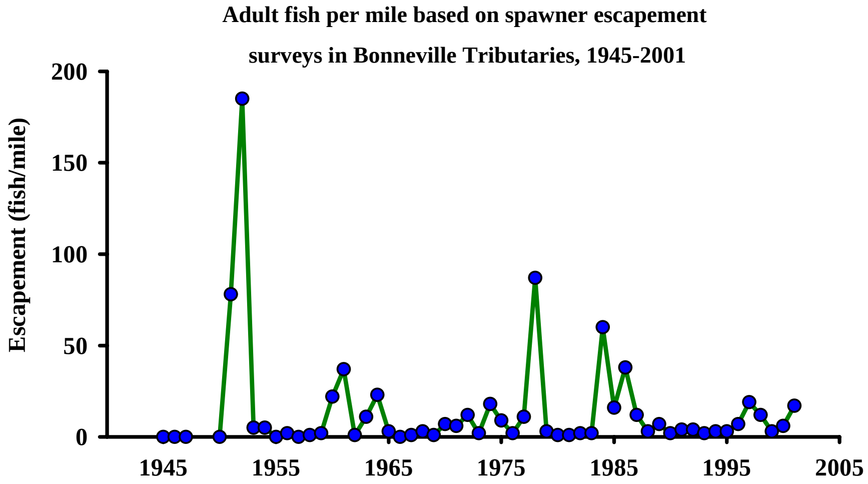
- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska and Columbia River commercial gill net and sport fisheries
- No specific CWT data is available for these populations, however migration patterns and harvest of the bright chinook populations is likely similar to upriver bright (URB) fall chinook and the tule populations similar to lower Columbia hatchery tule chinook
- Columbia River URB chinook harvest is limited to 31.29% based on Endangered Species Act (ESA) limits on Snake River wild fall chinook; however, lower river URB chinook are harvested at a lower rate as they do not pass through the Treaty Indian fishery
- Combined ocean and Columbia River tule fall chinook harvest is currently limited to 49% as a result of ESA limits on Coweeman tule fall chinook
- A popular sport fishery has developed in the mainstem Columbia in late September and early October, targeting on the late spawning bright chinook

14.2.2 Coho—Lower Columbia Subbasin

ESA: Candidate 1995 **SASSI: Bonneville Tributaries—Depressed 2002; Salmon Creek—Unknown 2002**







Distribution

- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Salmon Creek flows through Clark County (downstream of the Washougal River and upstream of the Lewis River) and has been largely impacted by urban development, but coho production potential exists in upper Salmon Creek and tributaries: Morgan, Rock, Mill, and Weaver Creeks
- Other creeks near the Salmon Creek watershed with coho production potential include Burnt Bridge and Whipple Creeks
- Hamilton, Hardy, Woodward, and Duncan Creeks are small Columbia River tributaries located just downstream of Bonneville Dam; Greenleaf Creek is a tributary of Hamilton Creek
- Gibbons, Lawton, and St. Cloud Creeks are located upstream of the Washougal River

Life History

- Adults enter the Columbia River from mid-September through mid-December
- Peak spawning occurs in December to early January for late stock coho
- Peak spawning occurs in late October to mid November for early stock
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Native population in the Bonneville tributaries (Duncan, Hardy, and Hamilton Creeks) were late stock coho (or type N)
- Both late and early stock (or Type S) coho are believed to be historically produced in Salmon Creek
- Other tributaries with historical coho production include: Gibbons Creek, Lawton Creek, St. Cloud Creek, Woodward Creek, and Greenleaf Creek (a tributary of Hamilton Creek)
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance

- Wild coho runs in these Bonneville area small tributaries are believed to be a fraction of historical size
- WDFW (1951) estimated a coho escapement of 2,050 for Salmon Creek and these small tributaries between the Washougal River and Bonneville Dam combined
- Escapement surveys from 1945-2001 on Duncan, Hardy, Hamilton, and Greenleaf Creeks documented a range of 0-185 fish/mile

Productivity & Persistence

- Natural coho spawning is presumed to be very low
- Salmon Creek habitat enhancement efforts have improved recent year production potential
- Chum recovery efforts in Duncan, Hardy, and Hamilton creeks should improve coho production potential

Hatchery

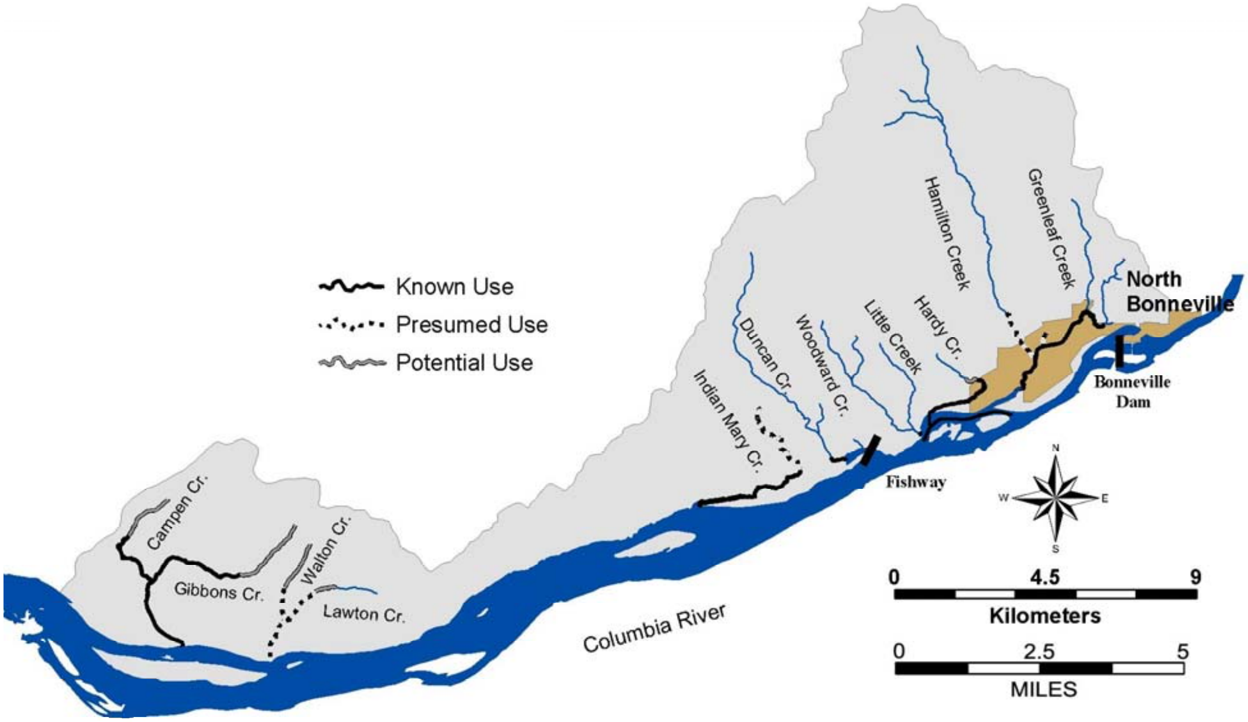
- There are no hatcheries on any of these tributaries
- Washougal Hatchery late coho were planted in Duncan and Greenleaf Creeks in 1983

Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Naturally-produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon listed Clackamas and Sandy coho
- During 1999-2002, harvest rates on ESA listed coho were less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained in September by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during peak abundance of late hatchery coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- There is no sport harvest in these tributaries
- Harvest of coho produced in these lower Columbia tributaries is assumed to be similar to Oregon’s Clackamas and Sandy coho, which were harvested at less then 15% during 1999-2002
- There are no adipose fin-clipped hatchery fish released in these tributaries

14.2.3 Chum—Lower Columbia Tributaries Subbasin (Bonneville Chum)

ESA: Threatened 1999 **SASSI: 2002**



Distribution

- Spawning occurs in the lower 1.0 miles of Hardy Creek and Hamilton Creeks, Hamilton Slough, Duncan Creek, in mainstem Columbia River side channels with springs near the I-205 bridge, and in the mainstem Columbia at Ives and Pierce Islands.

Life History

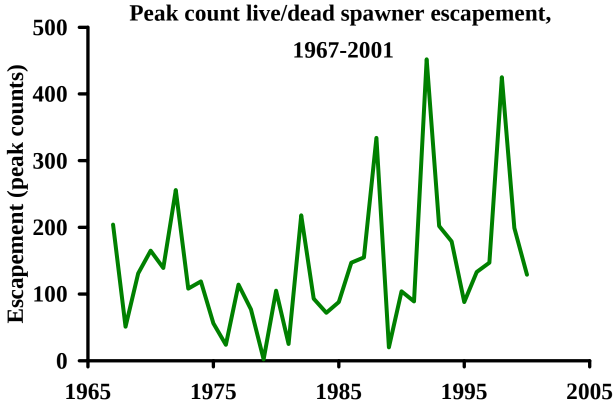
- Adults enter the lower Columbia tributaries from mid-October through November
- Peak spawning occurs in mid-December, but continues into January
- Dominant adult ages are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

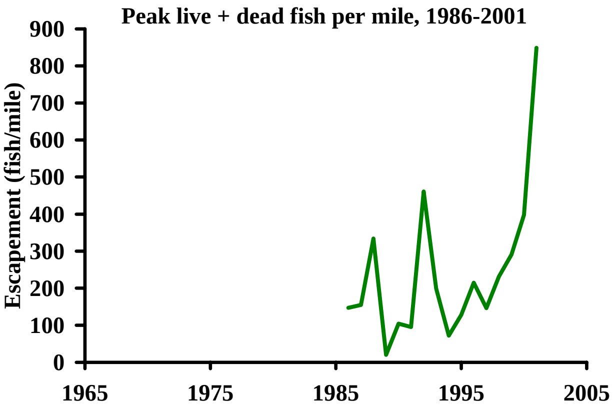
Diversity

- One of two genetically distinct populations in the Columbia River ESU
- Stock designated based on spawning distribution and genetic composition; allozyme and DNA analyses indicate that chum from Hardy Creek, Hamilton Creek, and the mainstem Columbia below Bonneville Dam are one stock (Bonneville chum) and distinct from other Washington Chum stocks

Abundance

- Adult fish/mile ranges from 20-849 for Bonneville chum from 1986-2001 as estimated from peak live/dead escapement ground spawner surveys.


Peak count live/dead spawner escapement, 1967-2001


Peak live + dead fish per mile, 1986-2001

Productivity & Persistence

- NMFS Status Assessment indicated a 0.0 risk of 90% decline in 25 years and a 0.01 risk of 90% decline in 50 years for Hardy Creek and a 0.4 risk of 90% decline in 25 years and a 0.86 risk of 90% decline in 50 years for Hamilton Creek; the risk of extinction was not applicable
- Hardy and Hamilton Creeks population forms one of the most productive populations remaining in the Columbia basin
- A chum habitat restoration and enhancement program is currently underway in Duncan Creek

Hatchery

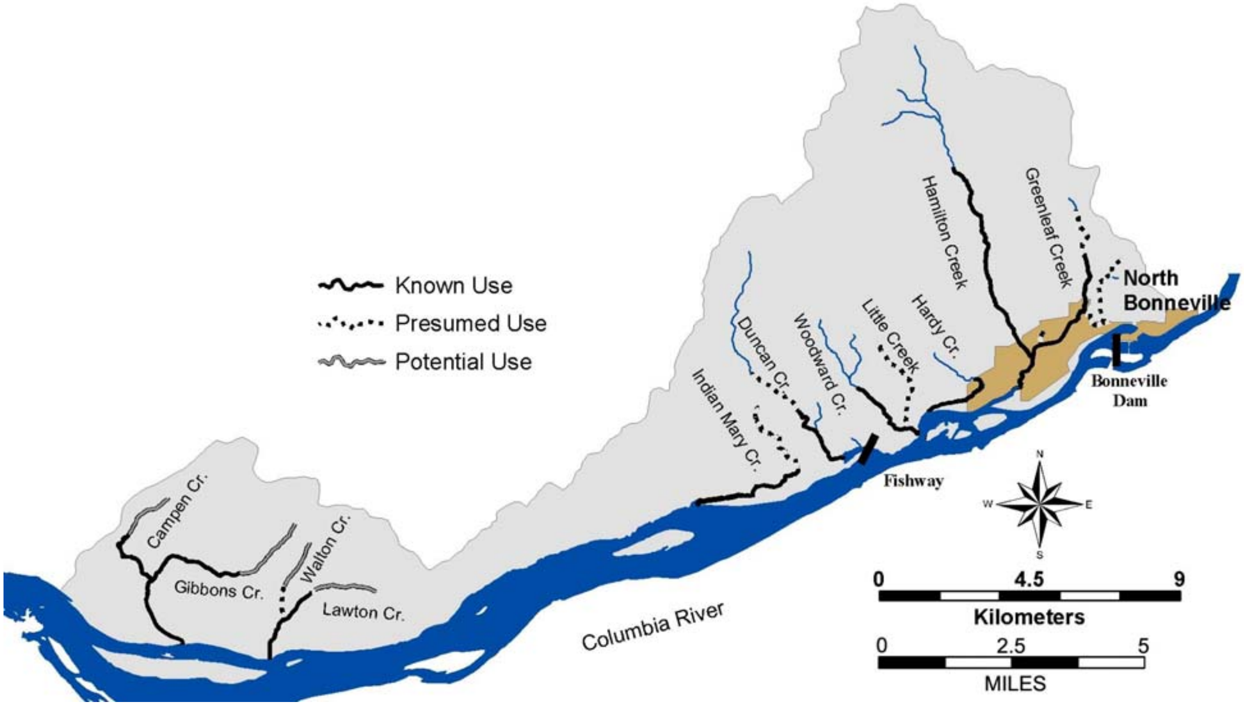
- Hatchery releases have not occurred on Hardy or Hamilton Creeks; USFWS maintains and artificial spawning channel in Hardy Creek to increase chum spawning habitat
- Washougal Hatchery is currently rearing Hardy Creek stock chum to enhance returns to Duncan Creek

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

14.2.4 Winter Steelhead—Lower Columbia Tributaries Subbasin (Hamilton)

ESA: Threatened 1998 **SASSI: Unknown 2002**



Distribution

- Winter steelhead are distributed throughout the lower reaches of Hamilton Creek (~2 mi)

Life History

- Adult migration timing for Hamilton Creek winter steelhead is from December through April
- Spawning timing on Hamilton Creek is generally from early March to early June
- Age composition data for Hamilton Creek winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

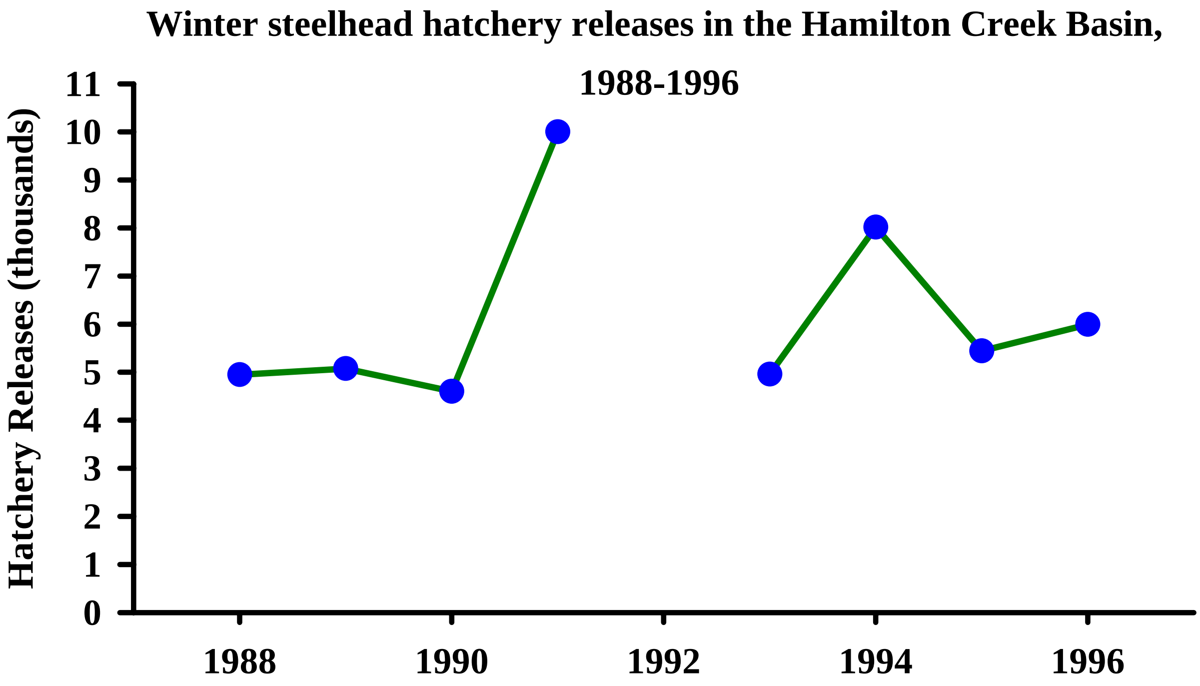
- Hamilton Creek winter steelhead stock is designated based on distinct spawning distribution
- Wild stock interbreeding with Skamania and Beaver Creek Hatchery brood stock is a potential concern

Abundance

- In 1936, steelhead were reported in Hamilton Creek during escapement surveys
- Wild winter steelhead escapement estimates for Hamilton Creek are not available

Productivity & Persistence

- Winter steelhead natural production is expected to be low



Hatchery

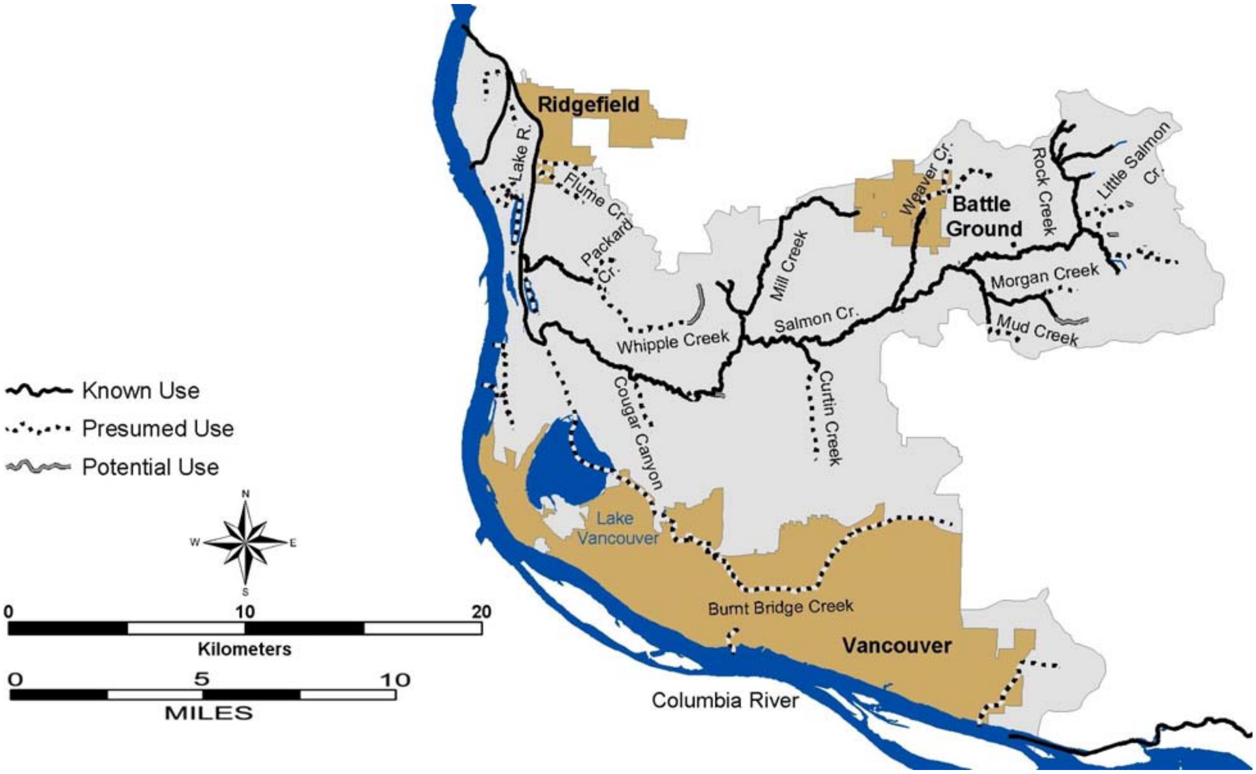
- There are no hatcheries on Hamilton Creek; hatchery winter steelhead from the Skamania (Washougal) and Beaver Creek (Elochoman) Hatcheries have been planted in the basin since 1958; release data are displayed from 1988-1991
- Hatchery fish contribute little to natural winter steelhead production in the Hamilton Creek basin

Harvest

- No directed commercial or tribal fisheries target Hamilton Creek winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Hamilton Creek basin
- Winter steelhead sport harvest (hatchery and wild) in Hamilton Creek from 1977-1986 averaged 21 fish; since 1992, regulations limit harvest to hatchery fish only
- ESA practice limits fishery impact on Hamilton Creek wild winter steelhead in the mainstem Columbia River and in Hamilton Creek

14.2.5 Winter Steelhead—Lower Columbia Tributaries Subbasin (Salmon)

ESA: Threatened 1998 **SASSI: Unknown 2002**



Distribution

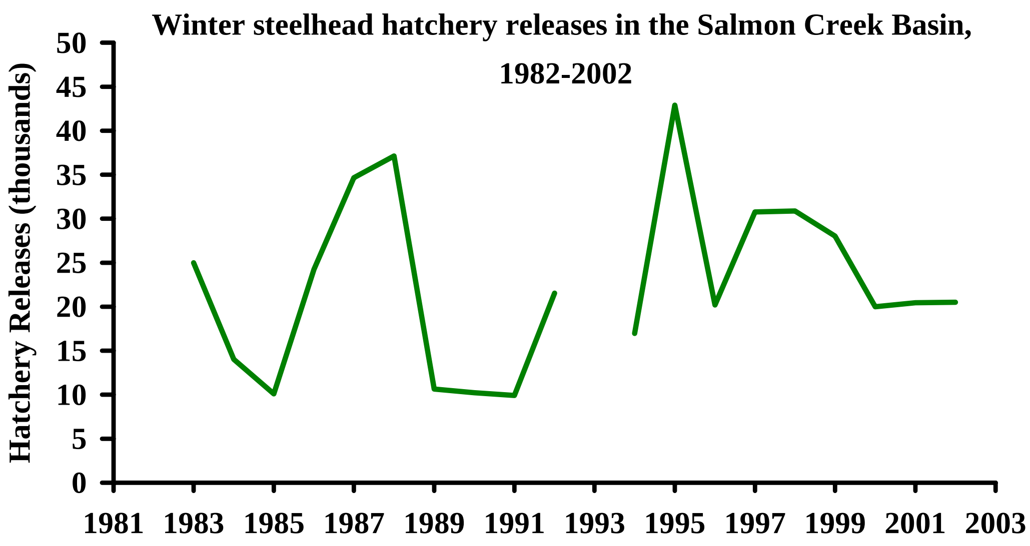
- Winter steelhead are distributed throughout Salmon Creek, the lower reaches of Gee, Whipple, and Burnt Bridge Creek, and portions of the Lake River

Life History

- Adult migration timing for Salmon Creek winter steelhead is from December through April
- Spawning timing on Salmon Creek is generally from early March to early June; limited escapement surveys suggest spawn timing may be early than most lower Columbia winter steelhead
- Age composition data for Salmon Creek winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Salmon Creek winter steelhead stock is designated based on distinct spawning distribution
- Wild stock interbreeding with Elochoman, Chambers Creek, Cowlitz, and Skamania hatchery brood stock may have occured



Abundance

- In 1936, steelhead were reported in Salmon Creek during escapement surveys
- In 1989, wild winter steelhead spawner surveys on Salmon Creek estimated 80 adult spawners
- Salmon Creek has a winter steelhead escapement goal of 400 wild adults

Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

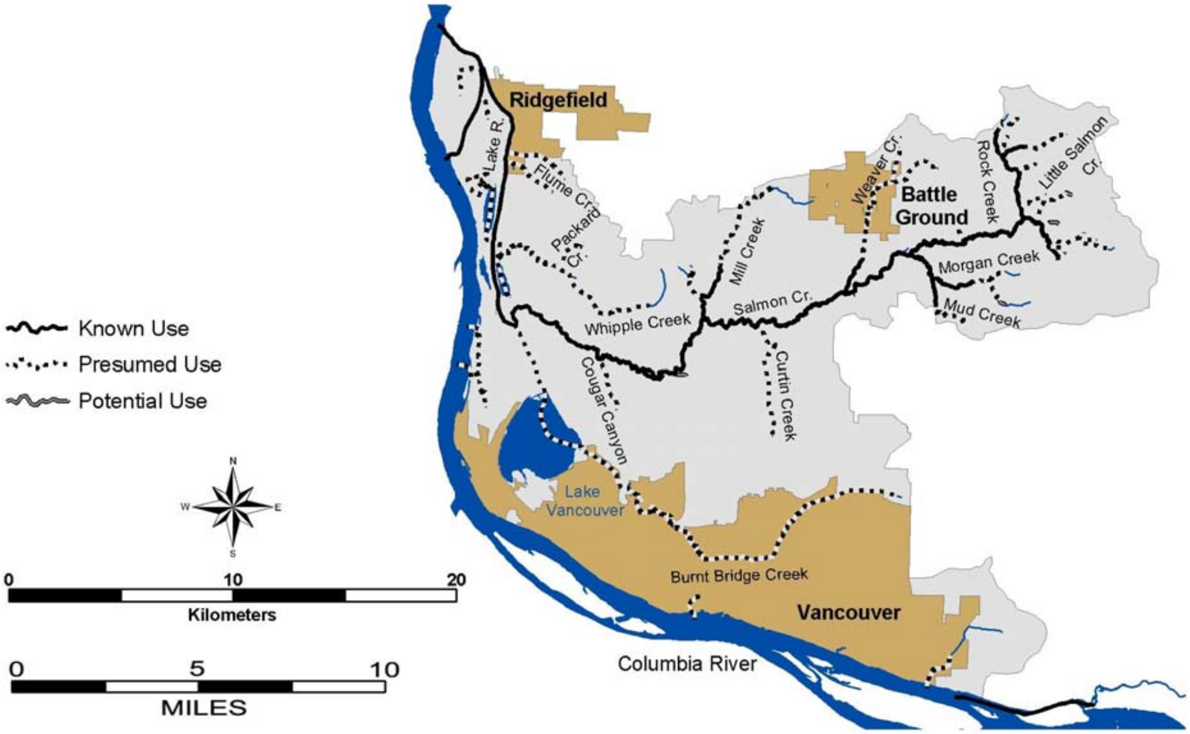
- There are no hatcheries on Salmon Creek; hatchery winter steelhead have been planted in the basin since 1957; release data are displayed from 1982-1992, and 1994-2002
- Hatchery fish contribute little to natural winter steelhead production in the Salmon Creek basin

Harvest

- No directed commercial or tribal fisheries target Salmon Creek winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Salmon Creek basin
- Winter steelhead sport harvest (hatchery and wild) in Salmon Creek from 1977-1986 averaged 89 fish; since 1992, regulations limit harvest to hatchery fish only
- ESA practice limits fishery impact on wild winter steelhead to 2 % per year

14.2.6 Cutthroat Trout—Columbia Lower Tributaries Subbasin (Salmon Creek)

ESA: Not Listed **SASSI: Unknown**



Distribution

- Anadromous forms have access to the entire subbasin
- Resident forms are documented throughout the system

Life History

- Anadromous and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Resident spawn timing is from February through June

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown

Abundance

- Insufficient quantitative data are available to identify wild cutthroat abundance or survival trends

Hatchery

- Hatchery origin anadromous cutthroat were released into Salmon Creek since at least 1952
- Presently 15,000 winter steelhead smolts, and about 145,000 coho fry are released into the subbasin annually

- The hatchery cutthroat release program was discontinued in 1999

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin-clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Salmon Creek
- Wild Salmon Creek cutthroat (unmarked fish) must be released in the mainstem Columbia and Salmon Creek sport fisheries.

14.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

14.3.1 Salmon Subbasin

- Loss of tributary habitat quality and quantity is an important impact for all species. Loss of estuary habitat quality and quantity is also important to chum. Harvest has a large relative impact on fall chinook and moderate impacts on coho and winter and summer steelhead. Harvest effects on chum are minimal.
- Harvest is a significant issue for coho, but not so for both chum and winter steelhead.
- Hatchery impacts are moderate for winter steelhead and coho, but are non-existent for chum.
- Predation is moderately important to all three species.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

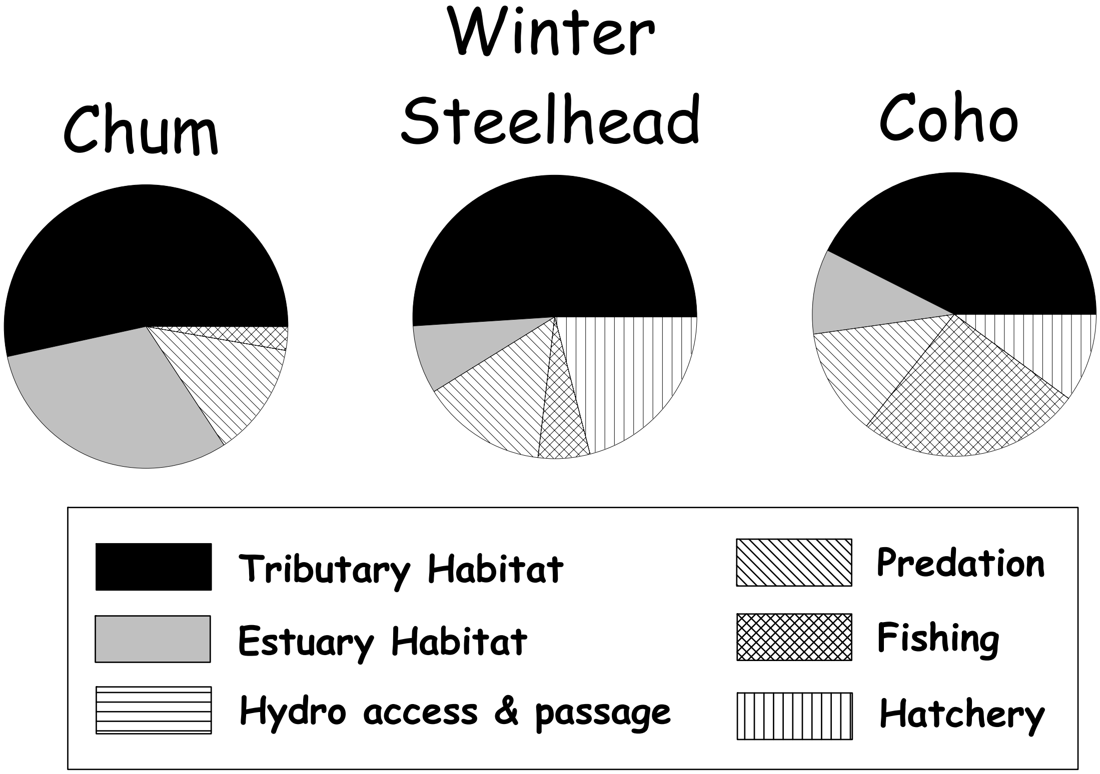


Figure 14-9. Relative index of potentially manageable mortality factors for each species in the Salmon Creek / Lake River subbasin.

14.3.2 Lower Gorge Subbasin

- Loss of tributary habitat quality and quantity is an important impact for all species. Loss of estuary habitat quality and quantity is most important to chum of the four species.
- Harvest has moderate impacts on coho and winter steelhead, but is relatively low for chum and fall chinook.
- Hatchery impacts are substantial for coho but are minimal for winter steelhead, chum, and fall chinook.
- Predation impacts are moderate for winter steelhead, but are less important for the other three species.
- Hydrosystem access and passage impacts appear to be relatively important for chum and fall chinook.

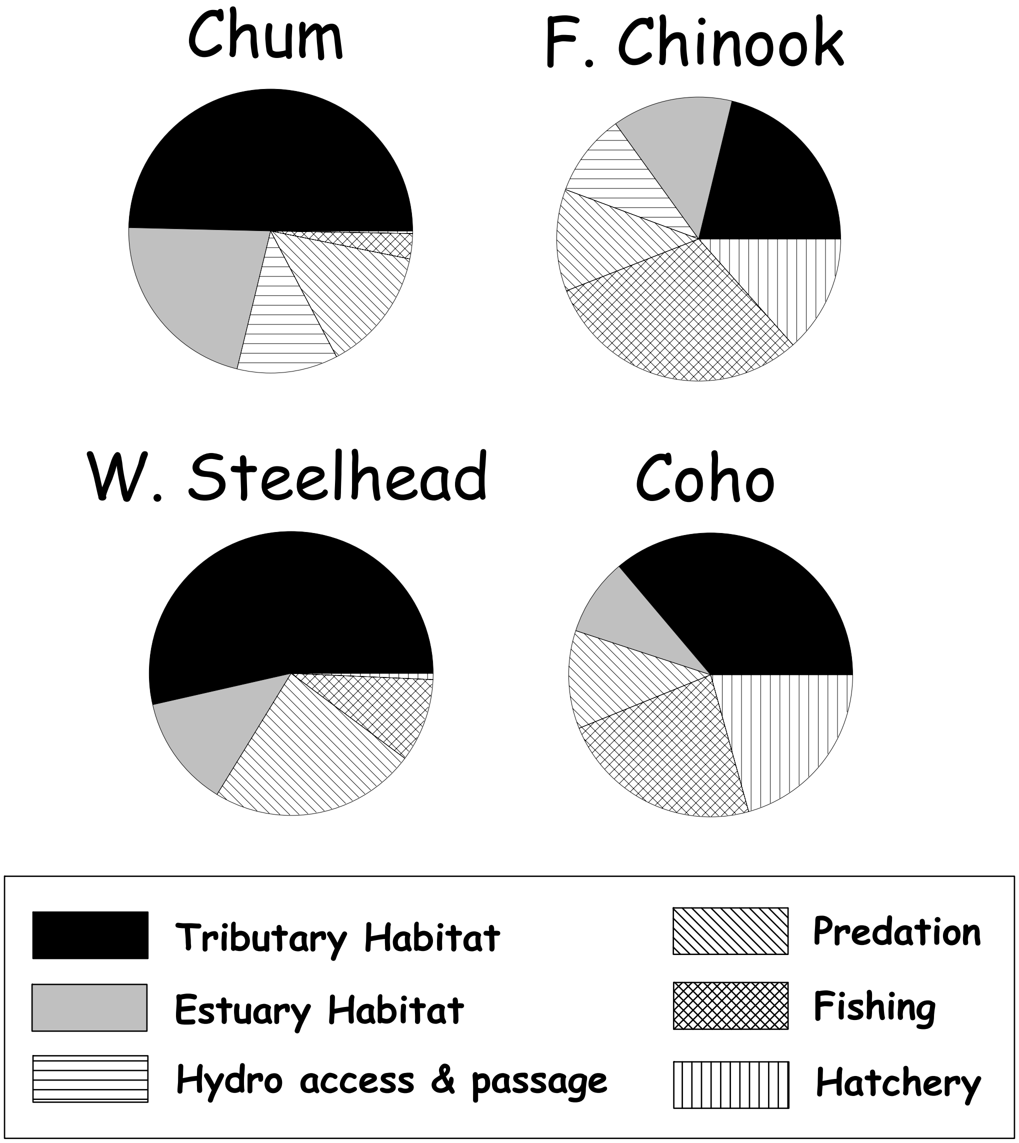


Figure 14-10. Relative index of potentially manageable mortality factors for each species in the Bonneville tributaries.

14.4 Hatchery Programs

14.4.1.1 Salmon Creek

There are no hatcheries in Salmon Creek. However, Skamania winter steelhead hatchery stock from Skamania Hatchery has been released in the basin since at least the early 1980s; current release goals are 20,000 winter steelhead smolts that are incubated at the Vancouver Hatchery (because of space limitations at Skamania), transferred to the Skamania Hatchery as fry, and acclimated in net pens in Klineline Pond, adjacent to Salmon Creek (Figure 14-11).

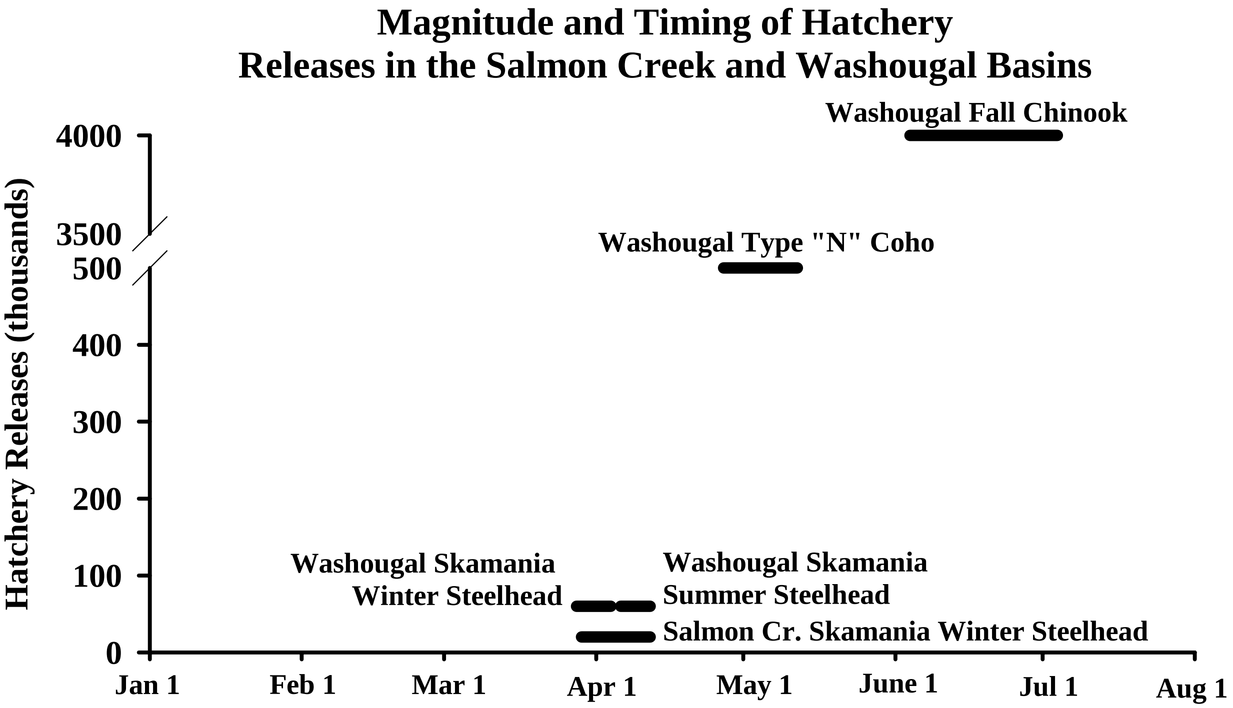


Figure 14-11. Magnitude and timing of hatchery releases in the Salmon Creek and Washougal River basins by species, based on 2003 brood production goals.

Genetics—Broodstock for the winter steelhead hatchery program at the Skamania Hatchery originated from local Washougal River winter steelhead; current broodstock collection comes from adults returning to the hatchery. Shortfalls in annual broodstock needs have been supplemented from Beaver Creek Hatchery winter steelhead stocks, which originated primarily from Chambers Creek and Cowlitz River stocks. Also, Cowlitz River stocks may have strayed to Salmon Creek after the 1980 eruption of Mt. St. Helens.

Interactions—Hatchery fish account for most adult winter steelhead returning to Salmon Creek; very few wild winter steelhead are present (Figure 14-12). Also, spawn timing of wild fish and naturally spawning hatchery fish is different, so there is likely minimal interaction between adult wild and hatchery winter steelhead. Winter steelhead natural production is low; returning hatchery adults contribute little to natural production. Hatchery winter steelhead are released as smolts and clear the river quickly, so competition for food resources with natural salmonids is probably minimal. Releases of winter steelhead into Salmon Creek are moderate in number and hatchery fish therefore are not expected to attract excessive amounts of predators toward wild fish.

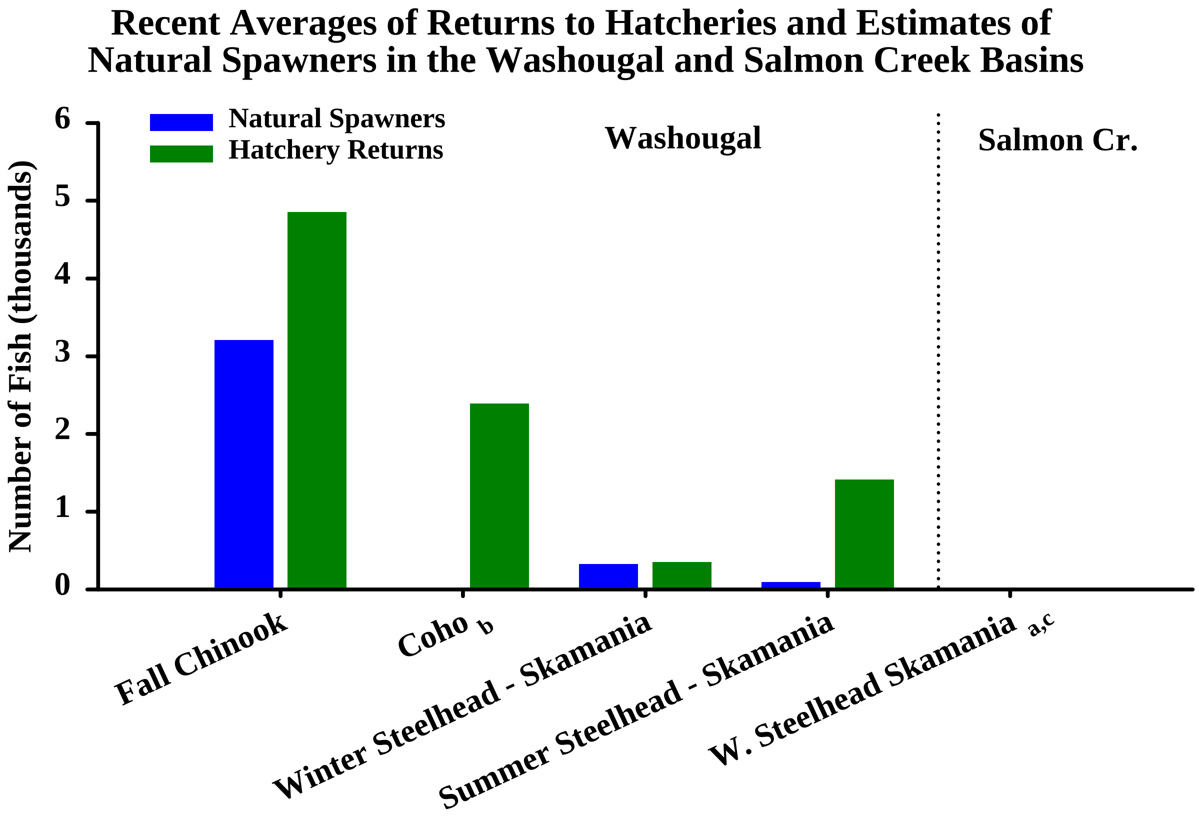


Figure 14-12. Recent average hatchery returns and estimates of natural spawning escapement in the Salmon Creek and Washougal River basins by species.

The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present. Calculation of each average utilized a minimum of 5 years of data.

[a] There is no hatchery facility in the basin to enumerate and collect returning adult hatchery fish. All hatchery fish released in the basin are intended to provide harvest opportunity.

[b] A natural stock for this species and basin have not been identified based on populations in WDFW's 2002 SASSI report; escapement data are not available.

[c] Although a natural population of this species exists in the basin based on populations identified in WDFW's 2002 SASSI report, escapement surveys have not been conducted and the stock status is unknown.

Water Quality/Disease—Refer to the Washougal River section for information on water quality and disease control issues related to Skamania Hatchery winter steelhead program operations.

Mixed Harvest—The purpose of the winter steelhead hatchery program at the Skamania Hatchery is to provide harvest opportunity to mitigate for winter steelhead lost as a result of hydroelectric development in the lower Columbia River basin. Fisheries that may benefit from this program includes lower Columbia and Salmon Creek sport fisheries. No adults are collected for broodstock needs in Salmon Creek, so all returning adults are available for harvest. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead likely were similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and Washington tributaries became selective during 1986–92 (except the Toutle in 1994). Current selective harvest regulations in the lower Columbia and tributary sport fisheries have targeted hatchery steelhead and limited harvest of wild winter steelhead to fewer than 10% (4% in Salmon Creek) This is a successful program supporting a popular fishery.

Passage—There are no hatcheries or facilities for adult hatchery fish collection in Salmon Creek.

Supplementation—Supplementation is not the goal of the Skamania winter steelhead hatchery releases in Salmon Creek; all hatchery winter steelhead are provided for harvest opportunities.

14.4.1.2 Bonneville Area Tributaries

There are no hatcheries in the Bonneville area tributaries. Sporadic hatchery releases of fall chinook, coho salmon, and winter steelhead have occurred over time. Hatchery winter steelhead from Skamania (Washougal) and Beaver Creek (Elochoman) stocks have been planted in Hamilton Creek beginning in 1958 and continued into the 1990s. In 1977, the Spring Creek NFH released approximately 50,000 tule fall chinook in Hamilton Creek. In 1983, the Washougal Hatchery released late-run coho in Duncan and Greenleaf creeks. More specific information regarding the hatchery programs that have released fish into the Bonneville area tributaries is available in the appropriate sections presenting information on each hatchery.

A spawning population of upriver bright fall chinook was discovered in 1994 in the mainstem Columbia River immediately downstream of Bonneville Dam. The population is considered to have originated from hatchery strays from the Bonneville Hatchery in Oregon and the Little White Salmon NFH in Washington. Allozyme analysis indicated that this population was genetically distinct from other Columbia River bright fall chinook stocks, although the population resembles Yakima bright fall chinook and upriver bright fall chinook produced at the Little White Salmon NFH and the Bonneville Hatchery. This population is not considered part of the LCR chinook salmon ESU.

A chum salmon hatchery program was recently started at the Washougal Hatchery with releases beginning in 2003. The program uses Hardy Creek chum for broodstock; the program goal is to enhance chum returns to Duncan Creek. The hatchery program occurs in conjunction with habitat restoration efforts in Duncan Creek. This program also acts as a safety-net in the event that mainstem Columbia flow operations severely limit the natural spawning of chum salmon in Hamilton and Hardy creeks and the Ives Island area below Bonneville.

14.5 Fish Habitat Conditions

14.5.1 Passage Obstructions

14.5.1.1 Lake River

Passage is naturally blocked on Salmon Creek by Salmon Falls at RM 24.1. On the lower river, a 4-foot high falls below the Hwy 99 Bridge might limit passage. The falls is the result of a headcut that followed the avulsion of the stream into gravel pits in 1996. There may be potential passage problems with the flushing channel entering Vancouver Lake due to high flow velocities. Other artificial passage barriers include several culverts, shallow flow where water courses over agricultural land, a stop gate at a private pond, headcuts, an inoperable fish passage structure on Baker Creek, a concrete flume on Burnt Bridge Creek, and railroad/road crossings on some of the Columbia River tributaries (Wade 2002).

14.5.1.2 Bonneville Tributaries

An historical wetland complex on Gibbons Creek was modified in 1966, creating fish passage problems. Fish passage restoration efforts completed in 1992 resulted in an elevated artificial channel with a fish ladder structure at the mouth. Observations in the summer of 2000 suggest that there may be some passage problems associated with the fish ladder and low flows at the mouth area. Passage problems are also associated with the structure that diverts water into the elevated channel at the head of the historical wetland complex. Bedload buildup during stormflows restricts overflow through a screened intake that feeds the wetlands, overwhelming the diversion channel and spilling fish into adjacent fields, where they become stranded (Wade 2001). Several culverts and other artificial barriers also block passage within the Gibbons Creek basin. Details are given in Wade (2001).

Culverts under State Route 14 and the railroad corridor provide various levels of passage concerns on Mary Creek, Woodward Creek, and Hardy Creek. Passage has been blocked on Greenia Creek (Hardy Creek tributary) to prevent fish access to a wetland managed as a western pond turtle refuge. On many of the streams, there are concerns with low flow problems associated with sediment buildup where the streams enter the Columbia. Flow becomes subsurface at times during the summer.

In the past, an earthen dam near the mouth of Duncan Creek restricted anadromous passage to this important chum spawning stream. Restoration of passage has been accomplished with the installation of a dam and fishway that allow for passage at critical migration periods, but retain recreational lake levels during the summer months.

14.5.2 Stream Flow

14.5.2.1 Lake River

Streamflows in the subbasin are generally a direct result of rainfall, as no substantial snow accumulations occur in these low elevation systems. The largest stream system, Salmon Creek, has a mean flow in December of nearly 450 cubic feet per second (cfs) and a mean flow in late summer of less than 25 cfs. The hydrologic regime of the Lake River basin has been highly impacted by urban and rural development, especially Burnt Bridge Creek, which exhibits the flashy flow typical of urban basins (Figure 14-13).

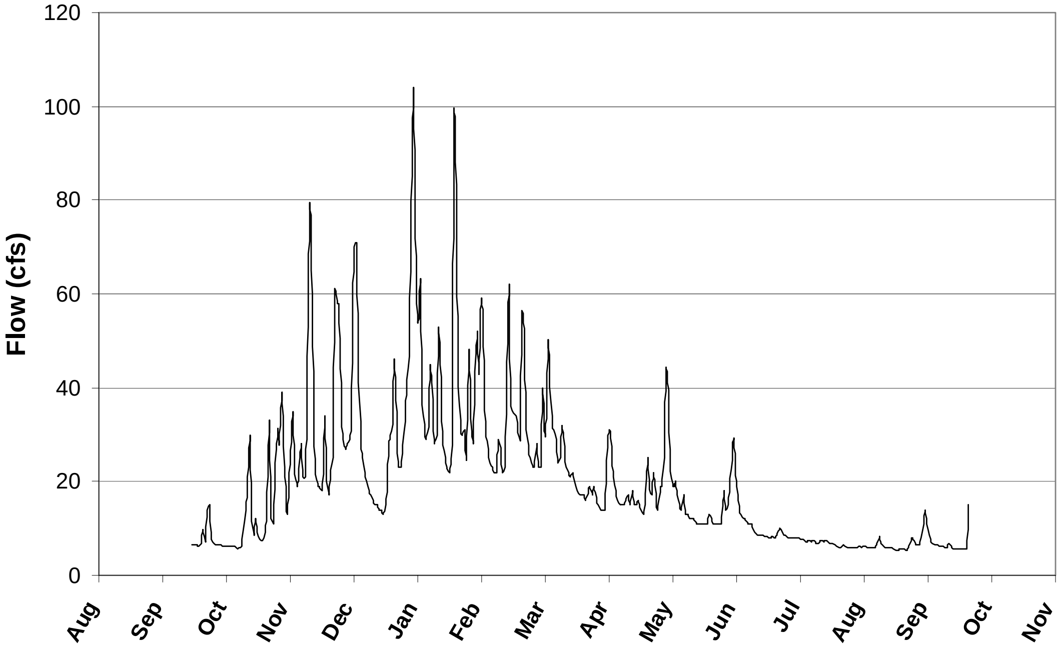


Figure 14-13. Burnt Bridge Creek for Water Year 2000. Flashy flow typical of urban basins is demonstrated by the preponderance of sharp peaks.

Many of the channels in the Lake River basin have been diked, floodplains have been filled or otherwise disconnected, and the amount of impervious land surface has increased dramatically since historical times. The area surrounding Vancouver Lake and to the west was once an extensive network of interconnected sloughs, wetlands, ponds, and tidal channels. Dikes along the Columbia and Lake River now protect developed lowlands from flooding. Vancouver Lake has had a history of water quality problems related to urban development in the basin, including eutrophication and excessive sedimentation. In order to improve water quality and recreational uses, a project in the early 1980s dredged the lake and constructed a flushing channel, which re-connected the lake to the Columbia River. Lake River and Vancouver Lake levels are influenced by tidal fluctuations and by Columbia River levels. Alterations to the flow of the Columbia from mainstem dams, disconnection of historical overflow channels, and the construction of the flushing channel have altered the flow regime of Vancouver Lake and Lake River, with subsequent impacts to water quality, nutrient levels, and sediment dynamics (Wade 2001).

Impaired runoff conditions are a concern in this highly developed basin. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 27 of the 34 subwatersheds (7th field) are “impaired” with respect to runoff conditions and the remaining 7 are “moderately impaired”. The widespread hydrologic impairment is related to the high percentage of watershed imperviousness, lack of mature forest vegetation, and alterations to the drainage network due to roads and other development. Over 87% of the Lake River basin is in non-forest or other uses and the road density is a very high 9.7 mi/mi^2. The significant increase in impervious surfaces associated with development has likely decreased infiltration, thereby increasing runoff and peak flows and decreasing base flows. Although stream gaging records on most streams in the area are too sparse or too short-term to detect anthropogenic alterations to flow regimes, there is evidence that on lower Burnt Bridge Creek, peak flows may have increased since the 1970s due to increased urbanization (EnviroData Solutions, Inc, 1998).

Watershed development and water withdrawals have likely reduced streamflows to below historical levels. Mean monthly flows in Salmon Creek fell below 12 cfs in five of the 10 years on record. Observations indicate that Mill Creek was perennial throughout its length prior to 1960; now it typically dries up by mid-July (Wade 2001). Low flow problems exist in the Salmon Creek tributaries Morgan Creek, Mud Creek, and Baker Creek. Instream flow analysis using the toe-width method revealed that, on Salmon Creek tributaries and in Whipple Creek, flows in the fall were considerably below optimum for salmonid spawning and rearing (Caldwell et al. 1999).

As part of the Phase 2 assessments for WRIA 27/28 under the Watershed Management Act, Pacific Groundwater Group completed an HSPF (Hydrologic Simulation Program – Fortran) model analysis of Salmon Creek. The analysis provided information that indicates low base flows during the summer months on Salmon Creek have been impacted by development. A summary of the results are as follows: 1) during summer months surface water diversions of 3-5 cfs may take 15-30% of stream flow when flow is 15-20 cfs, 2) reduced recharge due to impervious surfaces reduces annual base flow by 12%, 3) withdrawal of groundwater from wells (public and private) reduces base flow by an estimated 8%.

In the Salmon Creek basin, current (year 2000) levels of consumptive water use are approximately 5,000 million gallons per year (mgy) and are expected to increase by 5,475 mgy by 2020. Water use in this basin is a significant component of watershed hydrology, making up as much as 75% of late summer stream flow. Assuming full hydraulic continuity between ground and surface waters, the predicted use in 2020 may exceed late summer flows. In the Burnt Bridge Creek basin, current use already exceeds late summer stream flow volumes if one assumes full connection of ground and surface waters. Both Salmon Creek and Burnt Bridge Creek are closed to further surface water rights appropriation (LCFRB 2001).

14.5.2.2 Bonneville Tributaries

The Bonneville Tributary basins have not had substantial impacts to hydrologic regimes, as much of the area is steep and is now protected by the provisions of the Columbia River Gorge National Scenic Area legislation. There are no permanent stream gages in the basin and little information exists on flow conditions. The streams follow the same general pattern as precipitation due to a lack of storage in the form of impoundments or permanent snowpacks.

The operation of Bonneville Dam has altered flow regimes to some degree in lower Greenleaf and Hamilton Creeks due to reduced connections to overflow channels (Wade 2001). Manipulation of stream flow occurs in a couple of streams. In lower Gibbons Creek, flow exceeding 70 cfs is diverted out of the elevated, artificial channel and into a remnant channel. In Duncan Creek, flow is impounded at the dam near the mouth during the summer months to provide a recreational pond for area residents. Flows are released through the dam at other times of the year to provide adequate passage flows for fish.

Hydrologic (runoff) conditions were investigated as part of the Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter. The IWA results indicate that watershed conditions in 3 of the 7 subwatersheds are “impaired” with respect to conditions that influence runoff; 3 are “moderately impaired”; and only 1 is rated as “functional” (upper Hamilton Creek). The greatest impairments are located in the Lawton Creek, Hardy/Woodward Creek, Duncan Creek, and Indian Mary Creek basins. Runoff impairment in the basin is related primarily to low quantities of mature forest and high road densities. Nearly 60% of the land cover in the Gibbons and Lawton Creek basins is in either non-forest (i.e. urban, agriculture) or other (i.e. cleared, scrub) cover. Over 46% of the land cover in the Duncan, Woodward, Hardy, Hamilton, and Greenleaf Creek basins is in these categories. Land cover conditions, combined with moderate-to-high road densities (>2 mi/mi^2), increase the risk of elevated peak flows and reduced base flows.

An instream flow study utilizing the toe-width method was conducted in 1998 on Gibbons, Lawton, Duncan, Woodward, Hardy, Greenleaf, and Hamilton Creeks. Spot flow measurements were taken at three different times in the fall to compare to optimal flows for salmon and steelhead. Results suggested that for all streams, the flows were well below optimum for both salmon and steelhead spawning and rearing from the first part of September to November (Caldwell et al. 1999). Summer low flow problems have also been observed at the mouths of several streams and may possibly restrict fish passage and strand juvenile fish (Wade 2001).

Current and projected future consumptive water use in the basin is believed to represent only a minor component of available water. Surface water rights appropriation has not been closed for these streams (LCFRB 2001).

14.5.3 Water Quality

14.5.3.1 Lake River

Vancouver Lake is classified as hyper-eutrophic with very high phosphorous and correspondent algal blooms. The lake was historically 20 feet deep and clear, with sturgeon. Industrial development, two nearby superfund sites, and alterations to basin runoff dynamics have had large impacts. Lake River was listed on the 1998 Washington State 303(d) list of water quality impaired water bodies for fecal coliform, temperature, and sediment bioassay. Burnt Bridge Creek is on the 303(d) list for pH, DO, temperature, and fecal coliform. Salmon Creek is on the 303(d) list for temperature, turbidity, and fecal coliform (WDOE 1998). Salmon Creek and several tributaries regularly exceed state standards for fecal coliform, turbidity, DO, and temperature. Development, septic systems, and agricultural activities contribute to these problems. Low flows and constructed ponds in the upper basin are believed to contribute to elevated temperatures. A more complete description of water quality problems in specific Salmon Creek tributaries can be found in Wade (2001).

14.5.3.2 Bonneville Tributaries

Gibbons Creek is listed on the state 303(d) list for violation of fecal coliform standards. Fecal coliform levels are believed to originate from failing septic systems and small livestock operations. The greatest proportion of the fecal coliform load comes from the Gibbons Creek tributary Campen Creek (Post 2000). Temperature monitoring in the Gibbons Creek basin in the late 1990s showed regular exceedances of the state standard (64°F [18°C]) in lower Gibbons Creek and lower Campen Creek. This likely is a result of the low riparian canopy cover levels in these reaches. Water temperatures exceeded 68°F (20°C) in lower Hardy Creek on a few summer days in 1998 and 1999. Water temperature information is generally lacking for other streams.

The USFWS conducted a benthic macroinvertebrate survey at 4 sites on Gibbons and Campen Creek using the Benthic Index of Biotic Integrity (B-IBI). This survey methodology uses the presence of particular benthic macroinvertebrate communities as an indicator of overall stream health (Kerans and Karr 1994). Results revealed poor riffle and pool habitat in Campen Creek along the golf course and fair to excellent riffle and pool habitat conditions at the other locations (Wade 2001).

Nutrient deficiencies are an assumed problem due to low anadromous salmonid escapement levels compared to historical conditions. Low returns can reduce the input of carcass derived nutrients into stream systems.

14.5.4 Key Habitat

14.5.4.1 Lake River

Pool habitat is generally lacking in most of the stream systems. Poor conditions are likely associated with a dearth of LWD, alterations to channel morphology, and changes in the flow and sediment regimes as a result of urbanization. Stormwater runoff and a lack of LWD favors glides over pools in Whipple Creek. Channelization, vegetation removal, and dredging have decreased pool habitats in Burnt Bridge Creek. Surveys conducted by the Clark County Conservation District (CCCD) in Salmon Creek revealed that only 10-15% of the stream surface area was pool habitat. Conditions in tributaries were found to be similar, with generally less than 10% of the surface area in pools (Wade 2001).

The abundance and quality of side channels has decreased significantly as a result of the extensive dike network throughout most of the basins. Side channels in the area surrounding Vancouver Lake have been further impacted by placement of dredge spoils during the dredging of the lake. Upper Burnt Bridge Creek, which was once a series of interconnected wetlands, was diked and drained, eliminating most off-channel habitats. Whipple Creek is mostly incised with few side-channels. Diking and channelization eliminated many side channels that were once present in the lower, braided reach of Salmon Creek. Mining activities have eliminated side channel development in Salmon Creek near the I-5 crossing and upper basin side channels have been reduced by various land-use activities. Side channel habitats have also been degraded / eliminated on several Salmon Creek tributaries. Details can be found in Wade (2001).

14.5.4.2 Bonneville Tributaries

State Highway 14 and the Burlington Northern Santa Fe Railroad impact channel morphologies in the lower reaches of most streams. Pool habitat was found to be lacking in 13 out of 19 surveyed reaches in Woodward, Duncan, Good Bear, Hardy, Hamilton, and Greenleaf Creeks. Eight of 11 surveyed reaches in the Gibbons Creek basin had less than 15% of the stream surface area in pools, though a few pools in the basin have considerable area and depth that may provide adequate habitat (Wade 2001).

The presence of side channel habitats is limited to only the lower portions of most of the streams. State Route 14, the railroad, and other development have isolated some of the historical side channels. There is some good side channel and off-channel habitat in lower Hamilton Creek, including the Hamilton Springs chum spawning channel. Minimal side or off-channel habitat exists in Woodward, Good Bear, Hardy, Duncan, or Greenleaf Creeks. Historically abundant side channel habitat was eliminated in Gibbons Creek as a result of modifications to wetlands in the lower reaches. The stream currently courses though an elevated artificial channel in its lower mile (Wade 2001).

14.5.5 Substrate & Sediment

14.5.5.1 Lake River

Stream surveys conducted by the CCCD in the late 1980s determined that sedimentation and compaction of spawning substrate was a major limiting factor in the basin. In Salmon Creek and tributaries, 6 of the 20 surveyed habitat units had over 75% fines.

Fine sediment is readily delivered to streams in this highly developed area due to stormwater runoff, development in riparian zones, stream-adjacent roads and trails, utility corridors, cattle impacts, and recreational activities (Wade 2001). Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The IWA rates 20 of the 34 subwatersheds as “moderately impaired” with respect to landscape conditions that influence sediment supply. The remaining 14 subwatersheds were rated as “functional”. The presence of functional conditions is related to the flat topography of many subwatersheds, which decreases the potential for sediment delivery to stream channels. However, based on the high natural erodability of soils and the high degree of watershed development, the potential for sediment delivery to stream channels is high. For example, the road density in the basin is a very high 9.7 mi/mi^2 and there are over 44 miles of stream-adjacent roads.

14.5.5.2 Bonneville Tributaries

USFWS surveys indicate that fine sediment is a problem throughout the Gibbons Creek basin, with all of the 11 surveyed reaches having greater than 18% fines. Only a few reaches in the upper Gibbons Creek basin had substrates suitable for salmonids. USFS surveys revealed that only the 2 upper reaches of Woodward Creek suffered from embedded substrates and that most surveyed streams consisted primarily of gravels. Local experts have expressed a concern over fine sediments in spawning areas in Hardy Creek. While Hamilton Creek does not suffer from fine sediment problems, there are concerns with the effect of bedload instability on chum production (Wade 2001). Many streams deposit large amounts of coarse sediment as they emerge from steep canyons in the Gorge. Some of this material does not reach important spawning areas due to artificial obstructions and it also creates problematic changes to channel morphology as it is routed through culverts and diversions.

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The IWA rated all the subwatersheds in the basin as “moderately impaired” with respect to landscape conditions that influence sediment supply. Sediment supply impairments are related to steep slopes and moderately high road densities. Average road densities in the basin fall between 2-3 mi/mi2, considered moderate by most standards.There are a total of approximately 26 miles of stream-adjacent roads and an average of over four stream crossings per mile. These conditions may serve to increase sediment production and delivery to stream systems.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

14.5.6 Woody Debris

14.5.6.1 Lake River

Current levels of LWD are low in the Lake River basin. The disconnection of overflow channels and sloughs has prevented potential recruitment to stream channels. Furthermore, practices including agricultural development, diking, and road building removed riparian vegetation that could provide a source for instream large wood. Currently, only a few scattered areas have levels of natural vegetation capable of supplying wood to streams. The only stream system with any significant LWD levels is Rock Creek in the upper Salmon Creek basin (Wade 2001).

14.5.6.2 Bonneville Tributaries

USFS surveys noted low LWD levels in Woodward, Duncan, Good Bear, Hamilton, and Greenleaf Creeks, with a general increase in LWD levels in the upstream direction. All surveyed reaches had less than 0.2 pieces of LWD/meter of stream. Lower Hamilton and Greenleaf Creeks had the lowest amounts. Medium and large LWD is also lacking in the Gibbons Creek basin, with all surveyed reaches receiving a poor rating. LWD levels are also considered low in Hardy and Indian Mary Creeks (Wade 2001).

14.5.7 Channel Stability

14.5.7.1 Lake River

Streambank stabilization has occurred on most of the streams in the Lake River basin in order to protect urban and rural development. Bank hardening has protected most banks from erosion but in some cases has exacerbated erosion in adjacent areas. The avulsion of lower Salmon Creek into stream-adjacent gravel pits initiated an upstream migrating headcut. On Salmon Creek between I-5 and 182nd Avenue there is a high bank, 800-900 feet long, eroding into the creek. In agricultural areas upstream, removal of riparian vegetation has contributed to lateral channel migration. Several bank stability problem areas are located on Salmon River tributaries. These mostly involve livestock access and riparian vegetation removal. Morgan and Mill Creeks contain the most area of bank instability. Additional details can be found in Wade (2001).

14.5.7.2 Bonneville Tributaries

Information on bank stability is largely lacking. USFS surveys between 1994 and 1996 revealed generally good bank stability conditions on Hamilton and Greenleaf Creeks, except for a couple of portions of lower Hamilton Creek. Lower Woodward Creek is considered very unstable below the railroad. USFS surveys found moderately high width/depth ratios on many of the lower reaches of streams, indicating the potential for lateral bank erosion (Wade 2001).

14.5.8 Riparian Function

14.5.8.1 Lake River

Riparian conditions are poor in the Lake River basin. Residential and commercial development, agriculture, transportation corridors, placement of fill, and diking have eliminated most riparian vegetation on Lake River, Whipple Creek, Burnt Bridge Creek, and lower Salmon Creek. Upper basin reaches are impacted by agriculture, rural development, and forest practices (Wade 2001).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 25 of the 34 subwatersheds were rated as “impaired” with respect to riparian function, 5 were rated as “moderately impaired”, and 4 were not rated. These results are consistent with an analysis of georeferenced Landsat satellite imagery data that looked at the amount of vegetation cover and stand age to determine that 74% of riparian areas were in poor condition and only 1% were in good (mid- to late-seral stage) condition (Lewis County GIS 2000).

14.5.8.2 Bonneville Tributaries

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, riparian conditions are “moderately impaired” in all but 1 of the 7 subwatersheds in the basin. Only the upper Hamilton Creek subwatershed received a rating of “functional”. These results are consistent with an analysis of georeferenced Landsat satellite imagery data, which revealed that less than 10% of the riparian forests in the basin were in mid- to late-seral stages, and most of these were located in upper tributaries above the extent of anadromous habitats (Lewis County GIS 2000). Surveys by the USFS in the mid-1990s also revealed generally poor riparian conditions; only 5 of 18 surveyed reaches contained any large trees and most of the riparian areas were dominated by shrub/seedling, pole/sapling, or small tree associations. Riparian areas lack coniferous cover along lower Lawton Creek where Himalayan blackberry dominates. The Woodward Creek basin has experienced extensive logging and the riparian areas are dominated by deciduous species. Despite generally poor riparian conditions throughout the basin, surveys of canopy density in the Gibbons Creek basin showed good (>75%) cover in all but 2 reaches. These are lower Gibbons Creek (65%), where the stream flows in the artificial diversion channel, and lower Campen Creek (64%), where the stream flows through a golf course (Wade 2001).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

14.5.9 Floodplain Function

14.5.9.1 Lake River

Extensive urban and rural development has resulted in a substantial loss of floodplain habitats. The Vancouver Lake lowlands and Lake River were once hydraulically connected with the Columbia River and contained a network of overflow channels, sloughs, and wetlands that would have provided important salmonid rearing habitat. This area has been extensively diked, dredged, and drained over the course of human settlement in the area, primarily for agricultural and industrial purposes. Only very high flow events now flood only portions of these lowlands. One particular project that affected floodplain habitats was the dredging of Vancouver Lake in the early 1980s. This project, which was undertaken to improve lake water quality for recreational purposes, involved the placement of fill in wetlands surrounding the lake. Lake River is currently constrained by dikes and a railroad grade, and floodplain areas have been filled, drained, and leveled. Culverts and a railroad dike reduce floodplain connectivity on Whipple Creek. Burnt Bridge Creek has been highly altered through diking, draining, and rerouting into ditches and culverts. Salmon Creek suffers from extensive diking, road crossings, recreational development, bank hardening, and gravel mining operations. The stream is now incised and disconnected from its floodplain in many areas. Many Salmon Creek tributaries have been ditched and relocated as they course through areas of urban and rural development (Wade 2001).

14.5.9.2 Bonneville Tributaries

Most of the Bonneville tributaries emerge from steep canyons in the Columbia Gorge and historically contained only short sections with floodplains just upstream of their confluence with the Columbia. State Route 14, the railroad corridor, and other developments have largely eliminated floodplain connection and function (Wade 2001).

An historical wetland complex on lower Gibbons Creek was diked, drained, and diverted in the 1960s and fish passage problems were created. In an effort to restore the wetlands and fish passage, an artificial, elevated channel was constructed that provides access to spawning grounds further upstream. As a result, the stream has been disconnected from its floodplain in the lower mile, and fish access has been blocked to off-channel habitats that once existed in the Gibbons Creek and Columbia River floodplains (Wade 2001). On the Gibbons Creek tributary Campen Creek, a golf course has reduced the availability of complex floodplain habitats.

Floodplain connection has been disrupted on various other streams due to dikes, filling, gravel mining operations, channelization, and diversion. See Wade (2001) for a complete description.

14.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Salmon Creek fall chinook, chum, coho and winter steelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI. Model results are discussed in separate sections for Salmon Creek and for the Bonneville Tributaries.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

14.6.1 Salmon Creek / Lake River

14.6.1.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes. Habitat-based assessments were completed in the Salmon Creek basin for fall chinook, chum, coho and winter steelhead.

Model results indicate a decline in adult productivity for all species in the Salmon Creek subbasin. Declines in adult productivity (from historical levels) range from 79% for fall chinook to greater than 90% for winter steelhead. Similarly, adult abundance levels have declined for all species (Figure 14-14). Current estimates of abundance are only 21% of historical levels for fall chinook, 13% of historical levels for winter steelhead, 15% of historical levels for coho, and 0% of historical levels for chum, as they are functionally extirpated from the basin. Estimated species diversity has also decreased significantly for all species in the Salmon creek basin (Table 14-1). Species diversity has declined by 57% for both fall chinook and coho, by 61% for winter steelhead, and by 100% for chum.

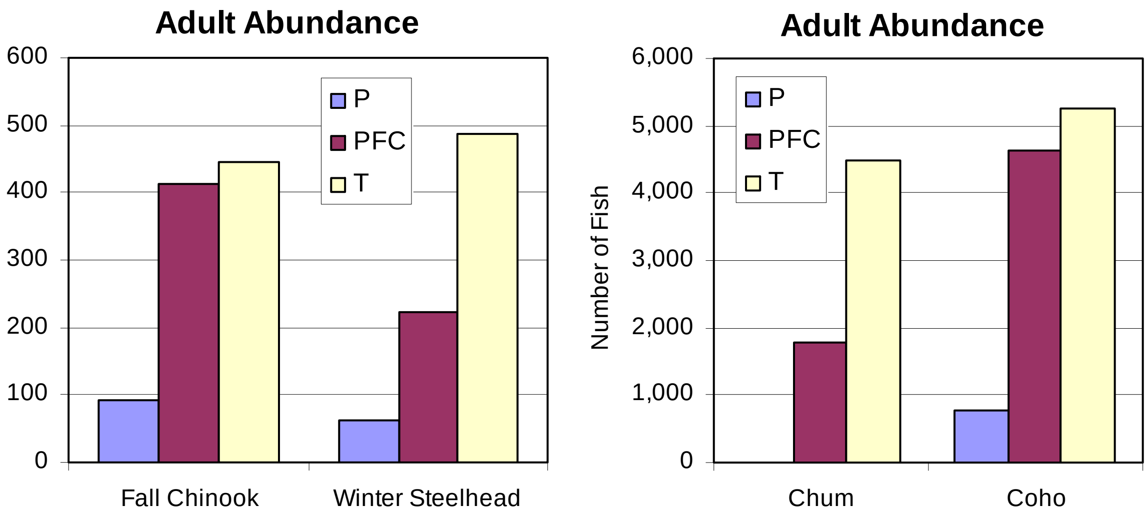
As with adult productivity, model results indicate that current smolt productivity is sharply reduced compared to historical levels. Current smolt productivity estimates are between 12% and 37% of historical productivity, depending on species (Table 14-1). Smolt abundance numbers are similarly low, especially for chum and coho (Table 14-1). Current smolt abundance estimates for chum and coho are at 0% and 14% of historical levels, respectively.

Model results indicate that restoration of PFC conditions would have large benefits in all performance parameters for all species (Table 14-1). For adult abundance, restoration of PFC conditions would increase current returns by 353% for fall chinook, by 251% for winter steelhead, and by 500% for coho. Adult chum returns would be approximately 1,800 fish. Similarly, smolt abundance numbers would increase for all species (Table 14-1). Coho would see an increase in smolt abundance of 538%. Chum smolts would increase in number from 0 to 484,000.

Table 14-1. Salmon Creek subbasin — Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	91	414	444	1.6	6.6	7.7	0.43	1.00	1.00	13,341	53,922	58,100	219	746	869
Chum	0	1,789	4,482	1.0	6.5	9.5	0.00	1.00	1.00	0	483,833	802,195	406	968	1,078
Coho	772	4,621	5,266	2.2	11.0	14.3	0.43	0.99	1.00	17,887	114,139	129,864	51	260	338
Winter Steelhead	64	223	486	2.4	13.9	36.4	0.39	0.98	1.00	1,136	4,038	4,655	43	255	354

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.


Adult Abundance

Adult Abundance

Figure 14-14. Adult abundance of Salmon Creek subbasin fall chinook, winter steelhead, chum and coho based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

14.6.1.2 Restoration an Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Fall chinook primarily use Salmon Creek mainstem reaches. Chum are believed to have historically had a similar distribution as fall chinook. Winter steelhead and coho are distributed throughout the mainstem and tributaries. See Figure 14-15 for a map of reaches in the Salmon Creek basin.

Reaches with a high priority ranking for winter steelhead are located in the middle and upper mainstem Salmon Creek (Figure 14-16). All high priority reaches, except reach Salmon 31, show a strong habitat restoration emphasis. Salmon 31 shows a combined habitat preservation and restoration emphasis (Figure 14-16). The reaches of Salmon 14A and 14C have the highest restoration potential of any reach modeled for winter steelhead.

Important reaches for both fall chinook (Figure 14-17) and chum (Figure 14-18) are generally located in the middle mainstem (Salmon 11-13, Salmon 14A-14C and Salmon 16). These reaches, as with the important winter steelhead reaches, all show a strong habitat restoration emphasis. For both species, the reaches of Salmon 14A and Salmon 14B have the highest restoration potential of any reach modeled within the basin.

For coho, the high priority reaches are primarily located in the middle and upper basin (Figure 14-19). Tributaries such as Suds, Lalonde, Morgan and Rock Creeks also contain high priority reaches for coho. All high priority reaches, except Salmon 31 and Lbtrib 11-1, show a habitat restoration emphasis. Salmon 31 and Lbtrib 11-1 have a combined habitat preservation and restoration emphasis. As with all other modeled species, the reaches of Salmon 14A and Salmon 14B have the highest restoration potential of any reach.

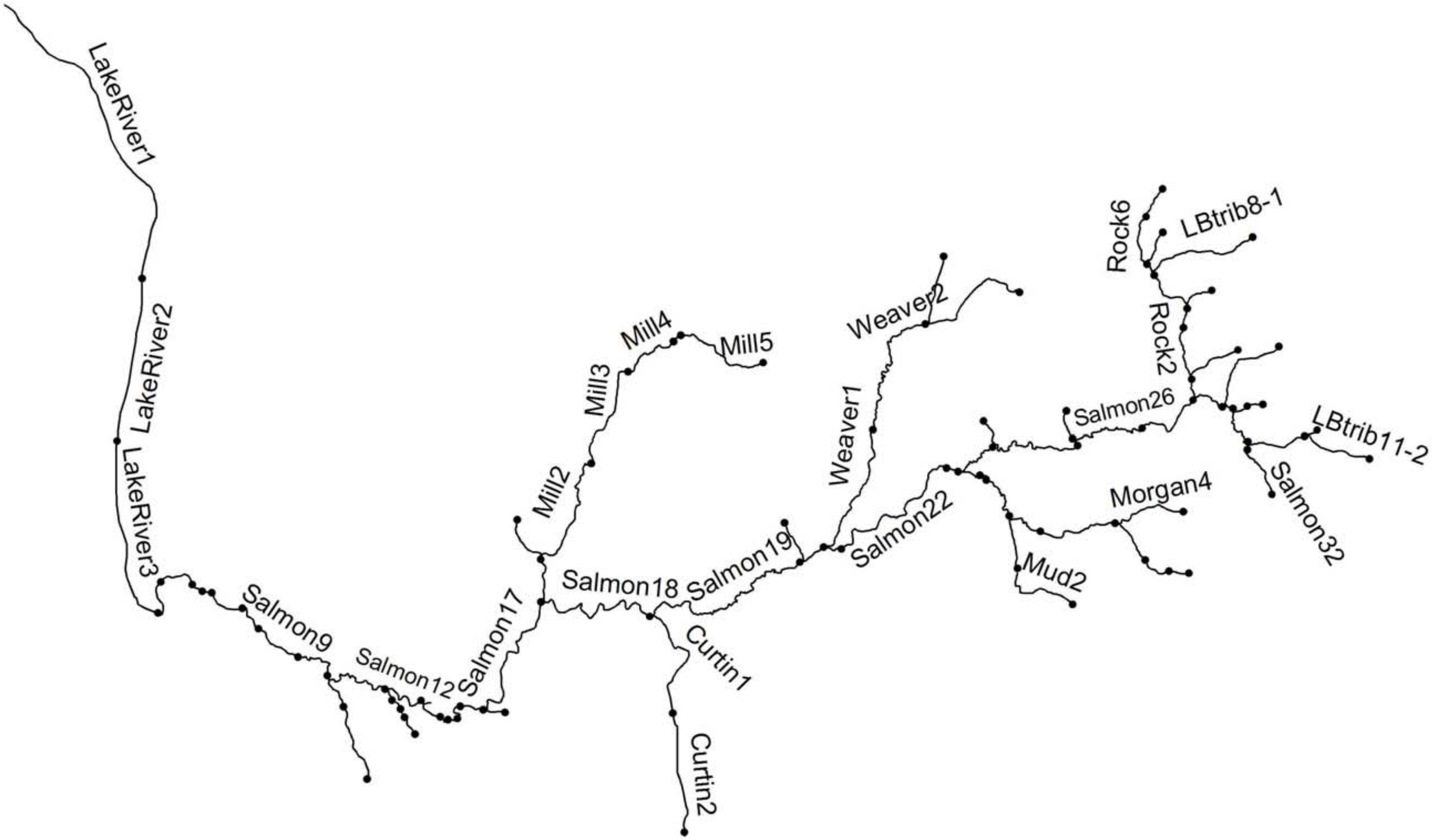
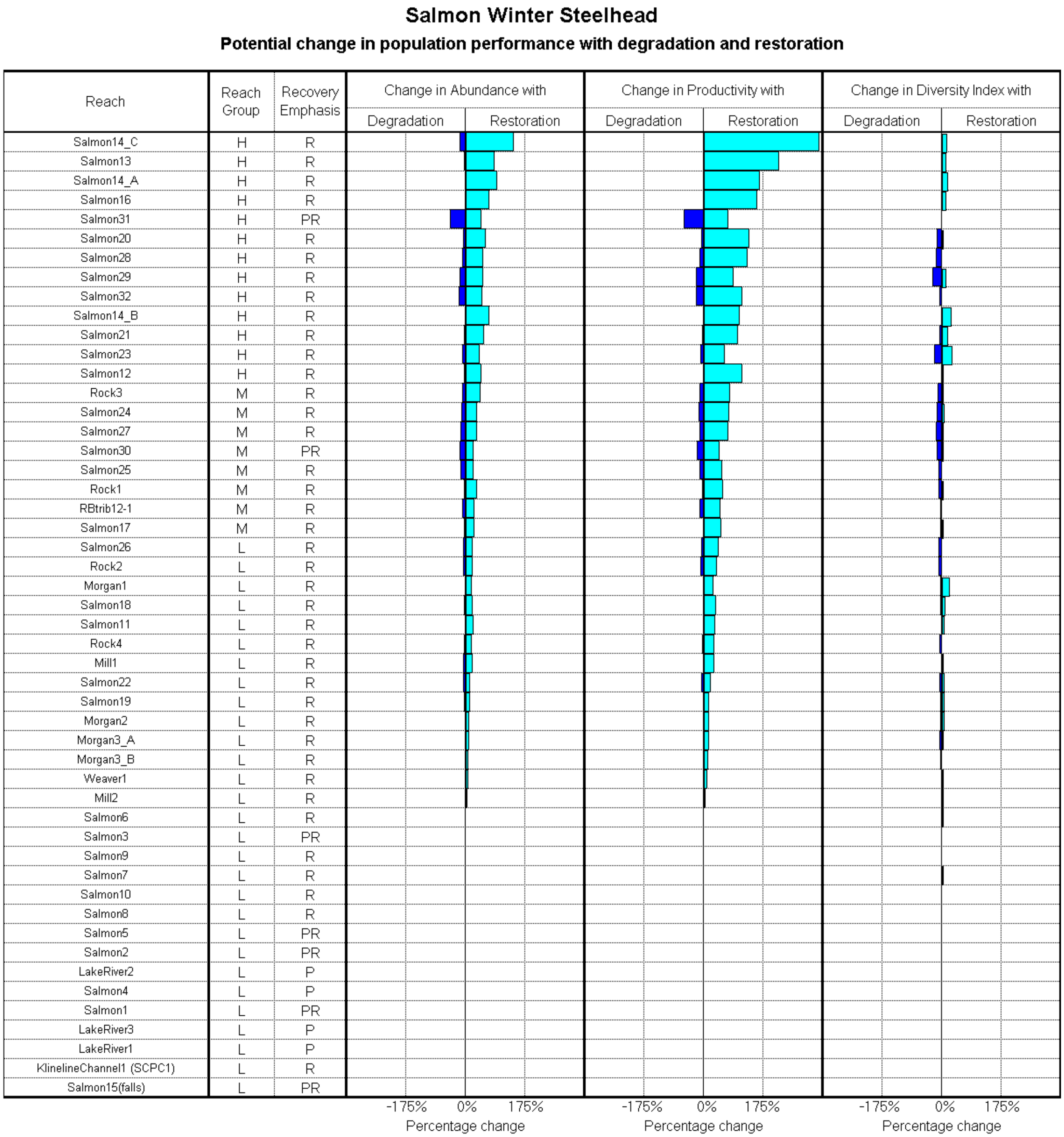


Figure 14-15. Salmon Creek basin EDT reaches. Some reaches are not labeled for clarity.


Salmon Winter Steelhead

Potential change in population performance with degradation and restoration

Reach	Reach Group	Recovery Emphasis
Salmon14_C	H	R
Salmon13	H	R
Salmon14_A	H	R
Salmon16	H	R
Salmon31	H	PR
Salmon20	H	R
Salmon28	H	R
Salmon29	H	R
Salmon32	H	R
Salmon14_B	H	R
Salmon21	H	R
Salmon23	H	R
Salmon12	H	R
Rock3	M	R
Salmon24	M	R
Salmon27	M	R
Salmon30	M	PR
Salmon25	M	R
Rock1	M	R
RBtrib12-1	M	R
Salmon17	M	R
Salmon26	L	R
Rock2	L	R
Morgan1	L	R
Salmon18	L	R
Salmon11	L	R
Rock4	L	R
Mill1	L	R
Salmon22	L	R
Salmon19	L	R
Morgan2	L	R
Morgan3_A	L	R
Morgan3_B	L	R
Weaver1	L	R
Mill2	L	R
Salmon6	L	R
Salmon3	L	PR
Salmon9	L	R
Salmon7	L	R
Salmon10	L	R
Salmon8	L	R
Salmon5	L	PR
Salmon2	L	PR
LakeRiver2	L	P
Salmon4	L	P
Salmon1	L	PR
LakeRiver3	L	P
LakeRiver1	L	P
KlinelineChannel1 (SCPC1)	L	R
Salmon15(falls)	L	PR

Figure 14-16. Salmon Creek winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. See Volume VI for more information on EDT ladder diagrams. Percentage change values are expressed as the change per 1000 meters of stream length within the reach.

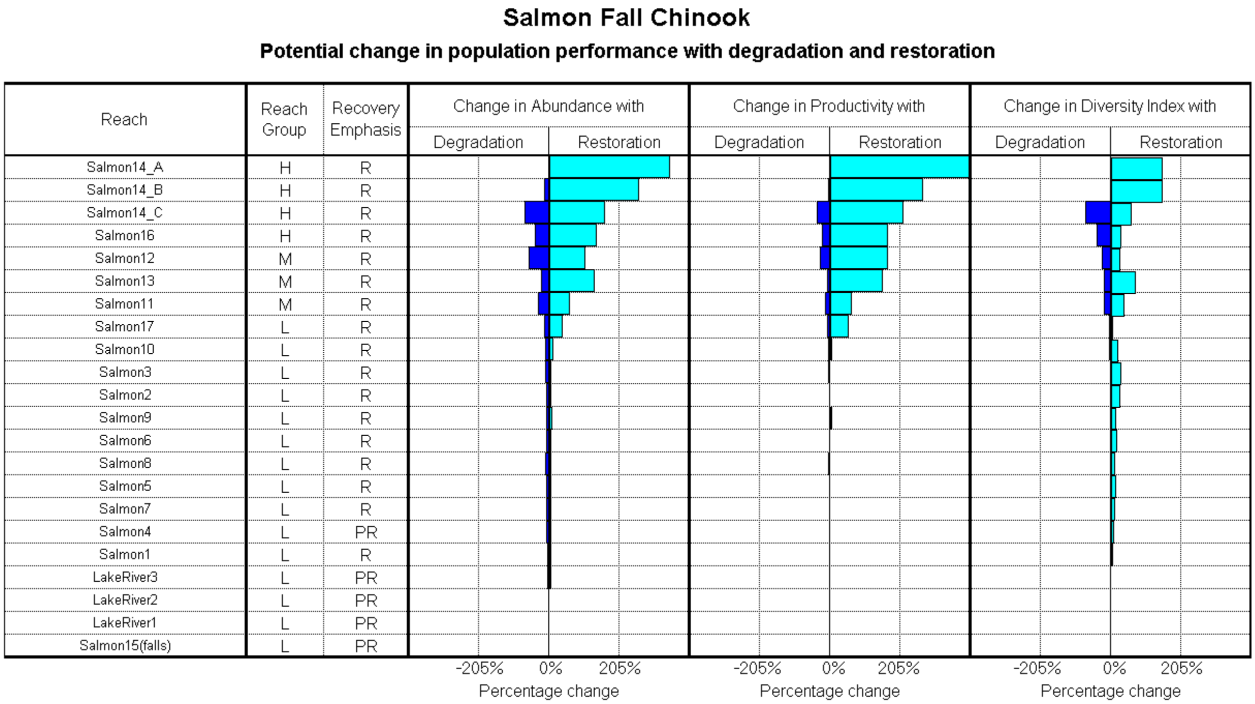


Figure 14-17. Salmon Creek fall chinook ladder diagram.

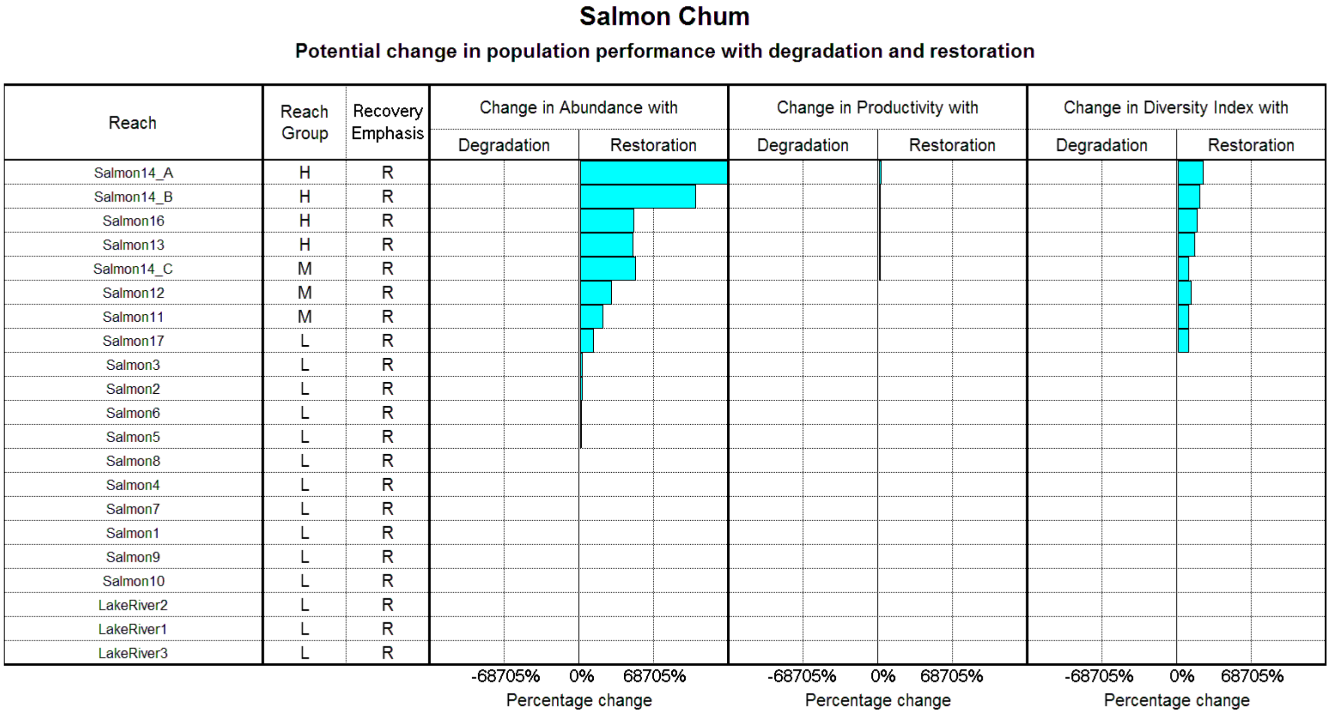
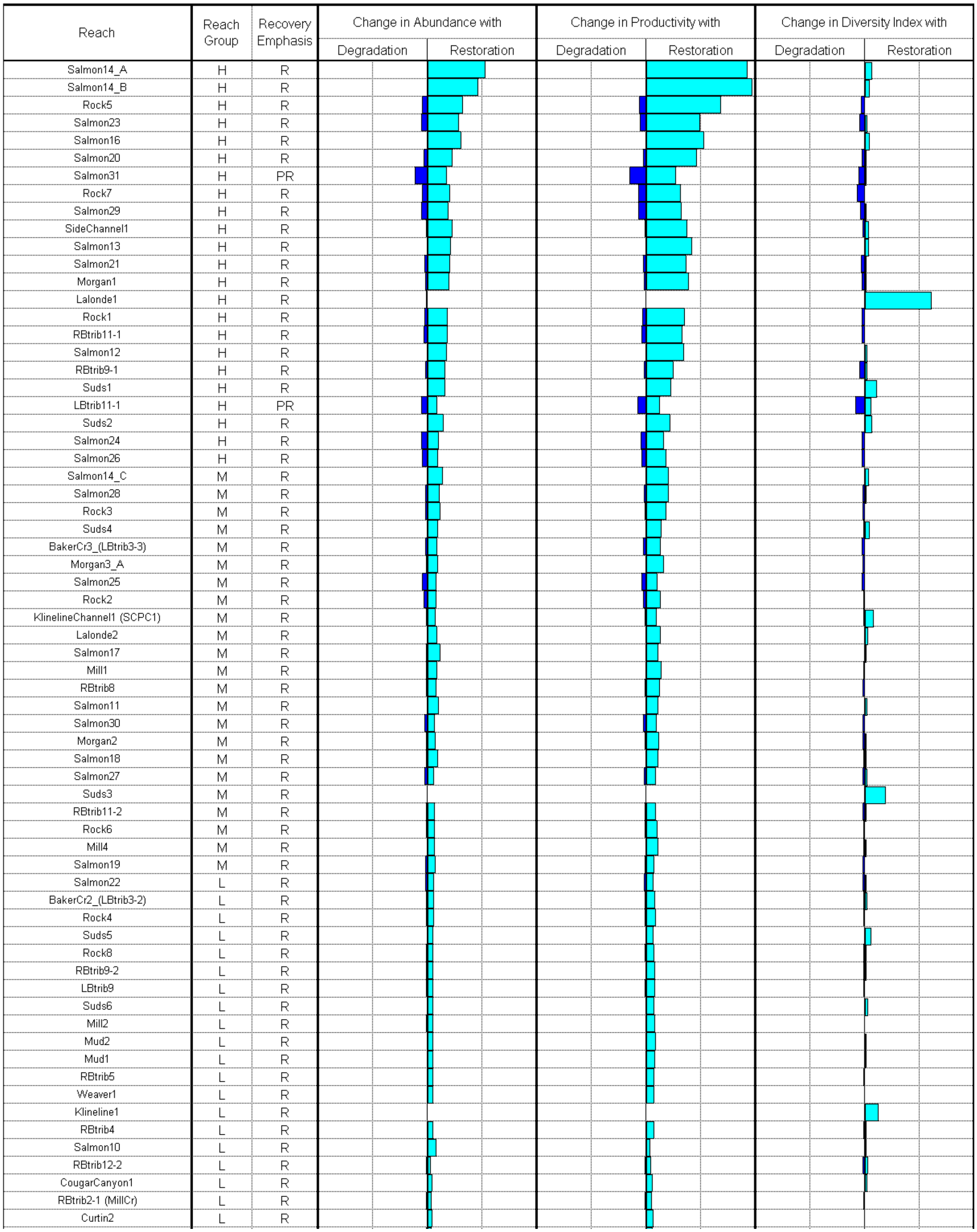


Figure 14-18. Salmon Creek chum ladder diagram.

Salmon Coho

Potential change in population performance with degradation and restoration



Reach	Reach Group	Recovery Emphasis
Salmon14_A	H	R
Salmon14_B	H	R
Rock5	H	R
Salmon23	H	R
Salmon16	H	R
Salmon20	H	R
Salmon31	H	PR
Rock7	H	R
Salmon29	H	R
SideChannel1	H	R
Salmon13	H	R
Salmon21	H	R
Morgan1	H	R
Lalonde1	H	R
Rock1	H	R
RBtrib11-1	H	R
Salmon12	H	R
RBtrib9-1	H	R
Suds1	H	R
LBtrib11-1	H	PR
Suds2	H	R
Salmon24	H	R
Salmon26	H	R
Salmon14_C	M	R
Salmon28	M	R
Rock3	M	R
Suds4	M	R
BakerCr3_(LBtrib3-3)	M	R
Morgan3_A	M	R
Salmon25	M	R
Rock2	M	R
KlinelineChannel1 (SCPC1)	M	R
Lalonde2	M	R
Salmon17	M	R
Mill1	M	R
RBtrib8	M	R
Salmon11	M	R
Salmon30	M	R
Morgan2	M	R
Salmon18	M	R
Salmon27	M	R
Suds3	M	R
RBtrib11-2	M	R
Rock6	M	R
Mill4	M	R
Salmon19	M	R
Salmon22	L	R
BakerCr2_(LBtrib3-2)	L	R
Rock4	L	R
Suds5	L	R
Rock8	L	R
RBtrib9-2	L	R
LBtrib9	L	R
Suds6	L	R
Mill2	L	R
Mud2	L	R
Mud1	L	R
RBtrib5	L	R
Weaver1	L	R
Klineline1	L	R
RBtrib4	L	R
Salmon10	L	R
RBtrib12-2	L	R
CougarCanyon1	L	R
RBtrib2-1 (MillCr)	L	R
Curtin2	L	R

Figure 14-19. Salmon Creek coho ladder diagram. Some low priority reaches are not included for display purposes.

14.6.1.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Key reaches for winter steelhead in the Salmon Creek basin are located primarily in the middle and upper mainstem. These reaches appear to be most impacted from sediment and habitat diversity, with somewhat lesser impacts related to flow, temperature, and predation (Figure 14-20). This area has been heavily modified since historical times. Rural residential development and agriculture are the primary sources of habitat impairments.

The greatest impacts to fall chinook and chum are located in the lower and middle mainstem reaches of Salmon Creek. As with steelhead, the primary impacts to key reaches are sediment and habitat diversity (Figure 14-21 and Figure 14-22). Other impacts include channel stability, flow, and harassment. These reaches are heavily impacted by the expanding Vancouver metropolitan area. Stream channels have been straightened and confined, riparian areas have been denuded of vegetation, floodplains have been isolated from channels, and uplands have been highly developed.

Important coho reaches in the Salmon Creek basin are generally located in both the middle and upper mainstem, as well as in many of the smaller tributaries. Habitat factors affecting these reaches are varied and include sediment, habitat diversity, channel stability, key habitat and flow (Figure 14-23). Lesser impacts related to food and temperature are also affecting these reaches. The causes of these impacts are similar to those discussed above.

Salmon Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Salmon14_C	●	⬤	⬤	⬤	•	●			⬤	⬤	●			●	•	+
Salmon13	•	⬤	●	●	•	●		•	●	●	•			●	•	+
Salmon14_A	●	⬤	●	●	•	•		•	●	⬤	•			●	•	+
Salmon16	•	⬤	●	●	•	•			●	⬤	•			•		+
Salmon31	•	●	●	•		•			●	⬤	●			•		╋
Salmon20	•	⬤	●	●	•	●			●	⬤	•			•		+
Salmon28	•	⬤	●	•		●			●	●	●			•		+
Salmon29	•	●	●	•		●			●	⬤	●			●	•	✚
Salmon32	•	⬤	•	•		•			●	⬤	●			•		╋
Salmon14_B	•	●	●	●	•	•			●	⬤	•			●	•	•
Salmon21	•	●	●	●	•	•			●	⬤	•			●	•	+
Salmon23	•	●	●	•		•			•	⬤	•			●		+
Salmon12	•	●	●	●	•	•		•	●	●	•			•	•	+
Rock3	●	●	●	•		•			●	⬤	●			•		●
Salmon24	•	●	●	•		•			●	●	•			•		
Salmon27	•	●	•	•		•			●	●	•			•		+
Salmon30	•	●	●	•	•	•			●	●	●			•		+
Salmon25	•	●	●	•		•			●	●	•			•		
Rock1	•	●	●	●		•			•	⬤	•			•		•
RBtrib12-1	•	●	•	•		•			●	⬤	•			•		╋
Salmon17	•	●	•	•		•			●	●	•			•		
Salmon26	•	●	●	•		•			•	●	•			•		
Rock2	•	•	●	•		•			•	●	•			•		•
Morgan1	•	•	●	•		•			•	⬤	•			•		•
Salmon18	•	●	•	•		•			●	•	•			•		
Salmon11	•	●	•	•		•			•	•	•			•		+
Rock4	•	•	●	•					•	⬤	•			•		•
Mill1	•	•	●	●		•			•	⬤	•			•		•
Salmon22	•	●	•	•		•			•	•	•			•		
Salmon19	•	●	•	•		•			•	•	•			•		
Morgan2	•	•	•	•					•	●	•			•		•
Morgan3_A	•	•	•	•					•	●	•			•		•
Morgan3_B	•	•	•						•	●				•		╋
Weaver1	•	•	•						•	●	•			•		╋
Mill2		•	•	•					•	•				•		
Salmon6																
Salmon3		•		•												
Salmon9		•								•						
Salmon7																
Salmon10										•						

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 14-20. Salmon Creek winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Salmon Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Salmon14_A	⬤	⬤	●	•	•			•	●	⬤	•			•	●	✛
Salmon14_B	●	⬤	●	•	•				●	⬤	•			•	●	⬤
Salmon14_C	●	⬤	●	•	•				●	⬤	•				•	•
Salmon16	●	⬤	●	•	•				●	⬤	•				•	✚
Salmon12	●	⬤	•	•	•				●	⬤	•				•	✛
Salmon13	●	⬤	•	•	•				●	⬤	•				•	✛
Salmon11	●	●	•	•	•	•			●	●	•				•	•
Salmon17	•	●	•						•	⬤	•				•	✛
Salmon10	•	•		•					•	•	•					•
Salmon3		•	•	•						•						
Salmon2		•		•						•						
Salmon9	•	•		•					•	•	•					
Salmon6		•		•						•						
Salmon8		•		•						•						
Salmon5		•		•						•						
Salmon7		•		•						•						
Salmon4		•		•						•						
Salmon1		•		•						•						
LakeRiver3		•								•						
LakeRiver2																
LakeRiver1																
Salmon15(falls)																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 14-21. Salmon Creek fall chinook habitat factor analysis diagram.

Salmon Creek Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Salmon14_A	●	⬤		•	•				●	⬤	●				⬤	➕
Salmon14_B	●	⬤		●	•				●	⬤	●				⬤	⬤
Salmon16	•	⬤		•	•				●	●	•				●	✚
Salmon13	•	⬤		•	•				●	●	•				●	✚
Salmon14_C	•	⬤		•	•				●	●	•				●	●
Salmon12	•	⬤		•	•				•	●	•				●	✚
Salmon11	•	●		•	•				•	●	•				•	+
Salmon17	•	●							•	●	•				•	✚
Salmon3		•		•					•	•	•					•
Salmon2		•		•					•	•	•					•
Salmon6		•		•					•	•						•
Salmon5		•		•						•						•
Salmon8																
Salmon4																
Salmon7																
Salmon1																
Salmon9																
Salmon10																
LakeRiver2																
LakeRiver1																
LakeRiver3																
Salmon15(falls)																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 14-22. Salmon Creek chum habitat factor analysis diagram.

Salmon Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Salmon14_A	⬤	⬤	●	●	•	●			⬤	⬤	●			•	•	●
Salmon14_B	⬤	⬤	●	⬤	•	●			●	⬤	●			•	•	•
Rock5	⬤	⬤	•	•		•			⬤	⬤	⬤					⬤
Salmon23	●	⬤	●	●		●			●	⬤	●			•		●
Salmon16	●	⬤	●	●	•	●			●	⬤	●			•		•
Salmon20	●	⬤	●	●	•	●			●	⬤	●			•		●
Salmon31	⬤	⬤	•	•		•			●	⬤	●					•
Rock7	●	⬤	•	•		•			●	⬤	●					⬤
Salmon29	●	⬤	●	•		●			●	⬤	●			•	•	●
SideChannel1	⬤	●	⬤	•		•			⬤	⬤	●			•		⬤
Salmon13	●	⬤	•	●	•	•			●	●	•			•	•	•
Salmon21	●	⬤	●	•	•	●			●	⬤	●			•	•	•
Morgan1	●	●	●	●		●			●	⬤	●			•		⬤
Lalonde1																
Rock1	●	⬤	●	•		●			●	⬤	●			•		●
RBtrib11-1	●	⬤	•	•		•			●	⬤	●					⬤
Salmon12	●	⬤	•	●	•	•			●	●	•			•	•	●
RBtrib9-1	●	⬤	•	•		●			●	⬤	●			•		●
Suds1	●	⬤	•	•	•	●			●	⬤	●			•	•	●
LBtrib11-1	⬤	●							•	⬤	•					⬤
Suds2	●	⬤	•		•	•			●	⬤	●					●
Salmon24	•	●	●	•		●			●	⬤	●			•		•
Salmon26	•	●	●	•	•	●			•	●	●			•		•
Salmon14_C	●	⬤	•	•	•	•			●	●	•			•		•
Salmon28	•	⬤	•	•		•			●	●	●			•		●
Rock3	●	●	●	•		•			●	⬤	●					●
Suds4	●	⬤				•			●	⬤	•					●
BakerCr3_(LBtrib3-3)	●	●	•			•			●	⬤	•					+
Morgan3_A	●	●	●	•		•			●	●	•					●
Salmon25	•	●	●	•		•			•	●	●			•		•
Rock2	•	●	●	•		•			●	⬤	●					●
KlinelineChannel1 (SCPC1)	•	●	●	•	•	•			•	⬤	•			•	•	●
Lalonde2	•	●				•			●	⬤	•					●
Salmon17	•	⬤	•	•		•			●	●	•			•		•
Mill1	●	●	•	•		•			●	●	•			•		●
RBtrib8	•	●	•	•		•			●	⬤	●			•		●
Salmon11	•	●	•	•	•	•			●	●	•			•		•
Salmon30	•	●	•		•	•			•	●	●					•
Morgan2	●	●	●	•		•			●	⬤	•					●
Salmon18	•	●	•	•		•			●	●	•			•		•
Salmon27	•	●	•	•		•			•	•	•					•
Suds3																
RBtrib11-2	•	●	•						•	●	•					⬤
Rock6	●	●	•			•			●	●	●					●
Mill4	●	●	•	•		•			•	●	•			•		●
Salmon19	•	●	•	•		•			•	•	•			•		•
Salmon22	•	●	•	•		•			•	•	•			•		•
BakerCr2_(LBtrib3-2)	•	●	•						•	●	•					●
Rock4	•	●	•	•		•			•	●	•					●
Suds5	•	●							•	●	•					●
Rock8	•	●							•	●	•					●
RBtrib9-2	•	●	•						•	⬤	•					●
LBtrib9	•	●	•			•			•	●	•					●

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ✚

Figure 14-23. Salmon Creek coho habitat factor analysis diagram. Some low priority reaches are not included for display purposes

14.6.2 Bonneville Tributaries

14.6.2.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for winter steelhead, fall chinook, chum and coho in the lower Columbia Gorge basins of Hardy, Hamilton, and Duncan Creeks. Salmon and steelhead use has also been documented in several other small lower Gorge tributaries (i.e. Gibbons and Lawton Creeks), but abundance in these streams is believed to be low. Although the EDT model was run independently for Hardy, Hamilton, and Duncan Creeks (HHD), the model outputs of these streams have been combined.

Model results indicate that adult productivity has declined for all species (Table 14-2). Both chum and winter steelhead have seen the sharpest decline in productivity, with current estimates at approximately 30% of historical levels. Adult abundance has also declined for all species in the HHD basins (Figure 14-24). Fall chinook and winter steelhead abundance has declined by 45% and 56% from historical levels, respectively. Chum and coho abundance has declined more significantly, to 14% and 20% of historical levels, respectively. Species diversity (as measured by the diversity index) has remained relatively constant for chum but has decreased by 47% for winter steelhead, by 50% for fall chinook, and by 63% for coho (Table 14-2).

Smolt productivity numbers are also lower for each species, except chum (Table 14-2). In the case of chum, this seems counter-intuitive due to the fact that chum adult abundance has declined the most out of the four species. This relatively higher smolt productivity is an artifact of the way the EDT model calculates productivity. That is, the higher productivity of chum smolts is because HHD chum now have many less trajectories (life history pathways) that are viable (those that result in return spawners); but the few trajectories that remain have higher productivities than historical trajectories (many of which were only marginally viable). Smolt abundance numbers have also declined for all species (Table 14-2). Current smolt abundance estimates range from 19% of historical levels for coho to 69% of historical levels for winter steelhead.

Model results indicate that restoration to PFC conditions would produce substantial benefits for all species (Table 14-2). Adult returns of winter steelhead and fall chinook would increase by an estimated 11% and 36%, respectively, while adult returns of chum and coho would increase by an estimated 144% and 117%, respectively. Similar results would be seen for smolt abundance (Table 14-2).

Table 14-2. Lower Gorge tributaries— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	124	168	225	4.4	5.9	7.0	0.44	0.44	0.88	36,961	52,311	64,512	817	1,040	1,130
Chum	797	1,943	5,842	3.5	8.5	11.4	0.97	1.00	1.00	80,161	121,877	166,842	164	164	137
Coho	57	123	280	5.1	7.5	10.2	0.37	0.44	0.98	1,663	3,760	8,528	154	234	313
Winter Steelhead	244	270	556	15.7	19.0	45.8	0.40	0.47	0.76	2,400	2,628	3,496	188	233	344

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

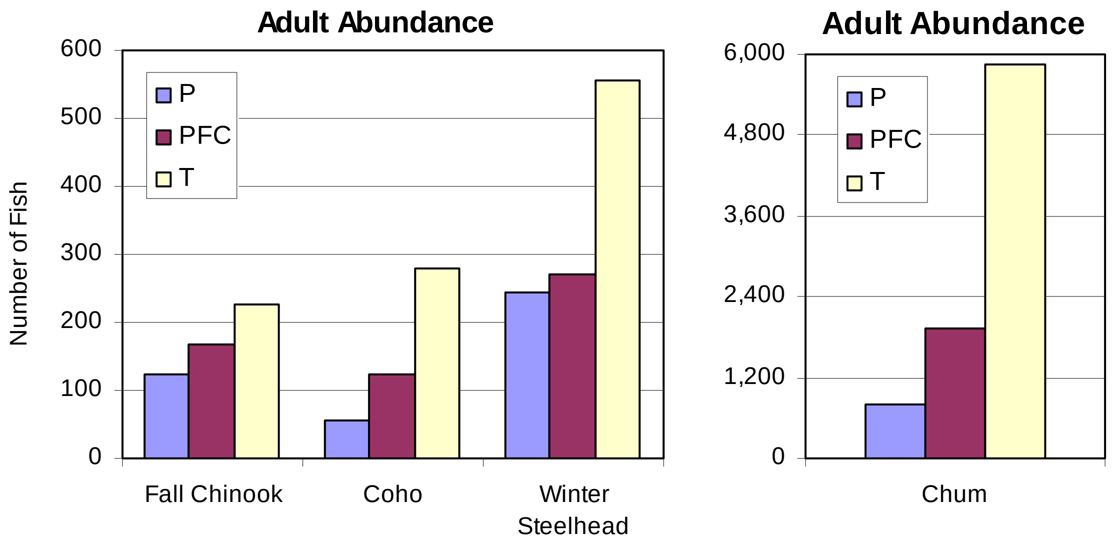


Figure 14-24. Adult abundance of Lower Gorge tributary fall chinook, coho, winter steelhead, and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

14.6.2.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

The lower Gorge tributaries of Hardy, Hamilton, and Duncan Creeks were divided into numerous individual reaches. These reaches represent the low gradient, lower portions of these systems that are accessible to anadromous fish. Upstream of these reaches, gradients increase dramatically where the stream valleys carve through the steep valley walls of the Columbia Gorge. Hamilton Creek has the greatest length and capacity for fish, and also has the longest tributary, Greenleaf Creek. See Figure 14-25 for a map of stream reaches within the HHD basins.

High priority areas for winter steelhead include only one reach in upper Hamilton Creek (Hamilton 4) (Figure 14-26). This reach is important for steelhead spawning, and appears to be the least degraded. This reach has the strongest habitat preservation emphasis of any winter steelhead reach in the three basin.

Important areas for chum include the Duncan Lake outlet (reach Lake outlet), lower Hamilton (Hamilton 1A, Hamilton 2 and Hamilton Springs) and Hardy Creeks (Hardy 2) (Figure 14-27). These reaches include some of the most productive chum spawning and rearing areas in the basin. These reaches (especially Lake Outlet) show a strong habitat preservation emphasis.

As with winter steelhead, there was only one high priority reach for fall chinook, located in lower Hamilton Creek (Hamilton 1A) (Figure 14-28). This high priority reach has a combined habitat preservation and restoration emphasis.

High priority reaches for coho are located in Hamilton and Duncan Creeks (Hamilton 2 and Duncan 1) (Figure 14-29). Although these areas are considered important spawning reaches, the available habitat has been somewhat degraded. As a result, both high priority reaches show a restoration emphasis. Reach Hamilton 2 has the highest restoration potential of any coho reach modeled in the three basins.

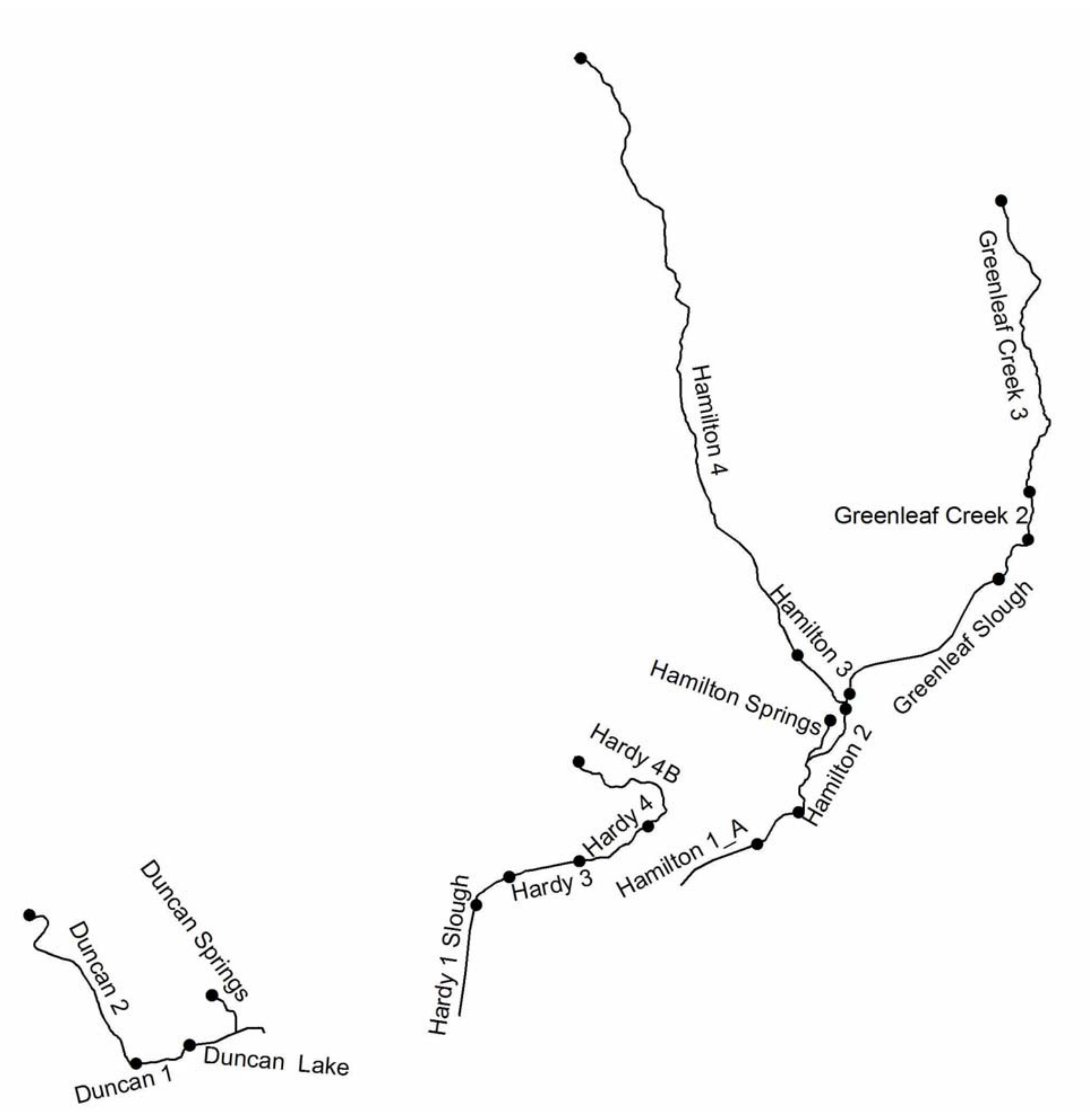


Figure 14-25. Bonneville Tributaries EDT reaches. Some reaches are not labeled for clarity.

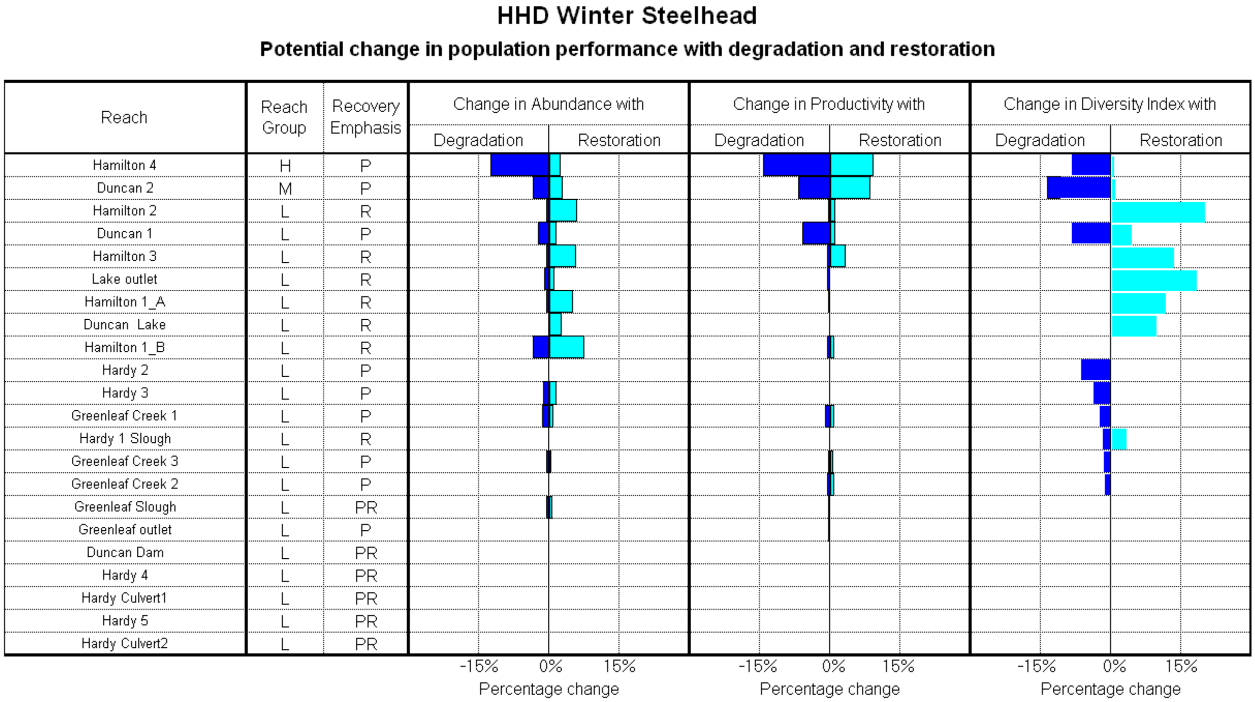


Figure 14-26. Bonneville Tributaries winter steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

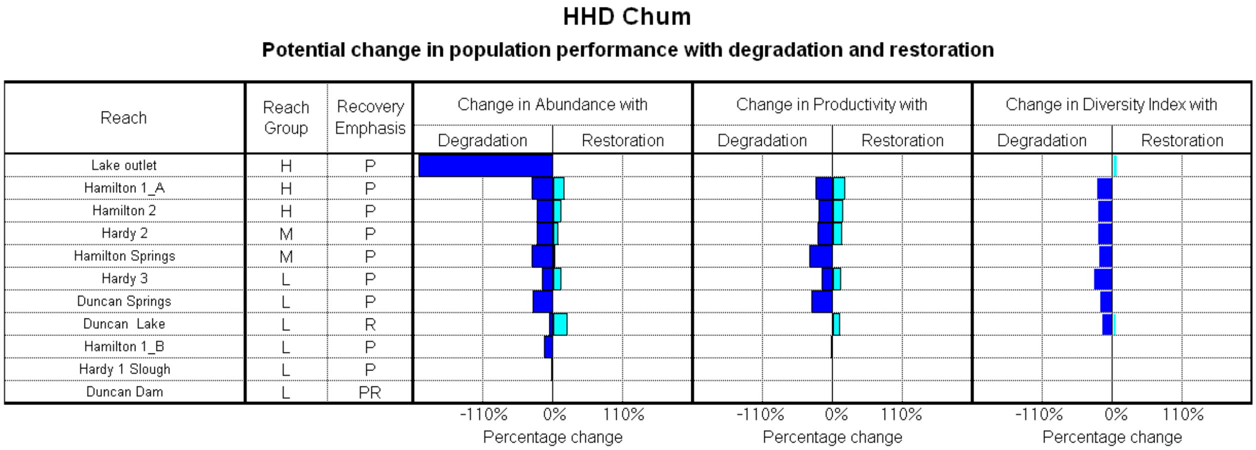


Figure 14-27. Bonneville Tributaries chum ladder diagram.

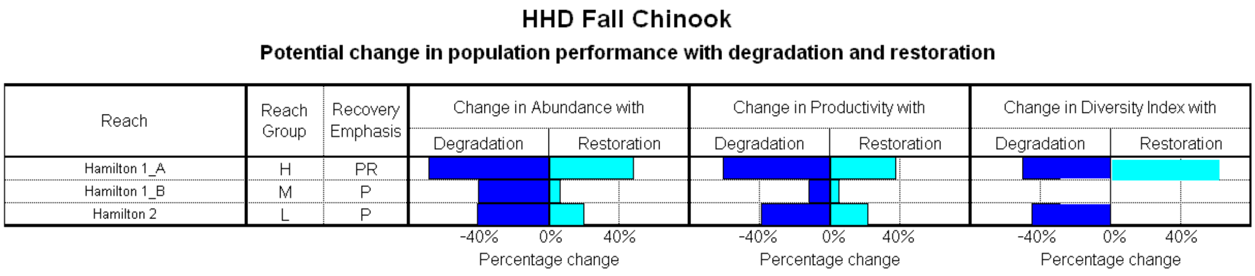


Figure 14-28. Bonneville Tributaries fall chinook ladder diagram.

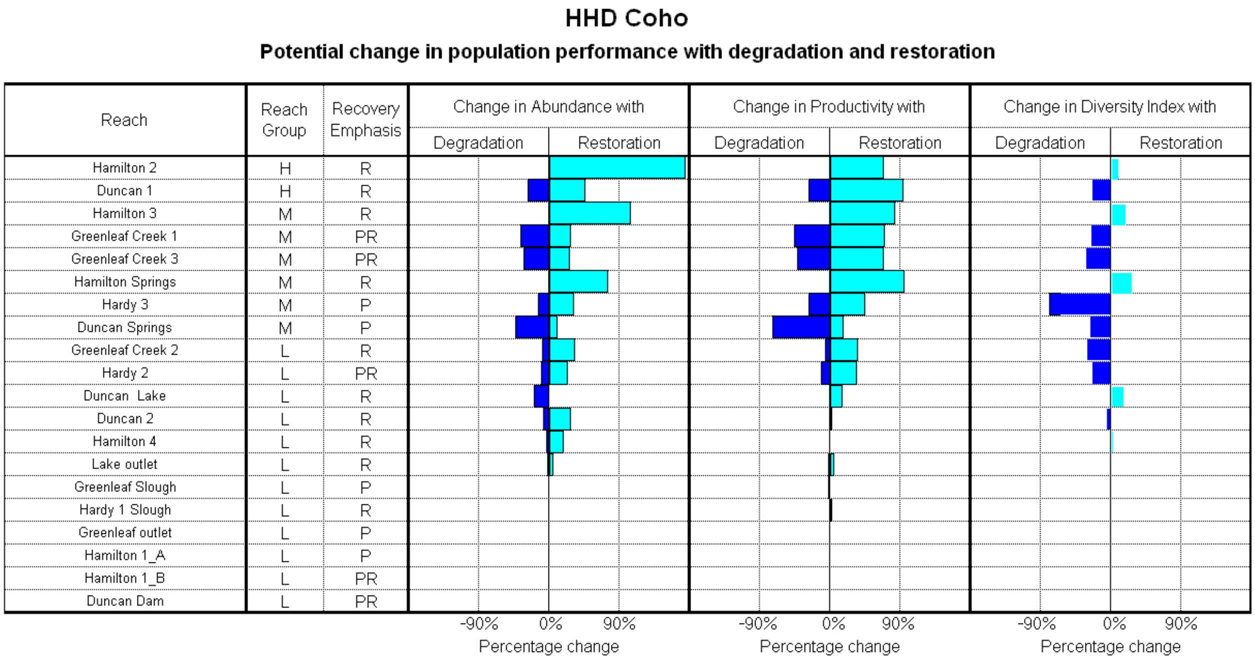


Figure 14-29. Bonneville Tributaries coho ladder diagram.

14.6.2.3 Habitat Factor Analysis

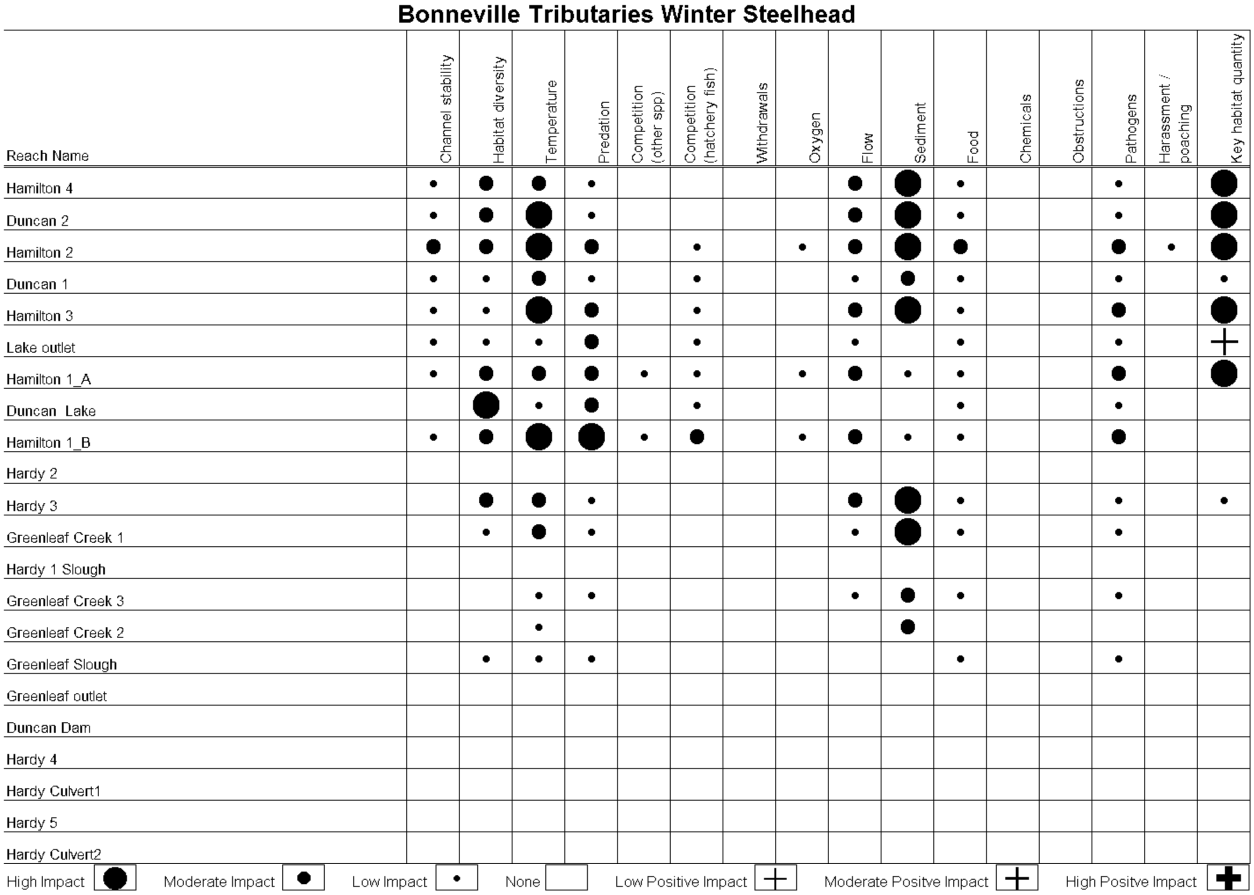
The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

In the priority areas for winter steelhead, key habitat, sediment, and temperature have the largest impacts (Figure 14-30). Key habitat has been reduced by loss of side channels and by subsurface flow conditions that reduce available summer rearing and holding habitat. Sediment, which originates primarily from upper basin sources, settles out in these low gradient reaches, impacting egg incubation and fry emergence. Flow alterations are also due to upper basin conditions, whereas temperature concerns are related to a lack of shade from riparian tree canopies.

For chum, the important reaches have suffered negative impacts from a loss of habitat diversity, loss of key habitat, increased sedimentation, and harassment (Figure 14-31). A lack of riparian function and low LWD levels contribute to habitat diversity problems. Sediment and key habitat impacts are similar to those discussed above for steelhead. There are no impacts in the Lake Outlet reach because this reach is most important for preservation.

All reaches modeled for fall chinook were in Hamilton Creek. These areas have been negatively impacted by a loss of key habitat, increased sediment, and altered temperature regimes (Figure 14-32). As with steelhead, habitat diversity and key habitat are low due to low quantities of instream LWD and channel incision/floodplain disconnection. Sediment impacts originate primarily from upstream hillslope and channel sources. Temperature alteration is due to a lack of riparian shading and increased channel widths.

Important reaches for coho are located in Hamilton, Duncan, and Greenleaf Creeks. A suite of factors has negatively impacted these areas, including impairments related to sediment, key habitat, temperature, flow, food, and habitat diversity (Figure 14-33). The causes of these impacts are similar to those discussed above for winter steelhead.



Bonneville Tributaries Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Hamilton 4	•	●	●	•					●	⬤	•			•		⬤
Duncan 2	•	●	⬤	•					●	⬤	•			•		⬤
Hamilton 2	●	●	⬤	●		•		•	●	⬤	●			●	•	⬤
Duncan 1	•	•	●	•		•			•	●	•			•		•
Hamilton 3	•	•	⬤	●		•			●	⬤	•			●		⬤
Lake outlet	•	•	•	●		•			•		•			•		+
Hamilton 1_A	•	●	●	●	•	•		•	●	•	•			●		⬤
Duncan Lake		⬤	•	●		•					•			•		
Hamilton 1_B	•	●	⬤	⬤	•	●		•	●	•	•			●		
Hardy 2																
Hardy 3		●	●	•					●	⬤	•			•		•
Greenleaf Creek 1		•	●	•					•	⬤	•			•		
Hardy 1 Slough																
Greenleaf Creek 3			•	•					•	●	•			•		
Greenleaf Creek 2			•							●						
Greenleaf Slough		•	•	•							•			•		
Greenleaf outlet																
Duncan Dam																
Hardy 4																
Hardy Culvert1																
Hardy 5																
Hardy Culvert2																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✚ High Positve Impact ➕

Figure 14-30. Bonneville Tributaries winter steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Bonneville Tributaries Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lake outlet																
Hamilton 1_A	•	⬤	•	●	•				●	●	●				⬤	⬤
Hamilton 2	•	⬤	•						•	●	•				⬤	⬤
Hardy 2	•	⬤		●	•				•	●	•					✛
Hamilton Springs																
Hardy 3	•	⬤							●	●	•					⬤
Duncan Springs																
Duncan Lake	•	●	+	●	•				•	⬤	●			●	⬤	✚
Hamilton 1_B																
Hardy 1 Slough										•						
Duncan Dam																

High Impact ⬤ Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 14-31. Bonneville Tributaries chum habitat factor analysis.

Bonneville Tributaries Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Hamilton 1_A	•	●	⬤	•	•			•	•	⬤	•				•	⬤
Hamilton 2	•	•	●						•	●	•				•	●
Hamilton 1_B	•	•		•	•				•	•	•					

High Impact ⬤ Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 14-32. Bonneville Tributaries fall chinook habitat factor analysis.

Bonneville Tributaries Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Hamilton 2	●	⬤	⬤	•		●		•	⬤	⬤	●			•	•	⬤
Duncan 1	•	●	●	•		●			●	⬤	●			•		●
Hamilton 3	●	•	⬤	•		●			●	⬤	●			•		●
Greenleaf Creek 1	•	•	●	•		•			●	⬤	●					•
Greenleaf Creek 3	•	•	●	•		•			●	⬤	●			•		•
Hamilton Springs									⬤		⬤					●
Hardy 3	•	●	●						●	●	•					●
Duncan Springs				•		●			•		●			•		
Greenleaf Creek 2	•	●	●			•			●	●	●					●
Hardy 2	•	●	•	●	•				•	●	•			•		•
Duncan Lake																
Duncan 2	•	●	●						•	●	•					●
Hamilton 4	•	●	•						•	•	•					●
Lake outlet		•		•												
Greenleaf Slough																
Hardy 1 Slough										•						
Greenleaf outlet																
Hamilton 1_A																
Hamilton 1_B																
Duncan Dam																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ＋ High Positve Impact ✚

Figure 14-33. Bonneville Tributaries coho habitat factor analysis.

14.7 Integrated Watershed Assessment (IWA)

The Lower Columbia Tributaries Subbasin includes two principal recovery planning watersheds evaluated in the IWA analysis. The Salmon Creek/Lake River watershed includes Salmon Creek, Burnt Bridge Creek, and other minor tributaries to the Lake River. The Bonneville Tributaries watershed is comprised of several independent tributaries to the Columbia River, including Hamilton Creek, Hardy Creek, and Duncan Creek. The IWA analysis for the Salmon Creek/Lake River watershed is discussed below. The Bonneville Tributaries analysis is discussed in section 14.7.2.

14.7.1 Salmon Creek/Lake River

The Salmon Creek/Lake River watershed (Salmon Creek watershed hereafter) is the major drainage in a system of several smaller drainages entering the Lake River, which is a low-lying, tidally influenced system that parallels the Columbia River within and to the north of the Vancouver city limits. Other drainages entering the Lake River system include Burnt Bridge Creek, Whipple Creek, and Flume Creek. The majority of this area is within or immediately surrounding the cities of Vancouver, Battle Ground, and Camas. Much of the area is extensively developed for commercial, industrial, and residential uses. Lower Burnt Bridge Creek is fed by springs that historically provided valuable spawning habitat for chum salmon, and may have the potential to support a reintroduced run in the future.

14.7.1.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Salmon Creek watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 14-3. A reference map showing the location of each subwatershed in the basin is presented in Figure 14-34. Maps of the distribution of local and watershed level IWA results are displayed in Figure 14-35.

Table 14-3. IWA results for the Salmon Creek watershed.

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
90101	M	M	I	M	M	90102, 90103, 90104, 90105, 90106, 90107, 90108, 90109, 90110, 90111, 90112, 90113, 90114, 90115, 90116, 90117, 90118, 90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130, 90131, 90132, 90133, 90134
90102	I	M	I	I	M	none
90103	I	F	I	M	M	90133
90104	M	M	M	M	M	90106, 90107, 90108, 90109, 90110, 90111, 90112, 90113, 90115, 90116, 90117, 90118
90105	I	F	I	I	F	none
90106	I	M	I	M	M	90107, 90108, 90109, 90110, 90111, 90112, 90113, 90116, 90117, 90118
90107	I	M	I	M	M	90108, 90109, 90111, 90112, 90113, 90118
90108	I	M	I	I	M	90109, 90112, 90113
90109	I	M	M	I	M	none
90110	M	M	I	M	M	none
90111	M	M	I	M	M	none
90112	I	M	M	I	M	none
90113	I	M	I	I	M	none
90114	M	F	I	I	F	90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130
90115	I	M	I	I	M	none
90116	I	F	I	I	F	none
90117	I	F	M	I	F	none
90118	I	M	I	I	M	none
90119	I	M	I	I	M	none
90120	M	M	I	I	F	90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
90121	I	F	I	I	F	none
90122	I	M	I	I	M	none
90123	I	F	I	I	F	90124, 90125, 90126, 90127, 90128, 90129, 90130
90124	I	F	I	I	F	90125, 90126, 90127, 90128, 90129, 90130
90125	I	F	I	I	F	90126, 90127
90126	I	M	ND	I	F	90127
90127	I	F	ND	I	F	none
90128	I	F	I	I	F	none
90129	I	F	ND	I	F	90130
90130	I	F	ND	I	F	none
90131	M	F	I	M	F	90105, 90114, 90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130
90132	I	M	I	I	M	none
90133	I	M	M	I	M	none
90134	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired
ND:	Not evaluated due to a lack of data

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

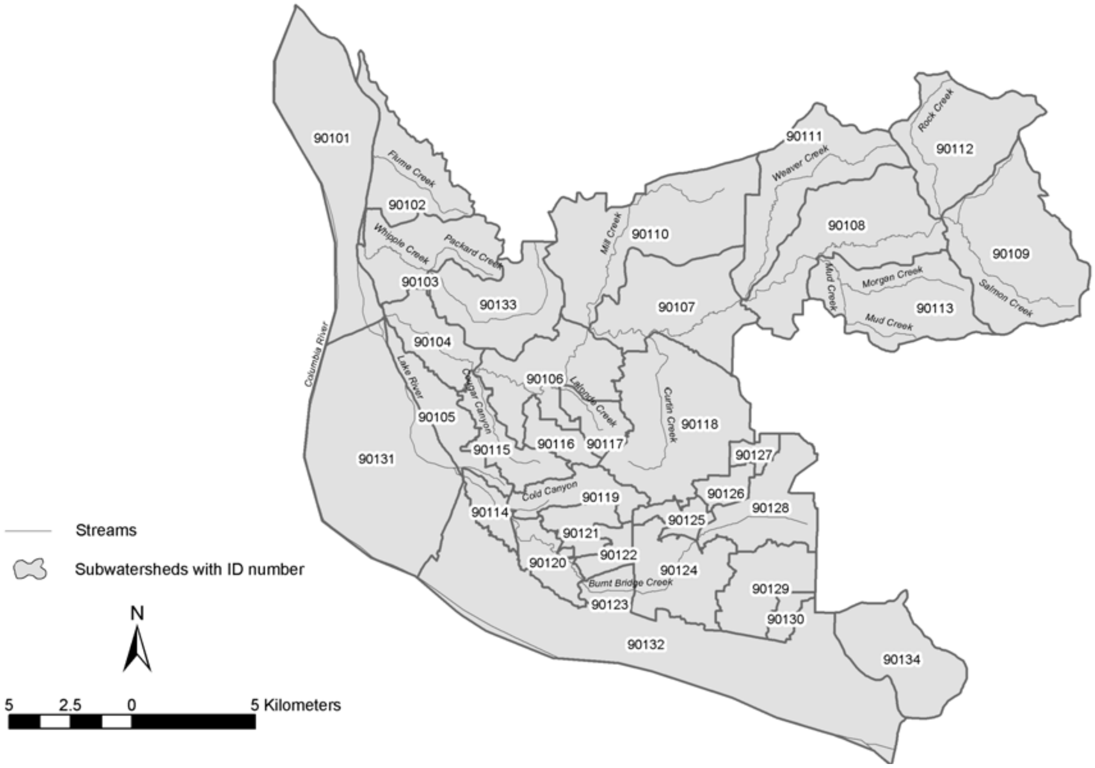


Figure 14-34. Map of the Lake River / Salmon Creek watershed showing the location of the IWA subwatersheds.

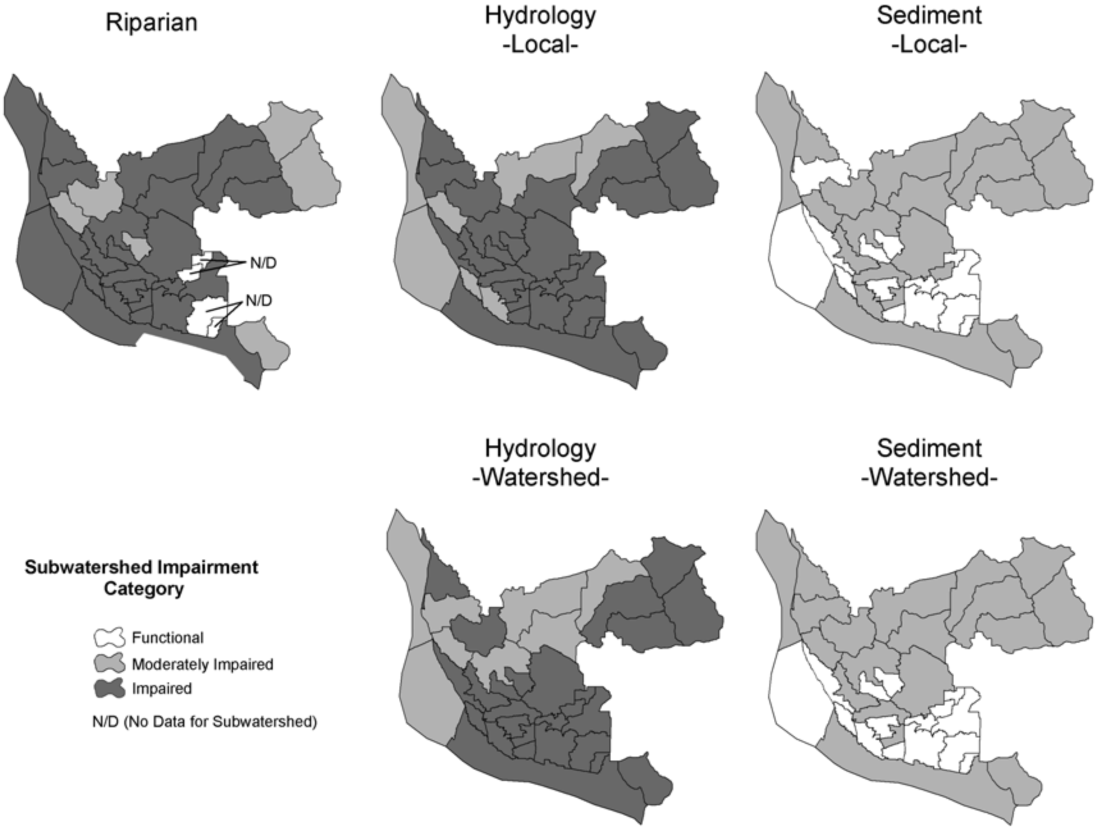


Figure 14-35. IWA subwatershed impairment ratings by category for the Lake River / Salmon Creek watershed.

Hydrology

The Salmon Creek watershed is primarily a low elevation, rain-dominated system, with the headwaters reaching an elevation of 1,998 ft. Total area of the watershed in the rain-on-snow zone is minimal. Because of the high levels of impervious surface, low levels of hydrologically mature forest cover, and high road densities found in this predominately developed area, local and watershed level hydrologic conditions are generally impaired throughout the majority of the watershed. No subwatershed was considered hydrologically functional at the local or watershed level.

Moderately impaired local and watershed level hydrology conditions are present in Mill Creek (90110), Weaver Creek (90111), and the lower mainstem of Salmon Creek (90104). Two additional subwatersheds along the Salmon Creek mainstem (90107 and 90106) are hydrologically impaired at the local level but only moderately impaired at the watershed scale, suggesting that Weaver and Mill Creeks are buffering downstream conditions to some degree. These mainstem Salmon Creek subwatersheds (90107 and 90106) are rated as moderately impaired because of currently low levels of impervious surface. The upper mainstem and headwaters of Salmon Creek (90108 and 90109) and headwater tributaries Rock Creek (90112) and Morgan Creek (90113) are all rated as hydrologically impaired at both the local and watershed level. These ratings are driven by high current levels of impervious surface, low levels of hydrologically mature forest cover (averaging 10%), and high road densities (exceeding 10 mi/sq mi). Approximately 20% of the Rock Creek and Salmon Creek headwaters subwatersheds are public lands, while an average of 15% of the lower Salmon Creek subwatersheds (90104 and 90106) are in public ownership. Other subwatersheds average less than 5% public ownership. Public lands are comprised primarily of state lands (WDNR) or county parks and open space.

Hydrologic conditions in lower Burnt Bridge Creek (90120 and 90114) are rated as moderately impaired at the local level; the rating is attributable to relatively small subwatershed area, lower impervious surface area, and some park lands. These subwatersheds are rated as impaired at the watershed level because of high levels of impervious surface in contributing upstream subwatersheds, including middle and upper Burnt Bridge Creek (90123, 90124, 90125 and 90128), as well as several contributing storm drainage basins (90126, 90127, 90190 and 90130). The Burnt Bridge Creek drainage lies entirely within the Vancouver city limits and is extensively developed.

In the Lake River mainstem, hydrologic conditions are strongly influenced by tidal fluctuations in the Columbia River. Subwatersheds 90101 and 90131 are rated moderately impaired at the local and watershed level and may be partially buffered by contributing upstream subwatersheds.

Sediment

Natural erodability rates in the Salmon Creek watershed are quite high relative to the rest of the region, with 12 of 34 exceeding a rating of 50 or greater on a scale of 0-126. One subwatershed (90116) within the Vancouver city limits has the highest natural sediment supply rating in the region (126). Sediment conditions are generally rated as moderately impaired at the local level, with the exception of some of the more heavily developed subwatersheds within the Vancouver city limits, which are rated as functional. None were rated as impaired.

The sediment results must be considered relative to the high natural erodability present. The threshold for impaired sediment conditions is a change in the erodability index under developed or disturbed conditions greater than 3 times the natural erodability index. Reaches within or downstream of subwatersheds with very high natural erodability levels that are rated moderately impaired or even functional may still be subject to considerable sediment loading, particularly in subwatersheds that are hydrologically impaired.

Sediment conditions in the Salmon Creek drainage are rated as moderately impaired throughout the majority of the system. Two small tributaries, Lalonde Creek and one unnamed stream (90117 and 90116), are rated as functional for sediment. However, given the very high natural sediment supply rates in these subwatersheds, 100 and 126, respectively, on a scale of 0-126, and the likelihood of impaired hydrologic conditions, these subwatersheds are likely to be contributing significant sediment loading to the lower mainstem of Salmon Creek.

Factors contributing to moderately impaired sediment ratings throughout the Salmon Creek drainage include high road densities and high levels of natural erodability. Because the majority of roads in the lower elevation areas of the drainage are surfaced and generally maintained, roads are considered to be less of a source of sediment supply than bank erosion from disrupted hydrologic conditions. In addition, the relatively flat topography of the Salmon Creek watershed mitigates impaired sediment conditions somewhat despite the extensive modifications of the landscape. However, the high natural erodability rates, in combination with impaired hydrologic conditions, suggest the potential for high levels of sedimentation from channel incision and bank erosion. This potential is confirmed by observed conditions (Wade 2001). High road densities in sensitive areas in headwaters contribute to moderately impaired ratings. Streamside road densities are particularly high in the Salmon Creek headwaters (90109, >0.8 miles/stream mile) and Rock Creek (90112). Unsurfaced streamside roads that are highly traveled are likely to be significant sources of sediment.

Sediment conditions in most of the Burnt Bridge Creek subwatersheds are rated as functional, despite high natural erodability. The functional ratings result from flat topography and surfaced and well maintained roads. As discussed above for Salmon Creek however, the IWA sediment analysis will underestimate the effects of increased peak flows from high levels of impervious surface on local bank erosion rates in areas with high natural erodability. Therefore, given the conditions observed in the Burnt Bridge Creek system, the functionality of sediment conditions are believed to be overestimated in this system. This is confirmed by observed conditions in the drainage (Wade 2001).

Riparian

Riparian conditions are rated moderately impaired or impaired in all 30 modeled subwatersheds. The majority of these (24 of 30) are rated as impaired, with moderately impaired ratings in the Salmon Creek headwaters (90109, 90112), Burnt Bridge Creek (90134), Whipple Creek (90133), Lalonde Creek (90117), and the lower mainstem (90104). Poor riparian conditions are related to urban, residential, and agricultural development.

Riparian conditions in Salmon Creek are moderately impaired to impaired across all subwatersheds, with the greatest impairments in the middle of the drainage. The mouth of Salmon Creek (90104), Lalonde Creek (90117), Rock Creek (90112) and Salmon Creek headwaters (90109) are moderately impaired. Lower Salmon Creek (90106) and middle Salmon Creek (90107, 90108) are rated as impaired.

Riparian conditions in the Burnt Bridge Creek drainage are rated as impaired. Riparian conditions in the independent drainages to the Columbia River are moderately impaired to impaired. Extensive development limits the potential for riparian recovery.

14.7.1.2 Predicted Future Trends

Hydrology

A portion of the Salmon Creek mainstem subwatersheds (90107, 90106) lie within the urban growth boundary of Battle Ground, and greater than 80% of these subwatersheds are zoned for development but are currently vacant. Given the likelihood for increasing development in these and other nearby subwatersheds (90104, Mill Creek 90110, and Weaver Creek 90111), the predicted trend for hydrologic conditions is to degrade further over the next 20 years.

Given the current level of and likelihood for further development, the predicted trend is for hydrologic conditions in Burnt Bridge Creek to continue to degrade.

Two hydrologically impaired subwatersheds (90134 and 90132) drain the southern portion of the watershed via steep bluffs into the mainstem Columbia River. While these subwatersheds do not support significant numbers of fish, groundwater from this area feeds springs in the mainstem Columbia that are spawning grounds for chum salmon (Wade 2001). Given the potential for development in and around Vancouver, the predicted trend in hydrologic conditions in these subwatersheds is for further degradation.

Sediment Supply

Given the potential for expanding development in the Salmon Creek drainage, the predicted trend for sediment conditions is to degrade further, particularly downstream from headwaters areas where steeper slopes are prevalent.

Given the extent of current development and the likelihood of increasing development in currently zoned areas, the predicted trend for sediment conditions in the Burnt Bridge Creek drainage is to degrade further over the next 20 years.

Riparian Condition

While development is likely to expand in all subwatersheds in the Salmon Creek drainage, existing riparian vegetation will generally be protected under existing critical areas ordinances. Given this assumption and the extent of existing development, riparian vegetation is predicted to trend stable across all impaired subwatersheds. In the moderately impaired headwaters subwatersheds, some potential for riparian recovery exists on less developed lands and publicly owned lands. However, this potential may be offset by expanding development, even under existing regulations. Given this potential, riparian conditions in the headwaters subwatersheds are predicted to trend stable, with gradual improvement in some areas.

Given the extensive development of the Burnt Bridge Creek drainage and the potential for development within existing management constraints, riparian conditions in this drainage are predicted to trend stable over the next 20 years. Similar to hydrology and sediment, given the potential for expanding development in the independent drainages to the Columbia River, riparian conditions are also predicted to trend stable.

14.7.2 Bonneville Tributaries

The Bonneville Tributaries watershed includes several small independent tributaries to the Columbia River to the east of the Washougal River. These streams include Hamilton, Hardy, Duncan, Lawton, and Gibbons Creeks. For the purpose of the IWA analysis, the Bonneville Tributaries watershed is comprised of seven LCFRB recovery planning subwatersheds, with the three most productive drainages for salmonids (i.e. Hamilton, Hardy, and Duncan Creeks) located in the eastern half of the watershed.

The primary drainages in the Bonneville Tributaries watershed are transitional, moving from snow-dominated highlands in the east, through the rain-on-snow zone, to rain dominated lowlands in the west. Overall drainage areas are small, ranging from 6,000 to 15,000 acres. Natural erodability rates range from low to moderate-low (7-28 on a scale of 0-126), with the higher erodability rates associated with low-lying, alluvial areas. Hydrologically mature forest coverage varies across the area, ranging from an average of 39% in Hamilton, Hardy, and Duncan Creeks, to less than 10% in the remaining western drainages. Historical fires in the region, and the presence of maintained powerline right of ways influence the extent of current forest cover. Land ownership also varies broadly, with 34% of the primary drainages in public ownership. Upper Hamilton Creek exceeds 50% public ownership, while only 11% of lands in the western three subwatersheds are publicly owned. Two of these, Gibbons Creek and Lawton Creek, have a significant proportion of area zoned for development (56% and 22%, respectively), but these subwatersheds do not support significant fish bearing streams. No zoning data were available for the remaining subwatersheds, but the lower Hamilton Creek drainage lies adjacent to modestly developed areas in North Bonneville and Fort Rains.

14.7.2.1 *Results*

IWA results were calculated for all subwatersheds in the Bonneville Tributaries watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). IWA results for each subwatershed are presented in Table 14-4. A reference map showing the location of each subwatershed in the basin is presented in Figure 14-36. Maps of the distribution of local and watershed level IWA results are displayed in Figure 14-37.

Table 14-4. IWA results for the Bonneville Tributaries basin

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
70101	M	M	M	M	M	70102
70102	F	M	F	F	M	none
70201	I	M	M	I	M	none
70202	I	M	M	I	M	none
70301	M	M	M	M	M	none
70401	M	M	M	M	M	none
70402	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

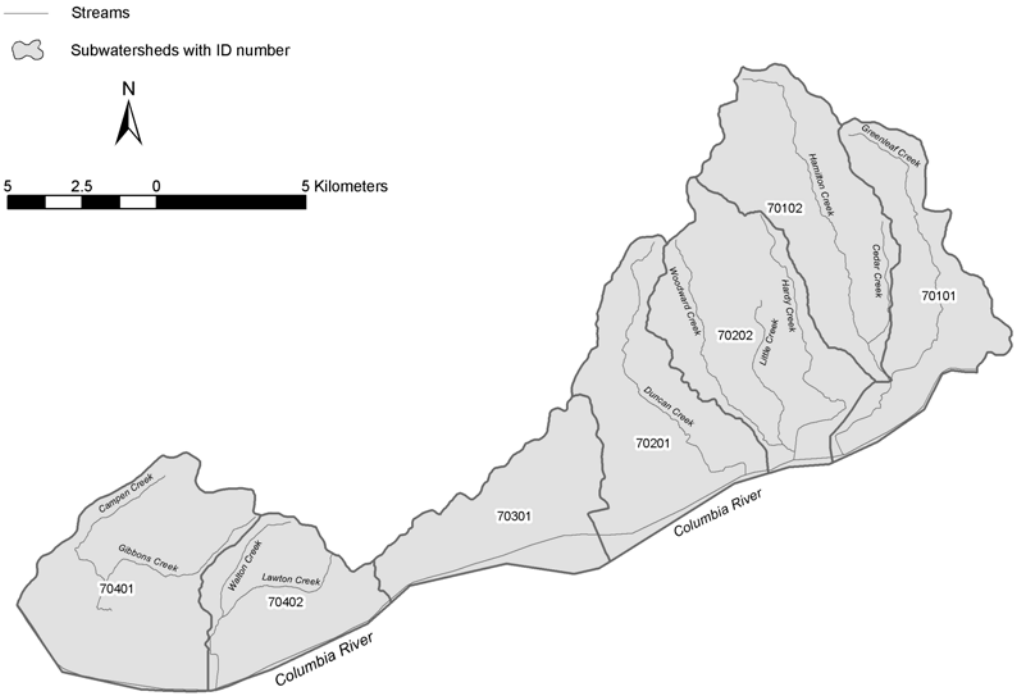


Figure 14-36. Map of the Bonneville Tributaries watershed showing the location of the IWA subwatersheds

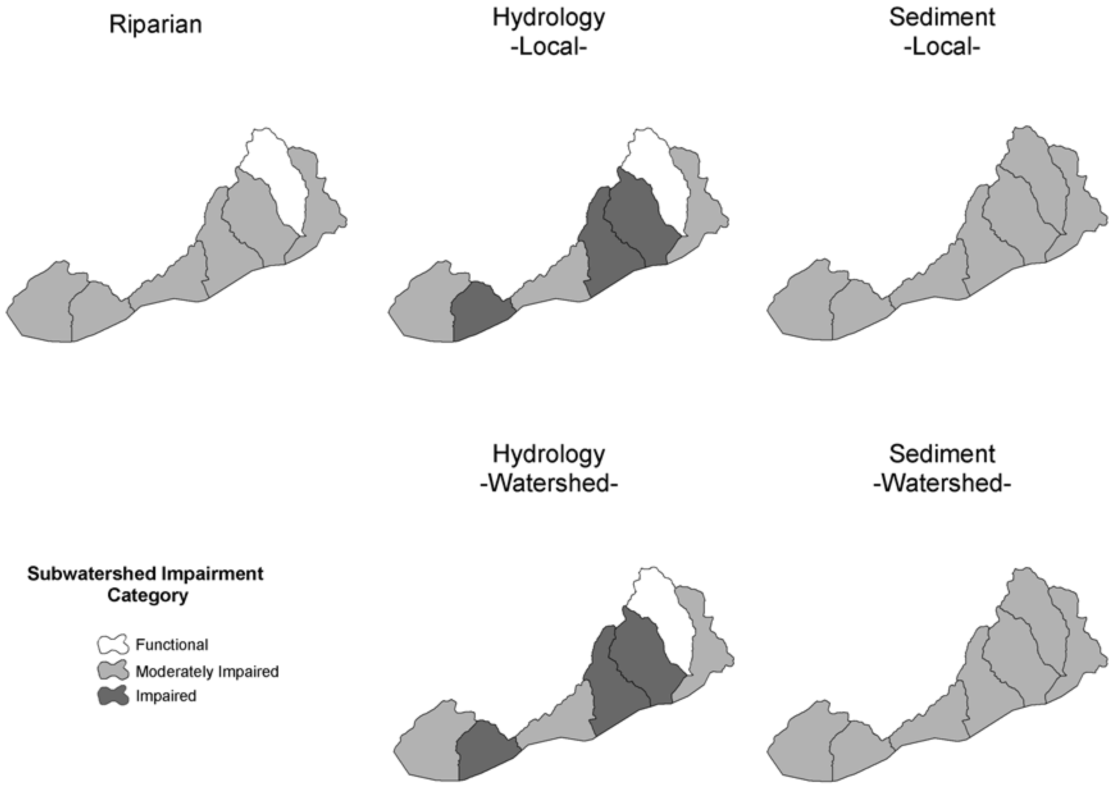


Figure 14-37. IWA subwatershed impairment ratings by category for the Bonneville Tributaries basin

Hydrology

The upper Hamilton Creek subwatershed (70102) is rated as functional for hydrology, with the remaining six subwatersheds split equally between moderately impaired and impaired ratings. Except for lower Hamilton Creek (70101), all subwatersheds in the area are terminal (i.e., having no upstream subwatersheds); thus, the watershed level results are the same as the local level results.

Functional hydrology conditions in upper Hamilton Creek are driven by relatively extensive mature forest coverage (64%) and moderate road densities (2.0 mi/sq mi). Impervious surface areas are low in this lightly developed area. Over half (53%) of upper Hamilton Creek is in public lands, administered by WDNR and Beacon Rock State Park.

Hydrologic conditions are rated moderately impaired in the lower Hamilton/Greenleaf Creek subwatershed (70101). Lower Hamilton Creek is rated as moderately impaired, based on moderate mature forest coverage levels (43%) and moderately high road densities (4.2 mi/sq mi). Roads in the lower Hamilton Creek/Greenleaf Creek subwatershed are concentrated around the Bonneville Dam facilities, which are located in the low lying areas of the watershed. Road densities in the upland areas of this subwatershed are considerably lower. Thus, the moderately impaired hydrology rating for subwatershed 70101 most likely overstates actual conditions, which may be closer to functional. In the lower Hamilton/Greenleaf Creek subwatershed, 19% is publicly owned (WDNR, state parks, and USACE). Development and land use regulations are relatively strict in the Columbia Gorge National Scenic Area.

Hydrologic conditions in Hardy and Duncan Creeks (70201, 70202) are rated impaired. Duncan Creek subwatershed (70201) has low mature forest coverage (17%) and moderately high road densities (3.4 mi/sq mi). As with lower Greenleaf Creek, a significant portion of road length in these subwatersheds are concentrated in the low-lying areas adjacent to the Columbia River. Therefore, the hydrologic conditions rating may overstate actual conditions, which may lean more towards moderately impaired. Several powerline right of ways traverse these drainages, affecting forest cover.

Hydrologic conditions in Lawton Creek subwatershed (70402) are impaired and are moderately impaired in Gibbons Creek (70401) and in 70302. Impairments here are related to young forests and high road densities (>3 miles/mi2).

Sediment

Sediment conditions in the Bonneville Tributaries watershed are rated as moderately impaired. As with hydrology, local and watershed level impairments are the same.

Erodability ratings for upper Hamilton Creek (70102) are low, whereas lower Hamilton/Greenleaf Creek (70101) is rated moderately low (7 and 26, respectively, on a scale of 0-126). The sediment supply rating for upper Hamilton Creek is borderline functional, only slightly above the threshold for a moderately impaired rating. Ratings for lower Hamilton/Greenleaf Creek are driven by high road densities on erodable geology in the low lying areas. Sediment conditions in the uplands are expected to be similar to upper Hamilton Creek, leaning towards functional. Streamside roads, which represent a significant potential source of erosion, are relatively infrequent (averaging less than 0.2 miles/mile of stream). This average is skewed by the high concentration of roads adjacent to the Columbia River and associated with Bonneville Dam facilities. Averages in the upstream areas are probably closer to 0.1 miles/stream mile.

Sediment conditions in Hardy and Duncan Creeks (70201, 70202) are rated as moderately impaired. Natural erodability ratings in this drainage are moderately low. The moderately impaired ratings are primarily driven by high road densities on erodable geology in the lowlands. Upland areas of the drainage have higher road densities relative to Hamilton Creek, exceeding 3 mi/sq mi. Streamside road densities in Duncan Creek are moderately high, approaching 0.5 miles/stream mile. Again, this average is skewed somewhat by the high density of roads adjacent to the Columbia River.

Sediment supply conditions are moderately impaired in Lawton Creek (70402), Gibbons Creek (70401), and subwatershed 70301. Road densities exceed 3 mi/mi2 in 70402 and 70401.

Riparian

Riparian conditions range from functional to moderately impaired. Upper Hamilton Creek (70102) is the only subwatershed rated as functional. Riparian conditions in lower Hamilton and Greenleaf Creek (70101) and Duncan Creek (70201) are rated as moderately impaired. These conditions track well with the hydrologically mature forest cover in these subwatersheds. Moderately impaired riparian conditions in Gibbons and Lawton Creek subwatersheds (70401, 70402) are related to residential and agricultural development.

14.7.2.2 Predicted Future Trends

Hydrology

Given the relatively high percentage of public lands in upper Hamilton Creek and upper Greenleaf Creek, combined with the land management regulations of the CRGNSA, the extent of hydrologically mature forest coverage in subwatersheds 70101 and 70102 is expected to expand over time with only limited increases in road density and development. Hydrologic conditions are therefore predicted to trend towards gradual improvement as forest cover matures.

Given the land management regulations of the CRGNSA, the extent of hydrologically mature forest cover in Hardy and Duncan Creek subwatersheds (70201, 70202) is expected to expand over time with only limited increases in road density and development. Hydrologic conditions are therefore predicted to trend towards gradual improvement as forest cover matures.

Sediment Supply

Given the extent of state park lands within both Hamilton Creek subwatersheds (70101 and 70102) and the low likelihood of expanding development or increasing forest road densities, sediment conditions are expected to trend stable in these subwatersheds.

Based on the high road densities and higher proportion of unsurfaced roads in the upper areas of the Duncan and Hardy Creek subwatersheds (70201, 70702), sediment conditions are predicted to trend stable over the next 20 years.

Riparian Condition

Given the restrictive development regulations in the CRGNSA and the emphasis on restoration of riparian zones, riparian conditions in upper and lower Hamilton Creek, Duncan Creek, and Hardy Creek subwatersheds (70101, 70102, 70201, 70202) are predicted to trend towards improvement over the next 20 years. Conditions are expected to trend stable in Gibbons and Lawton Creek subwatersheds (70401, 70402).

14.8 References

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Volume II, Chapter 15
Washougal River Subbasin

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15.0 Washougal River Subbasin

15.1 Subbasin Description

15.1.1 Topography & Geology

The headwaters of the Washougal River lie primarily in Skamania County. The river flows mostly southwest through Clark County and enters the Columbia River at RM 121, near the town of Camas, Washington. The drainage area is approximately 240 square miles. The subbasin is part of WRIA 28.

The upper mainstem of the Washougal flows through a narrow, deep canyon until it reaches Salmon Falls at RM 14.5. Below this, the river valley widens, with the lower two miles lying within the broad Columbia River floodplain lowlands. Elevations range from 3,200 feet in the headwaters of Bear Creek to nearly sea level at the Columbia. Due to steep and rugged conditions in most of the basin, development is limited to the lower valley within the Columbia River floodplain. Fish passage was historically blocked to most anadromous fish except steelhead at Salmon Falls (RM 14.5) until a fish ladder was built there in the 1950s. Anadromous fish currently reach only as far as Dougan Falls at RM 21, although summer steelhead regularly negotiate the falls and continue further upstream.

Surface geology in the basin is comprised of volcanic material in the headwater areas and sedimentary material in the lower basin. Alluvium ranging from boulders to sand was deposited in areas north and east of Washougal during repeated catastrophic flooding of the Columbia River during late Pleistocene ice ages. The coarsest sediments were deposited close to the Columbia and finer sediments were deposited further inland. The sand and silt make up of the lower basin is Columbia River floodplain alluvium deposited in more recent times.

15.1.2 Climate

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation is 85 inches at the Skamania Hatchery (WRCC 2003). Winter temperatures seldom fall below freezing, resulting in low and transient volumes of snowfall.

15.1.3 Land Use/Land Cover

Most of the basin is forested and managed for timber production. Of the basin’s land area, 61% is privately owned and most of the remainder is State Forest land. A small portion of the upper basin lies within the Gifford Pinchot National Forest, comprising approximately 8% of the total basin area. Not including the Lacamas Creek basin, most of the private land is owned by private commercial timber companies, except for agricultural land in the lower river valleys, scattered rural residential development, and the urban areas in and around the towns of Washougal and Camas. The Lacamas Creek drainage is made up largely of private land in rural residential or agricultural uses, with the westernmost portion of the basin within the expanding Vancouver metropolitan area. The year 2000 population of the Lacamas Creek basin of 23,800 persons is expected to increase by 35,000 persons by 2020. The population of the remainder of the Washougal subbasin is expected to increase from 12,800 to 34,000 persons (LCFRB 2001). These substantial population increases reflect the eastward expansion of the Vancouver metropolitan area and may serve to increase impacts on watershed processes.

Past timber harvest and large fires (e.g. Yacolt Burn, 1902) have had lasting impacts to the forest vegetation across much of the basin. Residential development has increased dramatically in the Lacamas Creek basin and along the lower 20 miles of the Washougal and in the Little Washougal watershed. Commercial and industrial development dominates the lower basin within the Columbia River floodplain. Land use and land cover in the Washougal River subbasin are illustrated by Figure 15-1 and Figure 15-2. Figure 15-3 displays the pattern of landownership for the basin. Figure 15-4 displays the pattern of land cover / land-use.

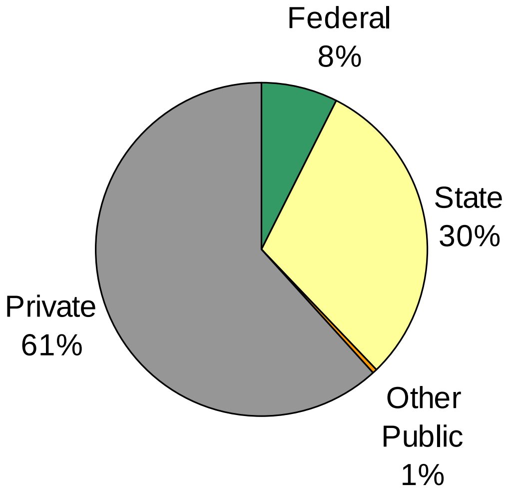


Figure 15-1. Washougal River subbasin land ownership

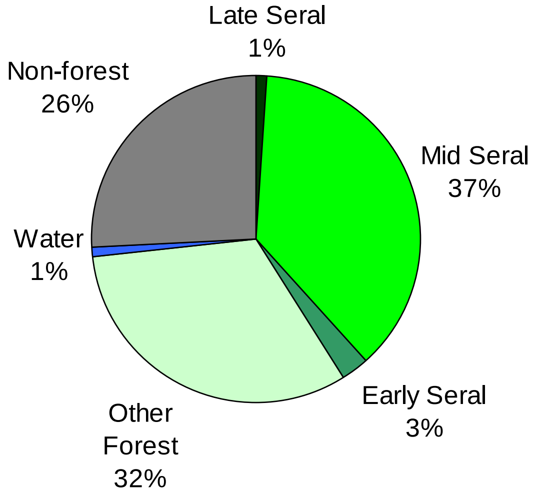


Figure 15-2. Washougal River subbasin land cover

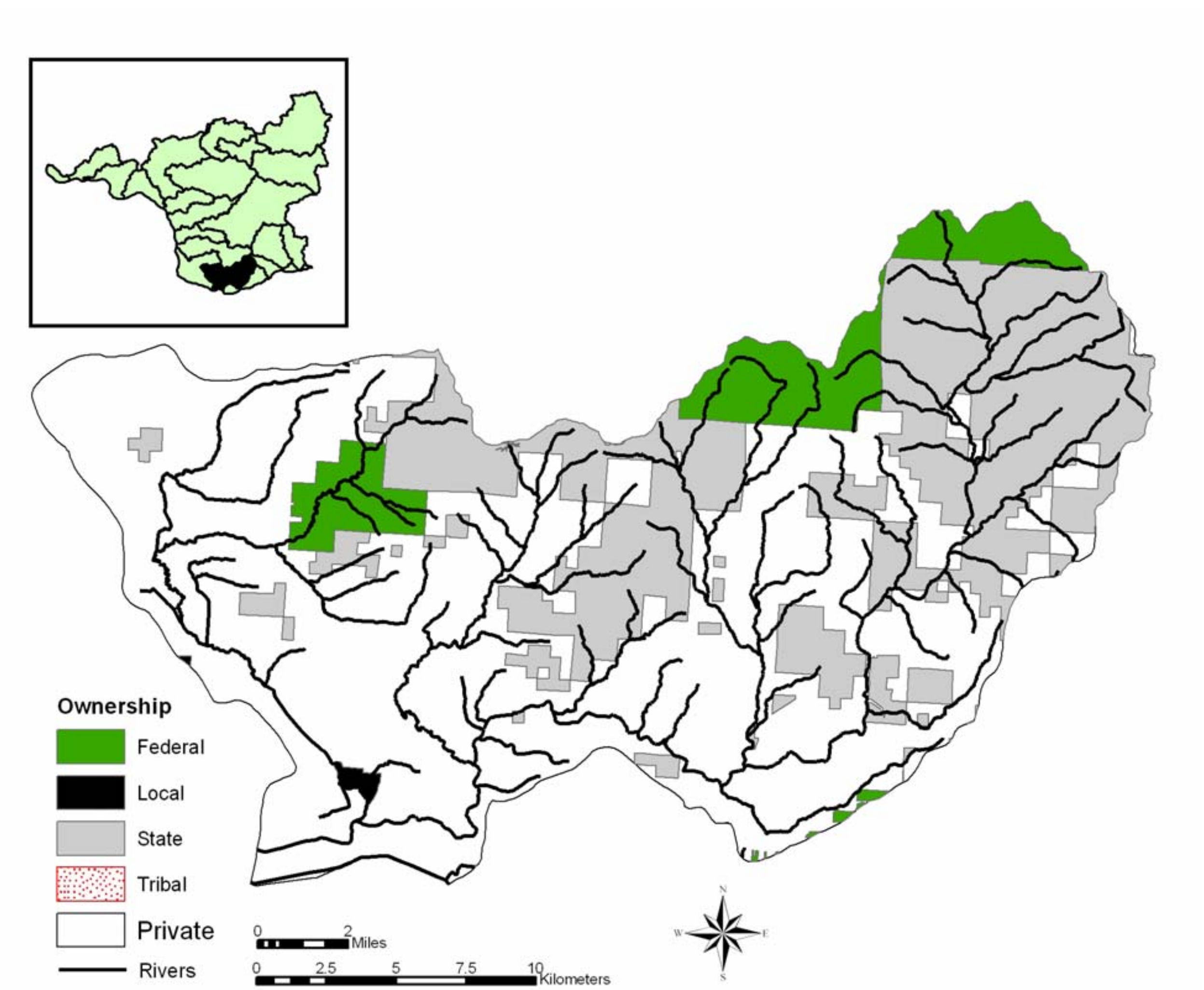


Figure 15-3. Landownership within the Washougal basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

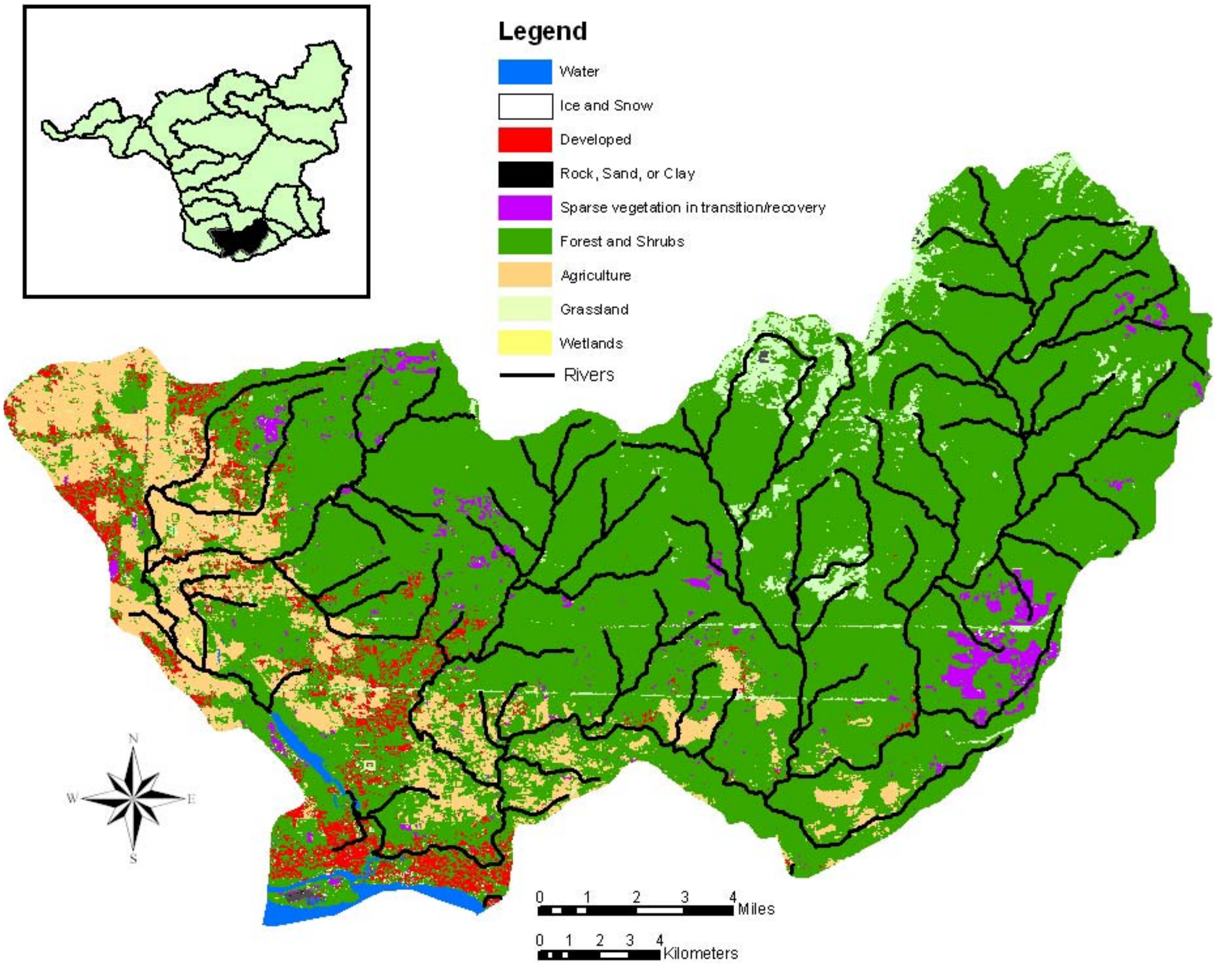
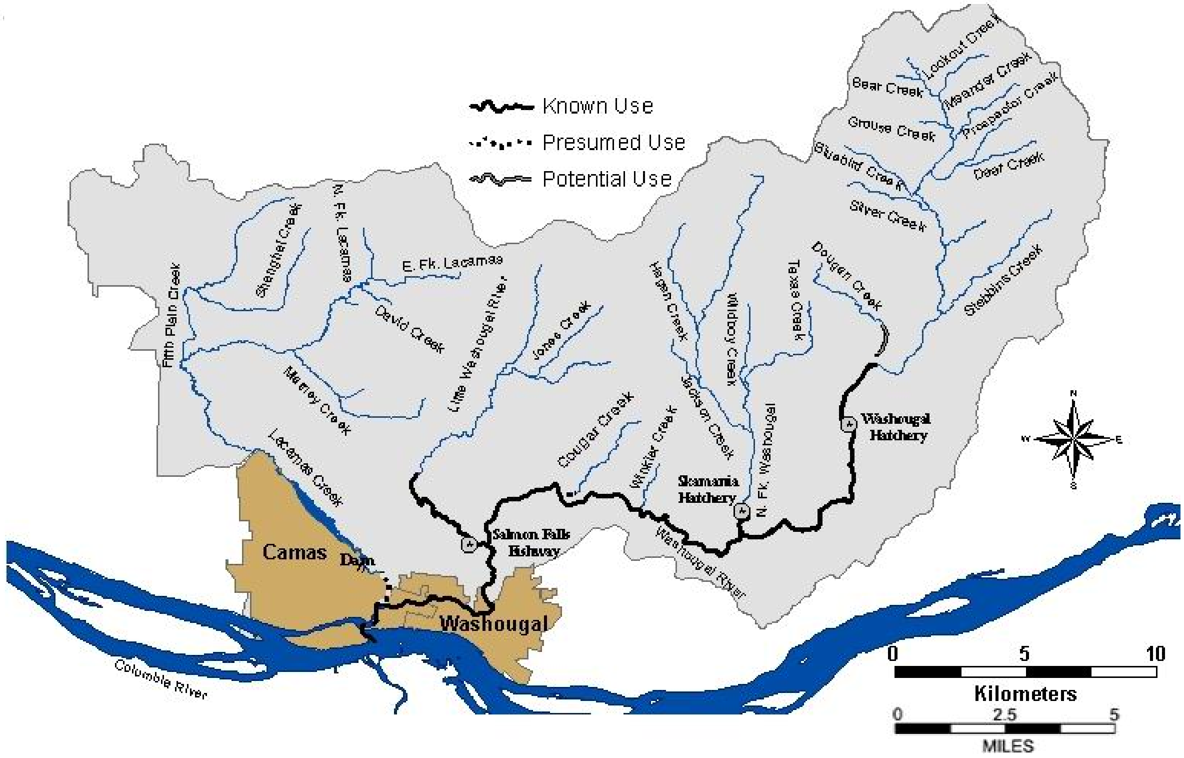


Figure 15-4. Land cover within the Washougal basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

15.2 Focal Fish Species

15.2.1 Fall Chinook—Washougal Subbasin

ESA: Threatened 1999	SASSI: Healthy 2002

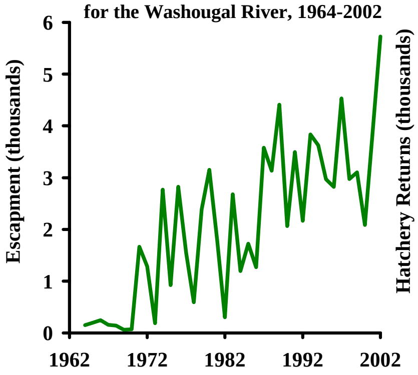


Distribution

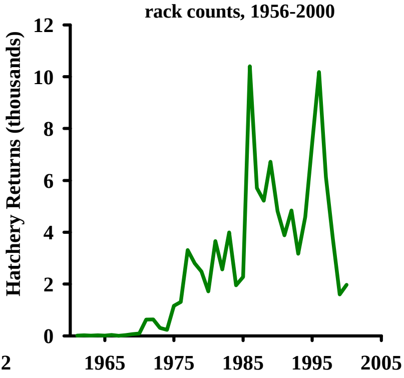
- Natural spawning occurs in the mainstem Washougal primarily between Salmon Falls Bridge (RM 15) and the fish and wildlife access area (~4 miles)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)
- Annual distribution of natural spawners in the mainstem Washougal is dependent on amount of rainfall from mid-September to mid-October

Life History

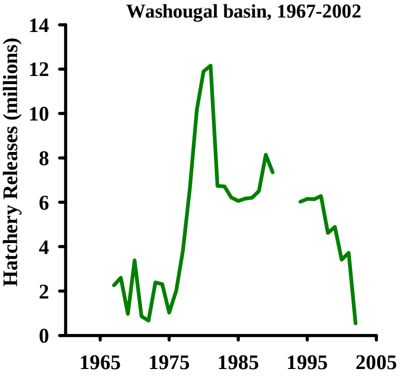
- Fall chinook upstream migration in the Washougal River occurs from late September to mid-November, depending on early rainfall
- Spawning in the Washougal River occurs between late September to mid-November
- Age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4 (averages are 24.8% and 55.2%, respectively)
- Fry emerge in March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings



Fall chinook spawner escapement estimates for the Washougal River, 1964-2002



Fall chinook Washougal River Hatchery rack counts, 1956-2000



Fall chinook hatchery releases in the Washougal basin, 1967-2002

Diversity

- Considered a tule population in the lower Columbia River Evolutionarily Significant Unit (ESU)
- The Washougal fall chinook stock designated based on distinct spawning distribution
- Genetic analyses of Washougal fall chinook in 1995 and 1996 indicated they are significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook

Abundance

- WDFW (1951) estimated fall chinook escapement to the Washougal basin was 3,000 fish
- Washougal River spawning escapements from 1964-2001 ranged from 70-4,669 (average 2,000)
- Hatchery production accounts for most fall chinook returning to the Washougal River

Productivity & Persistence

- NMFS Status Assessment for the Washougal River indicated a 0.0 risk of 90% decline in 25 years, 90% decline in 50 years, or extinction in 50 years
- A moderate level of natural production occurs, as illustrated by a WDFW estimate of 5,000,000 natural juvenile fall chinook emigrating from the Washougal basin in 1980
- Hatchery origin spawners that do not convert to the hatchery comprise a significant portion of the natural spawners
- The number of hatchery fish in the natural spawning population is increased in years when rain fall is not sufficient to provide river flows conducive for fish passage to the Washougal Hatchery

Hatchery

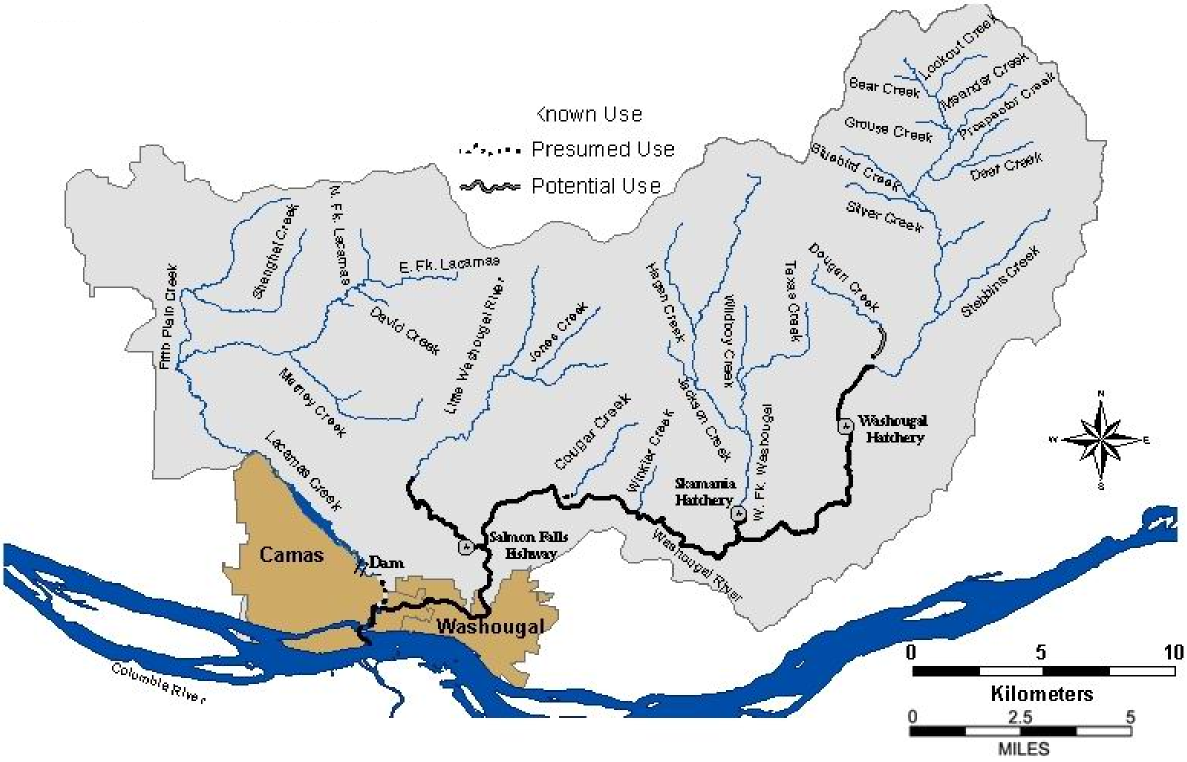
- The Washougal Hatchery (completed in 1958) is located about RM 16.0
- Hatchery releases of fall chinook in the Washougal basin began in the 1950s; numerous lower Columbia broodstock sources were used in the past for Washougal egg take
- Washougal Hatchery returns are generally spawned later than other Columbia River tule stocks; the later time developed over years of selection for the later timed fish because of conditions for passage to the hatchery often delayed until freshets in late October
- The current program releases 3.5 million fall chinook sub-yearlings annually; no outside basin stock have been used in recent years
- Washougal fall chinook releases are displayed for the years 1967-2002

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are important contributors to the Washington ocean sport and troll fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; the price is low compared to higher quality bright stock chinook
- Ocean and mainstem Columbia combined harvest is limited to 49% as a result of ESA limits on Coweemean tule fall chinook
- Current annual harvest rate dependent on management response to annual abundance in PSC (U.S/Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- Coded wire tag (CWT) data analysis of the 1989-1994 brood years indicates a Washougal fall chinook harvest rate of 28% during the mid 1990s
- The majority of 1989-94 brood Washougal fall chinook harvest occurred in Southern British Columbia (35.0%), Alaska (22%), Columbia River (16%), and Washington ocean (14%) fisheries
- Sport harvest in the Washougal River averaged 477 fall chinook annually from 1977-1987

15.2.2 Coho—Washougal Subbasin

ESA: Candidate 1995 **SASSI: Unknown 2002**

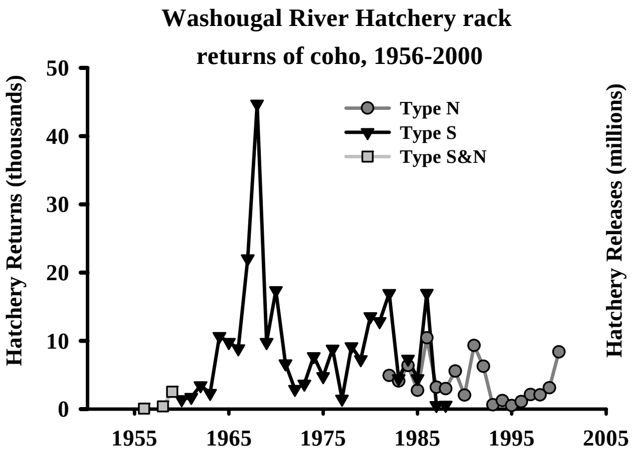


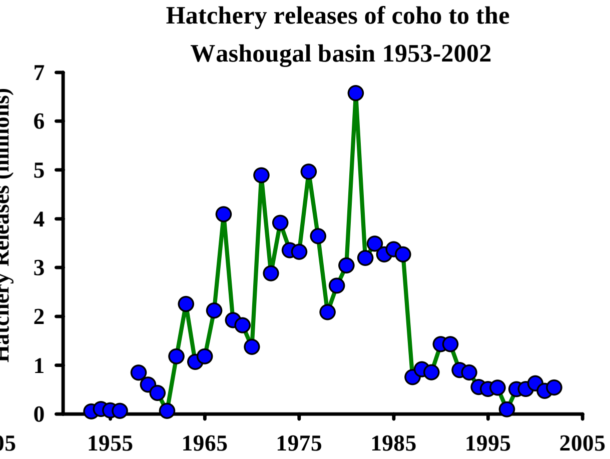
Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho, but principally in the Little Washougal River with 7.5 miles of stream area habitat
- The West Fork Washougal River and Winkler Creek are also potential production areas
- The mainstem Washougal is not a primary coho spawning area but has some production potential downstream of Salmon Falls (RM 17.5)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)

Life History

- Adults enter the Washougal River from early September and continue through December
- Peak spawning for early stock occurs in mid-October to November
- Peak spawning for late stock occurs in December and January
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in late winter/early spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring


Washougal River Hatchery rack returns of coho, 1956-2000


Hatchery releases of coho to the Washougal basin 1953-2002

Diversity

- Late stock coho (or Type N) were historically produced in the Washougal basin with spawning occurring from late November to March
- Early stock coho (or Type S) were also historically produced in the Washougal basin but in less numbers then the late stock
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Washougal River wild coho run is a fraction of its historical size
- In 1949, it was estimated that the Washougal had spawning area for 6,000 pair of salmon; 5,000 below Salmon Falls and 1,000 between Salmon and Dougan Falls
- In 1951, WDF estimated coho escapement to the basin was 3,000 fish
- Hatchery production accounts for most coho returning to the Washougal River

Productivity & Persistence

- Natural coho production is presumed to be very low
- Coho production limited to lower river tributaries downstream of Dougan Falls
- Natural production of coho has persisted at low levels in the Little Washougal River

Hatchery

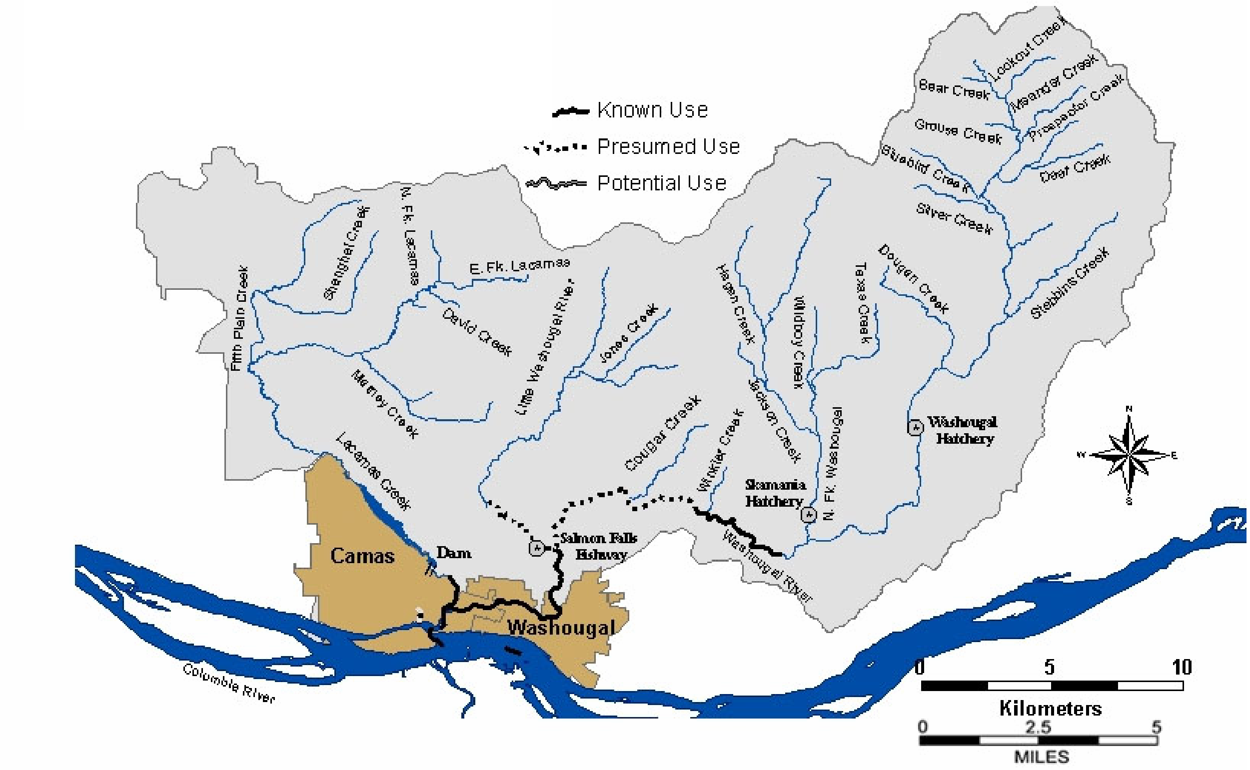
- The Washougal Hatchery (completed in 1958) is located about RM 16.0. Hatchery has produced early and late coho in the past but current program produces only late stock
- Coho have been planted in the Washougal basin since 1958; extensive hatchery coho releases have occurred since 1967
- Current program rears 2.5 million late coho but only releases 0.5 million into the Washougal River; the remaining 2 million are released into the Klickitat River as per a management plan agreement with the Columbia River tribes.

Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas wild coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- Naturally-produced lower Columbia river coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 924 coho (1979-1986) were harvested annually in the Washougal River sport fishery
- A special snag fishery for disabled fishermen was present near the hatchery until 1986 to harvest surplus hatchery fish; harvest from 1979-1986 averaged 1,193 coho annually
- CWT data analysis of 1995-97 brood Washougal Hatchery late coho indicates 71% were captured in a fishery and 29% were accounted for in escapement
- Fishery CWT recoveries of Washougal late coho are distributed between Columbia River (57%), Washington ocean (30%), and Oregon ocean (13%) sampling areas

15.2.3 Chum—Washougal Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Spawning is believed to occur in the lower reaches of the mainstem Washougal River
- Spawning is believed to occur in the Little Washougal

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- There are no recorded hatchery releases into the Washougal River

Abundance

- In 1951, estimated escapement to the Washougal River was a minimum of 1,000 chum per year
- Spawning ground surveys for other salmonids have resulted in chum observations; in 1998, WDFW found one chum in the Washougal; in 2000, one chum was found in Lacamas Creek (a lower tributary, RM 0.8)

Productivity & Persistence

- Chum salmon natural production is low

Hatchery

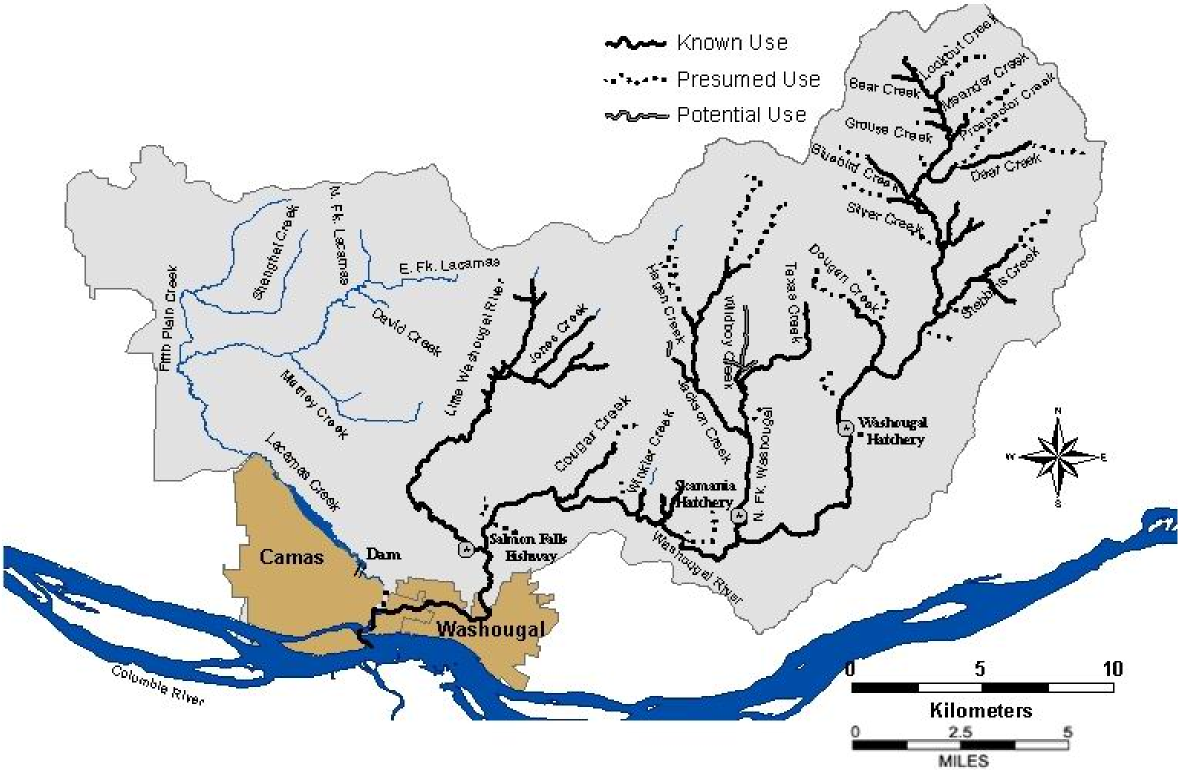
- Chum salmon have not been produced/released in the Washougal River

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

15.2.4 Summer Steelhead—Washougal Subbasin

ESA: Threatened 1998 **SASSI: Unknown 2002**

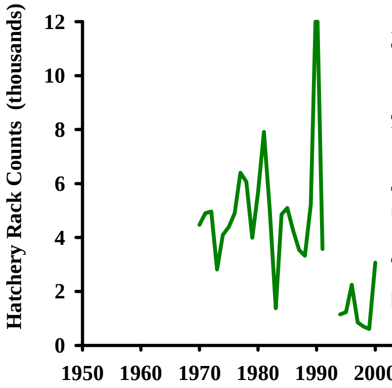


Distribution

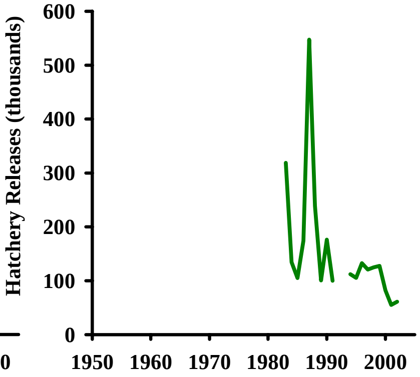
- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades

Life History

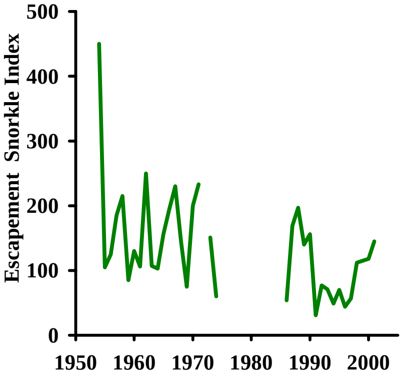
- Adult migration timing for Washougal summer steelhead is from May through November
- Spawning timing on the Washougal is generally from early March to early June
- The dominant age class is 2.2, although minimal age composition data are available
- Wild steelhead fry emerge from April through July; juveniles generally rear in fresh water for two years; emigration occurs from March to June, with peak migration from mid-April to mid-May



Skamania Hatchery summer steelhead returns, 1970-2000



Summer steelhead hatchery releases in the Washougal Basin, 1983-2002



Snorkel index escapement surveys, 1953-2001

Diversity

- Stock designated based on distinct spawning distribution and early run timing
- Skamania Hatchery summer steelhead broodstock were developed from native Washougal and Klickitat River steelhead
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks
- Genetic sampling in 1993 provided little information for determining stock distinctiveness

Abundance

- Between 1925-1933, steelhead run size was estimated at 2,500 fish
- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Snorkel index counts estimated wild steelhead escapement from 1953-2001 ranged from 31 to 500
- Hatchery summer steelhead usually comprise the majority of the spawning escapement; Skamania Hatchery returns have ranged from 1,380 to 13,567 from 1970-1991
- Escapement goal for the Washougal is 1,210 wild adult steelhead

Productivity & Persistence

- NMFS Status Assessment indicated a 0.89 risk of 90% decline in 25 years and a 1.0 risk of 90% decline in 50 years; the risk of extinction in 50 years was not applicable

Hatchery

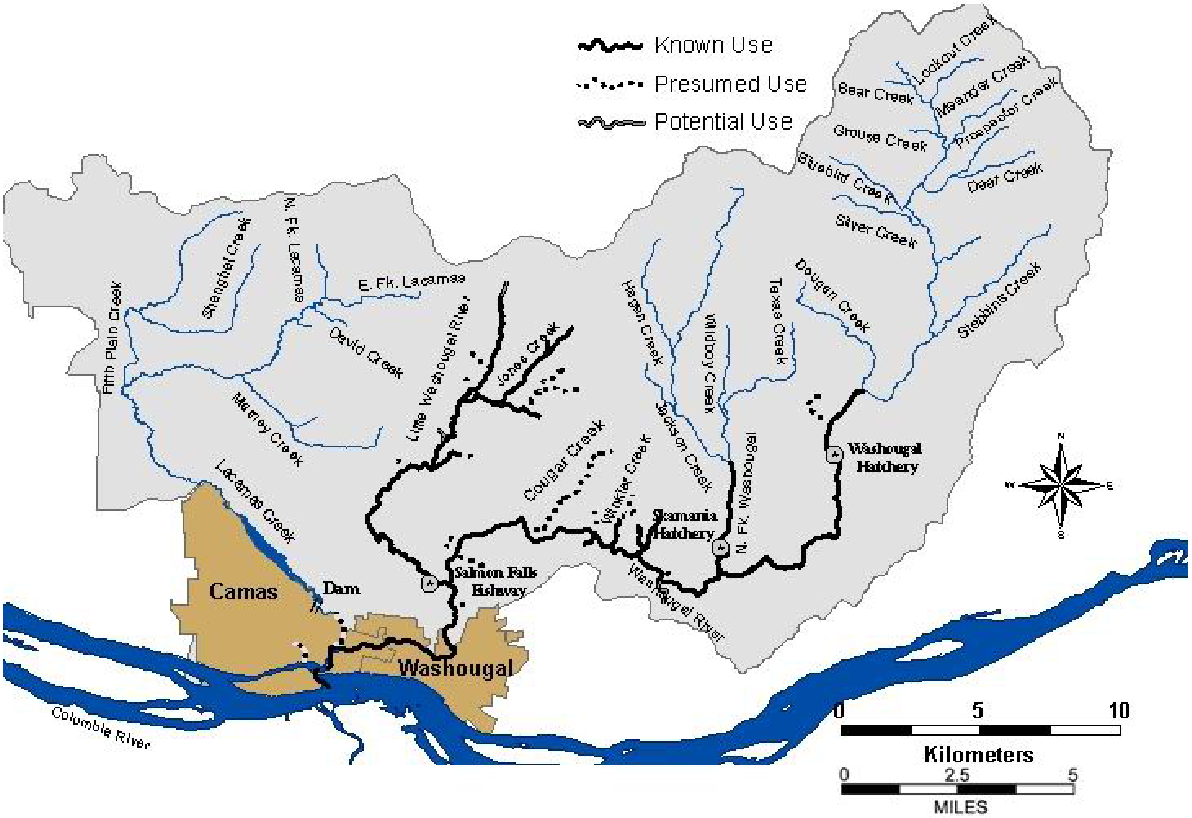
- The Washougal Hatchery (on the mainstem) does not produce summer steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; summer steelhead have been released in the basin since the 1950s
- Summer steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are displayed from 1983-2002

Harvest

- No directed fisheries target Washougal summer steelhead; incidental mortality can occur during the Columbia River fall commercial and summer sport fisheries
- Summer steelhead sport harvest in the Washougal River from 1964-1990 ranged from 272 to 5,699; average annual sport harvest from 1983-1990 was 1,560 fish; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild Washougal summer steelhead in the mainstem Columbia River and in the Washougal River

15.2.5 Winter Steelhead—Washougal Subbasin

ESA: Threatened 1998	SASSI: Depressed 2002

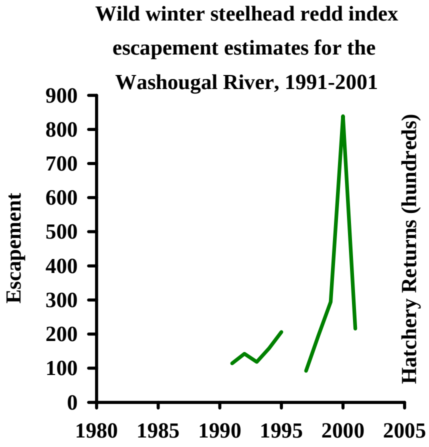


Distribution

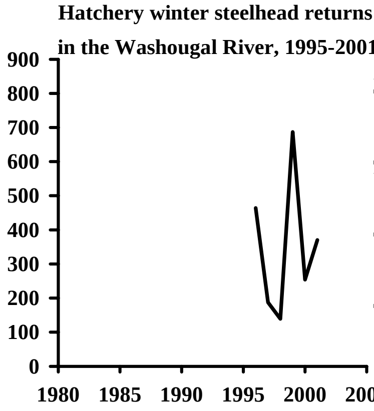
- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades

Life History

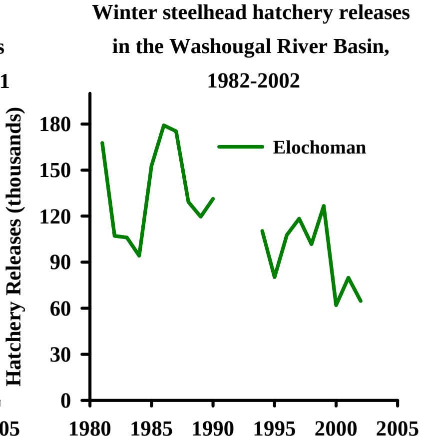
- Adult migration timing for Washougal winter steelhead is from December through April
- Spawning timing on the Washougal is generally from early March to early June
- Limited age composition data for Washougal River winter steelhead suggest that most adults are 2-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May



Wild winter steelhead redd index escapement estimates for the Washougal River, 1991-2001



Hatchery winter steelhead returns in the Washougal River, 1995-2001



Winter steelhead hatchery releases in the Washougal River Basin, 1982-2002

Diversity

- Washougal winter steelhead stock is designated based on distinct spawning distribution and late run timing.
- Wild stock interbreeding with Skamania Hatchery brood stock is thought to be low because of differences in spawn timing.
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks.

Abundance

- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Winter steelhead redd index escapement counts for the Washougal River from 1991-2001 ranged from 92 to 839 (average 237)
- Escapement goal for the Washougal River is 841 wild adult steelhead; escapement goal has been met once since 1991
- Hatchery origin fish comprise most of the winter steelhead run on the Washougal

Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

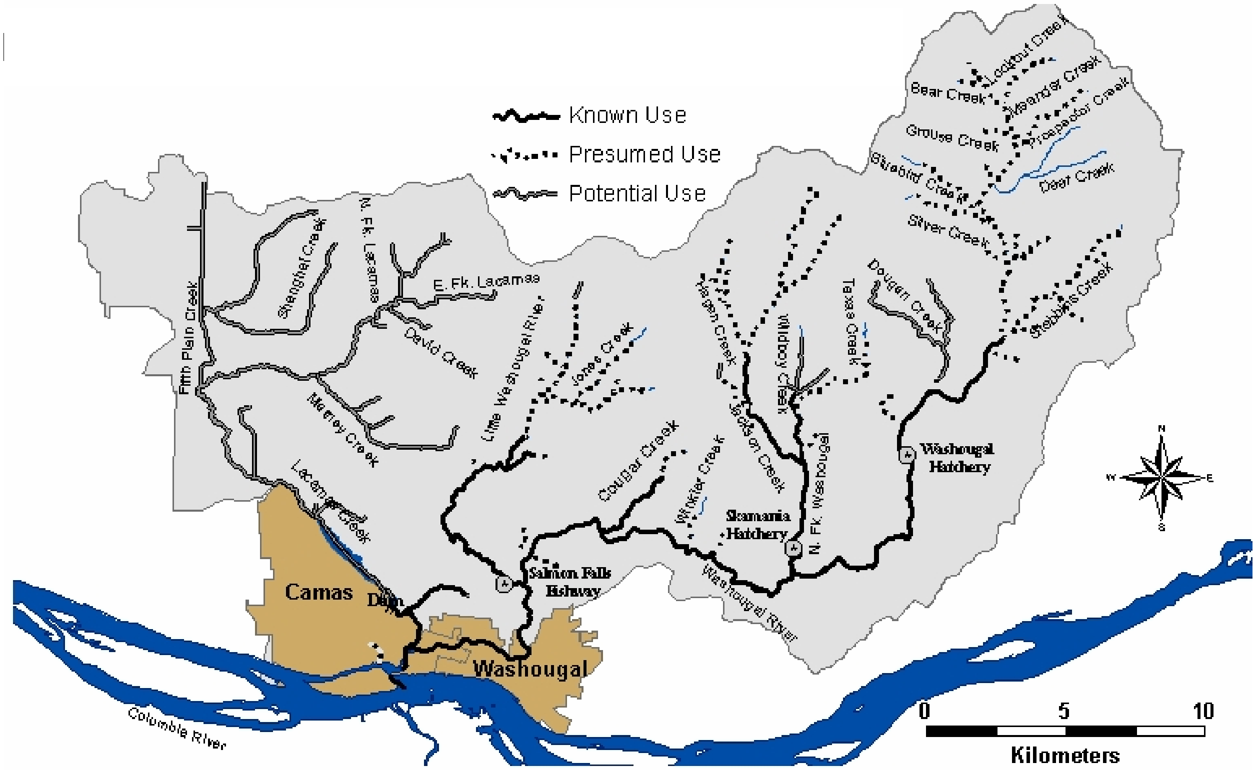
- The Washougal Hatchery (on the mainstem) does not produce winter steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; winter steelhead have been released in the basin since the 1950s; production of winter steelhead smolts was approximately 260,000 annually in the early 1990s; current winter steelhead releases are approximately 110,000 smolts annually
- Winter steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are available from 1982-2002
- Hatchery fish contribute little to natural winter steelhead production in the Washougal River basin

Harvest

- No directed commercial or tribal fisheries target Washougal winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook gillnet fisheries
- Treaty Indian harvest does not occur in the Washougal River basin
- Winter steelhead sport harvest (hatchery and wild) in the Washougal River from 1980-1990 ranged from 1,377 to 3,195 fish; since 1991 and 1992, respectively, regulations limit harvest on the mainstem and West Fork Washougal to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in the Washougal River

15.2.6 Cutthroat Trout—Washougal River Subbasin

ESA: Not Listed **SASSI: Unknown**



Distribution

- Anadromous forms are found up to Dougan Falls
- Advfluvial fish exist in Lacamas Lake
- Resident and fluvial forms are documented throughout the system

Life History

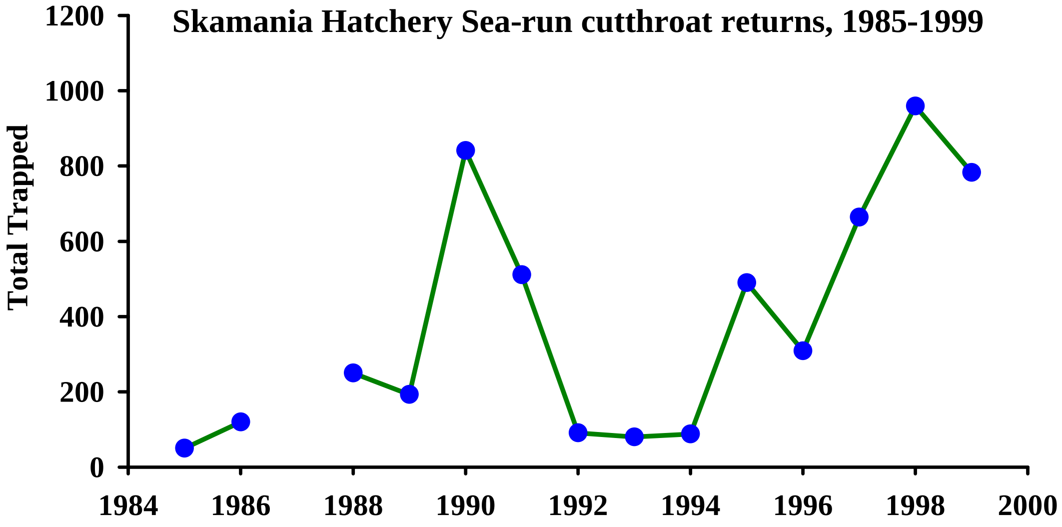
- Anadromous, fluvial, adfluvial and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Resident spawn timing is from February through June

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown

Abundance

- Insufficient quantitative data are available to identify wild cutthroat abundance or survival trends
- Adult sea-run cutthroat returns to Skamania Hatchery range from 50-959 fish for the period 1985-1998
- Anecdotal information from local residents suggest that the stock is Depressed



Hatchery

- Washougal and Skamania Hatcheries releases coho, chinook and steelhead into the subbasin each year
- Skamania Hatchery cutthroat trout program was discontinued in 1999

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Washougal River
- Wild Washougal cutthroat (unmarked) must be released in mainstem Columbia River and Washougal River sport fisheries

15.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quality and quantity is an important impact for all species, particularly for chum and steelhead. Loss of estuary habitat quality and quantity is also important, particularly for chum.
- Harvest has a large relative impact on fall chinook and moderate impacts on coho. Harvest effects on winter and summer steelhead and chum are minimal.
- Hatchery impacts are substantial for coho and winter steelhead, moderate for summer steelhead and fall chinook, and are minimal for chum.
- Predation impacts are moderate for winter and summer steelhead, but appear to be less important for coho, chum, and fall chinook.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

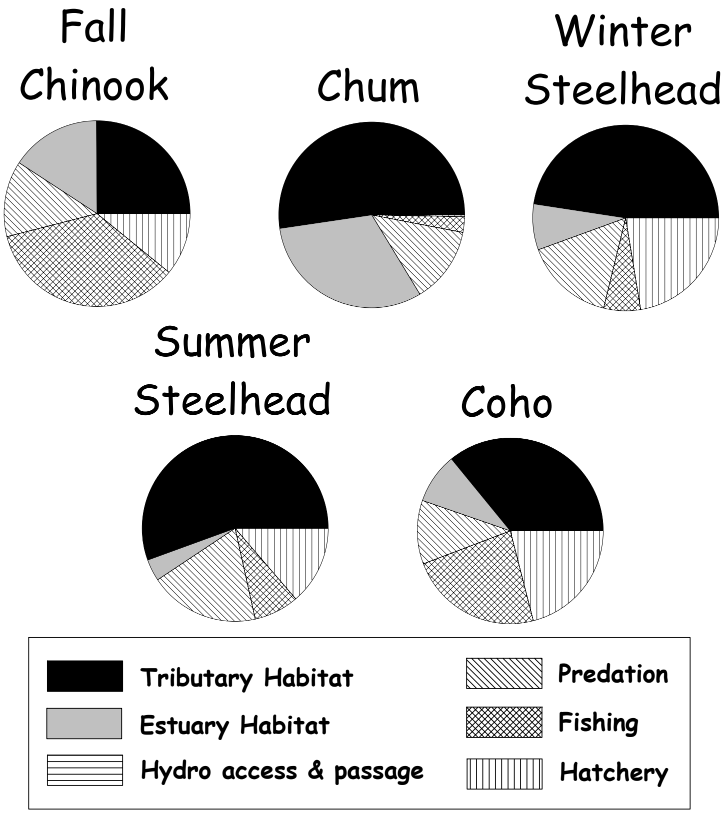


Figure 15-5. Relative contribution of potentially manageable impact factors on listed salmon and steelhead in the Washougal subbasin.

15.4 Hatchery Programs

There are two hatcheries in the Washougal River basin: the Washougal Hatchery and the Skamania Hatchery. The Washougal Hatchery is at about RM 16 of the mainstem and was completed in 1958. It has produced fall chinook, and early (Type-S) and late (Type-N) coho. Current annual releases average 3.5 million sub-yearling fall chinook and 3 million late-run coho smolts, although only 500,000 coho smolts are released in the Washougal basin (Figure 15-6). The remaining 2.5 million coho smolts produced at the Washougal Hatchery are released in the Klickitat River as part of the *US v. Oregon* agreement with the Columbia River treaty Indian Tribes.

The Skamania Hatchery is on the NF Washougal River approximately one mile from the confluence with the mainstem. The hatchery produces 309,000 summer smolts and 190,000 winter steelhead smolts. Steelhead smolts produced at the Skamania Hatchery are released in multiple basins throughout the lower Columbia River; annual release goals for the Washougal River are 60,000 smolts each of summer and winter steelhead (Figure 15-6).

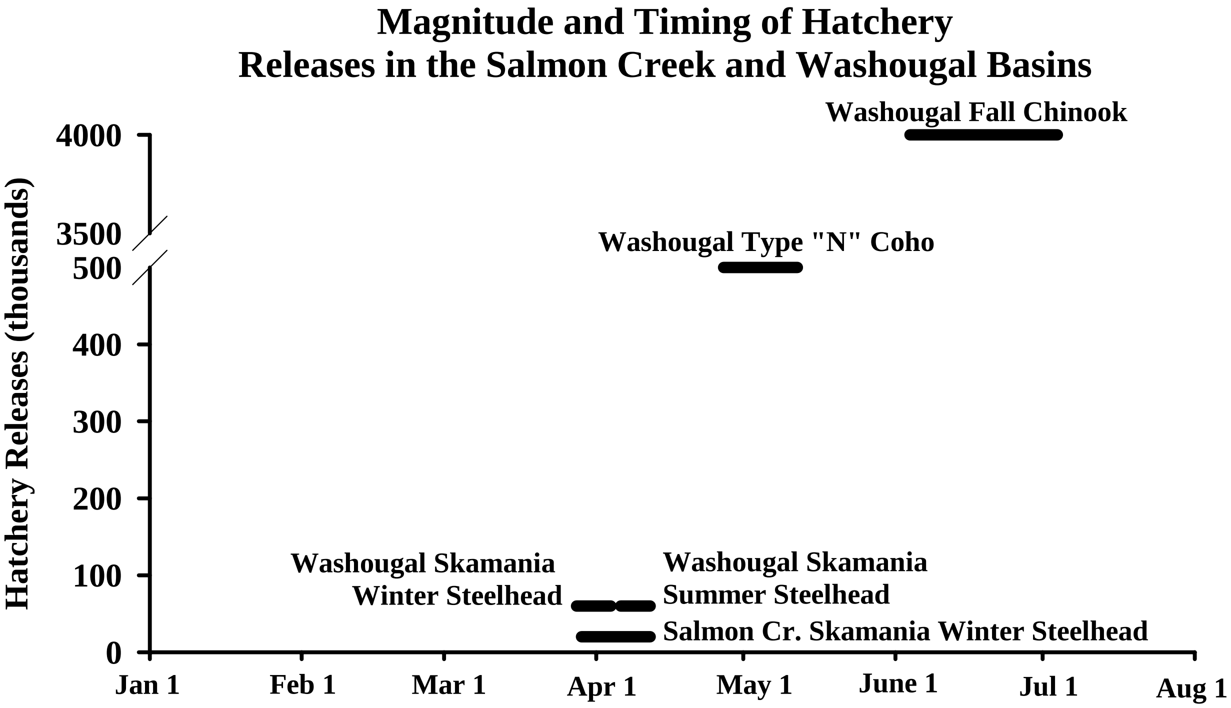


Figure 15-6. Magnitude and timing of hatchery releases in the Salmon Creek and Washougal River basins by species, based on 2003 brood production goals.

Genetics—Broodstock for the Washougal Hatchery fall chinook hatchery program originated from multiple lower Columbia River fall chinook stocks. There have been significant transfers of fall chinook over the years from Spring Creek NFH, Cowlitz Hatchery, Toutle Hatchery, and Kalama Hatchery. Current broodstock collection comes from adults returning to the hatchery. Genetic analysis of Washougal fall chinook in 1995 and 1996 indicated that they were significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook; this result is perplexing as Washougal fall chinook are considered a tule population.

Broodstock for the Washougal Hatchery coho hatchery program originated from local Washougal early-run coho, with some imported Toutle River early run coho stock used. In 1985, Cowlitz River late-run coho stock was introduced to the Washougal Hatchery broodstock. Since 1987, broodstock has been collected from late-run coho returning to the hatchery, except for 1993 when Lewis River late-run coho were used to supplement the Washougal Hatchery shortfall. Broodstock for the 2.5 million coho smolts released annually to the Klickitat River comes primarily from Lewis River late-run coho stocks. Any lower Columbia River Type-N coho stock has been deemed acceptable broodstock for the Washougal Type-N coho hatchery program.

Broodstock for Skamania Hatchery winter steelhead program originated from local Washougal River winter steelhead; current broodstock comes from adults returning to the hatchery. Shortfalls have been supplemented from Beaver Creek Hatchery winter steelhead stocks, which originated primarily from Chambers Creek and Cowlitz River stocks.

Broodstock for the Skamania Hatchery's summer steelhead program originated from wild fish taken from the Washougal and Klickitat rivers. Current broodstock collection comes from adults returning to the hatchery. Genetic sampling in 1993 was inconclusive in determining the distinctiveness of the Washougal summer steelhead stock. The Skamania summer steelhead stock is the source of nearly all summer steelhead smolt releases on the Washington side of the lower Columbia River, except for the Cowlitz and Lewis rivers.

Interactions—Hatchery production accounts for most adult fall chinook returning to the Washougal River (Figure 15-7). Hatchery-origin fish comprise a significant portion of the natural spawners; this proportion is higher when water flow is low and insufficient to provide for passage to the Washougal Hatchery. A substantial amount of natural production occurs in the system; WDFW estimated 5 million natural juvenile fall chinook emigrated from the Washougal River in 1980 so there may be competition for food and space between naturally produced fall chinook and the average 4 million hatchery fall chinook released annually. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear.

Hatchery production accounts for most adult coho salmon returning to the Washougal River (Figure 15-7); very few wild coho are present, resulting in minimal interaction between adult wild and hatchery coho salmon. Hatchery coho smolts are released volitionally as smolts and clear the river quickly, so competition for food resources with natural salmonids is likely minimal. Some limited natural production of coho has persisted in the Little Washougal River; this tributary is geographically separated from the Washougal Hatchery and any interaction between hatchery fish and naturally produced coho from the Little Washougal would be limited to the lower mainstem. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear.

Hatchery production accounts for most adult winter steelhead returning to the Washougal River (Figure 15-7). Hatchery-origin fish comprise a substantial portion of the natural spawners. However, spawn timing of wild fish and naturally spawning hatchery fish is different; therefore, there is likely minimal interaction between adult wild and hatchery winter steelhead. Hatchery winter steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is probably minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor residualization of steelhead smolts has been observed on the Washougal River.

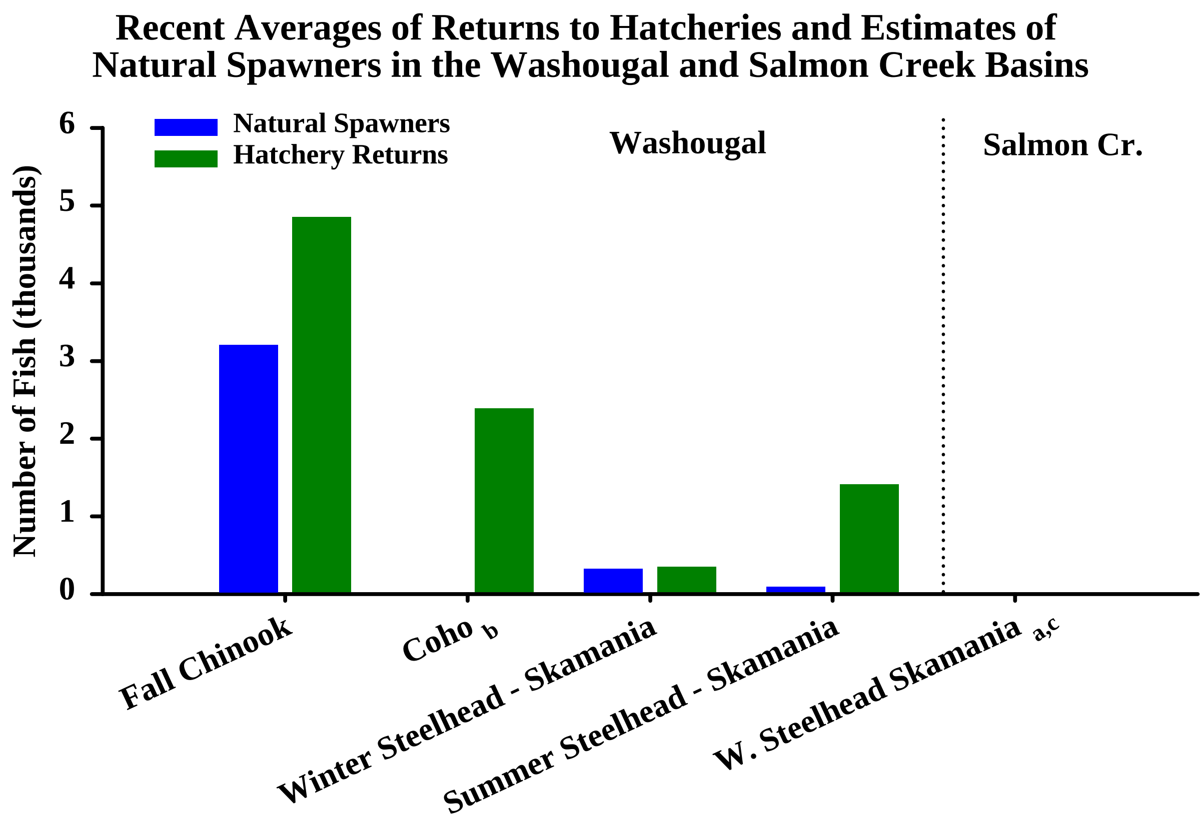


Figure 15-7. Recent average hatchery returns and estimates of natural spawning escapement in the Salmon Creek and Washougal River basins by species.

Hatchery production accounts for most adult summer steelhead returning to the Washougal River, although substantial numbers of wild summer steelhead can be present some years (Figure 15-7). However, because spawn timing of wild fish and naturally spawning hatchery fish is different, little interaction between adult wild and hatchery summer steelhead is thought to occur. Spawn timing between hatchery summer and wild winter steelhead is more similar and there is more potential for interaction between these fish. Hatchery summer steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is expected to be minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor amounts of residualization of steelhead smolts have been observed on the Washougal River.

Water Quality/Disease—The water source and disease treatment protocol for the Washougal Hatchery were not specified in the available hatchery operational plan. It is assumed that water for the hatchery comes from the Washougal River. Fungus and disease treatment at the Washougal River hatchery is likely similar to other Washington hatcheries; fungus control is presumably achieved with formalin treatments and disease treated with the advice of the area fish health specialist and according to procedures of the Co-Managers Fish Health Policy.

Water for the Skamania Hatchery comes from two sources: the North Fork Washougal River and Vogel Creek. Hatchery water rights total 11,670 gpm but the facility uses an average of 9,800 gpm. Vogel Creek water is used for incubation and early rearing, while Washougal River water is used for all other operations, such as final rearing and adult holding. Hatchery effluent is monitored under the hatchery's NPDES permit. At the adult collection facility, personnel and equipment are sanitized by chlorine disinfection. Fungus in the holding facility is controlled with formalin treatments. During the incubation phase, formalin treatments are used to control ecto-parasites and fungus and eggs and equipment are surface disinfected with iodophor. Fish health is monitored continuously by hatchery staff and the area fish health specialist visits monthly. Disease control is conducted according to the Fish Health Policy. The area fish health specialist inspects fish prior to release and recommends treatment when necessary; control of fish pathogens is done according to the Fish Disease Control Policy. IHN is a major problem in the hatchery and can limit production in some years.

Mixed Harvest—The Washougal River Hatchery provides harvest opportunity to mitigate for fall chinook and coho salmon lost as a result of hydroelectric development in the lower Columbia River basin. Historically, exploitation rates of hatchery and wild fall chinook likely were similar. Fall chinook are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years of Washougal fall chinook indicated a 28% exploitation rate on fall chinook; 72% of the adult return was accounted for in escapement. Exploitation of wild fish during the same period likely is similar. Hatchery and wild fall chinook harvest rates remain similar but are now constrained by ESA harvest limitations.

The purpose of the Washougal River Hatchery coho salmon hatchery program is to provide harvest opportunity to mitigate for Columbia River coho salmon lost to hydroelectric development in the basin. The coho program is specifically intended to provide coho for harvest in treaty Indian fisheries in Zone 6 and in the Klickitat River. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. Ocean and Columbia River combined harvest of Columbia River-produced coho ranged from 70% to over 90% from 1970–83. Ocean fisheries were limited beginning in the mid-1980s and Columbia River commercial fisheries were adjusted in the early 1990s to protect several wild coho stocks. Columbia River coho exploitation rates during 1997 and 1998 averaged 48.8%. CWT data analysis of the 1995–1997 brood years of Washougal River Type-N coho indicated a 71% exploitation rate on late run coho; 29% of the adult return was accounted for in escapement. Most of the Washougal River Type-N coho harvest occurred in the Columbia River. With the advent of selective fisheries for hatchery fish in 1998, exploitation of wild coho is low, while hatchery fish can be harvested at a higher rate. Washougal wild coho benefit from ESA harvest limits for Oregon Coastal natural coho in ocean fisheries and for Oregon lower Columbia Natural Coho in Columbia River fisheries

At the Skamania Hatchery, the summer and winter steelhead hatchery programs provide harvest opportunity to mitigate for summer and winter steelhead lost as a result of hydroelectric development in the lower Columbia River basin. Fisheries that may benefit from these programs include lower Columbia and Washougal River sport fisheries. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead were likely similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and the Washougal became selective during 1986–1992. and harvest regulations are aimed at limiting harvest of wild steelhead to fewer than 10%. The sport fishery impact in the Washougal is estimated at 5% for wild winter steelhead and 4% for wild summer steelhead. The hatchery steelhead harvest rate in the Washougal sport fishery is estimated to be 40% for both winter and summer steelhead.

Passage—The adult collection facility at the Washougal Hatchery consists of a weir across the river leading to a ladder and holding pond system. Adults enter the ladder volitionally and are contained in holding ponds until broodstock collection. Adults surplus to annual broodstock needs are distributed throughout the basin for nutrient enhancement of the freshwater rearing environment. In some years, low water flow in the mainstem Washougal River is not conducive to fish passage and broodstock needs are not met.

The adult collection facility at the Skamania Hatchery consists of a ladder, trap, and holding pond system. The ladder is approximately 80 ft long and the trap is approximately 20 ft x 20 ft. Adults enter the ladder volitionally and are routed to one of three holding ponds until broodstock collection. Many fish bypass the hatchery collection facility. Adults surplus to annual broodstock needs may be returned to the river (if in robust condition), planted in landlocked lakes for sport harvest, distributed to food banks, or distributed throughout the basin for nutrient enhancement of the freshwater rearing environment.

Supplementation—No Washougal hatchery program has supplementation as a primary goal. However, hatchery fall chinook and summer steelhead have successfully spawned in the Washougal River; annual natural production varies annually.

15.5 Fish Habitat Conditions

15.5.1 Passage Obstructions

Salmon Falls, at RM 14.5 was the upstream limit of most anadromous fish except steelhead, until a fishway was built in the 1950s to facilitate passage. Currently, Dugan Falls at RM 21 blocks salmon and most winter steelhead, though summer steelhead consistently ascend into the upper reaches. Small dams, weirs, and water diversions restrict access on the mainstem at the Washougal Hatchery, Vogel Creek (water intake for Skamania Hatchery), Jones Creek, Boulder Creek, and Wild Boy Creek. Seven culverts have also been identified that provide partial or complete blockages. A detailed description of passage barriers can be found in the WRIA 28 Limiting Factors Report (Wade 2001).

15.5.2 Stream Flow

The basin is rain-dominated, with little stream flow contributed by snowmelt. Peak flows generally occur in winter months and low flows occur in late summer (Figure 15-8). Flows regularly exceed 1,000 cfs November to April and typically fall below 100 cfs in late summer. The 37-year average discharge is 873 cfs, with a highest-recorded flow of 40,000 cfs in December 1977. The flashy nature of the stream has been attributed to basin topography, denuded vegetation due to large fires, and human alterations to watershed processes (WDF 1990). Major tributaries to the Washougal include Lacamas Creek, the Little Washougal River, Canyon Creek, the West Fork Washougal River, and Dougan Creek.

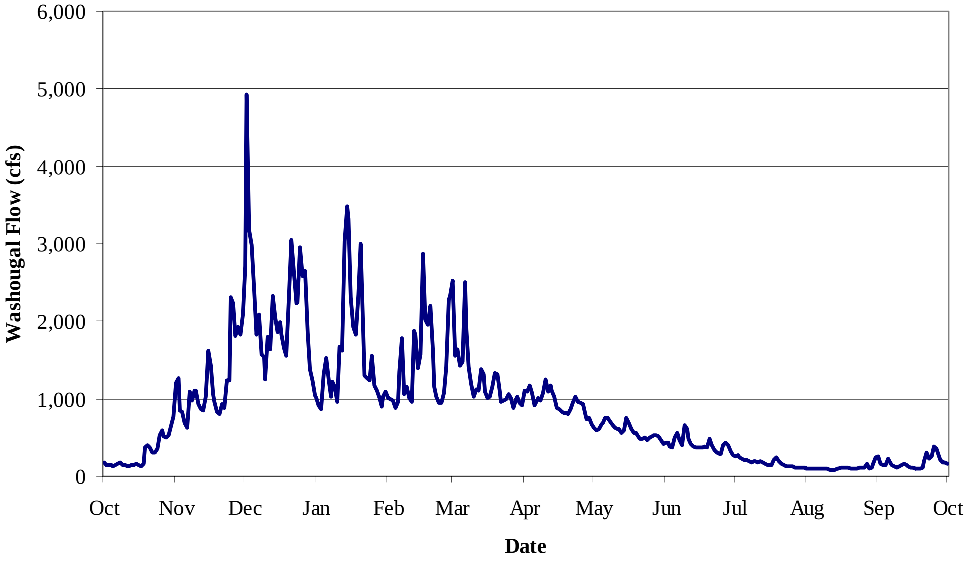


Figure 15-8. Average daily flows for the Washougal River (1972-1981). Peak flows are primarily related to winter and spring rain, with some high peaks occuring due to winter rain-on-snow. Flows fall below 100 cfs in late summer. USGS Stream Gage #14143500; Washougal River near Washougal, Wash.

Vegetation conditions, impervious surfaces, and high road densities in portions of the Washougal basin have potentially impacted runoff regimes. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, rates 14 of the 29 subwatersheds in the basin as “impaired” with respect to conditions that influence runoff properties. Nine of the subwatersheds are rated as “moderately impaired” and 6 are rated as “functional”. The greatest impairments are concentrated in the low elevation subwatersheds and in portions of the upper Lacamas drainage. Intact hydrologic conditions are located primarily in the upper mainstem Washougal headwaters. These results are consistent with an analysis by Lewis County GIS (2000) that identified only the upper Washougal basin as meeting the criteria of a hydrologically functioning watershed.

Instream flow studies have been conducted on several stream segments to assess potential problems with low flows (Caldwell et al. 1999). The IFIM was applied to the Washougal River at approximately RM 3.5. Below optimal flows were identified for chinook and steelhead rearing beginning in July and lasting into October. Other streams were assessed using the Toe-Width method. Data from the Little Washougal River indicated below optimal flows for chinook spawning in the fall and juvenile rearing June through October. Data from the NF Washougal revealed that flows didn’t reach optimal for juvenile rearing until October and were below optimal for salmon spawning in the fall. Other areas with low flow concerns include the lower Washougal River, Camas Slough, the Washougal River above Dugan Falls, Texas Creek, Wildboy Creek, Schoolhouse Creek, and Slough Creek (Wade 2001).

In the Lacamas Creek drainage, the current and projected consumptive water use is believed to represent a significant portion of watershed hydrology, although insufficient data exists for a valid comparison of water use and streamflow. For the remainder of the Washougal subbasin, consumptive use appears to represent greater than 10% of base flows and the projected year 2020 water use may approach 25% of summer base flow, assuming full hydraulic connection between ground water and stream flow. There are currenly low-flow restrictions for some surface water rights and the subbasin is near closure for further surface water rights appropriation (LCFRB 2001).

15.5.3 Water Quality

Water quality concerns in the basin include temperature, pH, fecal coliform, and DO. Lacamas Creek and several tributaries were listed on the 1998 state 303(d) list for exceedances of water quality standards (WDOE 1998). Lacamas Creek below Round Lake has elevated DO and temperature. In the 1970s, Lacamas Lake was identified as having eutrophication problems due to phosphorous loading. The Lacamas Lake Restoration Project has assisted many landowners with the adoption of agricultural Best Management Practices in order to correct this problem (Wade 2001).

Water temperatures consistently exceeded 64°F (17.8°C) during the summer at the Washougal Salmon Hatchery between 1987 and 1991. The Clark Skamania Flyfishers and Washington Trout staff measured high water temperatures in several upper basin tributaries between 1997 and 1999. Exposed bedrock, low flows, poor riparian canopy cover, and livestock watering detention systems are suspected of contributing to elevated water temperatures. Though only limited data exists, water temperatures in the lower river are also believed to be high. Elevated turbidity is seen as a potential problem in the Little Washougal, Jones, and Dougan Creeks (Wade 2001).

Historically, discharges from the paper mill created water quality problems in the Camas Slough. As late as the 1960s, concern over sulfite discharges led to the release of fish from the salmon hatchery on vacation weekends when the mill was closed (WDF 1990). Wastewater is now treated at facilities on Lady's Island though pollutants that have accumulated in sediments could still be a problem. There is also a concern about the Skamania and Washougal Salmon Hatcheries' release of potentially harmful effluent containing antibiotics and diseases (Wade 2001).

Nutrient levels are believed to be limited due to the lack of salmon carcasses as a result of low escapement levels for most species.

15.5.4 Key Habitat

Though little monitoring data exists, observations indicate that adequate pool habitat is generally lacking throughout the basin due to low large woody debris (LWD) concentrations and past channel scouring from splash-dam logging. Only a few, bedrock-formed, pools are located on the lower and middle mainstem, however, low flows and recreational use limits the ability of these pools to provide adequate steelhead rearing and adult holding. Pool abundance and quality is considered poor in the Little Washougal, Jones Creek, Boulder Creek, NF Washougal, and EF Washougal (Wade 2001).

Side channel habitat is similarly lacking, especially on the lower mainstem that has received extensive diking and riprap. Wade (2001) outlines several areas where decent side channel habitat exists and where there may be potential to restore historical off-channel habitats. Due to steep gradients and natural confinement, very little side channel habitat was ever available in the upper basin, with only a few exceptions. The Salmon Hatchery at RM 20 apparently is situated on a historical wetland from which it currently diverts water. There may be some side channel restoration potential at this site (Wade 2001).

Habitat unit fragmentation may result from the high number of stream crossings in portions of the basin. The Little Washougal, Upper Washougal, and Silverstar basins have over 6 stream crossings per square mile, potentially reducing channel complexity and altering sediment routing processes (Wade 2001).

15.5.5 Substrate & Sediment

Many reports mention a lack of spawning gravel as a major limiting factor in the Washougal basin. In the lower reaches, gravel was actually mined from the channel. In the rest of the basin, lack of gravel is attributed to removal of LWD, splash damming, and the hydrologic effects of the Yacolt Burn (1902) and logging. Much of the middle and upper mainstem consists of bedrock and boulder dominated channels. Dams on Lacamas and Wildboy Creeks have eliminated spawning gravel recruitment to downstream reaches (Wade 2001).

Sediment production may be elevated in some areas due to high (> 3 mi/mi^2) road densities, stream-adjacent roads, recreational vehicle use, vegetation removal, residential development, and cattle impacts to stream banks. Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. Nineteen of the 29 subwatersheds were given a rating of “moderately impaired” with respect to conditions influencing sediment supply; the remainder were rated as “functional”. High road densities on steep slopes and/or unstable soils are the primary driver of impaired conditions.

Although the overall road density is moderate (2.65 mi/mi^2), high road densities exist in the Lacamas Creek basin (3.28 mi/mi^2) and the little Washougal basin (3.36 mi/mi^2). The proliferation of stream-adjacent roads (29 miles within the Little Washougal alone) may also increase sediment delivery. Recreational vehicle access to powerline corridors and off-limit trails is seen as a potential source of fine sediment delivery to streams. Clearing of vegetation through logging or other practices is believed to increase sediment production throughout the watershed, particularly at sites in the Dougan Creek and Jones Creek basins. Residential development is suspected of increasing sediment accumulations in the Little Washougal basin and cattle impacts may be contributing fine sediments to Winkler Creek (Wade 2001).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

15.5.6 Woody Debris

Low quantities of LWD throughout the system are attributed to splash damming, past active removal, and low recruitment potential due to fires and logging. Quantities are especially low in the Little Washougal River. Portions of the upper Little Washougal, upper mainstem, and upper West Fork have riparian forests that are in good condition and may deliver much-needed LWD to streams in the near future (Wade 2001).

15.5.7 Channel Stability

Bank stability is generally considered good throughout the watershed though isolated areas of instability exist. A large, unstable hillside downstream from the Vernon Road Bridge appears to be associated with a road cut and subsequent clearing of vegetation. It is believed that a slide here could present a significant risk to river habitats though the immediacy of the problem is unknown. Other areas of instability are associated with motor-cross activities, cattle access, failed culverts, and vegetation removal. A complete description can be found in the Limiting Factors Analysis (Wade 2001). In some instances, increased erosion may be providing needed spawning gravels to downstream channels.

15.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 7 of the 29 subwatersheds have “impaired” riparian conditions,18 are “moderately impaired”, and 4 are “functional”. The greatest impairments are located along the lower mainstem and in the Lacamas Creek basin, whereas functional conditions are located in the headwaters of the mainstem and the West Fork.

Riparian forests along the lower mainstem and the Camas Slough have been cleared for industrial uses, residential uses, and road corridors and only a few places contain native deciduous species. Conditions improve as you move up the basin, except in portions of the West Fork and Dougan Creek, which are still recovering from past fires. Riparian conditions in Boulder, Jones, EF Jones, Winkler Creek, and Texas Creek are considered poor (Wade 2001).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

15.5.9 Floodplain Function

Past splash damming, logging, and reduced vegetation cover following the Yacolt Burn (1902) has resulted in channel scour and incision in many places on the mainstem, creating a channel that is disconnected with its floodplain and side-channel habitats. This reduction in habitat may be impacting overwinter survival of some species (Wade 2001).

Much of the lower mainstem (including Camas Slough) and the lower Little Washougal have experienced floodplain and side channel loss due to diking and channelization associated with industrial, transportation, residential, mining, and agricultural activities. The lower reach extending from the mouth to the Little Washougal River (RM 5.6) has been especially impacted by past and on-going floodplain development. Channel incision has also been observed in many of these areas. Wade (2001) provides an in-depth description of the location of channelization features.

15.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Washougal River winter steelhead, summer steelhead, chum, coho and fall chinook. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

15.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Washougal River subbasin for chum, fall chinook, coho, winter steelhead, and summer steelhead. For all modeled populations, adult productivity has declined sharply from historical levels (Table 15-1). Fall chinook productivity has declined by 63%, while chum, coho, winter steelhead, and summer steelhead productivities have declined by 85%, 80%, 89%, and 79%, respectively. Adult abundance has also decreased for all species (Figure 15-9). The decline in abundance has been least for fall chinook, currently at 53% of historical levels, and most severe for chum, currently at 4% of historical levels. Species diversity (as measured by the diversity index) has remained relatively stable for fall chinook and summer steelhead (Table 15-1), while declining anywhere from 30-50% for the rest of the species.

Trends in both smolt productivity and smolt abundance are similar, with current estimates far below historical levels (Table 15-1). Coho and winter steelhead have seen the largest decline in smolt productivity, to 17 and 20% of historical levels, respectively. Chum and coho have seen the largest decline in smolt abundance, to 7% and 18% of historical levels, respectively.

Model results indicate that restoration of properly functioning (PFC) habitat conditions throughout the basin would significantly benefit all species (Table 15-1). Restoration of PFC would provide the greatest benefit to chum and coho. Adult chum abundance would increase over 450% from current levels, while adult coho abundance would increase over 300% from current levels. Similarly, chum smolt abundance would increase over 550% from current levels, while coho smolt abundance would increase over 380% from current levels.

Table 15-1. Washougal subbasin— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	1,624	2,810	3,037	3.8	8.0	10.2	0.96	1.00	1.00	282,145	507,734	559,240	488	971	1,221
Chum	699	3,971	18,072	1.6	7.1	10.5	0.69	1.00	1.00	338,274	2,255,690	4,703,217	532	1,024	1,175
Coho	824	3,362	3,934	2.2	7.6	10.5	0.47	0.89	0.98	19,934	96,963	113,303	51	211	293
Winter Steelhead	500	909	1,947	3.8	12.6	33.8	0.72	1.00	1.00	7,065	13,699	15,906	69	242	352
Summer Steelhead	639	876	2,177	4.3	6.7	20.5	0.95	1.00	1.00	12,035	15,871	21,187	81	122	200

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

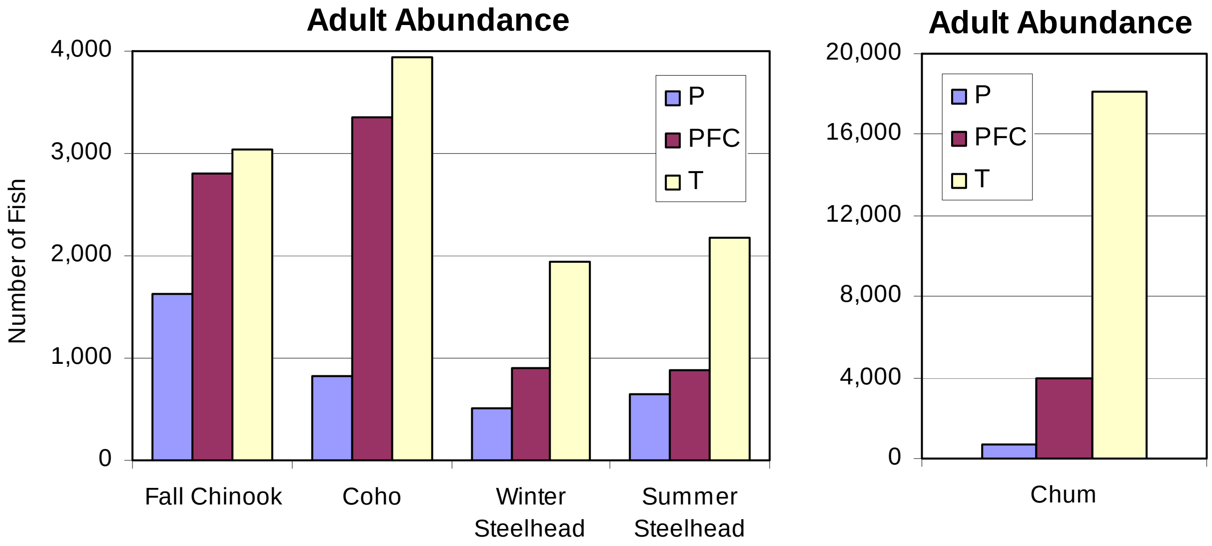


Figure 15-9. Adult abundance of Kalama fall chinook, spring chinook, coho, winter steelhead, summer steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

15.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Summer steelhead, which are able to ascend Dougan Falls at RM 22, utilize the greatest portion of subbasin reaches. Winter steelhead make extensive use of the lower and middle mainstem and tributaries. In order to avoid spurious results in EDT modeling, winter and summer steelhead were identified as using non-overlapping reaches during critical life stages. In reality, there is more overlap between these populations than is suggested by the reach priority results. Fall chinook primarily use the lower mainstem and major tributaries, whereas chum historically used only the lower few mainstem reaches. See Figure 15-10 for a map of EDT reaches within the Washougal subbasin.

For summer steelhead, high priority reaches lie in the upper (Washougal 14-16) and headwater (Washougal 17) sections, as well as in the lower WF Washougal (WF Washougal 1B and 2) (Figure 15-11). These areas provide significant spawning and rearing habitats. All high priority reaches, except Washougal 1B, show a habitat preservation emphasis. Washougal 1B shows a combined preservation and restoration emphasis.

High priority winter steelhead reaches include sections of the lower mainstem (Washougal 5), lower WF Washougal (WF Washougal 1), and the Little Washougal (Figure 15-12). These areas encompass the primary winter steelhead spawning and rearing sites. The majority of these reaches show a habitat restoration emphasis, however, the reaches of the lower Little Washougal (Little Washougal 1-3) show a combined habitat preservation and restoration emphasis.

Important reaches for fall chinook are primarily located in the lower and middle mainstem areas (Washougal 3- 9) (Figure 15-13). Reach Washougal 3 has the highest restoration value of any fall chinook reach, while reach Washougal 9 has the highest preservation value for any fall chinook reach.

Chum, although functionally extinct from the subbasin, have high priority reaches located in the extreme lower sections of the mainstem (Washougal tidal 1 and 2) (Figure 15-14). These reaches show a strong habitat restoration emphasis. It is important to note that Lower Lacamas Creek, although not included in this model run, has recently been found to contain chum (Rawding pers. comm. 2002), and should therefore be considered for restoration efforts.

High priority reaches for coho are located in sections of the lower (Washougal 3 and 4), middle (Washougal 8 and 9), and Little Washougal (Little Washougal 2C and 2E) (Figure 15-15). The majority of modeled coho reaches show a strong habitat restoration emphasis, with Little Washougal 2E having the highest restoration value of any coho reach.

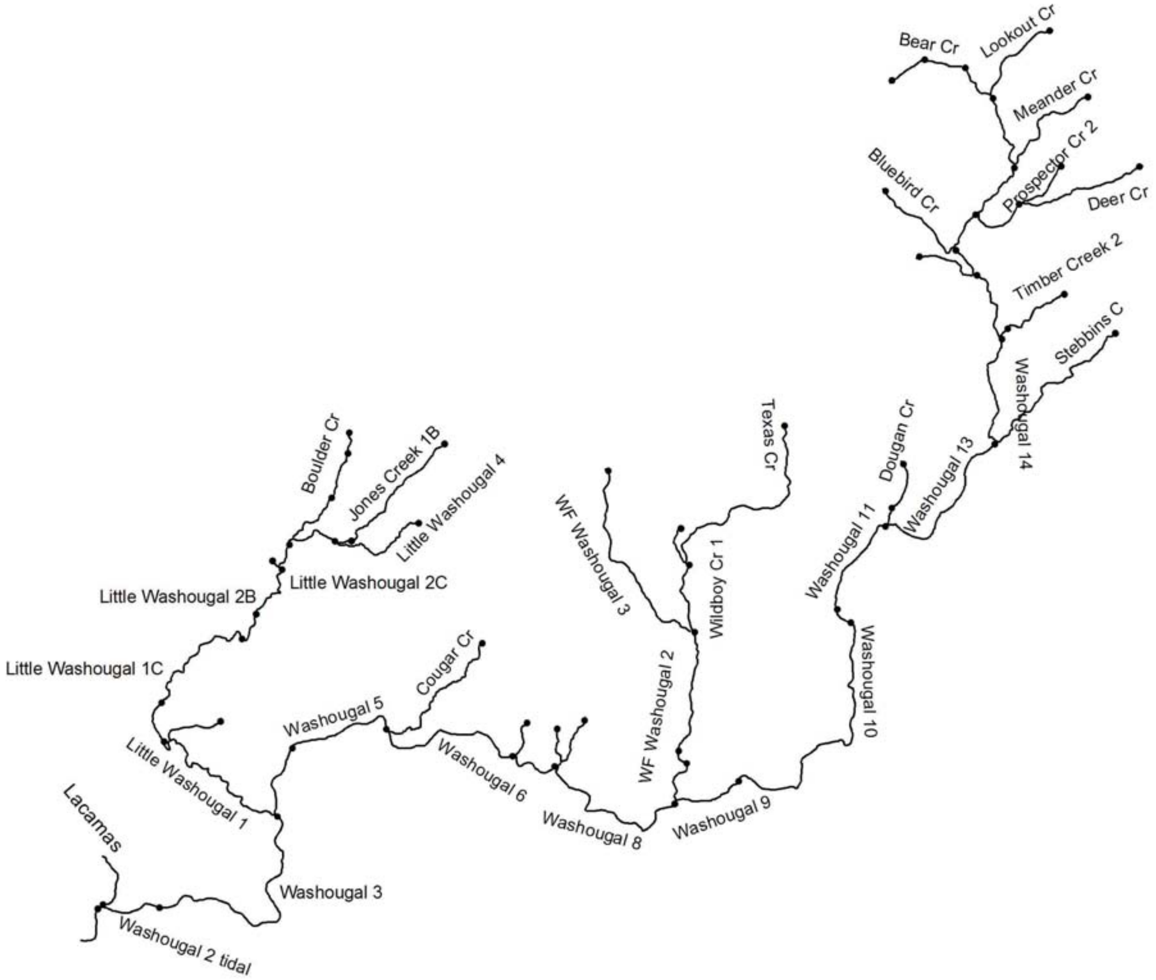
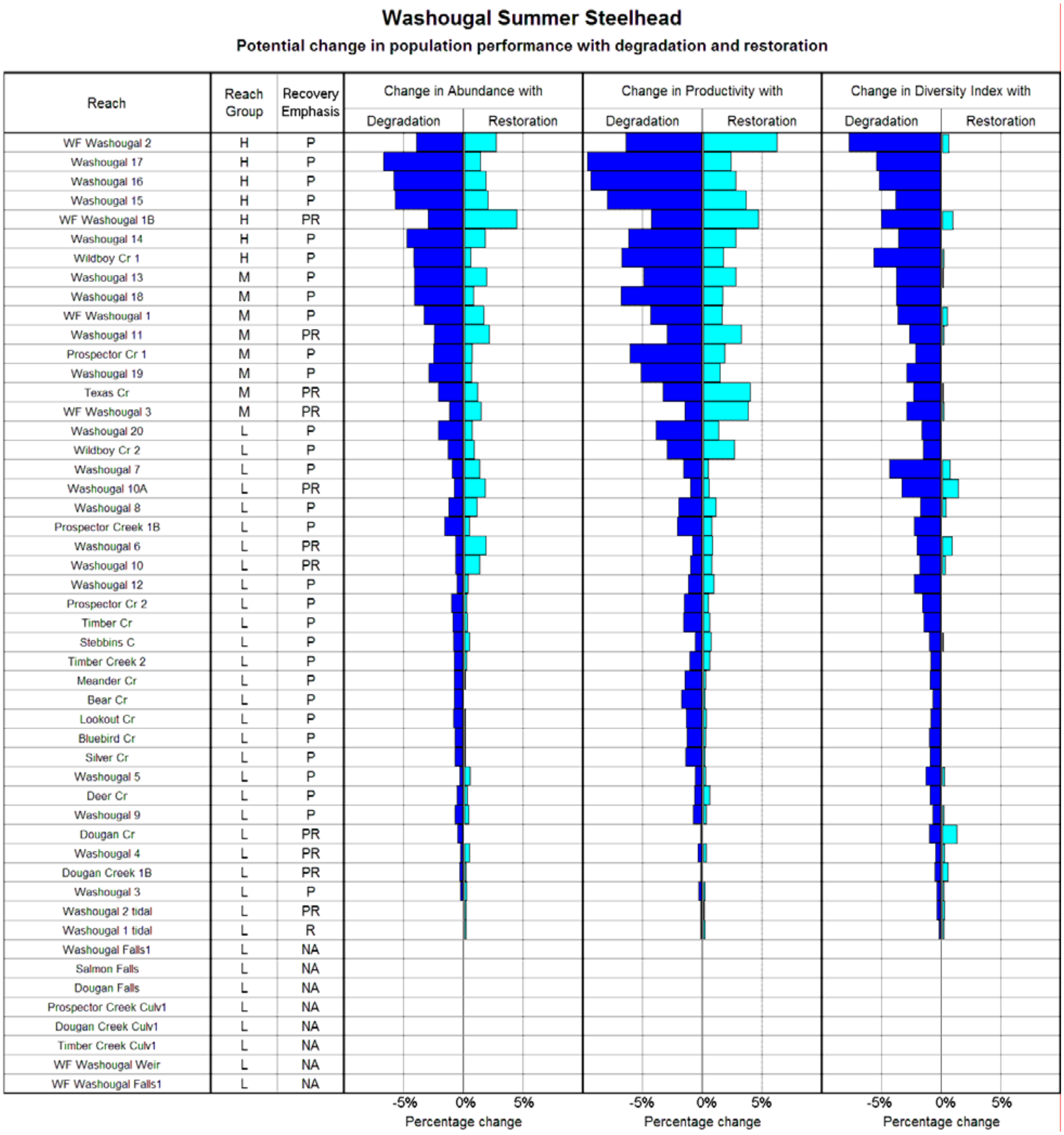


Figure 15-10. Washougal subbasin EDT reaches. Some reaches are not labeled for clarity.



Reach	Reach Group	Recovery Emphasis
WF Washougal 2	H	P
Washougal 17	H	P
Washougal 16	H	P
Washougal 15	H	P
WF Washougal 1B	H	PR
Washougal 14	H	P
Wildboy Cr 1	H	P
Washougal 13	M	P
Washougal 18	M	P
WF Washougal 1	M	P
Washougal 11	M	PR
Prospector Cr 1	M	P
Washougal 19	M	P
Texas Cr	M	PR
WF Washougal 3	M	PR
Washougal 20	L	P
Wildboy Cr 2	L	P
Washougal 7	L	P
Washougal 10A	L	PR
Washougal 8	L	P
Prospector Creek 1B	L	P
Washougal 6	L	PR
Washougal 10	L	PR
Washougal 12	L	P
Prospector Cr 2	L	P
Timber Cr	L	P
Stebbins C	L	P
Timber Creek 2	L	P
Meander Cr	L	P
Bear Cr	L	P
Lookout Cr	L	P
Bluebird Cr	L	P
Silver Cr	L	P
Washougal 5	L	P
Deer Cr	L	P
Washougal 9	L	P
Dougan Cr	L	PR
Washougal 4	L	PR
Dougan Creek 1B	L	PR
Washougal 3	L	P
Washougal 2 tidal	L	PR
Washougal 1 tidal	L	R
Washougal Falls1	L	NA
Salmon Falls	L	NA
Dougan Falls	L	NA
Prospector Creek Culv1	L	NA
Dougan Creek Culv1	L	NA
Timber Creek Culv1	L	NA
WF Washougal Weir	L	NA
WF Washougal Falls1	L	NA

Figure 15-11. Washougal subbasin summer steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

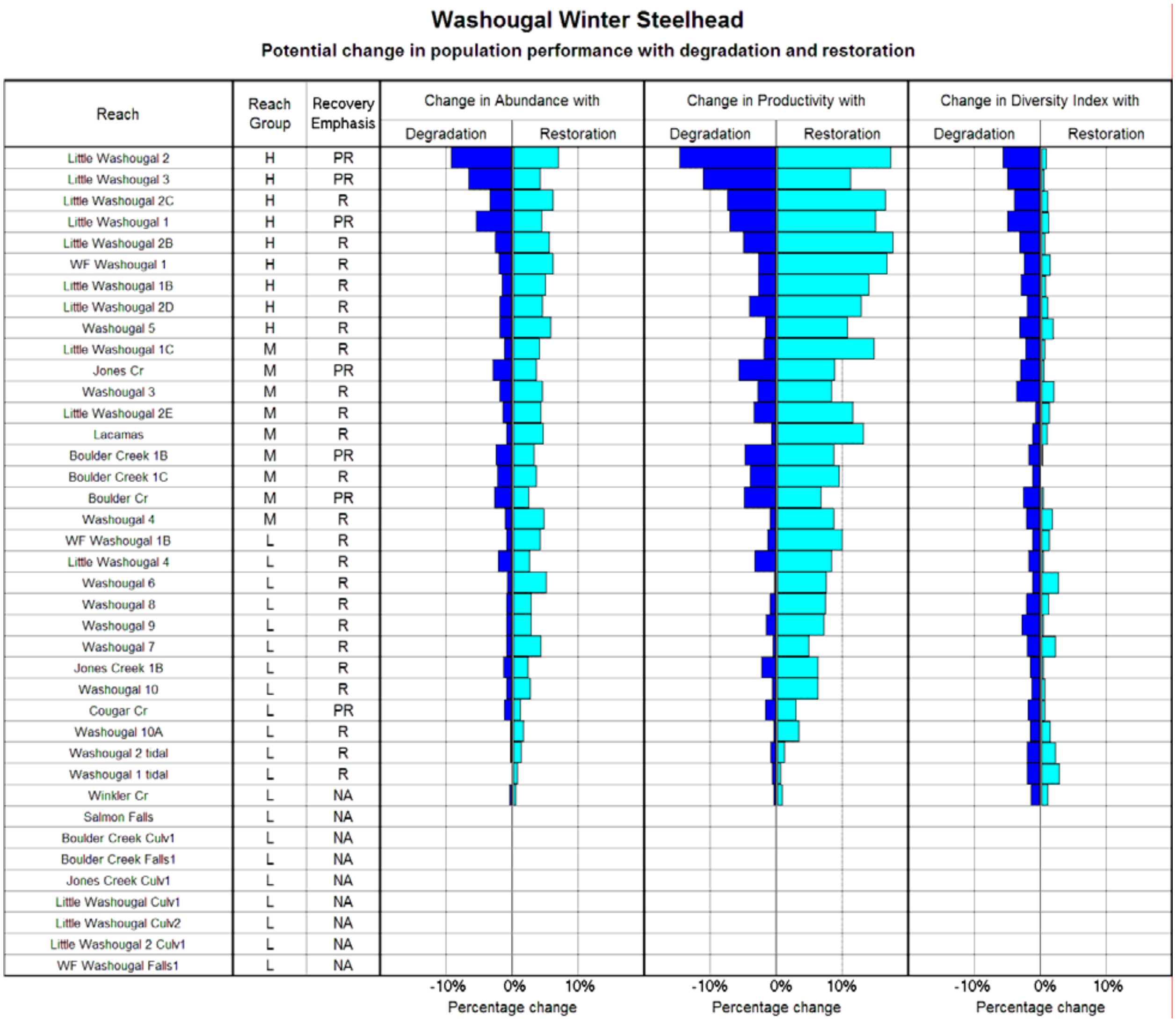


Figure 15-12. Washougal subbasin winter steelhead ladder diagram.

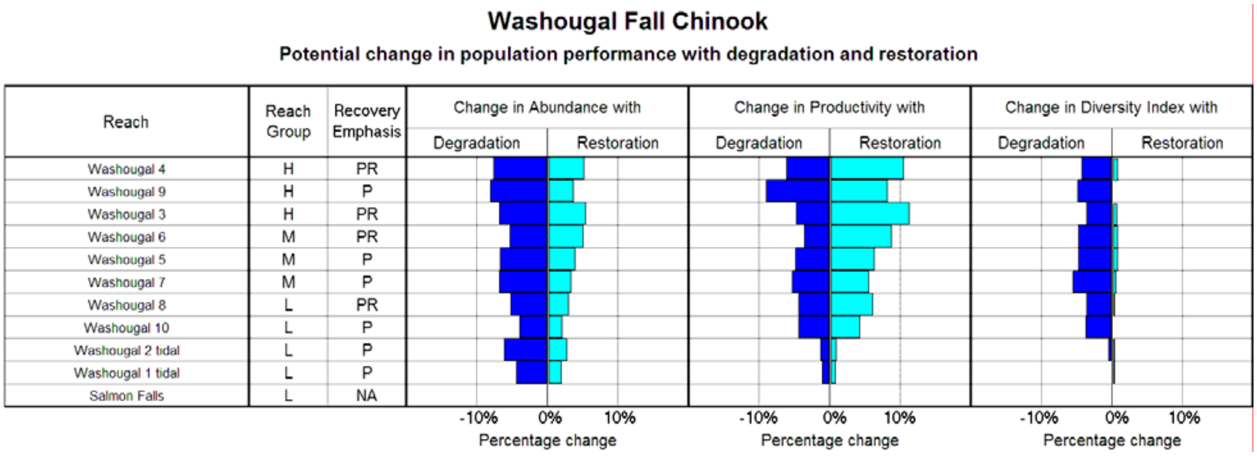
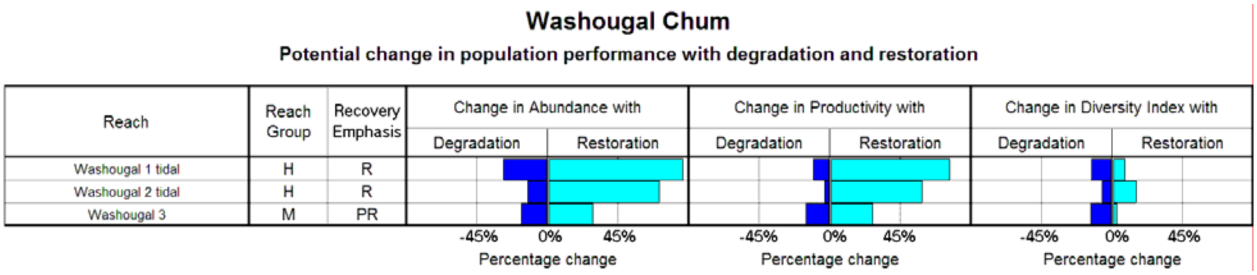
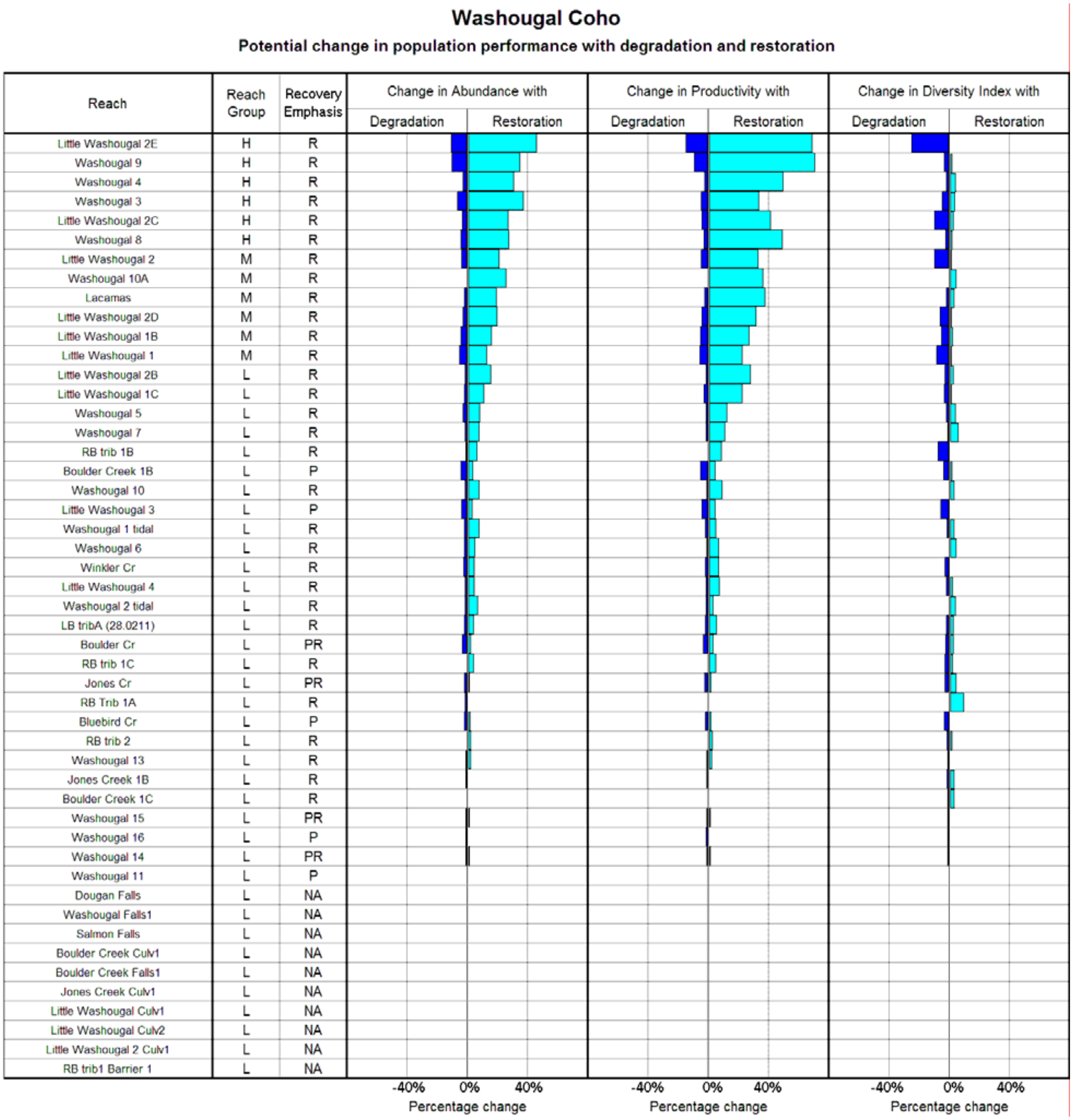


Figure 15-13. Washougal subbasin fall chinook ladder diagram.



Reach	Reach Group	Recovery Emphasis
Washougal 1 tidal	H	R
Washougal 2 tidal	H	R
Washougal 3	M	PR

Figure 15-14. Washougal subbasin chum ladder diagram.



Reach	Reach Group	Recovery Emphasis
Little Washougal 2E	H	R
Washougal 9	H	R
Washougal 4	H	R
Washougal 3	H	R
Little Washougal 2C	H	R
Washougal 8	H	R
Little Washougal 2	M	R
Washougal 10A	M	R
Lacamas	M	R
Little Washougal 2D	M	R
Little Washougal 1B	M	R
Little Washougal 1	M	R
Little Washougal 2B	L	R
Little Washougal 1C	L	R
Washougal 5	L	R
Washougal 7	L	R
RB trib 1B	L	R
Boulder Creek 1B	L	P
Washougal 10	L	R
Little Washougal 3	L	P
Washougal 1 tidal	L	R
Washougal 6	L	R
Winkler Cr	L	R
Little Washougal 4	L	R
Washougal 2 tidal	L	R
LB tribA (28.0211)	L	R
Boulder Cr	L	PR
RB trib 1C	L	R
Jones Cr	L	PR
RB Trib 1A	L	R
Bluebird Cr	L	P
RB trib 2	L	R
Washougal 13	L	R
Jones Creek 1B	L	R
Boulder Creek 1C	L	R
Washougal 15	L	PR
Washougal 16	L	P
Washougal 14	L	PR
Washougal 11	L	P
Dougan Falls	L	NA
Washougal Falls1	L	NA
Salmon Falls	L	NA
Boulder Creek Culv1	L	NA
Boulder Creek Falls1	L	NA
Jones Creek Culv1	L	NA
Little Washougal Culv1	L	NA
Little Washougal Culv2	L	NA
Little Washougal 2 Culv1	L	NA
RB trib1 Barrier 1	L	NA

Figure 15-15. Washougal subbasin coho ladder diagram.

15.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

As described previously, the greatest restoration potential for Washougal summer steelhead is in the upper mainstem, with substantial benefits also gained by restoring habitat in the WF Washougal. In these reaches, the greatest impacts to summer steelhead appear to be from a loss of habitat diversity, altered temperature and flow regimes, and sedimentation (Figure 15-16). Habitat diversity in these reaches is primarily impacted by a lack of instream LWD and degraded riparian function. Severe burns in the early and mid 20th century, combined with subsequent intense logging, have reduced the recruitment rate of stable LWD. In addition, some of these reaches may still be recovering from splash damming that scoured channels and reduced bank stability. Impacts to the flow regime are primarily a result of the high road density (>3 mi/mi^2) in some subwatersheds as well as the lack of mature forest cover. Degraded riparian conditions, scoured channels, and lack of large woody debris contribute to the degraded channel stability, key habitat, and food in these reaches. The headwater reaches (Washougal 16-20) suffer from many of the same impacts as the upper Washougal reaches. These headwater reaches, however, are less affected by flow regime changes due to a roadless basin upstream of reaches 19 and 20. Furthermore, in the last couple of years, the WDNR has obliterated many roads in the upper basin, resulting in a substantial reduction of road densities in the basin upstream of reach 16. Sediment and flow conditions are expected to improve as these areas recover.

In contrast to summer steelhead restoration priorities, restoration of winter steelhead habitat should focus on the lower Washougal and lower Little Washougal reaches. Sedimentation, temperature, and key habitat are the primary factors limiting performance of winter steelhead in the Washougal (Figure 15-17). Denuded riparian vegetation at streamside residences and along the highway that parallels the river contributes to these impacts, as does a general lack of instream LWD. Flow impacts arising from upper basin road and vegetation conditions are also a concern. Furthermore, there is a large amount of agricultural land along the lower Little Washougal and reaches suffer from low stream shade, low instream LWD, and sedimentation.

Restoration efforts for fall chinook should focus foremost on restoring channel stability, habitat diversity, sediment, and temperature conditions in the lower and middle mainstem (Figure 15-18). Sediment from upper basin sources settles out in low gradient portions of these reaches, which are important chinook spawning areas. Low LWD levels affect habitat diversity and channel stability. Channel stability is further impacted by changes to the flow regime. Many of these lower mainstem reaches suffer from bed scour. Riparian canopy cover (shade) has been reduced within the residential/highway corridor that follows the west bank of the lower river, thus increasing temperatures. Relatively minor impacts of predation, competition, and pathogens are related to the Washougal Hatchery program.

Chum salmon habitat in the lower river suffers from a lack of habitat diversity, increased sedimentation, and harassment (Figure 15-19). Habitat diversity has been lost due to low LWD levels and artificial confinement. Sediment impacts stem from upper basin sources, as the sediment tends to settle out in these lower portions of the basin. Harassment is due to the hatchery program and angling for hatchery fish.

Coho habitat in the Washougal subbasin is impacted by impaired conditions related to sediment, habitat diversity, key habitat, temperature, and channel stability (Figure 15-20). The causes of these impacts are similar to those discussed above for the other species.

Washougal Summer Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
WF Washougal 2	•	⬤	●	●		●			⬤	⬤	●			•		✚
Washougal 17	•	⬤	●	•					●	•				•		+
Washougal 16	•	⬤	●	•		•			⬤	•	•			•		+
Washougal 15	●	⬤	●	•		•			⬤	•	•			•		+
WF Washougal 1B	●	⬤	⬤	●		●			⬤	•	●			⬤	•	●
Washougal 14	•	⬤	●	•		•			●	•	•			•	•	●
Wildboy Cr 1		●	+	•					●	⬤				•		✚
Washougal 13	•	⬤	●	•		•			●	•	•			•	•	+
Washougal 18	•	●	•						●	•						+
WF Washougal 1	•	●	●	●		●			●	•	•			●		•
Washougal 11	●	⬤	●	●		●			●	•	•			●	•	•
Prospector Cr 1	•	●	•						●	⬤						
Washougal 19	•	●	•						●	•						+
Texas Cr	•	●	●	•					●	⬤				•		✚
WF Washougal 3	•	⬤	•	•		●			●	⬤						✚
Washougal 20	•	●	•						●	●						✚
Wildboy Cr 2	•	●	●	•					●	⬤				•		✚
Washougal 7	•	⬤	●	•		•			●	•	•			•	•	+
Washougal 10A	●	⬤	●	●		•			●		•			●	•	
Washougal 8	•	●	●	•		•			●	•	•			•	•	•
Prospector Creek 1B	•	●	•			•			●	●	•					
Washougal 6	●	⬤	●	•		•			●	•	•			•	●	●
Washougal 10	•	⬤	•	●		•			●		•			•	•	
Washougal 12	•	•	•	•		•			•	•	•			•	•	•
Prospector Cr 2	•	•	•						•	●						+
Timber Cr	•	•				•			●	●	•					+
Stebbins C	•	●	•						•	●	•			•		✚
Timber Creek 2	•								●	⬤						+
Meander Cr		•							•	•						+
Bear Cr																
Lookout Cr		•							•	•						+
Bluebird Cr		•							•							+
Silver Cr		•							•							+
Washougal 5	•	●	•	•		•			•		•					
Deer Cr	•	●							•	●						+
Washougal 9	•	•	•	•		•			•					•	•	
Dougan Cr																
Washougal 4	•	●	•	•		•			•		•					
Dougan Creek 1B	•	•							•	●						+
Washougal 3	•	•	•	•		•			•							
Washougal 2 tidal	•	•	•	•					•							
Washougal 1 tidal	•	•	•	•												
Washougal Falls1																
Salmon Falls																
Dougan Falls																
Prospector Creek Culv1																
Dougan Creek Culv1																
Timber Creek Culv1																
WF Washougal Weir																
WF Washougal Falls1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 15-16. Washougal subbasin summer steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Washougal Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Little Washougal 2	•	●	⬤	•					●	●	•			●		•
Little Washougal 3	•	●	●	•					●	●				•		•
Little Washougal 2C	•	•	⬤	•					●	⬤	•			•		●
Little Washougal 1	•	•	●	●		•			●	●	•			•		⬤
Little Washougal 2B	•	●	⬤	•		•			●	⬤	•			•		⬤
WF Washougal 1	•	•	⬤	●		•			●	⬤	•			●		●
Little Washougal 1B	•	•	⬤	•		•			●	●	•			•	•	●
Little Washougal 2D	•	•	⬤	•					●	⬤	•			•		⬤
Washougal 5	•	●	●	●		•			●	●	•			•		
Little Washougal 1C	•	•	●	•		•			●	●	•			•	•	⬤
Jones Cr	•	•	●	•		•			●	⬤	•			•		●
Washougal 3	•	●	●	●	•	•			●	●	•			•		•
Little Washougal 2E	•		⬤						•	⬤						●
Lacamas	•	•	⬤	●					•	⬤	•			●		●
Boulder Creek 1B		•	●	•		•			●	⬤	•			•		⬤
Boulder Creek 1C		•	⬤	•					•	⬤	•			•		⬤
Boulder Cr		•	●	•					●	⬤	•			•		●
Washougal 4	•	●	●	•		•			●	●	•			•	•	•
WF Washougal 1B	•	●	●	•		•			●	⬤	•			•		●
Little Washougal 4	•	•	●						●	⬤				•		⬤
Washougal 6	•	⬤	●	•		•			●	●	•			•		•
Washougal 8	•	●	●	•		•			•	●	•			•		•
Washougal 9	•	•	●	•		•			•	●	•			•	•	
Washougal 7	•	●	●	•		•			●	●	•			•		•
Jones Creek 1B	•	•	●						●	●	•					⬤
Washougal 10	•	●	●	•		•			•	•	•			•		●
Cougar Cr		•	●						•	●						⬤
Washougal 10A	•	●	●	•		•			•	•				•		•
Washougal 2 tidal	•	●	•	•		•			•		•			•		
Washougal 1 tidal	•	•	•	•		•			•					•		
Winkler Cr			•						•	•						+
Salmon Falls																
Boulder Creek Culv1																
Boulder Creek Falls1																
Jones Creek Culv1																
Little Washougal Culv1																
Little Washougal Culv2																
Little Washougal 2 Culv1																
WF Washougal Falls1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 15-17. Washougal subbasin winter steelhead habitat factor analysis diagram.

Washougal Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Washougal 4	●	●	●	•		•			•	●	•				•	•
Washougal 9	●	•	●	•					•	⬤	•				•	•
Washougal 3	●	●	●	•	•	•			•	⬤	●				•	•
Washougal 6	●	●	●	•					●	●	•				•	●
Washougal 5	●	●	●	•		•			•	●	•				•	●
Washougal 7	●	●	●	•					•	●	•				•	●
Washougal 8	●	●	●	•					•	●	•				•	•
Washougal 10	●	●	•	•					•	•	•				•	●
Washougal 2 tidal	●	●	•	●	•	•			•	•	●				•	•
Washougal 1 tidal	•	•	•	●	•	•			•	•	•				•	•
Salmon Falls																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ＋ High Positve Impact ✚

Figure 15-18. Washougal subbasin fall chinook habitat factor analysis diagram.

Washougal Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Washougal 1 tidal	●	●		●	•				•	●	•				●	●
Washougal 2 tidal	•	●		•	•				•	●	•				●	•
Washougal 3	•	●		•					•	●	•				●	+

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ＋ High Positve Impact ✚

Figure 15-19. Washougal subbasin chum habitat factor analysis diagram.

Washougal Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Little Washougal 2E	⬤	⬤	⬤	•					●	⬤	•					⬤
Washougal 9	⬤	⬤	●	●		●			●	⬤	●			●	•	+
Washougal 4	●	⬤	●	•		•			●	●	●			•	•	•
Washougal 3	●	⬤	⬤	●	•	●			●	⬤	●			•	•	•
Little Washougal 2C	⬤	⬤	⬤	•					●	⬤	•					⬤
Washougal 8	⬤	⬤	●	•		•			●	⬤	●			•	•	•
Little Washougal 2	●	⬤	●	•					●	●	•					●
Washougal 10A	●	⬤	•	•		•			●	•	•			•	•	●
Lacamas	●	⬤	●	•					●	⬤	•					⬤
Little Washougal 2D	●	⬤	●						●	⬤	•					⬤
Little Washougal 1B	●	●	●	•		•			●	⬤	•			•	•	⬤
Little Washougal 1	●	●	●	•		•			●	●	•			•		⬤
Little Washougal 2B	●	⬤	●						●	●	•					⬤
Little Washougal 1C	●	●	●	•		•			•	●	•			•	•	⬤
Washougal 5	•	●	•	•		•			•	•	•					•
Washougal 7	•	●	•	•		•			•	•	•					•
RB trib 1B	●	●	•						•	●	•					+
Boulder Creek 1B	•	●	•						•	●	•					●
Washougal 10	●	●	•	•		•			•	•	•			•		●
Little Washougal 3	•	●	•						•	●						•
Washougal 1 tidal	•	●	•	●	•	•			•		•			•		•
Washougal 6	•	●	•			•			•	•	•					•
Winkler Cr	•	●	•						•	●	•					•
Little Washougal 4	•	●	•						•	●						●
Washougal 2 tidal	•	●	•	•		•			•		•			•		•
LB tribA (28.0211)	•	●	•						•	●	•					●
Boulder Cr	•	•							•	•	•					•
RB trib 1C	•	●							•	•	•					•
Jones Cr	•	•								•						•
RB Trib 1A										•						
Bluebird Cr	•	•							•							•
RB trib 2	•	•							•	•	•					•
Washougal 13		•	•						•							•
Jones Creek 1B																•
Boulder Creek 1C																
Washougal 15		•														
Washougal 16		•														
Washougal 14		•														•
Washougal 11																
Dougan Falls																
Washougal Falls1																
Salmon Falls																
Boulder Creek Culv1																
Boulder Creek Falls1																
Jones Creek Culv1																
Little Washougal Culv1																
Little Washougal Culv2																
Little Washougal 2 Culv1																
RB trib1 Barrier 1																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ╋ High Positve Impact ✚

Figure 15-20. Washougal subbasin coho habitat factor analysis diagram.

15.7 Integrated Watershed Assessments (IWA)

The Washougal River watershed comprises 29 subwatersheds covering a total of approximately 137,600 acres. The Washougal River watershed is primarily a lower elevation, rain dominated system with low to moderate levels of natural erodability. Nine subwatersheds are considered headwaters, with high elevation types and low to moderate erodability; the majority of these are predominantly in the rain-on-snow zone. Thirteen subwatersheds are the low elevation tributary type, with low to moderate erodability levels. The seven mainstem river subwatersheds can be divided into three moderate size mainstem river types (between 20,000 and 200,000 acres total drainage area), and four low elevation moderate - sized mainstem river types. Natural erodability in these seven mainstem subwatersheds is classified as low to moderate.

15.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Washougal River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in. IWA results for each subwatershed are presented in Table 15-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 15-21. Maps of the distribution of local and watershed level IWA results are displayed in Figure 15-22.

Table 15-2. IWA results for the Washougal River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60101	F	M	F	F	M	60103
60102	F	F	F	F	F	none
60103	F	M	M	F	M	none
60201	M	M	M	F	M	60101, 60102, 60103, 60202, 60204
60202	F	M	F	F	M	none
60203	I	M	M	I	M	none
60204	F	F	M	F	F	none
60301	M	F	M	I	M	60302, 60303, 60304
60302	M	F	M	M	F	none
60303	I	M	M	I	M	none
60401	I	M	M	M	M	60101, 60102, 60103, 60201, 60202, 60203, 60204
60402	I	M	M	I	M	none
60501	I	M	I	I	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60502	I	M	M	I	M	60503, 60506
60503	M	F	M	M	F	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60504	I	M	M	I	M	60101, 60102, 60103, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60505	I	M	M	I	M	none
60506	M	M	M	M	M	none
60601	I	M	I	M	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304, 60602, 60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60602	M	F	M	I	M	60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60603	M	F	I	I	M	60604, 60605, 60606, 60607, 60608, 60609, 60610
60604	I	M	I	I	M	none
60605	M	M	M	M	M	none
60606	I	M	M	I	M	none
60607	M	F	I	I	F	60608, 60609, 60610
60608	I	F	I	I	F	none
60609	I	M	I	I	M	none
60610	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

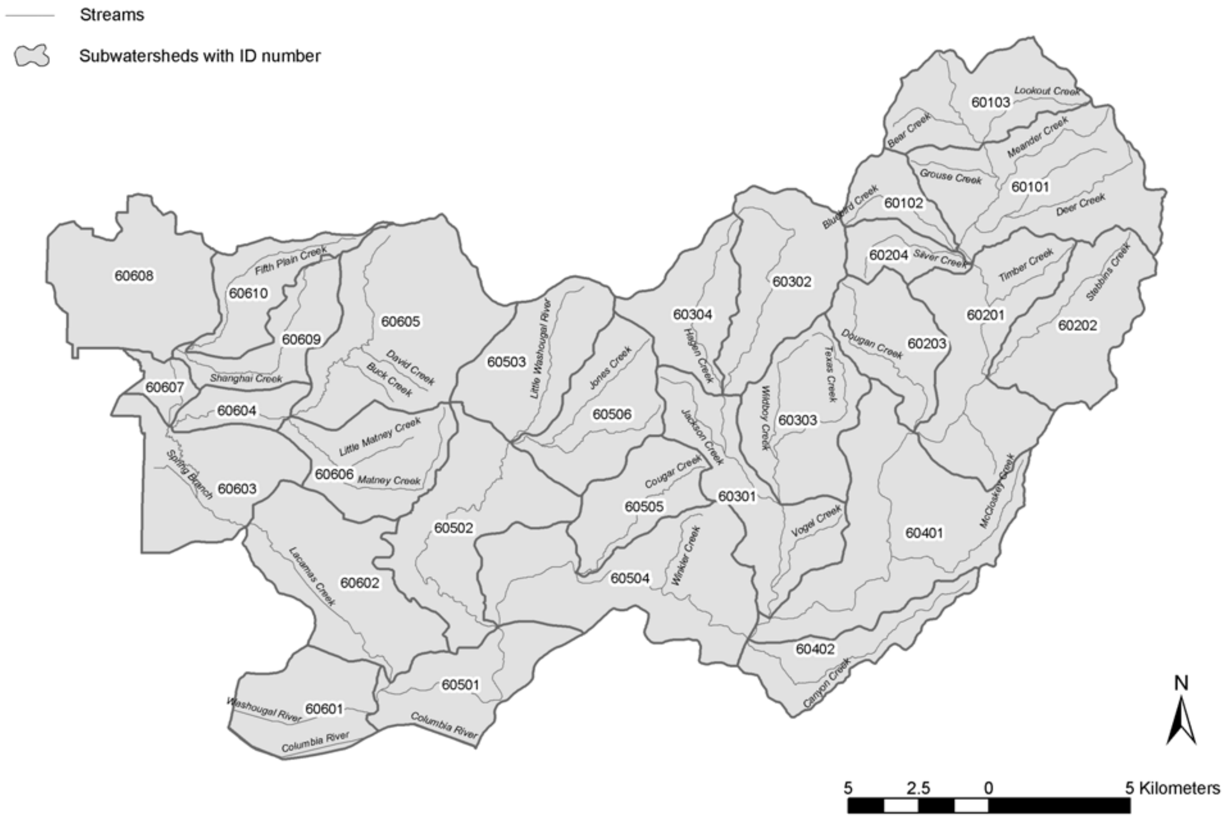


Figure 15-21. Map of the Washougal basin showing the location of the IWA subwatersheds.

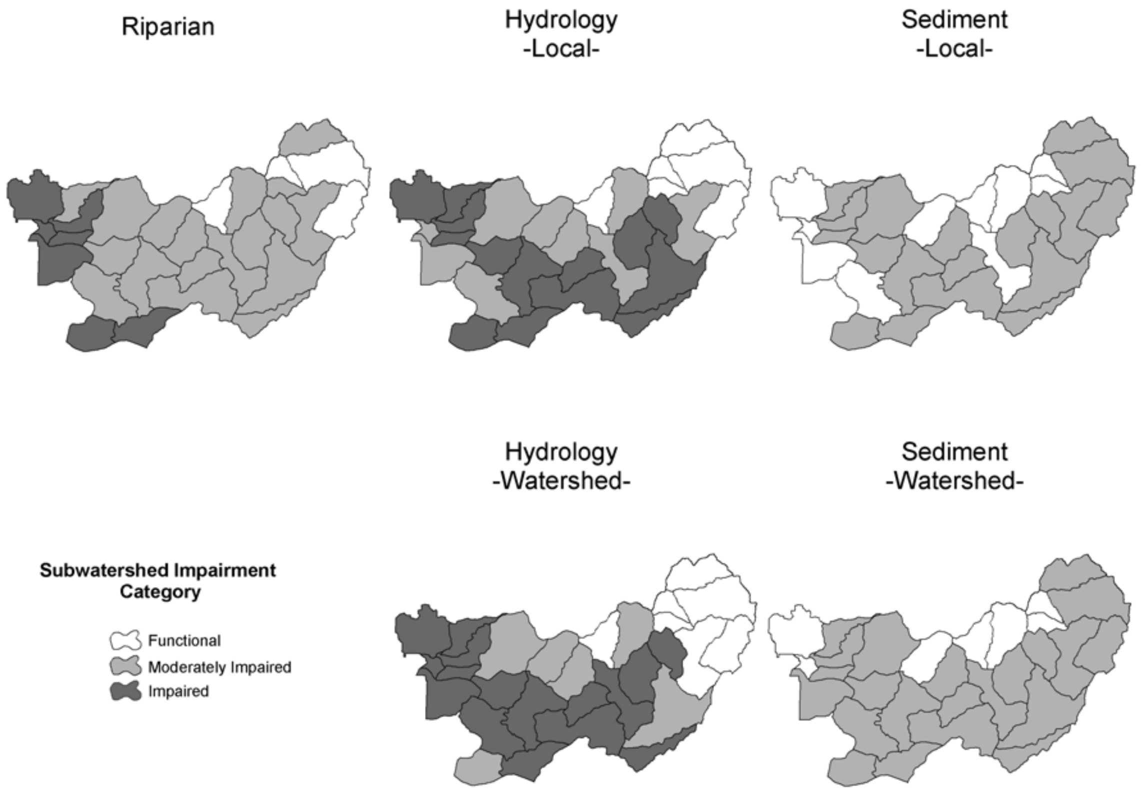


Figure 15-22. IWA subwatershed impairment ratings by category for the Washougal basin

15.7.1.1 Hydrology

Hydrologic conditions across the Washougal River watershed range from functional to impaired, with functional subwatersheds located in headwaters areas in the upper mainstem and upper West Fork. Conditions become increasingly impaired on a downstream gradient. Hydrologically impaired subwatersheds are primarily concentrated in the moderate to low elevation areas of the mainstem Washougal River and the lower Little Washougal River, as well as some tributary streams. An exception to this pattern is the Lacamas Creek drainage, which has several hydrologically impaired headwaters subwatersheds.

Hydrologically intact conditions in headwaters subwatersheds appear to buffer downstream conditions. These subwatersheds include the headwaters of the Washougal (60103), Bluebird Creek (60102), the upper mainstem (60101), Stebbins Creek (60202), Silver Creek (60204), and Hagen Creek in the West Fork Washougal headwaters (60304). The upper mainstem subwatershed (60101) is especially important for summer steelhead. The majority (90%) of the land area in these upper subwatersheds is publicly owned, and managed by either the USFS or WDNR. These subwatersheds are susceptible to potential hydrologic impacts because of high rain-on-snow area (72%). However, mature forest cover in these subwatersheds averages 69% and road densities are relatively low (all < 3 mi/mi^2).

Impaired watershed level conditions in the lower West Fork Washougal River (60301) are strongly influenced by impaired hydrologic conditions in the Wildboy Creek drainage (60303) and moderately impaired conditions locally and in the upper West Fork Washougal River (60302). Relatively intact hydrologic conditions in Hagen Creek (60304) appear to be an important buffer. The upper West Fork (60302) is primarily public lands (64%) administered by USFS or WDNR. However, current land cover conditions are poor, with only 21% of subwatershed area in hydrologically mature forest. The upper West Fork has 67% of its area in the rain-on-snow zone, and therefore is more sensitive to hydrologic degradation. Current road densities are moderate (2.1 mi/mi^2). Wildboy Creek is largely in private land holdings (81%), the majority being active timber lands. Mature forest cover is low (27%) and road densities are high (4.9 mi/mi^2).

The Cougar Creek drainage (60505) and the upper Little Washougal River (60506) are both terminal (i.e., no upstream subwatersheds) and relatively low elevation, with less than 25% of area in the rain-on-snow zone. They are almost evenly divided between public and private lands. Hydrologic conditions in the Cougar Creek drainage are impaired, because of relatively low mature forest cover (39%), and moderately high road densities (3.3 mi/mi^2). The majority of privately held lands, comprising nearly 50% of total area, are zoned for commercial forestry. Approximately 4% is zoned for development but currently vacant. The upper Little Washougal River (60506) is moderately impaired as a result of a high percentage of mature vegetation (64%) and public lands ownership (62%), but also high road densities (5.4 mi/mi^2).

The middle mainstem Washougal River subwatersheds (60201 and 60401) contain important habitat for multiple species. These subwatersheds are moderately impaired and impaired at the local level, respectively, but appear to be buffered by hydrologically functional upstream subwatersheds, resulting in functional and moderately impaired watershed level ratings, respectively. Degraded hydrologic conditions in the Dougan Creek drainage (60203) contribute to the moderately impaired watershed level rating in subwatershed 60401. With regard to local conditions, the majority of subwatershed 60201 is owned by WDNR, and currently has 63% mature forest cover. Road densities are relatively high (3.4 mi/mi^2). Approximately 56% of this subwatershed is in the rain-on-snow zone. Subwatershed 60401 is

26% publicly owned, has only 26% mature forest cover, and has relatively high road densities at 4.5 mi/mi^2. Approximately 31% of this subwatershed is in the rain-on-snow zone; 47% is publicly owned. Road densities are moderately high at 4.2 mi/mi^2, and hydrologically mature forest coverage is relatively low (37%). The remainder of land ownership in these two subwatersheds is primarily in private timber holdings.

Hydrologic conditions in the lower mainstem Washougal River (60504 and 60501) are rated as impaired at both the local and the watershed levels. Locally impaired ratings result primarily from high road densities, impervious surface, and poor forest cover associated with development within and surrounding the towns of Camas and Washougal. A high percentage of these subwatersheds (64%) is zoned for development but currently vacant. The lower mainstem Washougal River has been developed and channelized; impervious surface rates are increasing as development expands. Hydrologic conditions in these subwatersheds are also affected by impaired conditions in the West Fork and Little Washougal Rivers.

15.7.1.2 Sediment

The majority of subwatersheds have moderately impaired sediment supply conditions, with functional sediment conditions occurring mostly in headwaters tributaries, the lower West Fork Washougal (60301), and the lower Lacamas Creek drainage (60602, 60603). All sediment functional subwatersheds have very low natural erodability ratings, based on geology type and slope class, averaging less than 10 on a scale of 0-126. This suggests that these subwatersheds would not be large sources of sediment impacts under disturbed conditions. Road densities and streamside road densities in these subwatersheds are also relatively low. Moderately impaired sediment conditions are present in all subwatersheds important to anadromous fish. These problems are likely to be exacerbated in subwatersheds where hydrologic conditions are also impaired.

Four headwaters subwatersheds (60102, 60204, 60302 and 60304) have locally functional sediment conditions. Three of these, the upper Washougal (60102), Silver Creek (60204), and Hagen Creek (60304) are also rated hydrologically functional. These subwatersheds will buffer sediment conditions in important downstream subwatersheds.

Other headwaters and tributary subwatersheds have moderately impaired or impaired sediment conditions, including the Washougal headwaters (60103), Stebbins Creek (60202), Dougan Creek (60203) and Wildboy Creek (60303). All of these subwatersheds have low natural erodability ratings, ranging from 12-13, except for Dougan Creek which has a low moderate rating of 29. Road densities in Dougan and Wildboy Creeks exceed 4 mi/mi^2, and stream crossing density is also relatively high at 2.8 crossings/stream mile, leading to the hydrologically impaired rating. Stebbins Creek and the Washougal headwaters have lower road and stream crossing densities (2.7 and 1.1 mi/mi^2, and 2.0 and 0.3 crossings/stream mile, respectively). Streamside road density in the Washougal headwaters is very low.

Sediment conditions in the Cougar and Little Washougal subwatersheds (60505 and 60506) are moderately impaired. Natural erodability in these subwatersheds is quite low (less than 3); however, road densities in these subwatersheds contribute to moderate impairments. Moderate to high streamside road densities are additional sources of sediment in these watersheds.

Important mainstem subwatersheds in the Washougal system are all moderately impaired for sediment at both local and watershed levels. Consistent with the majority of the watershed, the natural erodability of these subwatersheds is relatively low (less than 27). The fact that functional sediment conditions fail to mitigate locally impaired conditions in downstream subwatersheds suggests that local sources are primary drivers. The WF Washougal (60301) has a moderately high density of streamside roads (0.5 miles/stream mile); however, many of these roads are surfaced county roads that contribute less sediment than unsurfaced roads.

15.7.1.3 Riparian

Moderately impaired riparian conditions predominate throughout the watershed, with only four functional subwatersheds in the headwaters of the mainstem and West Fork Washougal River. Impaired riparian conditions are present in five of nine subwatersheds in the Lacamas Creek drainage and in the developing subwatersheds around Washougal and Camas.

The four subwatersheds having functional riparian conditions (>80% functional riparian vegetation) include Hagen Creek (60304), Bluebird Creek (60102), Stebbins Creek (60202), and the upper mainstem Washougal (60101). These four subwatersheds are also rated hydrologically functional, and two (Bluebird Creek and Hagen Creek) are also functional for sediment.

Riparian conditions in all other subwatersheds are rated as moderately impaired, including the tributary subwatersheds of Cougar Creek (60505) and the headwaters of the Little Washougal River (60506).

15.7.2 Predicted Future Trends

15.7.2.1 Hydrology

Trends in hydrologic conditions are expected to remain stable or improve gradually in the headwaters subwatersheds (including 60101, 60102, 60103, 60202, 60204, Upper WF 60302, Wildboy Creek 60303, 60304). Hydrology trends in these subwatersheds are based on the high percentage of public lands, the low intensity of forest practices, and maturing of forest cover.

Hydrology conditions in the mainstem subwatersheds (60201 and 60401) are expected to trend stable because of the opposing effects of improving headwater conditions and locally high road densities. However, hydrologic conditions in Cougar Creek and the upper Little Washougal River may degrade further over the next 20 years because of the potential for development.

Given the high percentage of developable (i.e., zoned but currently vacant) land in the lower mainstem Washougal River (60504 and 60501), and the currently impaired conditions, the predicted trend is for hydrologic conditions to degrade further. This predicted trend also applies to the West Fork Washougal River (60301) because of continually increasing development adjacent to the stream channel.

15.7.2.2 Sediment Supply

Most sediment functional subwatersheds (i.e. headwaters) have been designated as such because of a high percentage of public land ownership and a relatively low level of current impacts; these conditions are not expected to change. Thus, the trend in sediment conditions for the current functional subwatersheds is expected to remain relatively constant over the next 20 years.

Most mid-elevation subwatersheds throughout the basin have moderately impaired sediment conditions; trends in sediment conditions are expected to be constant over the next 20 years. The predicted trend is based on the assumption that existing land uses will continue in the future (specifically, the likelihood for ongoing timber harvests on privately held lands and associated vehicle traffic on unsurfaced roads). Sediment conditions in these subwatersheds have the potential for improvement if timber harvests are limited.

Trends in sediment conditions in mainstem subwatersheds are expected to remain relatively constant (i.e. moderately impaired) or degrade further because of ongoing timber harvest on privately held lands, high road densities in upland areas, moderately high streamside road densities (ranging from 0.4 to 0.6 miles/stream mile), and the potential for increased development. Given the potential for development, sediment conditions in the Cougar, Little Washougal, and lower mainstem subwatersheds are susceptible to further degradation.

15.7.2.3 Riparian Condition

Currently functional riparian conditions in the upper watershed (Hagen Creek 60304, Bluebird Creek 60102, Stebbins Creek 60202, and the upper mainstem 60101) are expected to continue to improve over the next 20 years due to regulatory protections and functional hydrologic conditions.

The middle mainstem Washougal (60201, 60401) and the West Fork Washougal (60301) have large areas of public and private lands managed for timber harvest; the predicted trend in these subwatersheds is for riparian conditions to remain relatively constant. Some riparian recovery is expected on timber lands where streamside roads are not present, but these gains are expected to be offset by increasing streamside development (streamside road densities in these subwatersheds currently averages 0.5 miles/stream mile).

Riparian conditions in the lower mainstem Washougal (60504 and 60501) are expected to trend downward over the next 20 years, as development continues around the towns of Camas and Washougal. Channelization in these subwatersheds limits the potential for riparian recovery. Degrading riparian trends are also expected in Cougar Creek (60505), which has 24% of its area zoned for development but is currently vacant. Zoning information was not available for the Little Washougal headwaters (60506), but the proximity to other developable lands in the area suggests the potential for similar downward trends in riparian conditions.

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Volume II, Chapter 16
Wind River Subbasin

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16.0 Wind River Subbasin

16.1 Subbasin Description

16.1.1 Topography & Geology

The Wind River subbasin covers about 143,504 acres (224 mi^2) in central Skamania County. The headwaters of the mainstem arise in the McClellan Meadows area in the southern Gifford Pinchot National Forest (GPNF). The major tributaries in the basin include the Little Wind River, Bear Creek, Panther Creek, Trout Creek, Trapper Creek, Dry Creek, Falls Creek, and Paradise Creek. Elevation in the basin ranges from 80 to 3,900 feet. The northwest portion of the basin is steep and the northeast portion is relatively flat and consists of high elevation meadows. Trout Creek, a major tributary to the west, has a broad alluvial bench (Trout Creek Flats) in the upper central portion of the basin. A broad alluvial valley extends along several miles of the middle mainstem before entering into a steep V-shaped canyon in the lower 20 miles of stream. The lower southeast portion of the basin, including the Panther Creek and Little Wind River basins, is quite steep. Shipherd Falls, actually a set of four 10-15 foot falls, is located at approximately RM 2 and historically blocked all anadromous fish except for steelhead, until it was laddered in the 1950s.

Basin geologic history consists of old and new volcanic activity combined with more recent glacial and alluvial processes. The older basalt flows date back 12 to 25 million years, while the newer ones emanating from Trout Creek Hill are as recent as 300,000 years ago. The older material, which makes up most of the basin, is the most susceptible to erosion due to weathering into finer material. Relatively recent glacial activity contributed glacial sediments and has shaped river valleys. Alluvial deposits from the massive Bretz Floods, which originated from eastern Washington during the late Pleistocene, have resulted in highly erodable soils in portions of the lower basin.

16.1.2 Climate

The climate is marine-influenced, consisting of cool, wet winters and warm, dry summers. Mean annual precipitation is 109 inches at Stabler. Most of the precipitation falls from November through April (WRCC 2003). 70% of the basin is in the rain-on-snow zone, with low elevation areas in the rain-dominated zone and the highest elevation areas in the snow-dominated zone.

16.1.3 Land Use/Land Cover

The subbasin is 93% forested. Non-forested lands include alpine meadows in the upper northeast basin and areas of development in lower elevation, privately-owned areas. Forest stands above 3,500 feet are generally in the Pacific silver fir plant association, while lower elevation areas tend to be in the Hemlock zone. Approximately 9.6% of the land is private, while almost all of the remainder lies within the GPNF. Forestry land uses dominate the subbasin. The percentage of the forest in late-successional forest stages has decreased from 83,500 acres to 31,800 acres since pre-settlement times. This change is attributed to timber harvest and forest fires (USFS 1996). The largest population centers are the towns of Carson and Stabler. Carson draws its water supply from Bear Creek, a Wind River tributary. The year 2000 population of the subbasin was estimated at 2,096 persons and is expected to increase to 3,077 by 2020 (Greenberg and Callahan 2002). Land ownership and land cover are illustrated in Figure 16-1 and Figure 16-2. Figure 16-3 displays the pattern of landownership for the basin. Figure 16-4 displays the pattern of land cover / land-use.

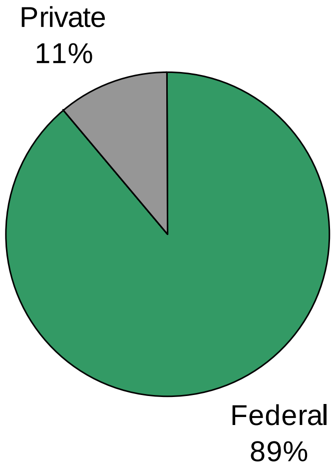


Figure 16-1. Wind River subbasin land ownership

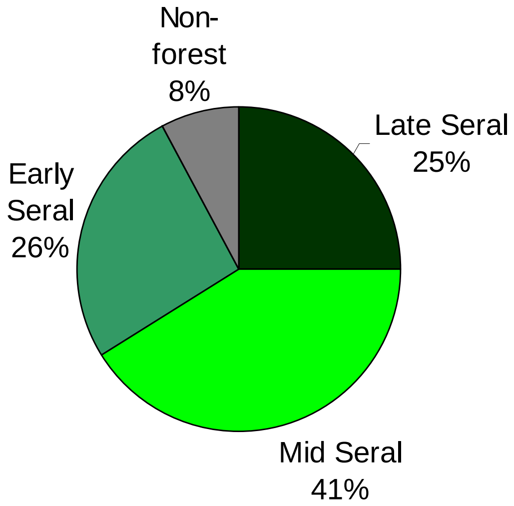


Figure 16-2. Wind River subbasin land cover

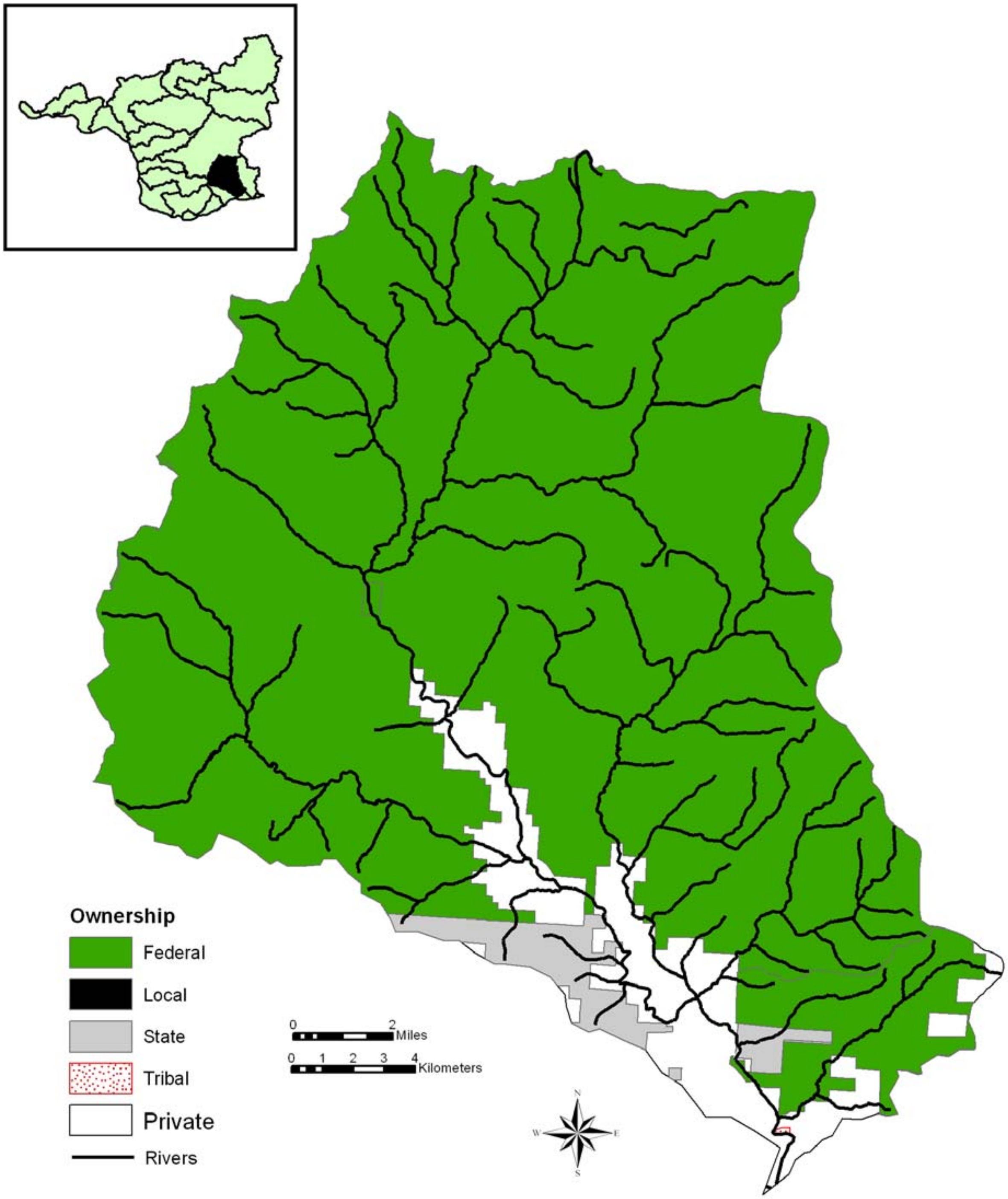


Figure 16-3. Landownership within the Wind basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

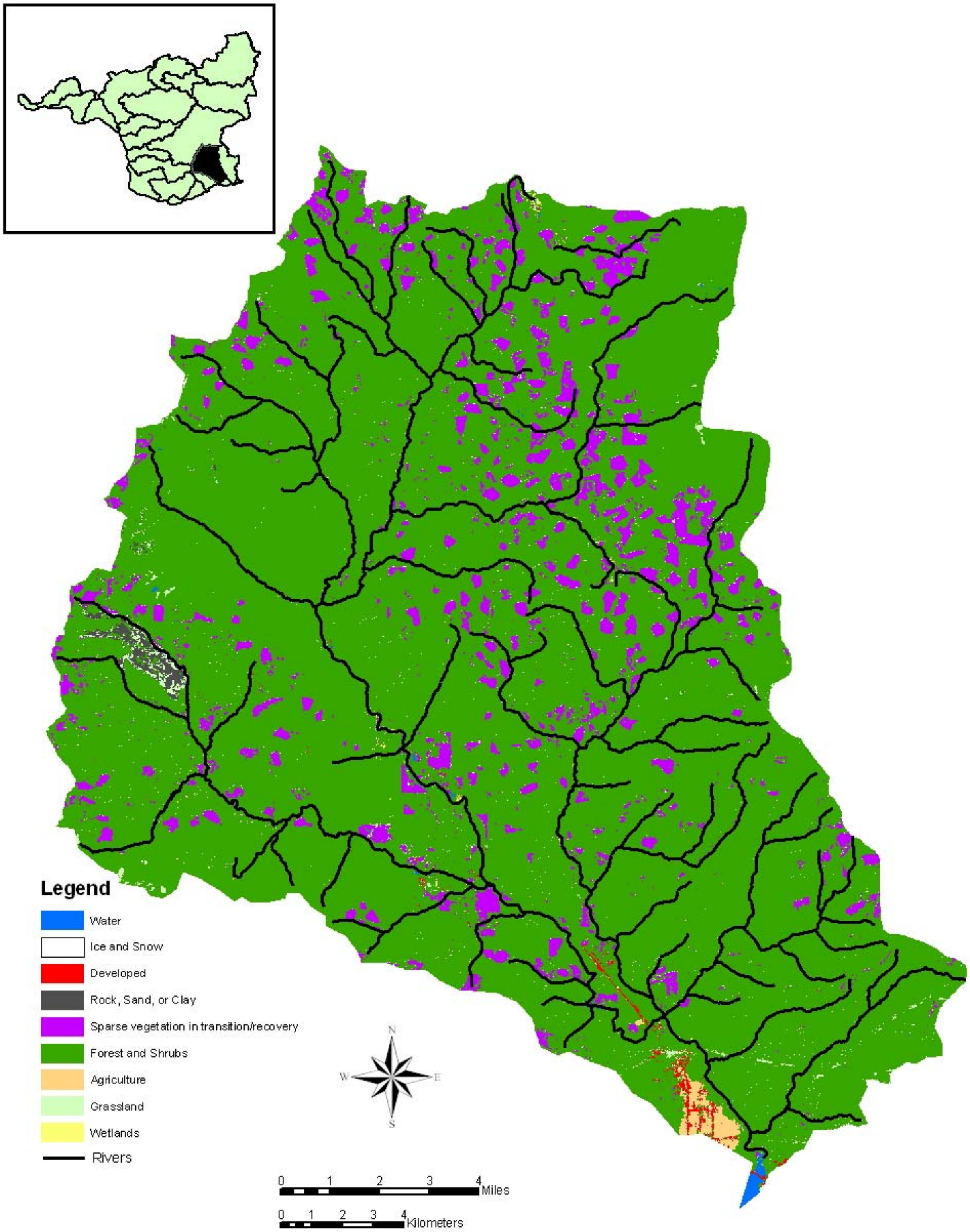
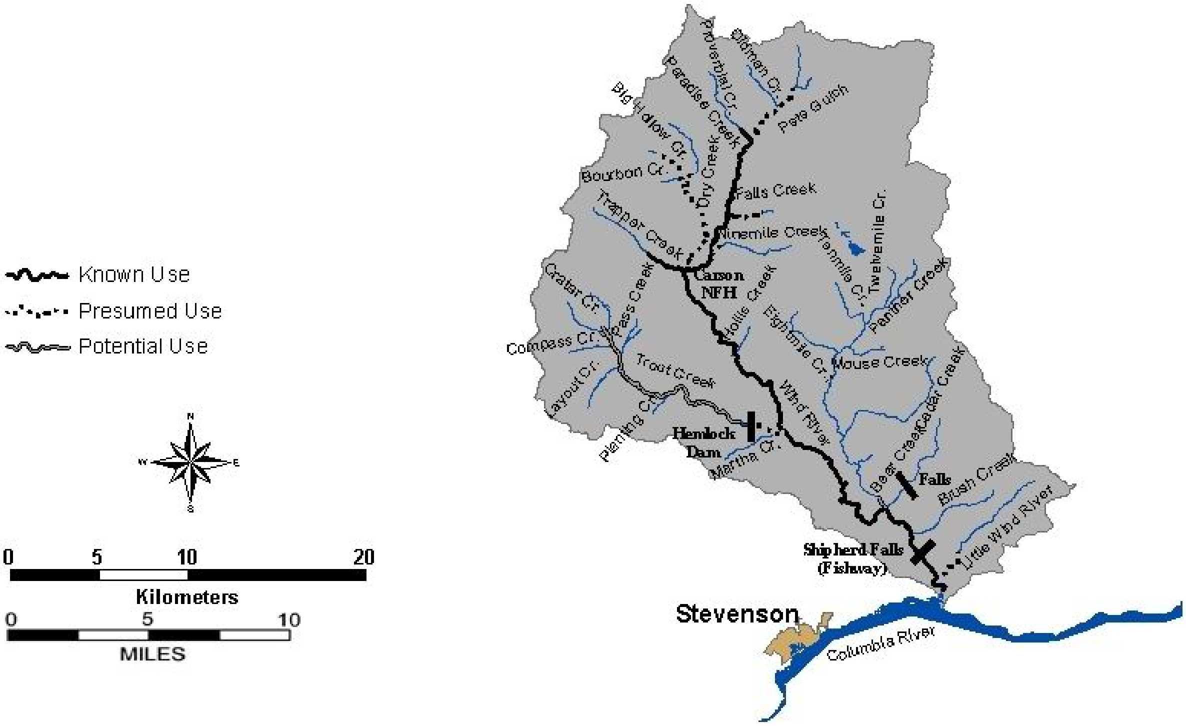


Figure 16-4. Land cover within the Wind basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

16.2 Focal Fish Species

16.2.1 Spring Chinook—Wind Subbasin

ESA: Not listed (non-native species) **SASSI: Healthy 2002**



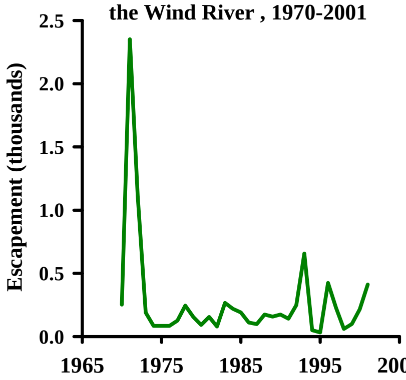
Distribution

- Historically, spring chinook were not found in the Wind River basin
- A ladder was constructed at Shipherd Falls (RM 2) in the 1956 as part of a spring chinook introduction program, providing fish access to the upper watershed
- Currently, natural spawning occurs in limited numbers from the mouth of Paradise Creek (RM 25) downstream approximately 10 miles

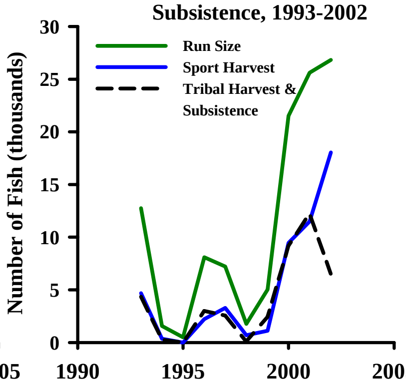
Life History

- Spring chinook return to the Wind River from March through June; spring chinook counts peak at Bonneville Dam in late April
- Spawning in the Wind River occurs between early August and mid-September, with peak activity in late August
- Age ranges from 3-year old jacks to 6-year old adults, with 4- and 5-year olds usually the dominant age class (averages are 58.5% and 38.0%, respectively)
- Fry emerge between November and March, depending on time of egg deposition and water temperature; spring chinook fry spend one full year in fresh water, and emigrate in their second spring as age-2 smolts

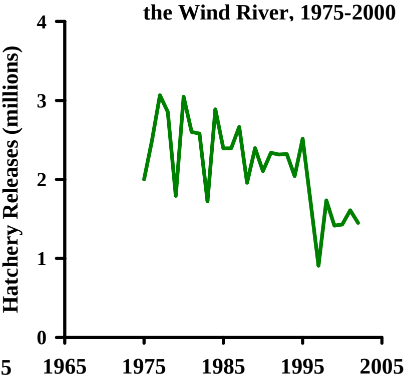
Spawner escapement surveys for the Wind River , 1970-2001



Spring Chinook Hatchery Run Size, Sport Harvest and Tribal Harvest & Subsistence, 1993-2002



Spring chinook hatchery releases in the Wind River, 1975-2000



Diversity

- Spring chinook did not historically return to the Wind River
- Spring chinook were introduced to the Wind River basin; brood stock is mixed upriver spring chinook stock
- Allozyme analysis of Carson National Fish Hatchery (NFH) spring chinook indicate they resemble upper Columbia River spring chinook stocks in the Wenatchee, Entiat, and Methow basins

Abundance

- Wind River spawning escapements from 1970-2002 ranged from 26 in 1995 to 1,936 in 1971
- The average fish per mile from 1970-84 was 21; fish per mile ranged from 4-112
- Spring chinook are not native to the Wind River basin; hatchery strays account for most spring chinook spawning in the Wind River

Productivity & Persistence

- National Marine Fisheries Service Status Assessment for the Wind River indicated a 0.01 risk of 90% decline in 25 years and a 0.03 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.0
- Smolt density model predicted natural production potential for the Wind River was 157,533 smolts
- Juvenile production from natural spawning is presumed to be low; population is not considered self-sustaining

Hatchery

- The state operated a salmon hatchery near the mouth of the Wind River from 1899-1938 to produce fall chinook
- Carson NFH was constructed in 1937 at Tyee Springs (RM 18); hatchery releases of spring chinook in the Wind River began in the 1930s; early attempts to introduce spring chinook to the Wind basin were unsuccessful
- Spring chinook releases into the Wind River 1972-1990 averaged 3,443,636
- Carson NFH brood stock was developed from spring chinook from the Snake River and mid- and upper Columbia River collected at Bonneville Dam in the 1970s

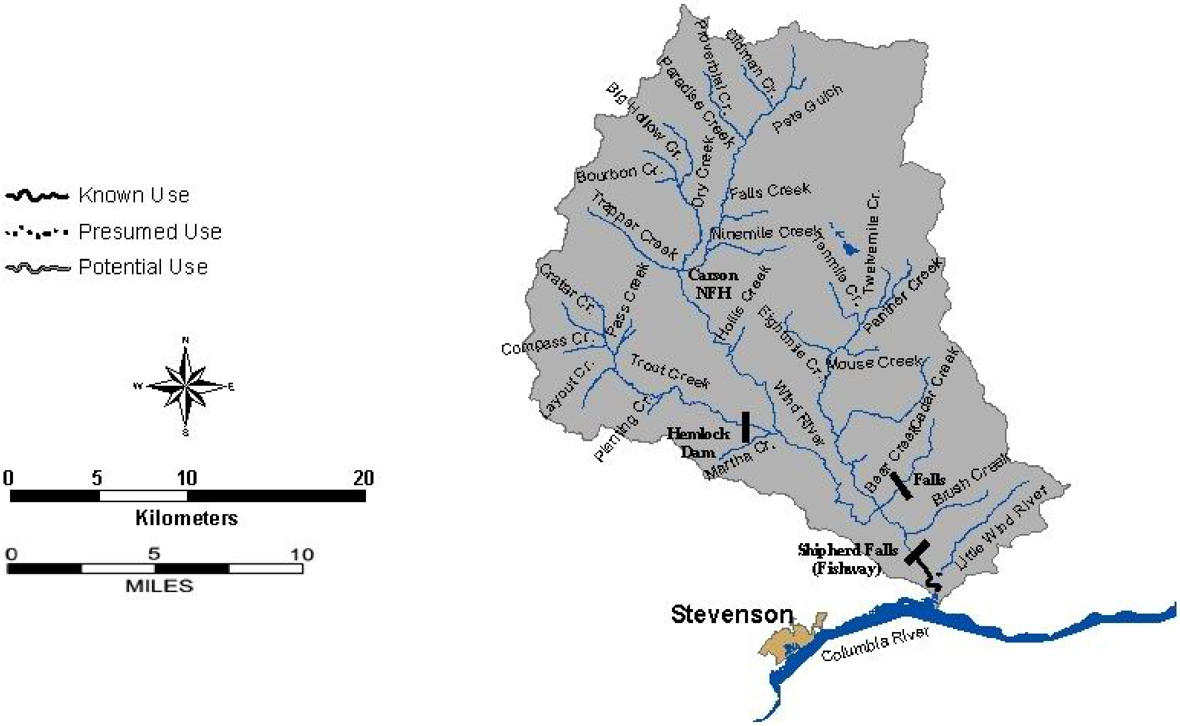
- The current Carson hatchery program releases 1.6 million spring chinook smolts annually into the Wind River

Harvest

- Spring chinook to harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial and sport fisheries
- CWT analysis indicated that upriver spring chinook are impacted less by ocean fisheries than other Columbia River chinook stocks; CWT recovery data suggest that Carson Hatchery spring chinook are recovered primarily as recreational harvest, incidental commercial harvest, and hatchery escapement
- From 1938-1973, about 55% of upriver spring chinook runs were harvested in directed Columbia River commercial and sport fisheries; from 1975-2000 (excluding 1977), no lower river fisheries have targeted upriver stocks and the combined Indian and non-Indian harvest rate was limited to 11% or less
- Beginning in 2001, selective fisheries and abundance based management agreement through *US vs. Oregon* has enabled an increase in Columbia harvest of hatchery spring chinook
- WDF and the Yakama Indian Nation negotiate an annual harvest plan for sharing the Little White Salmon Hatchery surplus between the sport fishery and the tribal commercial and subsistence fisheries in Drano Lake
- Sport harvest in the Wind River from 1993-2002 averaged 5,130; with a record 18,036 harvested in 2002
- Tribal harvest averaged 869 and tribal hatchery subsistence distributions averaged 3,189 from 1993-2002

16.2.2 Fall Chinook—Wind Subbasin

ESA: Threatened **SASSI: Critical 2002**

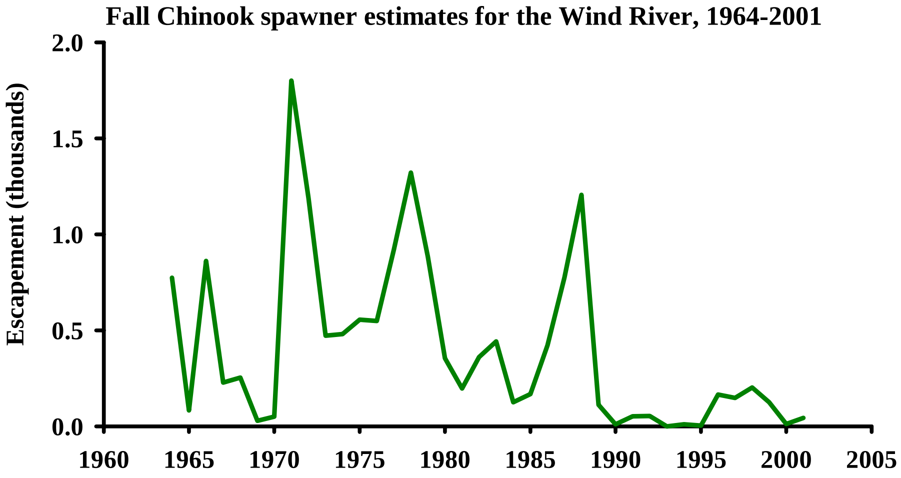


Distribution

- Historically, fall chinook were limited to the lower Wind River; a ladder was constructed at Shipherd Falls (RM 2) in 1956, providing fish access to the upper watershed
- Fall chinook have been observed up to the Carson NFH (RM 18), but the majority of spawning occurs in the lower two miles of the mainstem; spawning may also occur in the Little Wind River (RM 1)
- Completion of Bonneville Dam (1938) inundated the primary fall chinook spawning areas in the lower Wind River

Life History

- Bonneville Pool tule stock fall chinook upstream migration in the Columbia River occurs from August through September; peak counts at Bonneville Dam range from September 4-9
- Tule fall chinook enter the Wind River in September
- Spawning in the Wind River generally occurs in September
- Age ranges from 2-year old jacks to 4-year old adults, but age 3- and 4-year old spawners predominate
- Fry emerge from January through March, depending on time of egg deposition and water temperature; fall chinook fingerlings emigrate from the Wind River in spring



Diversity

- Considered a tule population in the lower Columbia River Evolutionarily Significant Unit (ESU)
- The Wind River fall chinook stock was designated based on spawning distribution, spawning timing, river entry timing, appearance, and age composition
- Hybridization between native Wind River tule fall chinook and Spring Creek NFH fall chinook is likely

Abundance

- In the late 1930s, fall chinook escapement to the Wind River basin was 200 fish
- WDFW (1951) estimated a 5-year average return of 1,500 fall chinook
- Wind River, spawning escapements from 1964-2001 ranged from 0 to 1,845 (average 416)

Productivity & Persistence

- NMFS Status Assessment for the Wind River fall chinook indicated a 0.52 risk of 90% decline in 25 years, 0.67 risk of 90% decline in 50 years, and 0.74 risk of extinction in 50 years
- Fall chinook smolt capacity was estimated at 206,608 for the Wind River basin
- Naturally produced fall chinook fry are observed each year in the lower Wind River smolt trap, documenting successful natural spawning

Hatchery

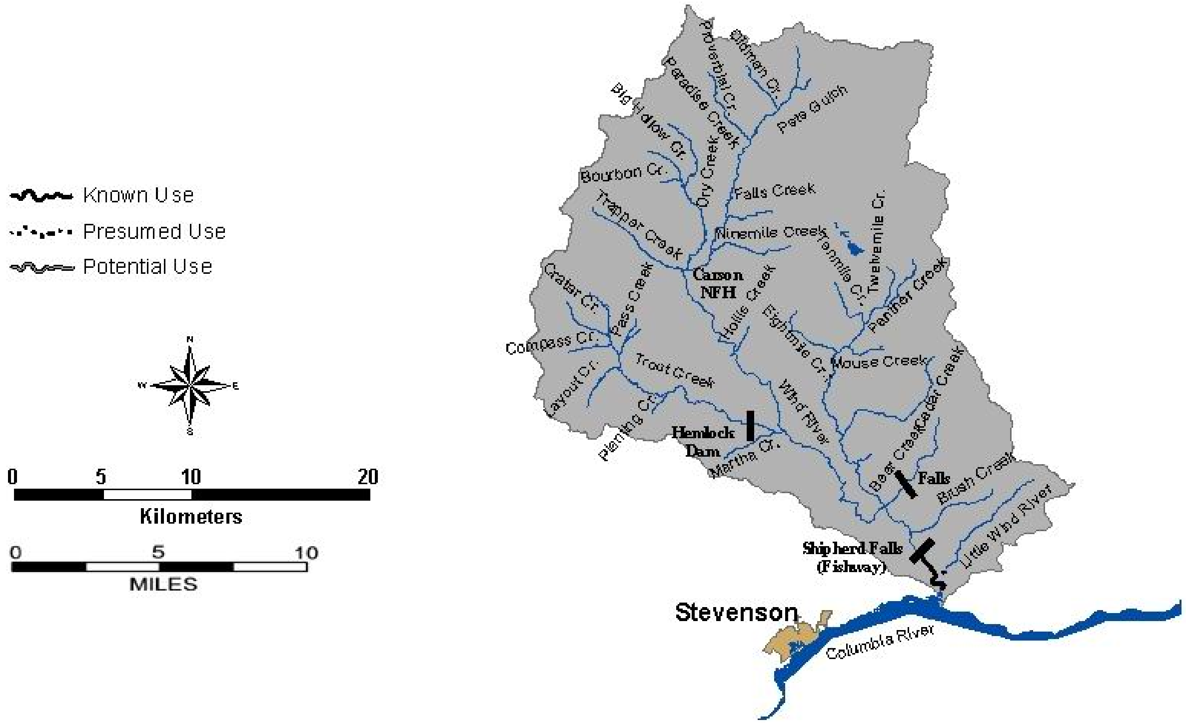
- The state operated a salmon hatchery near the mouth of the Wind River from 1899 until 1938 when the hatchery was flooded by Bonneville Dam Reservoir
- The state hatchery produced only fall chinook during 1899-1938, with egg take ranging from 1-4 million in most years, but as high as 10-20 million in some years; broodstock was taken directly from the Wind River
- Carson NFH was constructed in 1937 at Tyee Springs (RM 18); broodstock was developed primarily from Spring Creek NFH fall chinook stock
- Total fall chinook releases in the Wind River basin averaged 2 million from 1952-1976
- Fall chinook hatchery releases into the Wind River were discontinued after 1976

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Columbia River commercial harvest occurs in August and September, but flesh quality is low once tule chinook move from salt water; the price is low compared to higher quality bright stock chinook
- Fall chinook destined for areas upstream of Bonneville Dam are harvested in August and September Treaty Indian commercial and subsistence fisheries
- Annual harvest dependent on management response to annual abundance in Pacific Salmon Commission (PSC) (US/Canada), Pacific Fisheries Management Council (PFMC) (US ocean), and Columbia River Compact forums
- Ocean and lower Columbia River harvest limited to 49% due to Endangered Species Act (ESA) limit on Coweeman tules
- Fall chinook originating upstream of Bonneville Dam are subject to Federal Court Agreements regarding Indian and non-Indian harvest sharing
- CWT data analysis of the 1971-1972 brood years from Spring Creek NFH indicates that the majority of Bonneville Pool Hatchery fall chinook stock harvest occurred in British Columbia (28%) and Washington (38%) ocean commercial and recreational fisheries
- Bonneville Pool tule stock fall chinook are important contributors to the Columbia River estuary (Buoy 10) sport fishery; in 1991, Bonneville Pool Hatchery fish comprised 25% of the Buoy 10 chinook catch
- Sport harvest in the Wind River averaged 9 fall chinook annually from 1977-1986

16.2.3 Mid-Columbia Bright Late Fall Chinook—Wind Subbasin

ESA: Threatened 1999 **SASSI: Healthy 2002**



Distribution

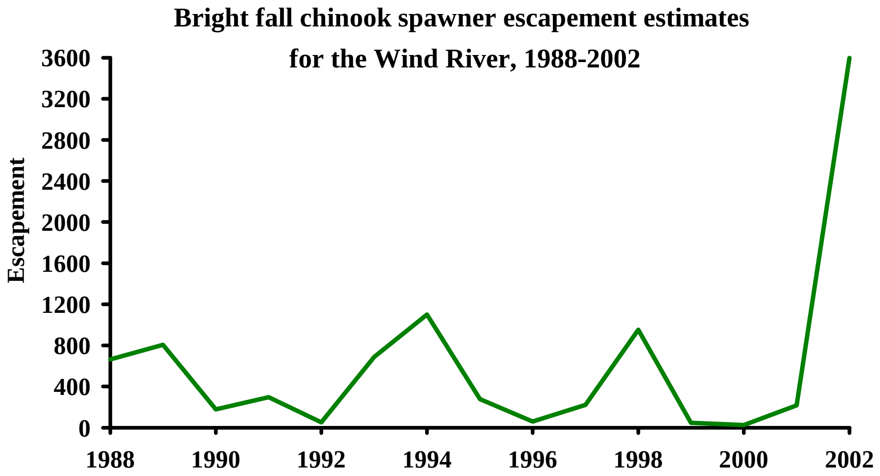
- Completion of Bonneville Dam (1938) inundated the primary spawning areas in the lower Wind River; a ladder was constructed at Shipherd Falls (RM 2) in 1956, providing fish access to the upper watershed
- Fall chinook have been observed up to the Carson NFH (RM 18), but the majority of spawning occurs in the lower two miles of the mainstem Wind River

Life History

- Mid Columbia bright fall chinook upstream migration in the Columbia River occurs from August to October; peak counts at Bonneville Dam range from September 4-9
- Mid Columbia bright fall chinook enter the Wind River in late September to October
- Spawning in the Wind River occurs from late October through November, later than the Wind River tule fall chinook stock
- Age ranges from 2-year old jacks to 6-year old adults, age 4 and 5-year old spawners predominate
- Fry emerge in the spring, depending on time of egg deposition and water temperature; fall chinook fingerlings emigrate from the Wind River in spring and early summer

Diversity

- Considered a late spawning upriver bright stock (URB), likely developed as a result of straying from URB fall chinook produced at nearby hatcheries
- The Wind River URB late fall chinook stock was designated based on spawning distribution, spawning timing, river entry timing, appearance, and age composition



Abundance

- Historically, URB late fall chinook were not found in the Wind River basin; presence in the basin is likely a result of straying from nearby hatcheries (Little White Salmon NFH and Bonneville Hatchery in Oregon)
- Presence of URB fall chinook in the Wind was discovered by WDFW in 1988 and was likely a result of displaced Bonneville Hatchery produced adults, which started with URB adults trapped at Bonneville Dam in 1977
- In the Wind River, URB spawning escapements from 1988-2001 ranged from 25-1,101 (average 397)

Productivity & Persistence

- Fall chinook smolt capacity was estimated at 206,608 for the Wind River basin
- Although the URB stock fall chinook likely originated from hatchery production, the run appears to be self-sustaining

Hatchery

- Hatchery production of URB fall chinook has not occurred in the Wind River; nearby hatcheries that release this stock include Little White Salmon NFH and the Bonneville Hatchery

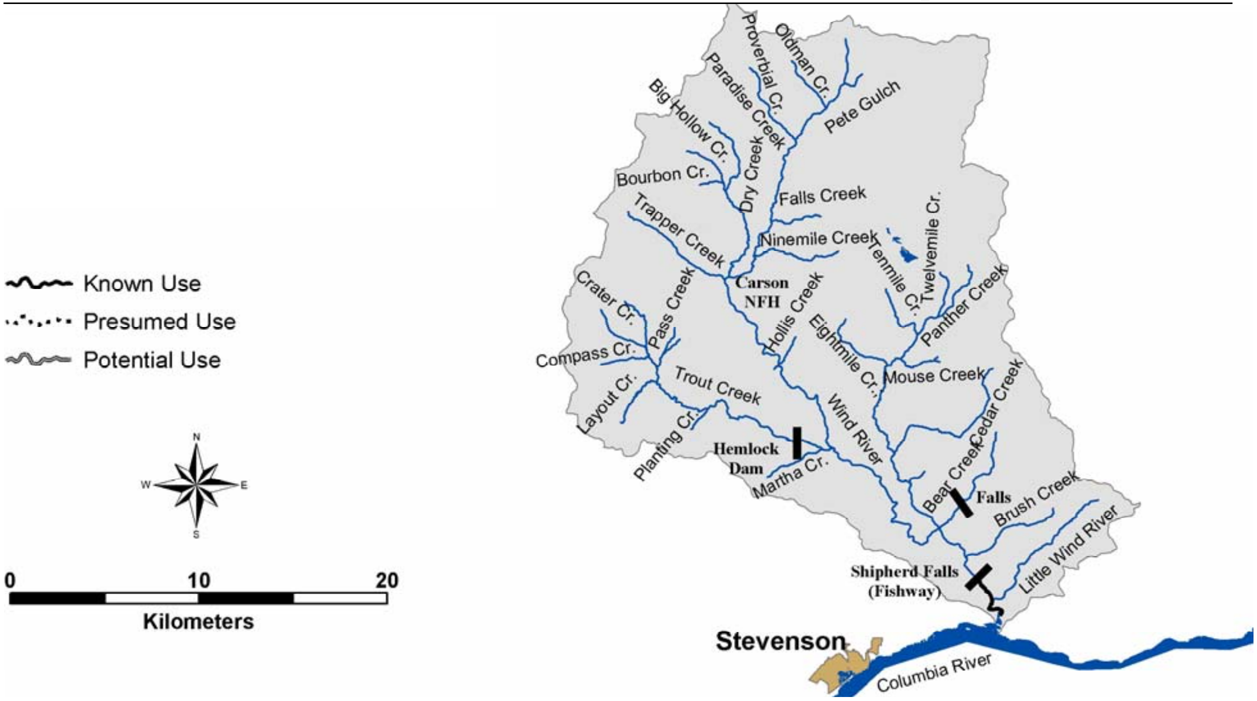
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, and in Columbia River commercial gill net and sport fisheries
- URB fall chinook migrate farther north in the ocean than lower Columbia chinook, with most ocean harvest occurring in Alaska and Canada
- URB fall chinook are also an important sport fish in the mainstem Columbia from the mouth upstream to the Hanford Reach, and an important commercial fish from August into early October
- Fall chinook destined for above Bonneville Dam are and extremely important fish for Treaty Indian commercial and subsistence fisheries during August and September
- CWT data analysis of the 1989-94 brood URB fall chinook from Priest Rapids Hatchery indicates that the majority of the URB fall chinook stock harvest occurred in Alaska (24%), British Columbia (23%), and Columbia River (42%) fisheries during the mid 1990s

- Current annual harvest dependent on management response to annual abundance in PSC (U.S./Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- Columbia River harvest of URB fall chinook is limited to 31.29% (23.04% Indian/ 8.25% non-Indian) based on Snake River wild fall chinook ESA limits
- Fall chinook originating upstream of Bonneville Dam are subject to Federal Court Agreements regarding Indian and non-Indian harvest sharing

16.2.4 Chum—Wind Subbasin

ESA: Threatened 1999 **SASSI: Depressed 1992**



Distribution

- There appears to be potential chum spawning in the Wind River in the lower river below Shipherd Falls

Life History

- Adults enter the lower Columbia River from mid-October through November
- Peak spawning occurs in late November
- Dominant adult ages are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts

Diversity

- No hatchery releases have occurred in the Wind River

Abundance

- Historical Wind River chum abundance data are not available
- Bonneville Dam count of chum ranged from 788-3,636 during 1938-1954
- Since 1971, chum counts at Bonneville Dam have ranged from 1-147

Productivity & Persistence

- Chum salmon natural production is low

Hatchery

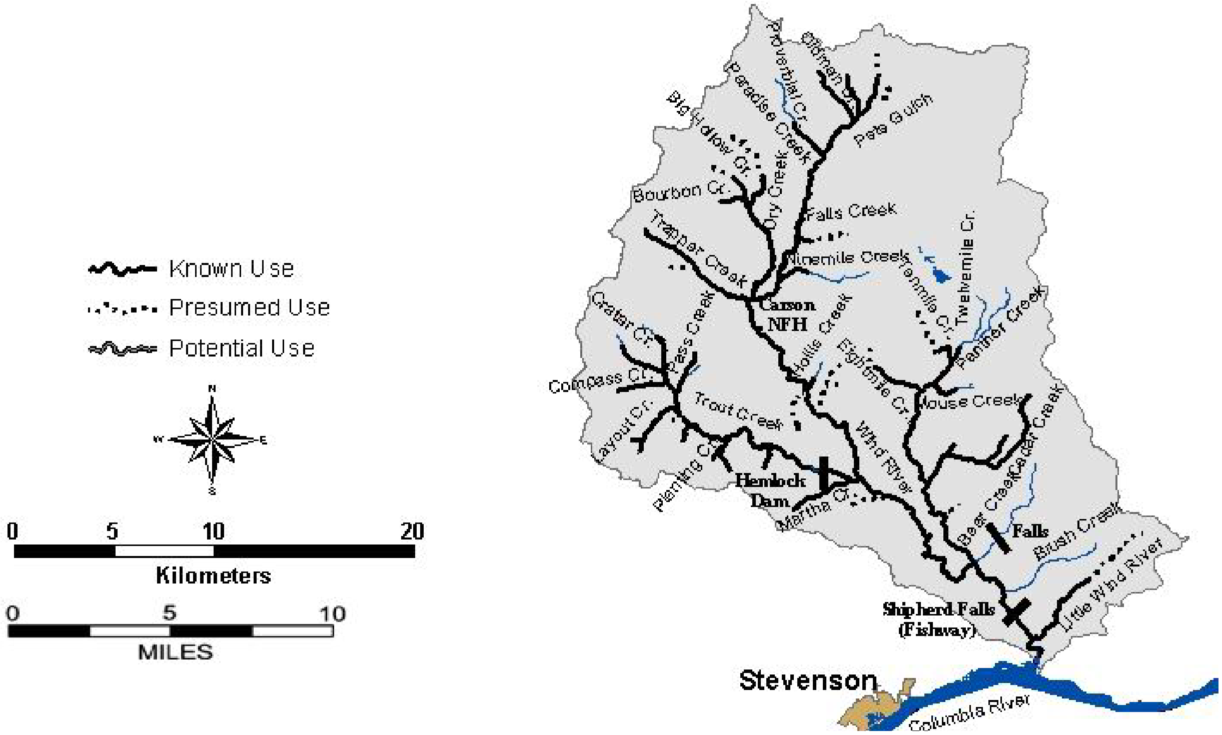
- Chum salmon have not been produced/released in the Wind River

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000-650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less than 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

16.2.5 Summer Steelhead—Wind Subbasin

ESA: Threatened 1998 **SASSI: Depressed 2002**

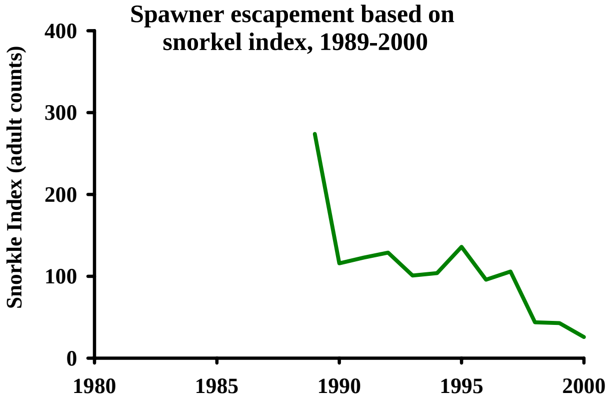


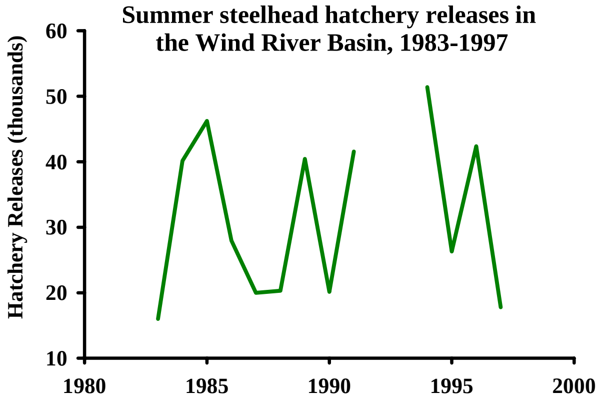
Distribution

- Summer steelhead are distributed throughout the Wind River basin, including the mainstem Wind River, the Little Wind River (RM 1.1), Panther Creek (RM 4.3), Bear Creek (RM 4.3), Trout Creek (RM 10.8), Trapper Creek (RM 18.9), Dry Creek (RM 19.1), and Paradise Creek (RM 25.1)
- High drop-offs and waterfalls exist throughout the basin; some have been modified to promote fish passage while others remain as impediments to upstream steelhead migration
- Shipherd Falls (40 ft cascade) located at RM 2.1 on the mainstem was laddered in 1956, allowing anadromous fish passage to the upper basin
- Construction of Bonneville Dam inundated the lower one mile of river, flooding spawning and rearing habitat

Life History

- Adult migration timing for Wind River summer steelhead is from May through November
- Spawning timing in the Wind River basin is generally from early March through May
- Limited age class data indicate that the dominant age class is 2.2 and 2.3 (58% and 26%, respectively)
- Wild steelhead fry emerge from April through July; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May


Spawner escapement based on snorkel index, 1989-2000


Summer steelhead hatchery releases in the Wind River Basin, 1983-1997

Diversity

- Wind River summer steelhead stock (including Panther and Trout Creek) was designated based on distinct spawning distribution and early run timing
- 1994 allozyme analyses clustered mainstem Wind River and Panther Creek summer steelhead with a number of lower Columbia summer and winter steelhead stocks, including Skamania Hatchery summer steelhead; Trout Creek summer steelhead were part of an outlier group that included SF Nooksack summer steelhead, Washougal steelhead, and Cowlitz native late winter steelhead

Abundance

- In 1936, steelhead were observed in the Wind River during escapement surveys
- Prior to 1950, wild summer steelhead run size was estimated to be between 2,500 and 5,000 fish
- Trout Creek escapement was estimated at over 100 wild summer steelhead in the 1980s but declined to less than 30 fish in the 1990s
- Snorkel index adult counts from 1989-2000 ranged from 26 to 274
- Escapement goal for the Wind River basin is 957 wild adult steelhead

Productivity & Persistence

- NMFS Status Assessment indicated a 0.0 risk of 90% decline in 25 years and a 0.91 risk of 90% decline in 50 years; the risk of extinction in 50 years was 0.0
- The smolt density model estimated potential summer steelhead smolt production for the Wind River basin was 62,273
- Wild steelhead smolt yield has been monitored in the Wind River basin since 1995; the trend indicates increasing smolt yield
- WDFW indicated that natural production in the watershed is primarily sustained by wild fish

Hatchery

- The Carson National Fish Hatchery operates in the basin but does not produce summer steelhead
- Skamania and Vancouver Hatchery stock were planted in the Wind River Basin; release data are displayed from 1983-1997

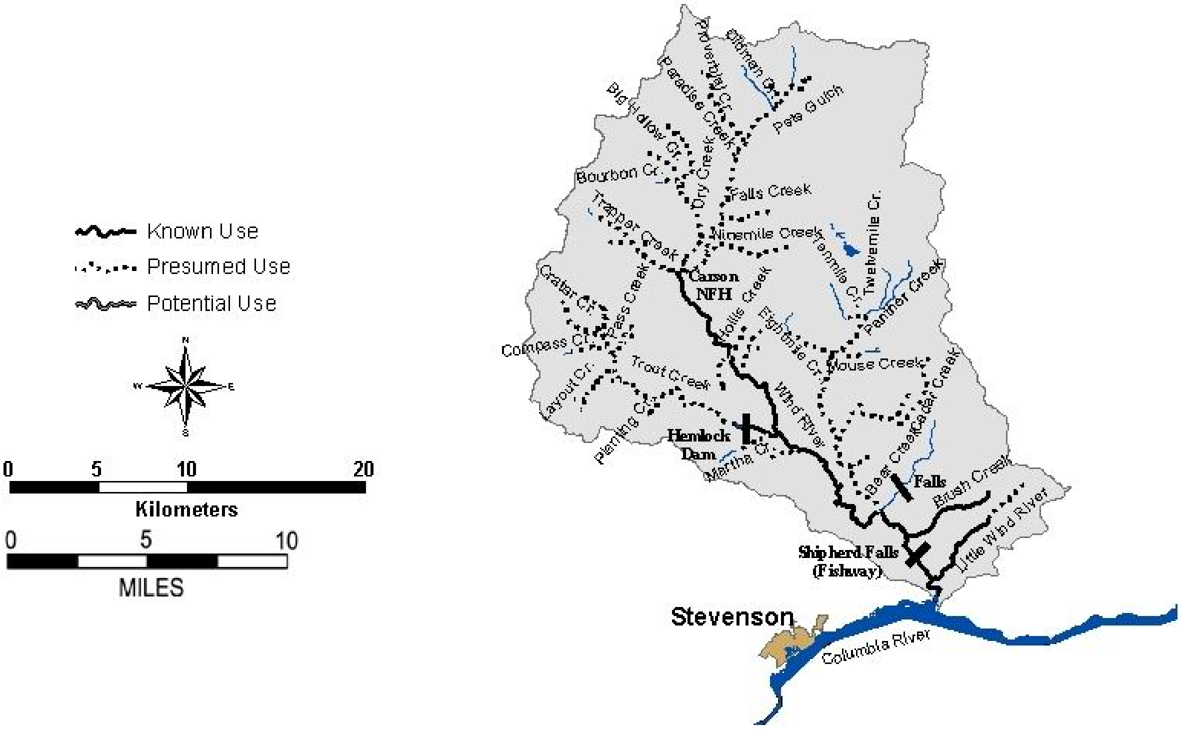
- Summer steelhead hatchery releases began in the basin in 1960; releases were suspended in the early 1980s for wild steelhead management then reinstated in the mid 1980s; releases of catchable rainbow trout were discontinued in 1994 and hatchery steelhead releases were discontinued in 1997
- Snorkel surveys from 1989-1998 indicated that hatchery summer steelhead comprised 41-60% of the spawning escapement
- Trout Creek trap counts conducted in 1992 indicate almost no migration of hatchery steelhead into this drainage; the hatchery fish that are captured are excluded from the drainage to preserve genetic diversity of the wild stock

Harvest

- No directed non-Indian commercial fisheries target Wind River summer steelhead; incidental mortality currently occurs during the Columbia River fall gill net fisheries
- Summer steelhead are harvested in the Columbia River Treaty Indian fall commercial and recreational fisheries in Zone 6
- Current steelhead harvest is primarily in the lower Wind and Cowlitz of hatchery steelhead from other Columbia basins which temporarily enter the Wind River before continuing their Columbia River migration
- Summer steelhead sport harvest in the Wind River from 1977-1982 averaged 1,373 and declined to an average annual harvest of 421 fish from 1983-1991; since 1981, regulations limit harvest to hatchery fish only
- ESA limits Wind wild summer steelhead fishery impact (Indian and non-Indian combined) to 17% per year

16.2.6 Winter Steelhead—Wind Subbasin

ESA: Threatened 1998 **SASSI: Unknown 2002**



Distribution

- Winter steelhead are distributed throughout the lower mainstem Wind River (~11 mi) and Trout Creek (RM 10.8)
- High drop-offs and waterfalls exist throughout the basin; some have been modified to promote fish passage while others remain as impediments to upstream steelhead migration
- Shipherd Falls (40 ft cascade) located at RM 2.1 on the mainstem was laddered in 1956, allowing anadromous fish passage to the upper basin
- Construction of Bonneville Dam inundated the lower one mile of river, flooding spawning and rearing habitat

Life History

- Adult migration timing for Wind River winter steelhead is from December through April
- Spawning timing on the Wind is generally from early March to early June
- Age composition data for Wind River winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Wind River winter steelhead stock is designated based on distinct spawning distribution and run timing
- Wild stock interbreeding with Chambers Creek Hatchery brood stock may have occurred but is assumed to be minimal

Abundance

- In 1936, steelhead were observed in the Wind River during escapement surveys
- Trout Creek escapement was estimated at over 100 wild steelhead in the 1980s but has declined to less than 30 fish in the 1990s
- Wild winter steelhead escapement estimates for the Wind River are not available

Productivity & Persistence

- Wild steelhead smolt yield has been monitored in the Wind River basin since 1995; the trend indicates increasing smolt yield in recent years
- WDFW indicated that natural production in the watershed is primarily sustained by wild fish

Hatchery

- The Carson NFH operates in the basin but does not produce winter steelhead
- Hatchery releases of Chambers Creek and Skamania stock occurred in the Wind River Basin in the 1951, 1956, 1959, and 1963; releases ranged from 2,500 to 10,000 smolts
- Because of concern with wild steelhead interactions, releases of catchable-size rainbow trout were discontinued in 1994 and hatchery steelhead releases were discontinued in 1997
- No anadromous fish except unmarked (wild) steelhead are allowed past Hemlock Dam on Trout Creek

Harvest

- No directed commercial fisheries target Wind River winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Harvest occurs in the Columbia River Zone 6 winter commercial tangle net fishery and in tribal ceremonial and subsistence fisheries
- Winter steelhead sport harvest data in the Wind River are not available but approximately 25-50 wild winter steelhead are estimated to be harvested annually; since 1991, regulations limit harvest to hatchery fish only
- ESA limits fishery impact (Indian and non-Indian) of Wind River wild winter steelhead to 17% per year

16.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quantity and quality is an important relative impact on all species, while estuary habitat impacts appear to be of lesser importance.
- The impact of hydrosystem access and passage is one of the more important factors for chum and fall chinook. Hydrosystem effects on chum are substantial enough to minimize the relative importance of all other potentially manageable impact factors.
- Harvest has relatively high impacts on fall chinook, while harvest impacts to steelhead and coho salmon are moderate. The relative impact of harvest on chum is minor.
- Hatchery impacts are relatively moderate for coho and summer steelhead. Hatchery impacts on chum salmon, fall chinook, and winter steelhead are low.
- Impacts of predation are moderate for winter steelhead, summer steelhead, and coho, but are low for fall chinook and chum.

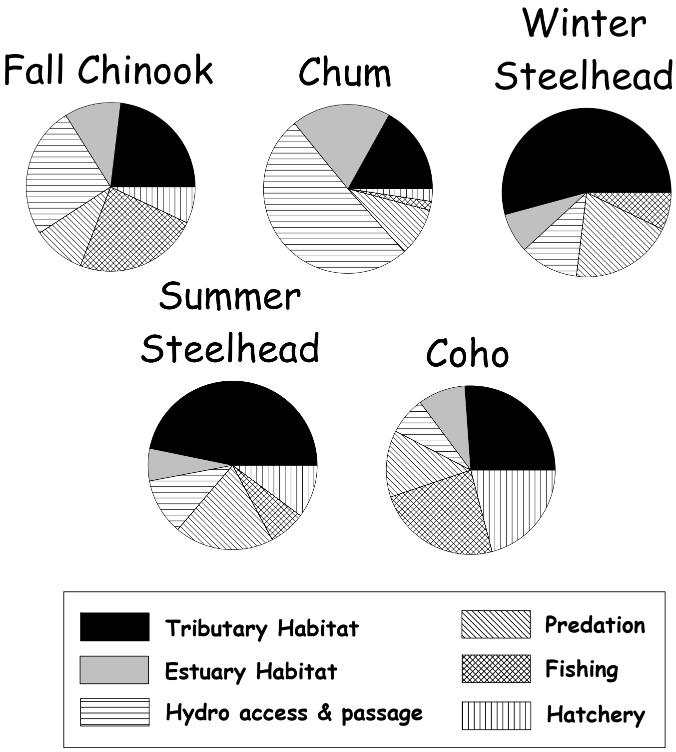


Figure 16-5. Relative index of potentially manageable mortality factors for each species in the Upper Gorge subbasin.

16.4 Hatchery Programs

Washington operated a salmon hatchery near the mouth of the Wind River from 1899 to 1938, when the hatchery was flooded by the Bonneville Dam reservoir. The hatchery produced fall chinook and broodstock was taken directly from the Wind River. Annual egg take was generally between 1 and 4 million; in some years, egg take was as high as 20 million.

The Carson National Fish Hatchery in the Wind River basin is at Tyee Springs (RM 18); the facility was constructed in 1937 and expanded in 1952–1955. Historically, the dominant species produced at the hatchery was tule fall chinook. Many other species of salmon and trout were also raised intermittently in large numbers from 1938 to 1981. In 1981, production switched to spring chinook exclusively, and this remains the only species produced. Current annual spring chinook release goals are 1.42 million yearlings (Figure 16-6). Skamania summer and winter steelhead were released in the basin until 1997; annual releases of summer steelhead ranged from 20,000 to 50,000 smolts while winter steelhead releases were generally fewer than 10,000 smolts. Steelhead releases were discontinued to promote wild steelhead management in the basin. The Wind River historically had a naturally spawning tule fall chinook population but only a small remnant of that population remains due to Bonneville reservoir inundating the spawning habitat in the lower river. In recent years, a self-sustaining population of mid-Columbia upriver bright late fall chinook, historically not found in this basin, has been observed in the lower river below Shipperd Falls. It most likely originated from hatchery strays, possibly from the two hatcheries in the area that produce this stock—the Little White Salmon (Willard) NFH and Bonneville Hatchery.

Genetics—The former tule fall chinook hatchery program at the Carson NFH used broodstock originating primarily from Spring Creek NFH stock, which was developed from the Big White Salmon River tule fall chinook stock. Fall chinook releases into the Wind River basin averaged 2 million from 1952 to 1976 but were discontinued in 1976. A small tule fall chinook population persists in the basin; the current population likely is a hybridization between native Wind River tule fall chinook and Spring Creek Hatchery tule fall chinook.

Spring chinook were not native to the Wind River. Historically, spring chinook eggs were transferred to Carson NFH from the Clackamas River and a Willamette River hatchery in Oregon, and from Camas Creek in Idaho. All of these stocking efforts failed because of adult passage problems at Shipperd Falls (RM 2); fish passage facilities were constructed at the falls in 1954. During the 1950s and 1960s, approximately 500 spring chinook captured annually at Bonneville Dam were transferred to the Carson NFH for broodstock collection. Genetic data indicates that the Carson NFH spring chinook stock was developed from a mixture of upper Columbia and Snake River spring chinook passing Bonneville Dam. Current broodstock collection comes from adults returning to the Carson NFH. CWT data indicates that Carson NFH spring chinook stray into the Little White Salmon NFH and are harvested in the Drano Lake fisheries, but because these stocks were developed from the same broodstock, there is little concern with genetic introgression. Carson NFH spring chinook straying into other lower Columbia basins is not considered a problem.

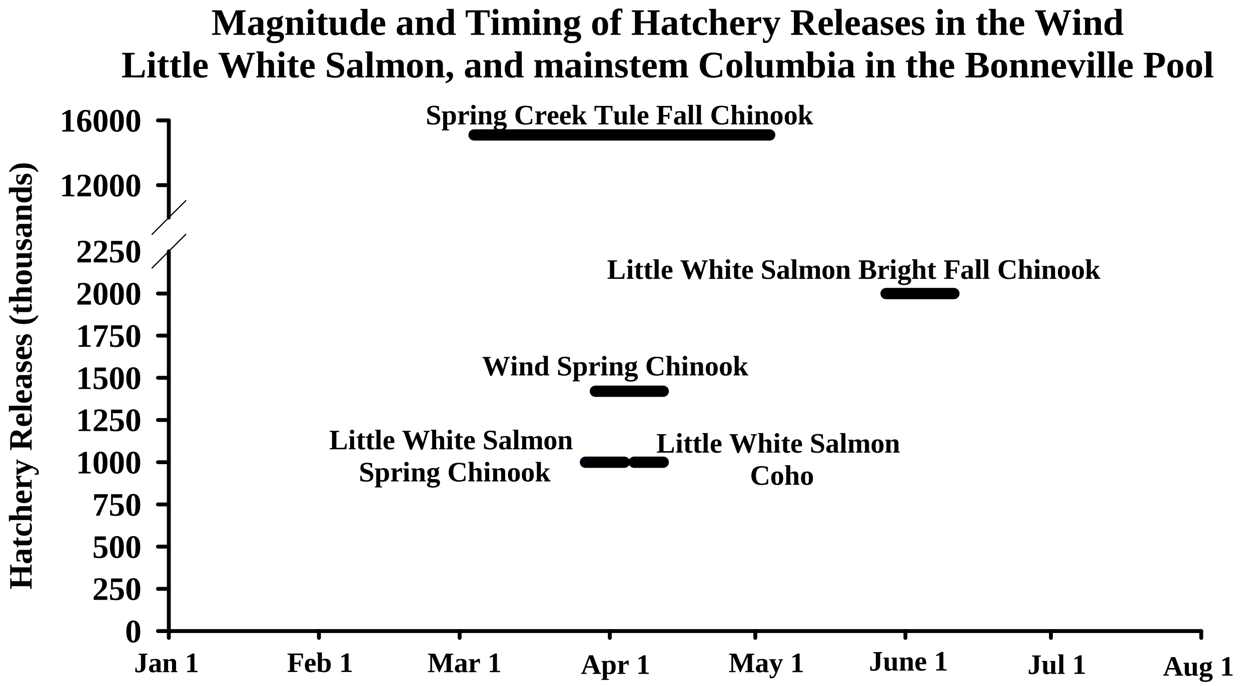


Figure 16-6. Magnitude and timing of hatchery releases in the Wind and Little White Salmon rivers and mainstem Columbia by species, based on 2003 brood production goals.

Summer steelhead releases into the Wind River basin came from Skamania and Vancouver Hatchery stocks. Allozyme analysis in 1994 clustered mainstem Wind River and Panther Creek summer steelhead with a number of lower Columbia River summer and winter steelhead stocks, including Skamania Hatchery summer steelhead. Trout Creek summer steelhead stocks were part of an outlier group that included South Fork Nooksack River summer steelhead, Washougal steelhead, and Cowlitz native late winter steelhead. Winter steelhead releases into the Wind River basin came from Chambers Creek and Skamania Hatchery stocks. Only unmarked summer and winter steelhead have been allowed to pass Hemlock Dam and access the upper watershed of Trout Creek, thereby preserving the genetic integrity of this stock. Both hatchery summer and winter hatchery steelhead stocking programs have been discontinued.

Interactions—Fall chinook hatchery releases were discontinued in 1976; the existing tule fall chinook population is sustained from wild production and strays from Spring Creek NFH. There are no wild/hatchery tule fall chinook interactions in the Wind River, other than from straying tule fall chinook from other basins.

Spring chinook are not native to the Wind River basin; the current population is sustained through hatchery production and any natural spawners are hatchery-origin fish (Figure 16-7). Therefore, there is no interaction between hatchery and wild spring chinook in the Wind River basin. However, hatchery spring chinook adults may interact with wild fall chinook, summer steelhead, and winter steelhead. Based on run timing, possible spring chinook effects are more likely on summer steelhead than the other species. In 2001 and 2002, the Carson NFH adult collection facility was closed to adult spring chinook on August 1; fish health personnel were concerned that this early closure would keep more spring chinook adults in the river and increase potential transmission of IHNV to steelhead. Juvenile outmigration trapping and PIT tag monitoring at Bonneville Dam indicate that Carson spring chinook exit the Wind River quickly after release and Carson spring chinook are not known to residualize. Therefore, although steelhead parr occupy the mainstem Wind River below the hatchery, competition between hatchery spring chinook and juvenile steelhead is thought to be minimal. Also, the size of steelhead parr (>80mm) that occupy the spring chinook migration corridor suggests that steelhead are not susceptible to predation by Carson spring chinook. Emigrant sampling conducted in the Wind River indicates that steelhead smolts and presmolts are not drawn out of the Wind River basin early by releases of hatchery spring chinook.

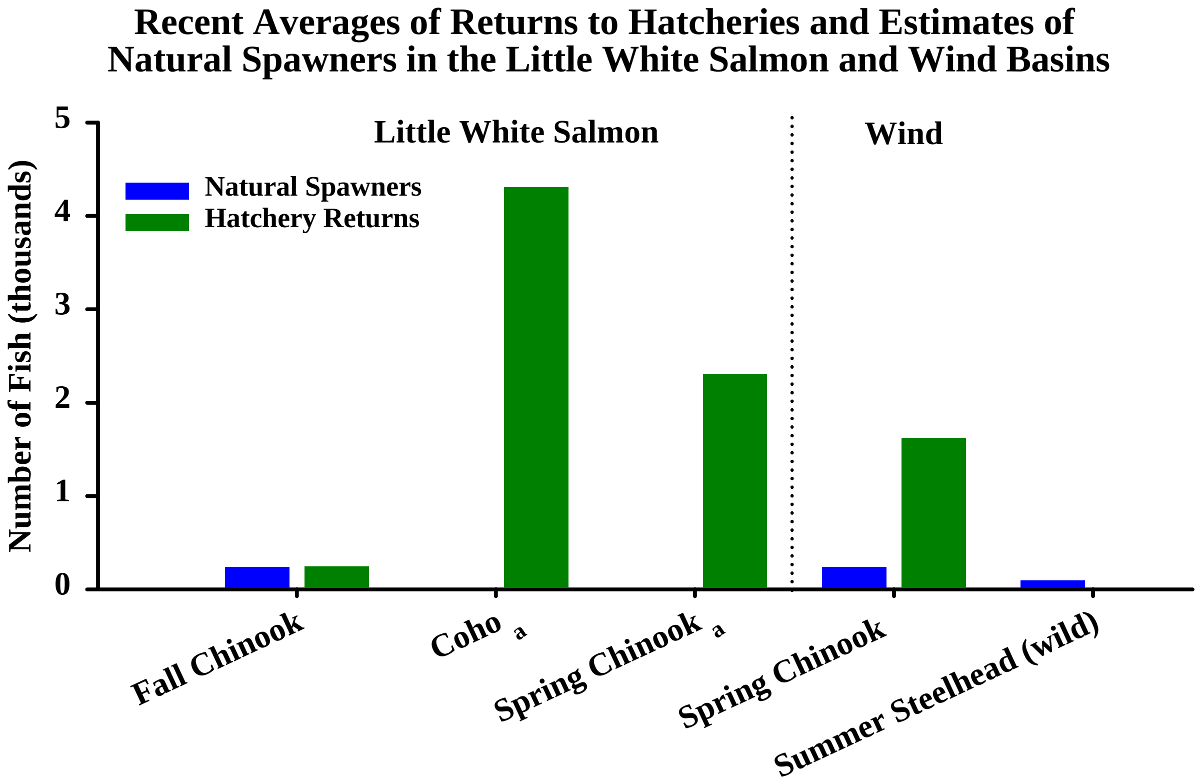


Figure 16-7. Recent year average hatchery returns and estimates of natural spawning escapement in the Wind and Little White Salmon River basins by species.

The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from the period 1992 to the present. Calculation of each average utilized a minimum of 5 years of data, except for Little White Salmon fall chinook, which represents the 1996–99 average.

[a] A natural stock for this species and basin has not been identified based on populations in WDFW's 2002 SASSI report; escapement data are not available.

Water Quality/Disease—The primary water source for the Carson NFH is Tyee Springs, approximately 3/8 mile from the hatchery; the springs produce 44 second-feet of 44°F, high-quality water. A feral brook trout population exists in Tyee Creek, which supplies the spring water to the Carson NFH. BKD is present in the brook trout population at low levels; periodic monitoring is conducted to determine the level of infection. The presence of this trout population in the hatchery water source has had no noticeable effect on the hatchery fish in recent years. The Wind River is a backup source of water for the hatchery and is used only as needed, primarily in September, after most natural spring chinook carcasses have drifted below the hatchery intake. Because there is evidence that using Wind River water in the hatchery may contribute to outbreaks of IHNV, BKD, and furunculosis in hatchery fish, the use of this water source is minimized.

The Lower Columbia River Fish Health Center (FHC) in Underwood, Washington, provides fish health care for the Carson NFH under guidance of the Fish and Wildlife Service Manual, the Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries, and the Co-Managers Salmonid Disease Control Policy. A pathologist from the FHC examines fish at various times during the hatchery operation. Adult certification examinations are performed at spawning; adult fish tissues are collected to ascertain viral, bacterial, and parasite infections and to provide a brood health profile for the progeny. Progeny from females with high levels of BKD are culled (if not needed to meet annual production goals) or segregated from progeny at lower risk. A ponding examination for viral infections is performed on newly hatched fish when approximately 50% of the fish are beyond the yolk-sac stage and begin feeding. Rearing fish are randomly examined monthly to determine general health. These monthly exams generally include a necropsy with detailed external and internal exams and tests for bacterial and viral infections are performed. Diagnostic exams are performed on rearing fish as needed, depending on unusual fish behavior or higher than normal mortality. Pre-release examinations are performed before fish are released or transferred from the hatchery and these focus on testing for listed pathogens. Numerous chemicals are used at various stages to prevent or treat infection. Erythromycin is injected into adults being held for broodstock collection; the number of injections ranges from 0-2, depending on the arrival time of fish to the hatchery compared to the actual egg take. Injections must be completed 30 days before spawning to be effective. Adults being held for broodstock also are treated with formalin three times per week to control external pathogens. All eggs received at the hatchery must be disinfected before they are allowed to come in contact with the hatchery’s water or equipment. Salmonid eggs are hardened and disinfected with a 50-ppm iodine solution buffered in sodium bicarbonate. Formalin is also used to control fungus on eggs during incubation.

Mixed Harvest—The purpose of the spring chinook hatchery program at the Carson NFH is to mitigate for loss of spring chinook salmon as a result of hydroelectric and other development in the lower Columbia River basin and to contribute to terminal area tribal ceremonial and subsistence fisheries and non-tribal sport and commercial fisheries. Historically, exploitation rates of hatchery and wild spring chinook likely were similar. Upriver spring chinook are an important target species in Columbia River commercial and recreational fisheries, as well as in tributary recreational fisheries. Upriver spring chinook are impacted less by ocean fisheries than other Columbia River chinook stocks. CWT data suggests that Carson NFH spring chinook are recovered primarily as recreational harvest, with the remaining fish recovered as tribal harvest, incidental commercial harvest, and hatchery escapement. Carson NFH spring chinook contribute primarily to terminal area sport and tribal fisheries at the mouth of the Wind River; average terminal area harvest rate from 1989–98 was 44% for years when fisheries occurred. Selective fishery regulations in recent years in the Columbia River basin have targeted hatchery fish and maintained low harvest rates of wild spring chinook. Beginning with the 2000 brood, all Carson NFH spring chinook have been externally marked with an adipose fin-clip to allow for selective fisheries.

Passage—The adult collection facility at the Carson NFH consists of a fish ladder adjacent to the mainstem and two holding ponds. Returning adults enter the hatchery fish ladder volitionally; a barrier dam does not exist across the Wind River. Fish are maintained in holding ponds until broodstock collection. Prior to 2001, all returning adults were allowed into the hatchery through August or the end of the spawning run; this practice likely minimized potential interactions and disease transmission between hatchery spring chinook and wild steelhead. However, in 2001 and 2002, the hatchery ladder was closed to returning adults on August 1, allowing more spring chinook to remain in the Wind River.

Supplementation—Supplementation is not the goal of the current spring chinook hatchery program nor was it the goal of former fall chinook, summer steelhead, or winter steelhead hatchery programs on the Wind River.

16.5 Fish Habitat Conditions

16.5.1 Passage Obstructions

All anadromous fish except for steelhead were blocked by Shipherd Falls at RM 2 until a fish ladder was constructed there in the 1950s to allow spring chinook to return to the Carson National Fish Hatchery (RM 18). Upstream migration is regulated by a trap at the fish ladder. A significant portion of the riverine habitat downstream of Shipherd Falls was inundated by Bonneville Dam impoundment in 1938.

Hemlock Dam, at RM 2.1 on Trout Creek, is the other major migration barrier. This concrete dam replaced temporary splash dams in 1935 and was used to generate electricity for the USFS Ranger Station that is located nearby. The dam was eventually used only to provide irrigation water to the Wind River Tree Nursery. Since the nursery’s 1997 closure, the dam provides a reservoir (Hemlock Lake) for recreation. A fish ladder built in 1936 at the dam has efficiency problems and the lake, which is rapidly filling with sediment, has problems with high temperatures. The dam is ranked as the highest priority for restoration in the Wind River Watershed Analysis—second iteration (2001), and dam removal options and benefits are currently being evaluated.

There are various culverts that restrict passage in Youngman and Oldman Creeks, although the impact on steelhead is believed to be minimal. Subsurface flow may be a problem in Martha Creek, Dry Creek, and portions of the Trout Creek Flats area. Passage in Tyee Creek is blocked by the water intake for the Carson Hatchery.

16.5.2 Stream Flow

Wind River flows are unregulated and thus driven primarily by watershed conditions and weather patterns. Flows in the Wind River mainstem range from an average monthly flow of 250 cubic feet per second (cfs) in the summer to over 2,000 cfs in winter months. Peak flows occur between November and March in response to rainfall or rain-on-snow events (Figure 16-8). The highest recorded flow was 45,700 cfs in January 1974, though the estimate of the February 1996 flood (gage was not operating) was 54,000 cfs (USFS 1996). Summer flows are maintained by snowmelt and groundwater recharge.

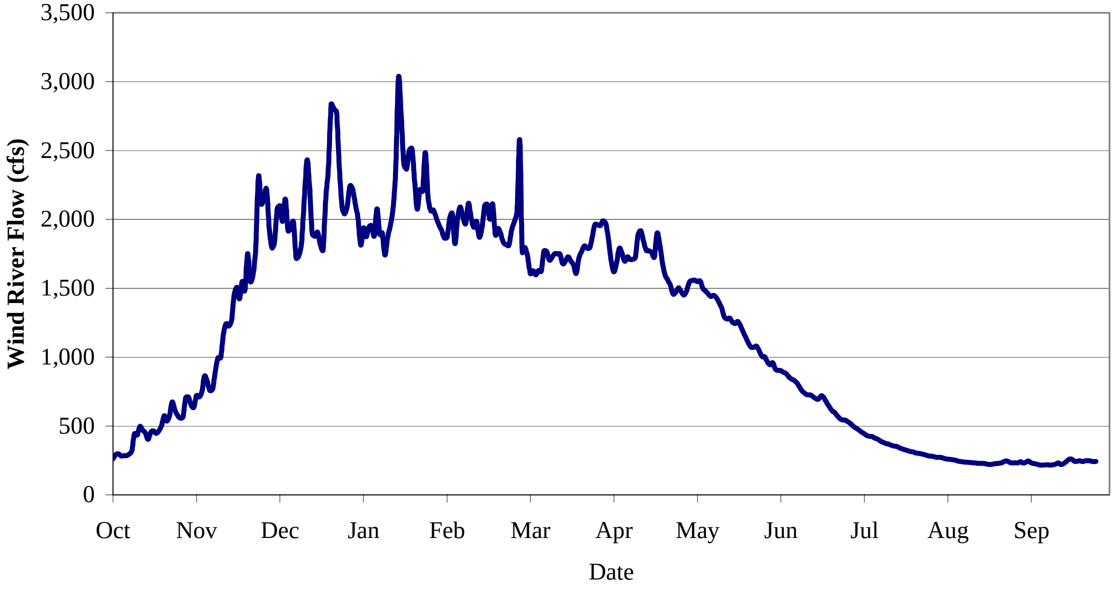


Figure 16-8. Wind River hydrograph (1934-1980). Peak flows are primarily related to winter and spring rain, with some high peaks occuring due to winter rain-on-snow. Flows fall below 300 cfs in late summer. USGS Gage #14128500; Wind River near Carson, WA.

Forest cover characteristics are believed to impact runoff conditions in the subbasin. Approximately 20% of the subbasin is in early-seral vegetation due to past fires and timber harvest. This condition, combined with moderately high road densities in a few watersheds (Lower Wind, Middle Wind, Trout Creek), has likely increased the potential for altered peak flow timing and magnitude. The 1996 and 2001 (second iteration) watershed analyses estimated risk of increased peak flows by calculating aggregate recovery percentage (ARP), which looks at the age of forest stands as a representation of hydrologic maturity. Watersheds with 100% ARP are fully hydrologically mature. Watersheds with low ARP levels would be at greater risk of increased peak flows associated with rain-on-snow events.

ARPs in 1995 ranged from 72% in Lower Falls Creek to 97% in Trapper Creek. 2001 levels ranged from 74% in Lower Falls and Eightmile Creek to 99% in Trapper Creek. Most sub-watersheds increased in ARP since 1995 due to tree growth, however, 5 out of 26 sub-watersheds decreased in ARP due to vegetation removal. In 2001, 5 of the 26 sub-watersheds had an ARP of less than 80%. A “relative risk” of increased peak flows was calculated for the 26 subwatersheds as part of the 1996 watershed analysis (USFS 1996). The analysis used road density, ARP, and percent of area in rain-on-snow zone to evaluate “relative risk”. The Headwaters Wind, Ninemile, Compass/Crater, Upper Trout, Upper Panther, and Layout Creek subwatersheds ranked the highest for risk of increased peak flows. The remainder of the subbasin has a relatively low risk of increased peak flows.

Summer low flows may also be a problem in some stream reaches. Dry Creek, Martha Creek, and portions of the Trout Creek basin regularly go subsurface in late summer, possibly stranding fish. Water withdrawals from the subbasin are not believed to have a substantial impact on summer flow levels in the mainstem, though withdrawals do occur at the Carson Hatchery and at a few irrigation diversions. Withdrawal conditions in tributary streams warrant further investigation, especially in Trout Creek, where irrigation water rights may have an impact on the already very low summer flows. In the subbasin as a whole, the net streamflow depletion in the summer due to water withdrawals is approximately 3.9 cfs, representing up to 2.4% of the 90% exceedance flow in late summer (Greenberg and Callahan 2002).

16.5.3 Water Quality

The major water quality concerns in the subbasin are temperature and sediment. Bear Creek, Eight-mile Creek, and Trout Creek were listed on the State's 1996 303(d) list of impaired water bodies for exceedance of the 60.8ºF (16ºC) temperature standard (WDOE 1996). Only Bear Creek and Eight-mile Creek were included on the 1998 list (WDOE 1998). Water temperature monitoring has been conducted in the basin for many years. The USGS measured temperatures over 64.4ºF (18ºC) in the summer of 1977 in the Lower Wind River. In more recent years the USFS, USGS Columbia River Research Lab (CRRL), and UCD have conducted water quality monitoring using continuously recording thermographs. USFS and USGS monitoring has focused on the federally owned lands while the UCD monitoring has focused primarily on privately owned lands in the lower subbasin. USFS monitoring goes as far back as 1977 for some sites, whereas CRRL and UCD monitoring is limited to the past several years. A total of approximately 46 different locations have been monitored since 1977, all with various periods of record. At 32 of the sites, the temperature has exceeded 60.8ºF (16ºC) on at least one day during the sampling period. Fifteen of the sites have exceeded 64.4ºF (18ºC). Sites exceeding 68ºC (20ºC) include the mouth of Eight-mile Creek, the Wind River at the 3065 Road Bridge, and Trout Creek below Crater Creek, below Compass Creek, above Hemlock Lake, below Hemlock Dam, and at the mouth. The Trout Creek above Hemlock Lake station has been under the 60.8ºF (16ºC) standard for only one year since 1977 (USFS, CRRL, UCD published and unpublished data).

A Total Maximum Daily Load (TMDL) analysis was performed in the subbasin to identify problems and potential solutions related to high stream temperatures. High summer temperatures were attributed to loss of riparian cover, channel widening, and reduced summer base flows. Modeling indicated that an increase in stream shade would potentially be adequate to lower temperatures in the mainstem Wind River and Panther Creek. In Trout Creek, it was determined that a reduction in channel widening, combined with increased shading, would be the most effective strategy for lowering temperatures (WDOE 2002 Draft, as cited in Michaud 2002). The USFS developed a Water Quality Restoration Plan (WQRP) for the Wind River as part of requirements by the WDOE and EPA due to stream temperature problems. The analysis focused on stream shading, stream widening, and water withdrawals as sources for stream heating. GIS modeling of riparian shade revealed that the Middle Wind, Trout Creek, and the lower Wind had shade levels greater than 10% less than potential levels. The Lower Wind had shade levels approximately 50% less than the potential. Air photo analysis revealed that channel widening occurred on most of the surveyed stream reaches in the period dating from 1959 to 1979 and the period dating from 1989 to 1999. Most channels narrowed during the interim period. Channel widening was attributed to periods of large flood events. The analysis of the impact of water withdrawals indicated that Trout Creek and Bear Creek were the most susceptible to temperature increases due to water withdrawals (USFS 2001). Water withdrawals in Trout Creek are primarily for irrigation while withdrawals from Bear Creek are for the City of Carson's domestic water supply.

Turbidity is also regarded as a concern in the subbasin. Sampling of 16 sites at 4 different flow levels by the USFS in 1995 revealed that Lower Panther Creek, Trout Creek, and the Lower Wind River have the highest turbidity levels at high flow volumes. The Lower Wind

River had the highest turbidity levels at all flow volumes. It should be noted that investigators caution the use of such a limited data set (USFS 2001).

USGS and UCD have measured pH levels that are below standards, but low pH conditions are believed to be from natural sources (Michaud 2002).

16.5.4 Key Habitat

The USFS has conducted habitat surveys on many of the streams within public ownership. Pool quantity and quality are low in many of the surveyed streams. The 1996 watershed analysis reported that 93% of surveyed reaches did not meet desired condition for pool frequency. It should be noted, however, that investigators caution the use of pool frequency due to problems associated with observer bias. The use of a pool quality index that relates pool area to depth is recommended over pool frequency measures, and such an analysis was conducted. USFS stream surveys reveal that pool depths are low (surface area / volume > 68) in the Panther Creek tributaries Eight-mile, Cedar, and Mouse Creeks, as well as in the Headwaters Wind River and Upper Falls Creek. Width-to-depth ratios are high (>9) in the middle Wind River, Eight-mile Creek, and Cedar Creek, with only one stream segment, Upper Panther Creek, having “excellent” width-to-depth ratios (<6). Restoration efforts by the USFS have improved pool quality and quantity in several locations. In particular, reconnection of side channel / floodplain habitats restored 600 feet to Layout Creek and increased the channel length in the Mining Reach (middle Wind River) by 48%. In addition, bankfull pool volume in the Mining Reach was increased by 520% (USFS 2001).

16.5.5 Substrate & Sediment

There is not a lot of direct information on stream substrate conditions; however, as part of the USFS Watershed Analysis – second iteration (2001), McNeil Core Sediment samples were taken on 9 streams. Dry Creek the Upper Wind River had the highest percentages of fines and small sediment size classes. Both streams had greater then 34% of sediments less than 6.3 mm, with a high percentage (15% for Dry Creek and 16% for Upper Wind) of fines (<1.6 mm).

Observations indicate that Youngman and Dry Creeks have excessive in-stream sediment levels. Landslide activity appears to be contributing to instream sediment levels in Paradise Creek and Pete’s Gulch. The Trout Creek basin has fine sediment aggradations due to basin morphology that includes steep headwater streams emptying into the broad alluvial valley known as Trout Creek Flats (WCC 1999). Sedimentation of channels is a problem in the lower and Little Wind Rivers due to landslide activity related to roads, utility corridors, timber harvest, a golf course, and naturally unstable soil conditions. Accumulation of sediment at the mouth of the Wind has long been a concern to local fishermen and to the Port of Skamania County who wish to preserve adequate water depths for commercial shipping traffic.

A number of watershed-scale sediment supply assessments have been conducted in the subbasin. Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. Ten of the 25 IWA subwatersheds were rated as “moderately impaired” with respect to landscape conditions that influence sediment supply; the remaining subwatersheds were rated as “functional”. High road densities, steep topography, and naturally unstable soils are the primary drivers of these sediment supply impairment ratings. The moderately impaired subwatersheds are scattered throughout the basin and include the Little

Wind, lower Trout Creek, headwaters Trout Creek, Trapper Creek, Paradise Creek, Falls Creek, and lower Panther Creek subwatersheds.

A similar investigation conducted as part of the USFS Watershed Analysis used road crossings per square mile, peak flow turbidity, mass wasting, surface erosion, and channel stability information to identify subwatersheds with the greatest threat of erosion and sedimentation. Twelve of the 26 USFS subwatersheds were identified as having a high risk of fine sediment impact on aquatic habitats. The percentage of land area with landslides, debris flows, and potentially unstable soils was calculated for the same 26 sub-watersheds. The sub-watersheds over 20% were Paradise Creek, Ninemile Creek, Layout Creek, Mouse Creek, Cedar Creek, North Fork Bear Creek, and East Fork Bear Creek (USFS 1996).

Approximately 20% of the forest cover in the subbasin is in early-seral stages, suggesting that portions of the basin may not have adequate vegetation to prevent excessive soil erosion, however, the presence of an extensive road network may be the factor contributing most to sediment production and delivery. The entire subbasin has an average road density of 2.2 mi/mi^2. This level has been reduced from 2.6 mi/mi^2 in 1995 due to road decommissioning efforts by the USFS (USFS 2001). Road densities greater than 3 mi/mi^2 are generally considered high, while those between 2 and 3 mi/mi^2 are considered moderate. Although the subbasin as a whole has only moderate road densities, several portions of the subbasin have high road densities. The 6th field basins with the greatest road densities are the Lower Wind, Middle Wind, and Trout Creek basins. All of the 6th field basins have seen an increase in the length of the drainage network due to roads. The increase has been greatest (up to 40%) in the Lower Wind, Middle Wind, and Trout Creek basins. The amount of stream crossings per mile is greatest in the Upper Wind, Middle Wind, Trout Creek, and Panther Creek basins (USFS 2001).

Several restoration projects by the USFS and Underwood Conservation District have attempted to restore bank stability and reduce sediment delivery rates to streams. Monitoring of a USFS restoration project in Layout Creek reveals a decrease of 73% of eroding banks in the reach (USFS 2001).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

16.5.6 Woody Debris

Pieces of LWD per mile have been collected as part of USFS stream surveys. In general, LWD conditions are very poor throughout the basin. This can be attributed to loss of recruitment due to past harvest of riparian areas and past stream clean-outs. Currently, 12 out of 20 regularly surveyed reaches contain less than 75 pieces of LWD per mile.

Restoration efforts conducted by the USFS and UCD have placed wood into streams in order to increase aquatic habitat complexity and to restore natural levels of bank stabilization. Monitoring of USFS restoration projects reveals that the number of LWD pieces has increased by 333% in Layout Creek and by 497% in the middle Wind River (Mining Reach) (USFS 2001).

16.5.7 Channel Stability

USFS surveys have revealed bank stability concerns in the Compass Creek, upper Trout Creek, middle Wind, Layout Creek, and upper Wind basins. High width-to-depth ratios can be an indicator of low channel stability causing excessive lateral bank erosion. High ratios (>9) have been measured in the middle Wind, Eight-mile Creek, and Cedar Creek. The middle Wind from RM 12-19 is a highly dynamic alluvial section that experiences rapid channel migration and avulsions during high flow events. Avulsions are often associated with the accumulation of large log jams that serve to re-direct the stream course through overflow / floodplain channels. The instability of this reach is believed to be partly due to excess sedimentation from upstream sources, loss of bank stability due to degradation of riparian forests, and the loss of stable in-stream large wood pieces. USFS and UCD restoration projects have increased bank stability through re-introduction of large wood assemblages and re-planting efforts. USFS efforts on the Mining Reach have increased bank stability by 58% (USFS 2001). Bank stability is also a concern in the Trout Creek basin. Accumulation of sediments from past logging operations resulted in lateral bank cutting as well as dramatic downcutting through aggraded substrates. Restoration efforts have alleviated some of these problems through large wood re-introduction and re-routing of the stream into stable channels with intact riparian forests.

The lower Wind River suffers from bank stability problems related to mass wasting. The most prominent feature is an eroded gully created by excessive runoff from the golf course in Carson. The gully, which is several hundred feet long, has contributed large amounts of sediment to the lower mile of the Wind River. There are other landslides along the lower Wind and the Little Wind River that are related to roads, timber harvest, utility corridors, and commercial development.

16.5.8 Riparian Function

The sub-watersheds with greater than 25% early-seral vegetation in riparian areas are the upper Wind, Eightmile Creek, Lower Trout, and the Little Wind River. Non-forest, seedling / sapling / pole, and small tree assemblages make up over 67% of riparian areas. The percent in the large tree category is under 33%, compared to the desired future condition of 75% (USFS 2001).

The mainstem Wind River between RM 12 and RM 19 contains rural residential development and past agricultural development that has resulted in cleared riparian forests. As a result, canopy cover and bank stability have been substantially reduced. The reduction of bank stability and LWD recruitment is partially responsible for dramatic channel shifts and rapid channel migration that has occurred in this reach.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

16.5.9 Floodplain Function

Alluvial reaches with developed floodplains are located on the middle Wind River, upper Wind River, Dry Creek, Panther Creek, and Trout Creek. There is a lack of quantitative information on channel connectivity and function of these floodplains. Observations gathered as part of the 1999 Limiting Factors Analysis (WCC 1999) reveal a few areas of concern. On the middle Wind River, floodplain connectivity is reduced by the 30 Road, which closely abuts the river in several places. Diking associated with residential development, the Beaver Campground, and the Carson Fish Hatchery also limit floodplain function in this segment. In the Mining Reach, Forest Road 30 intercepts the floodplain from RM 21 to RM 25. On Trapper Creek, cabins are located within the historical floodplain on the lower mile of stream. Some filling of flood channels has occurred in order to protect property. Portions of Trout Creek withinTrout Creek Flats have downcut to the point where the stream can no longer access its floodplain. Similar problems exist on Layout Creek, where stream restoration efforts recently reconnected 600 feet of side-channel habitat (USFS 2001).

16.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Wind River winter steelhead, summer steelhead, chum, and fall chinook. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

16.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT Model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Wind River subbasin for fall chinook, chum, coho, winter steelhead, and summer steelhead. Model results indicate declines in adult productivity for all species from historical levels (Table 16-1). Current productivity is only 17% and 19% of historical levels for winter steelhead and chum, respectively. Similarly, summer steelhead have experienced a decline in productivity to 25% of historical levels. The two species with the smallest estimated decline in adult productivity are fall chinook and coho. Fall chinook productivity has declined by 55% and coho productivity has declined by 47%.

As with productivity, adult abundance levels have also declined from historical levels for all five species (Figure 16-9). The decline in abundance has been most severe for chum and winter steelhead. Current chum abundance is estimated at only 3% of historical levels, while winter steelhead abundance is estimated at only 24% of historical levels. For fall chinook, coho and summer steelhead declines in adult abundance have been less severe, with current levels ranging from 32-44% of historical levels. Diversity (as measured by the diversity index) appears to have remained relatively steady for summer steelhead, with greater declines estimated for fall chinook, chum, and winter steelhead (Table 16-1). Coho diversity appears to have declined the most, with a current diversity level only 19% of the historical level (Table 16-1).

Modeled historical-to-current changes in smolt productivity and abundance show declines for all species (Table 16-1). The decrease in subbasin smolt productivity is greatest for winter steelhead and coho, with a decrease from historical levels of 88% for coho and 74% for winter steelhead. Smolt productivity appears to have declined the least for chum. However, this relatively higher productivity is merely an artifact of the way the EDT model calculates productivity. That is, the higher productivity of chum smolts is because Wind chum now have many less trajectories (life history pathways) that are viable (those that result in return spawners); but the few trajectories that remain have higher productivities than historical trajectories (many of which were only marginally viable).

Current smolt abundance is substantially less than the historical level for all species (Table 16-1), reflecting the significant loss of trajectories (which is also reflected in the life history diversity index). Historical-to-current change in fall chinook, coho, and chum smolt abundance shows an 81%, 90%, and a 94% decrease, respectively, from historical levels. Summer and winter steelhead smolt abundance appears to have declined somewhat less dramatically, with a modeled 40% and 56% decrease from past levels, respectively.

Model results indicate that restoration of properly functioning habitat conditions (PFC) would substantially increase adult abundance for all species (Table 16-1). Chum, fall chinook, and coho would benefit from an approximate 600%, 150%, and 100% increase, respectively, in adult abundance due to restoration of PFC. Restoration of PFC habitat conditions throughout the basin would also significantly improve adult productivity for all species (Table 16-1). Restoration of PFC conditions would have substantial effects on chum (229% increase), winter steelhead (122% increase) and fall chinook (104% increase). Somewhat lower effects would be seen for coho (64% increase) and summer steelhead (38% increase).

Table 16-1. Wind River— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T^1**	**P**	**PFC**	**T^1**	**P**	**PFC**	**T^1**	**P**	**PFC**	**T^1**	**P**	**PFC**	**T^1**
Fall Chinook	954	2,418	2,584	4.85	9.92	10.78	0.62	0.98	0.99	158,081	755,887	835,275	568	1,234	1,316
Chum	361	2,582	10,886	1.67	5.50	9.02	0.45	1.00	1.00	227,457	1,715,208	3,829,348	720	1,000	1,083
Coho	418	898	946	2.88	4.75	5.40	0.11	0.56	0.56	1,384	12,730	14,062	35	244	288
Winter Steelhead	70	123	280	3.46	7.70	20.81	0.56	0.77	0.79	1,403	2,550	3,198	71	181	272
Summer Steelhead	1,230	1,437	3,814	4.37	6.04	17.73	0.88	0.95	1.00	24,673	28,658	41,020	84	117	185

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

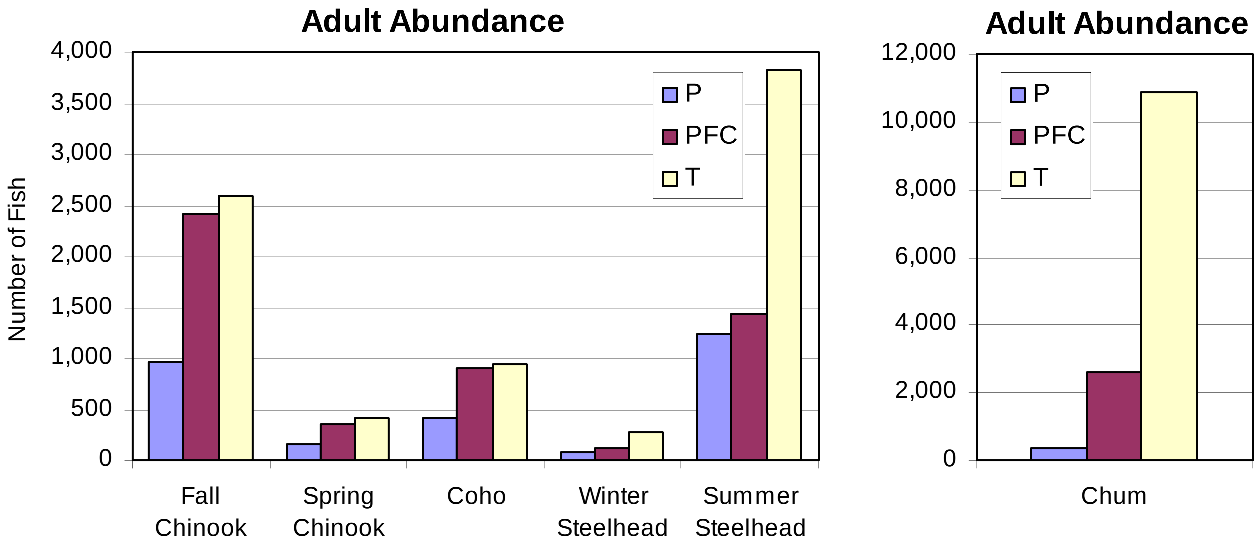


Figure 16-9. Adult abundance of Wind river fall chinook, spring chinook, chum, coho and winter and summer steelhead based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

16.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

The Wind River subbasin includes approximately 60 reaches and has significant production potential for salmon and steelhead. Historically, Shipherd Falls could be passed by summer steelhead but the falls limited chum and fall chinook to the lower 3 miles of the river. Winter steelhead used the Lower Wind and the Little Wind River. The location of EDT reaches is displayed in Figure 16-10.

For Wind River fall chinook, chum, coho, and winter steelhead the high priority reaches (Wind 1, Wind 2, and Little Wind 1) are located in the lower river (Figure 16-11 - Figure 16-14). In this lower section of the river, reach Wind 1 consistantly provides the greatest restoration potential. However, restoring this reach would require substantial changes to the operation or configuration of Bonneville Dam. Significant improvements in fall chinook, chum, and coho habitat could be gained by restoration activities in reach Wind 2. Resoration activities in Little Wind 1 would benefit winter steelhead. Reach Wind 3 generally has both restoration and preservation value (see ladder diagrams below).

High priority reaches for summer steelhead in the Wind River appear most concentrated in the mid to lower sections of the subbasin (Figure 16-15). The high priority reaches in the mainstem include Wind 4a, 4b, and 6b, each with a preservation emphasis. Tributaries flowing into the mainstem Wind River also contain high priority reaches for summer steelhead. Reach Trout 1a and Panther 1a and 1b are all high priority for summer steelhead, again each with a preservation emphasis. Juvenile trapping has indicated that up to 70% of the Wind River steelhead smolt production is believed to originate in mainstem canyon reaches (Wind 4a-4b) (Rawding and Cochran 2000). Many age-1 parr move into these areas in May and rear for one year before out-migration. These canyon reaches, which are in relatively good condition, therefore have high preservation value. Some potential for restoration exists in the mainstem Wind between Trout Creek and Tyee Springs (Wind 5a and 5c), often referred to as the Wind Flats reach; the mainstem between Falls and Paradise Creeks (Wind 6d), often referred to as the mining reach; Panther Creek from the mouth to Eight-mile Creek (Panther 1a, 1b, and 1c); and Trout Creek between Hemlock Dam and Layout Creek (Trout 1c and 1d), referred to as Trout Flats.

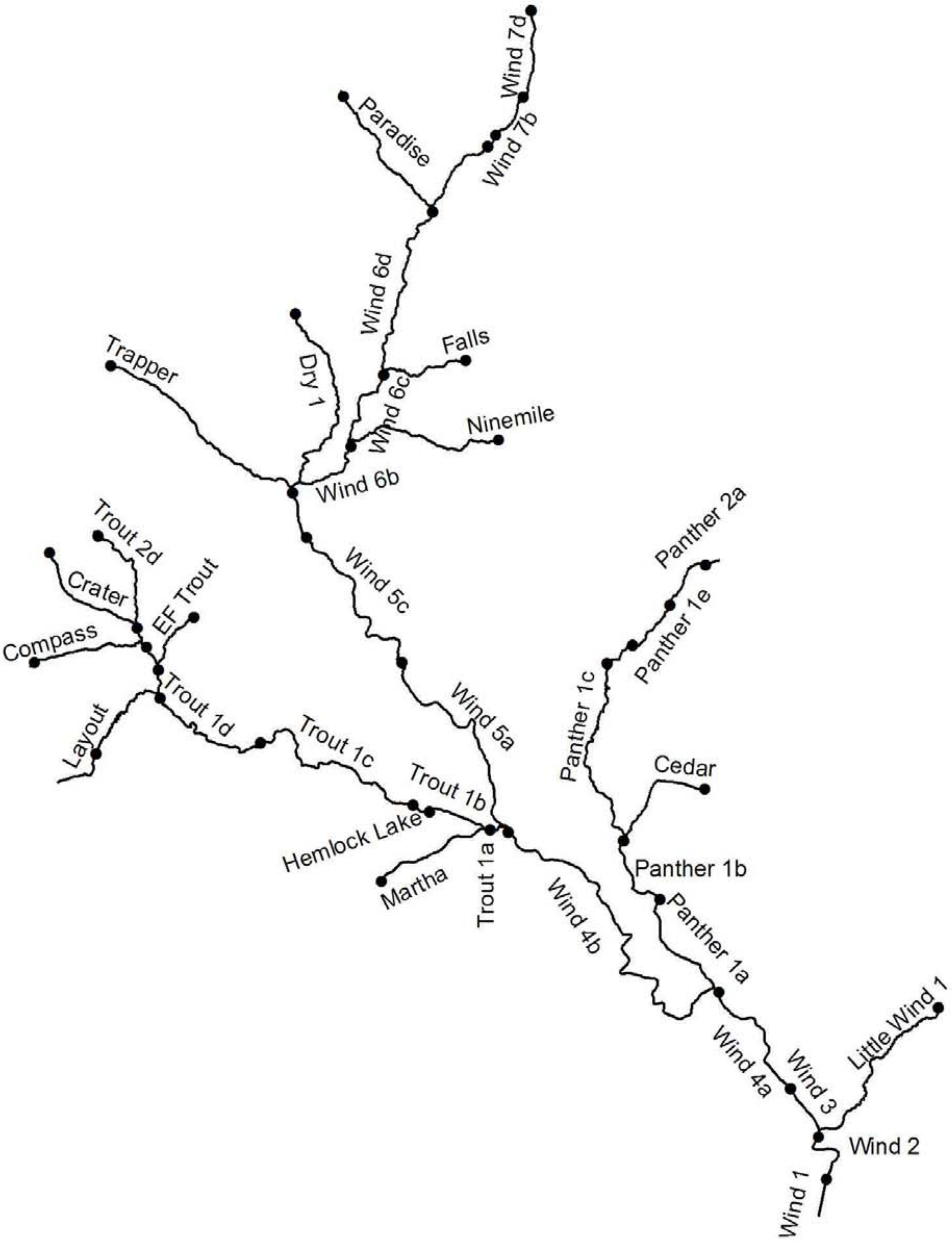


Figure 16-10. Wind River Basin EDT reaches. For readability, not all reaches are labeled.

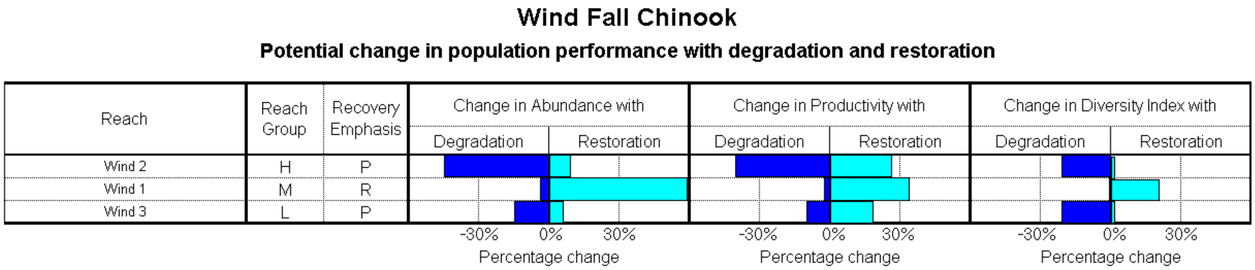


Figure 16-11. Wind River fall chinook ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphazsis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

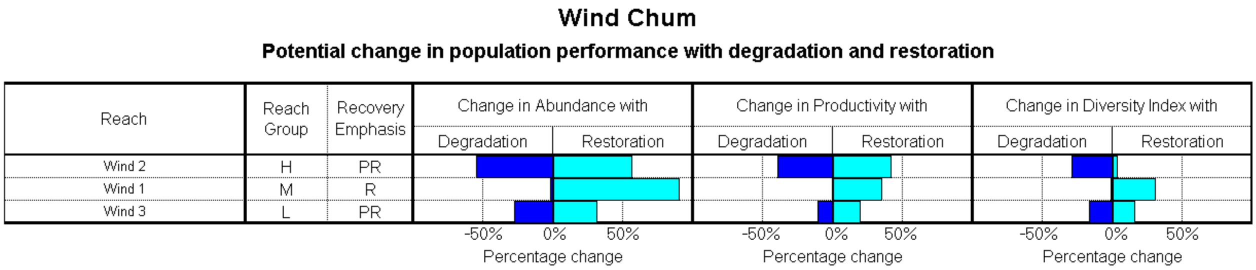


Figure 16-12. Wind River chum ladder diagram.

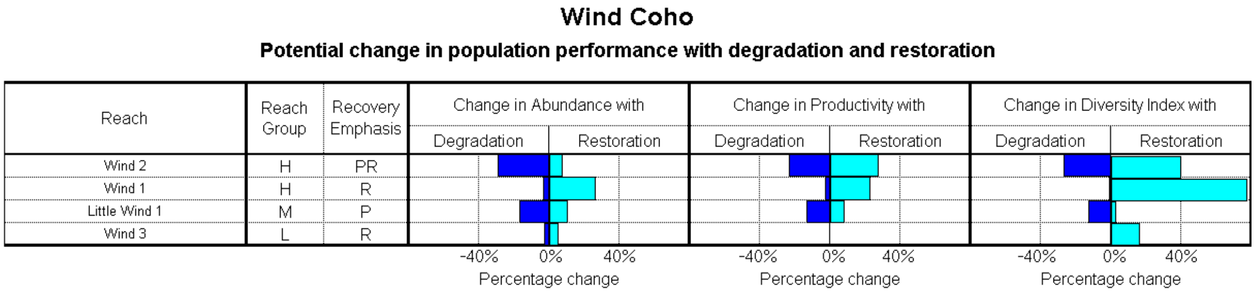


Figure 16-13. Wind River coho ladder diagram.

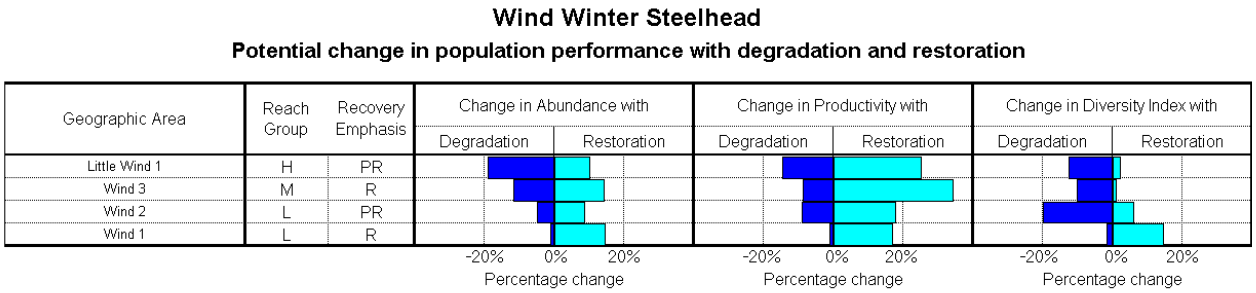
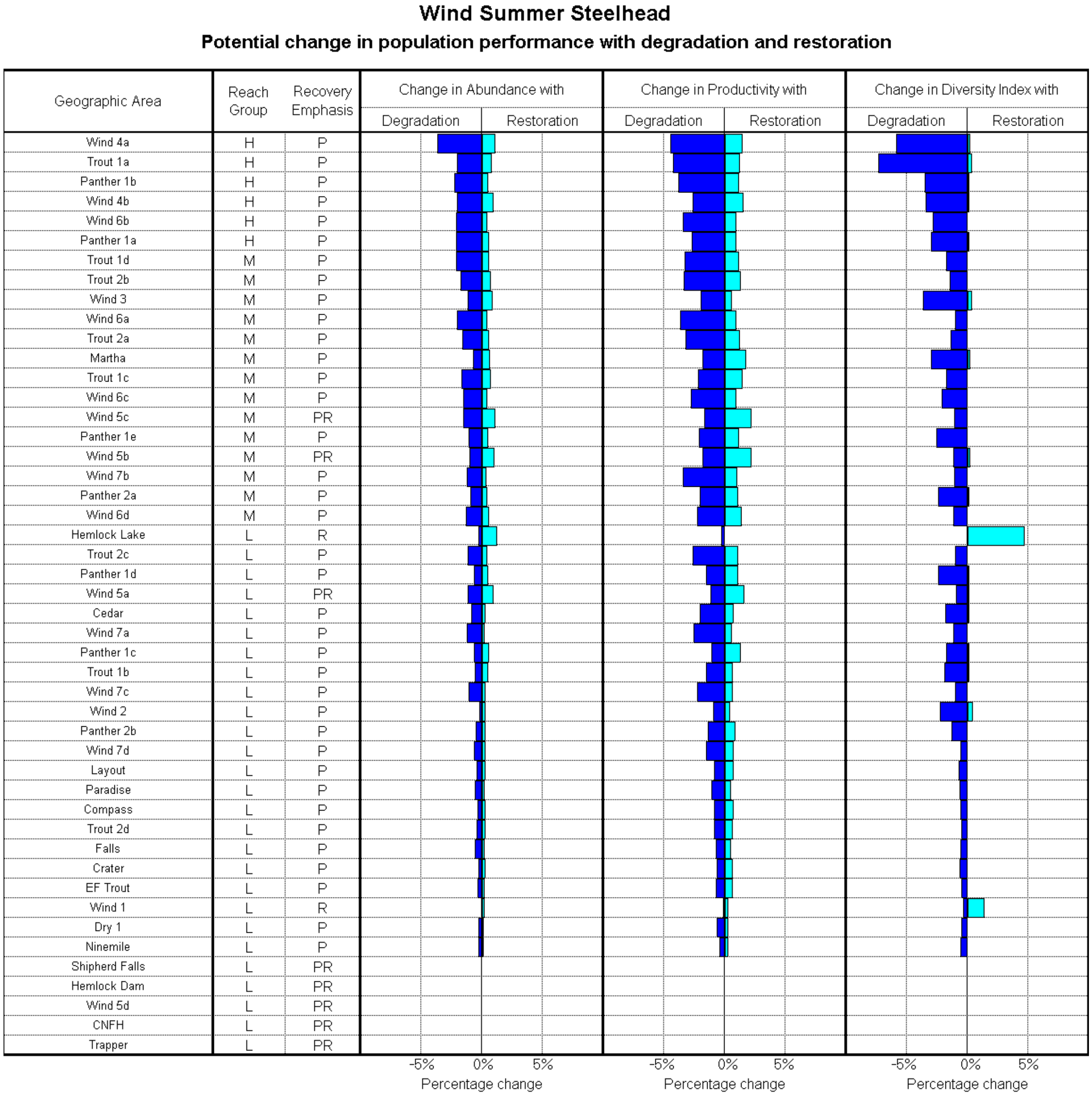


Figure 16-14. Wind River winter steelhead ladder diagram.



Geographic Area	Reach Group	Recovery Emphasis
Wind 4a	H	P
Trout 1a	H	P
Panther 1b	H	P
Wind 4b	H	P
Wind 6b	H	P
Panther 1a	H	P
Trout 1d	M	P
Trout 2b	M	P
Wind 3	M	P
Wind 6a	M	P
Trout 2a	M	P
Martha	M	P
Trout 1c	M	P
Wind 6c	M	P
Wind 5c	M	PR
Panther 1e	M	P
Wind 5b	M	PR
Wind 7b	M	P
Panther 2a	M	P
Wind 6d	M	P
Hemlock Lake	L	R
Trout 2c	L	P
Panther 1d	L	P
Wind 5a	L	PR
Cedar	L	P
Wind 7a	L	P
Panther 1c	L	P
Trout 1b	L	P
Wind 7c	L	P
Wind 2	L	P
Panther 2b	L	P
Wind 7d	L	P
Layout	L	P
Paradise	L	P
Compass	L	P
Trout 2d	L	P
Falls	L	P
Crater	L	P
EF Trout	L	P
Wind 1	L	R
Dry 1	L	P
Ninemile	L	P
Shipherd Falls	L	PR
Hemlock Dam	L	PR
Wind 5d	L	PR
CNFH	L	PR
Trapper	L	PR

Figure 16-15. Wind River summer steelhead ladder diagram.

16.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The Habitat Factor Analysis of the Wind is most easily discussed in two areas within the subbasin. The first is the lower river, below Shipherd Falls, which provides habitat for winter steelhead, fall chinook, and historically, chum. The second area constitutes the remainder of the basin, which is accessed by wild summer steelhead.

For the lower river, Wind 1 suppresses the performance of fall chinook and chum due to loss of key habitat, habitat diversity, increased sediment, and increased temperatue (Figure 16-16 and Figure 16-17). All of these are related to Bonneville Pool inundation. For chum, reach Wind 2 has similar impacts. For winter steelhead, habitat diversity, temperature, and sediment are a problem in all of the Lower Wind and Little Wind reaches accessed (Figure 16-18). Sediment from upstream sources collects in reaches Wind 1 and Wind 2 as the velocity slows in these low gradient reaches. Sediment originates from upper basin hillslope sources, upstream channel erosion, and local mass wasting. Upper basin hillslope sources contribute sediment due to high road densities and early-seral stage forests. This is especially a problem in the Trout Creek and Middle Wind basins (USFS 2001). Sediment is also contributed during storm flows from upstream channel sources, mainly from the Wind Flats and Trout Creek alluvial channels. There is also considerable contribution of sediment from bank erosion in the Lower Wind itself. This area is underlain by Bretz Flood deposits that continue to deliver sediment through mass wasting events. Mass wasting from landslides and debris flows is exacerbated by roadways, denuded riparian vegetation, and concentrated runoff from the greater Carson urban area, in particular the Carson Golf Course.

Loss of key habitat is another major concern in the lower river. Riffle habitat has been lost by Bonneville Pool inundation and much of reach Wind 2 is in glide habitat. The prevalence of glides may be due in part to natural conditions but is also likely exacerbated by hydro-confinement from a rip-raped roadway along the east bank of reach Wind 2. Temperature is also a concern in the Lower Wind reaches. Wind 1 has elevated temperature due to the influx of Columbia River water, a condition that is unlikely to change. Temperature problems also exist in Wind 3 and on the Little Wind River, related primarily to loss of adequate riparian tree canopy cover. Habitat diversity is a concern in all of the Lower Wind reaches. This is related to confinement, denuded riparian vegetation, and lack of LWD.

For the remainder of the basin, summer steelhead abundance is degraded primarily by habitat conditions in a few general areas. These include the reaches Wind 4a and 4b (canyon), Wind 5a–5c (wind flats), reach Wind 6d (mining reach), reaches Trout 1c and 1d (Lower Trout), and Panther 1a, 1b, and 1c (Lower Panther) (Figure 16-19). These areas represent major steelhead spawning and rearing sites. The main impacts result from degraded key habitat, sediment, flow, habitat diversity, temperature, and channel stability. Key habitat has been altered due to a combination of interacting factors, and in some cases may reflect natural conditions. In general, in the Wind Flats, Mining reach, Lower Trout, and Lower Panther Creek reaches, key habitat in the form of pools and riffles has decreased. Filling of pools with sediment, increased gradient from confinement, and lack of LWD are mostly to blame for their degradation. Excess sedimentation has a high impact in the wind flats, Lower Trout, and Lower Panther reaches. Sediment is contributed from hillslope as well as in-channel sources. High road densities in the Trout Creek basin and early-seral stage vegetation in the Trout, upper Wind, and Panther basins contribute to sedimentation. Sources of in-channel sediment are high in the wind flats and reach Trout 1d, where past practices have reduced channel stability. Dramatic alterations to channel planforms, including avulsions and rapid meander migrations, have occurred in these reaches. Denuded riparian conditions, isolated floodplains, sediment aggradation, and large wood accumulations all contribute to this instability.

Flow condition is another degrading factor in the subbasin, with major effects once again in the highly degraded areas of Wind Flats, Lower Trout, and Lower Panther. Low hydrologic maturity of forests (early seral-stages) in the rain-on-snow zones in Upper Wind, Falls Creek, Trout, and Panther Creek basins (USFS 2001) are believed to contribute to these problems. High road densities and an increase in drainage density due to roads in Upper Wind, Trout, and Falls Creek basins are also likely contributors. Historically, large stand-replacement fires also would have affected snow accumulation, snowmelt, and water delivery to streams (USFS 1996), however, these events were infrequent (return intervals of hundreds of years) and channels and floodplains were in a better condition to accommodate flood flows.

Another habitat factor impacting steelhead is loss of habitat diversity. Habitat diversity is affected by hydro-confinement, degraded riparian conditions, lack of LWD, and direct channel manipulations. Direct impacts to stream channels have occurred only rarely in recent years, though many of the channels, especially the middle mainstem Wind (Wind Flats) and Lower Trout Creek, still suffer from past splash dam logging and past LWD removal inappropriately aimed at facilitating fish passage (USFS 1996). Channel straightening/confinement and floodplain isolation occur in the wind flats and mining reaches, where Hwy 30 parallels the river. Straightening increases gradient, which increases scour of the channel bed and facilitates transport of woody debris. Bank hardening projects (i.e. rip-rap) associated with Hwy 30 have further reduced LWD and streambank vegetation that is important for fish food and cover.

Riparian manipulations have contributed to stream temperature impairments. Stream temperature is especially high in portions of Trout Creek and the middle Wind (wind flats and mining reach). Temperature problems in the Wind basin are also related to an increase in channel width-to-depth ratios (USFS 2001), which result from bank erosion and sedimentation.

Impacts from changes in biological community are of lesser magnitude than changes in hydrologic and stream corridor characteristics. There are however, minor concerns of competition with hatchery spring chinook and brook trout in the middle wind and Trout Creek, respectively. There are also concerns regarding the impact of potential pathogens originating from the Carson Hatchery. The food resource has been increased in reach Wind 5c due to an increase in spring chinook salmon carcasses since historical times.

Wind Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Wind 2	•	•	•						•	•					•	•
Wind 1	•	●	⬤	●	•				•	●	•			•	●	⬤
Wind 3	●	•								•					•	✛

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 16-16. Wind River fall chinook habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Wind Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Wind 2	•	●		•					•	•	•				●	●
Wind 1	•	●	•	•	•				•	•	•			•	●	⬤
Wind 3	•	●		•					•	•					•	•

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 16-17. Wind River chum habitat factor analysis diagram.

Wind Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Little Wind 1	•	•	●	•		•			•	●	•			•		⬤
Wind 3	•	●	•	●		•			•	●				•	•	✚
Wind 2	•	●	•	•		•			•	•	•			•	•	•
Wind 1	•	●	●	●	•	•				•				●	•	⬤

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 16-18. Wind River winter steelhead habitat factor analysis diagram.

Wind Summer Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Wind 4a	•	⬤	•	●		●			●	⬤				●		✚
Trout 1a	•	⬤	●	•		•			●	●	•			•		✛
Panther 1b	•	●		•					●	⬤						+
Wind 4b	•	●	●	●		●			●	⬤				●		✚
Wind 6b	•	●	•	•					●	●	+			•		●
Panther 1a	•	⬤		•					●	●						✛
Trout 1d	•	●	●	•		•			●	⬤	•			•		✛
Trout 2b	•	●	•	•		●			●	⬤	●					✚
Wind 3	•	⬤	•	●		●			●		•			●		
Wind 6a	•	●	•	•		●			•	●	+			•	•	+
Trout 2a	•	●	•	•		●			●	⬤	●					✚
Martha	•		⬤	•		•			●	⬤	•			•		●
Trout 1c	•	●	●	•		•			●	●	•			•		●
Wind 6c	•	●		•					●	●						●
Wind 5c	●	⬤	•	●		●			●	●	+			●	•	●
Panther 1e	•	●				•			●	●	•					✛
Wind 5b	●	⬤	•	•		●			●	●	•			●	•	●
Wind 7b	•		●	•					●	⬤						+
Panther 2a	•	●				•			●	●	•					✛
Wind 6d	•	●	•	•		•			●	⬤	•					✛
Hemlock Lake		⬤	●	•		•			✛	⬤	•			•	•	⬤
Trout 2c	•	●		•		•			●	⬤	•					✛
Panther 1d	•	●				•			●	●	•					●
Wind 5a	●	●	•	●		●			●	●	•			●	•	●
Cedar		●	•	•		•			●	●	•					✛
Wind 7a	•		•	•					●	⬤						+
Panther 1c	•	⬤				•			●	●	•					●
Trout 1b	•	●	●	•		•			●	●	•			•		+
Wind 7c	•		•	•					●	⬤						+
Wind 2	•	●	•	•		•			•		•			•		
Panther 2b	•	●				•			●	●	•					+
Wind 7d	•		•	•					●	⬤						✚
Layout	•		●	•		•			●	●	•			•		+
Paradise		•				•			•	⬤	•					
Compass	•	•	•	•		•			●	⬤	•					•
Trout 2d	•	●				•			●	●	•					✛
Falls	•	●							•	●						•
Crater			●	•		•			•	⬤	•			•		•
EF Trout			●	•		•			•	⬤				•		
Wind 1	•	•	•	•		•								•		
Dry 1		•	•			•			•	●	•					
Ninemile		•				•			•	•						✛
Shipherd Falls																
Hemlock Dam																
Wind 5d																
CNFH																
Trapper																

High Impact ⬤ Moderate Impact ● Low Impact • None ☐ Low Positive Impact + Moderate Positve Impact ✛ High Positve Impact ✚

Figure 16-19. Wind River summer steelhead habitat factor analysis diagram.

16.7 Integrated Watershed Assessment (IWA)

The Wind River watershed includes 25 subwatersheds, which make up the 144,000 acres in the basin. The majority of the basin is in public ownership (91%), most of it under federal management, with privately held lands in the southern portion of the basin and in the middle mainstem valley.

16.7.1 Results and Discussion

Due to a lack of available geospatial data, IWA results were calculated only for sediment conditions in the Wind River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in Table 16-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 16-20. Maps of the distribution of local and watershed level IWA results are displayed in Figure 16-21.

Table 16-2. IWA results for the Wind River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
10101	ND	F	ND	ND	F	10102, 10103
10102	ND	M	ND	ND	F	10103
10103	ND	F	ND	ND	F	none
10104	ND	M	ND	ND	M	none
10201	ND	M	ND	ND	M	10202, 10203
10202	ND	F	ND	ND	F	10203
10203	ND	M	ND	ND	M	none
10301	ND	M	ND	ND	M	none
10302	ND	F	ND	ND	F	none
10401	ND	F	ND	ND	F	10101, 10102, 10103, 10104, 10201, 10202, 10203, 10301, 10302, 10402, 10403
10402	ND	F	ND	ND	F	10101, 10102, 10103, 10104, 10201, 10202, 10203, 10301, 10302, 10403
10403	ND	F	ND	ND	F	10101, 10102, 10103, 10104, 10201, 10202, 10203
10501	ND	M	ND	ND	M	10502, 10503, 10504
10502	ND	F	ND	ND	M	10503, 10504
10503	ND	F	ND	ND	M	10504
10504	ND	M	ND	ND	M	none
10601	ND	M	ND	ND	F	10602, 10603, 10604
10602	ND	F	ND	ND	F	10603, 10604
10603	ND	F	ND	ND	F	10604
10604	ND	F	ND	ND	F	none
10701	ND	F	ND	ND	F	10702
10702	ND	F	ND	ND	F	none
10801	ND	M	ND	ND	F	10101, 10102, 10103, 10104, 10201, 10202, 10203, 10301, 10302, 10401, 10402, 10403, 10501, 10502, 10503, 10504, 10601, 10602, 10603, 10604, 10701, 10702, 10802, 10803
10802	ND	F	ND	ND	M	10101, 10102, 10103, 10104, 10201, 10202, 10203, 10301, 10302, 10401, 10402, 10403, 10501, 10502, 10503, 10504
10803	ND	M	ND	ND	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170701051#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired
ND:	Not evaluated due to a lack of data

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

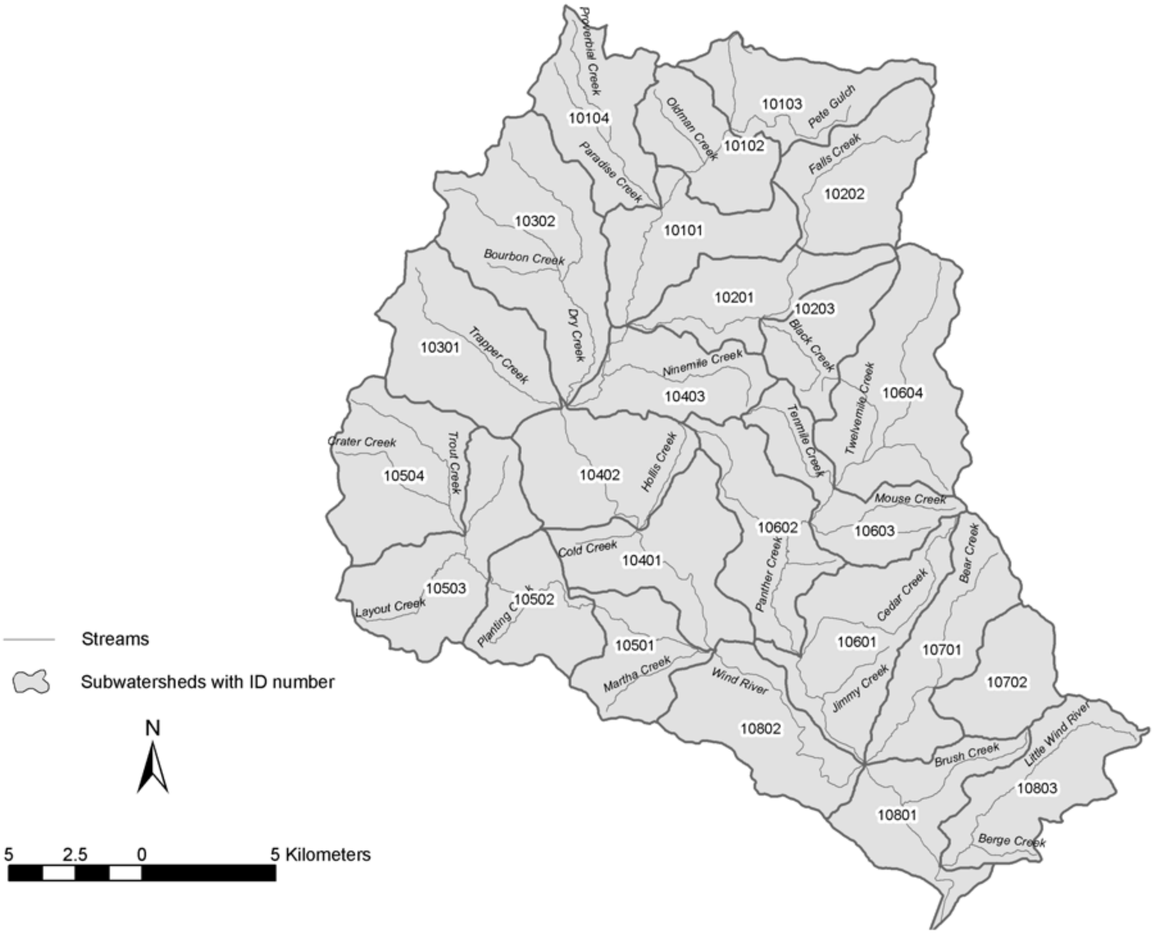


Figure 16-20. Map of the Wind River basin showing the location of the IWA subwatersheds

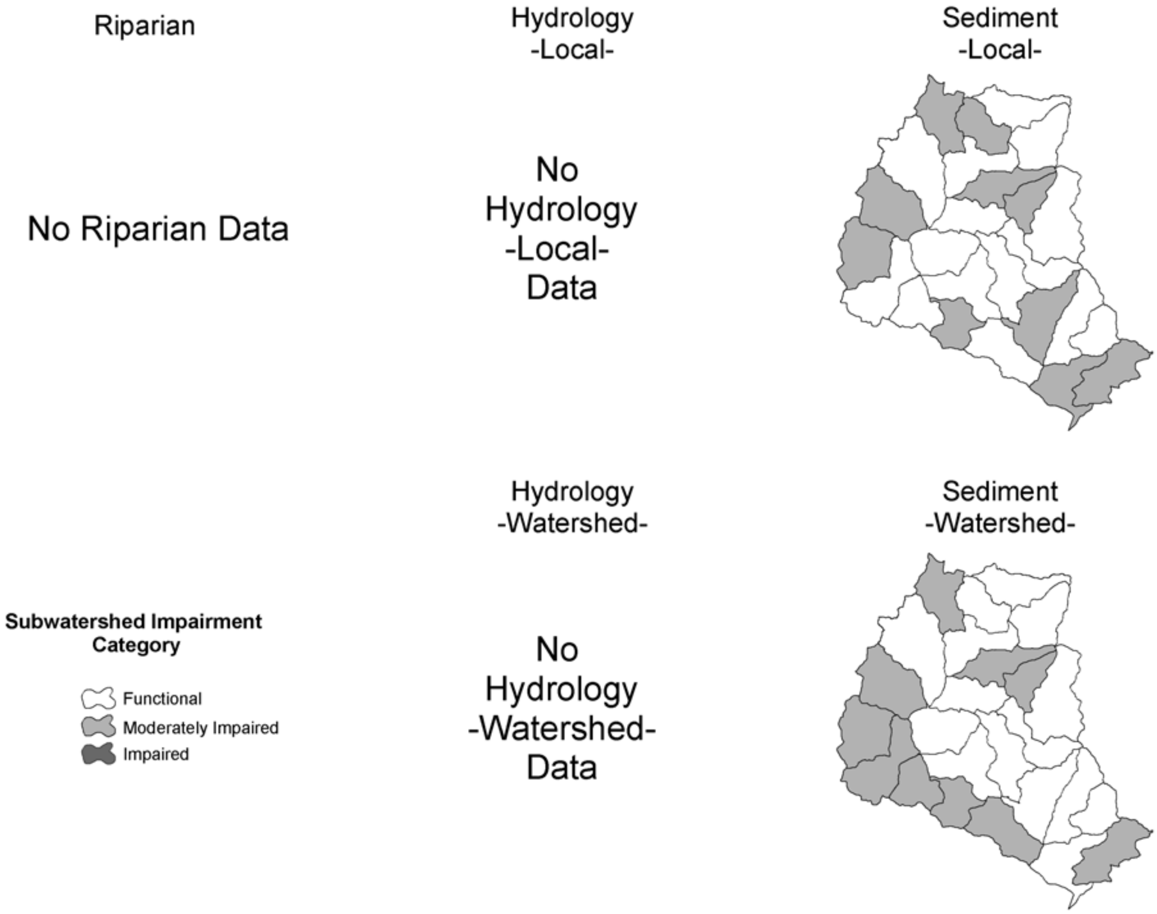


Figure 16-21. IWA subwatershed impairment ratings by category for the Wind River basin

16.7.1.1 Hydrology

IWA results were not developed for hydrologic and riparian conditions in the Wind River watershed due to the lack of GIS based data for forest cover. However, ratings for local hydrologic conditions can be derived from available sources of information. The 1996 watershed analysis conducted by the USFS indicates that 14% of the subbasin is in hydrologically immature forest cover (USFS 1996). The USFS watershed analysis divided the watershed into 26 subwatersheds, which are somewhat compatible with the 25 LCFRB recovery planning subwatersheds that comprise the Wind River drainage. Based on these results, all subwatersheds in the Wind River drainage appear to have hydrologically mature vegetation in excess of 50% of total area. In the IWA analysis, percent immature hydrologic vegetation and road density are used to rate likely hydrologic condition where impervious surface information is not available. Because of generally uniform coverage with hydrologically mature vegetation, road densities would be the determinants of hydrologic conditions in the IWA analysis.

Based on these derived ratings, hydrologic conditions in the upper Wind River are mixed. Local conditions are rated as moderately impaired in the upper mainstem (10102), lower Falls Creek (10201),and the middle mainstem (10401 and 10402). Conditions in remaining subwatersheds—including the upper mainstem key subwatershed 10101—are rated as locally functional. The upper Wind River is 97% publicly owned, with the vast majority of this area contained in national forest. This portion of the watershed has 48% of its area in the rain-on-snow zone, with much of the remainder in the snow-dominated zone. The high proportion of area in the rain-on-snow prone zone indicates a higher sensitivity to hydrologic impacts from poor forest cover and high road densities. Rain-on-snow area is particularly high (>70%) in the upper mainstem (10101 and 10102), Falls Creek (10201 and 10202), and the middle mainstem Wind River (10403). Road densities in excess of 3 mi/sq mi) are present in lower Falls Creek (10201) and the upper mainstem Wind (10102). This combination of factors suggests that these subwatersheds may be particularly prone to hydrologic impacts. This tendency is moderated somewhat by the presence of wetlands in the Wind River headwaters (10103) and Black Creek in the Falls Creek drainage (10203), covering approximately 3% and 6% of watershed area, respectively. These relatively extensive wetlands will serve to buffer hydrologic conditions in downstream subwatersheds.

Hydrologic conditions in Trout Creek and Panther Creek are similarly mixed in comparison to the upper Wind River. Based on ratings derived for these drainages from available data, local hydrologic conditions in the headwaters of Trout Creek (10504 and 10503) and Panther Creek (10604 and 10603) are moderately impaired. These ratings are attributed to the high road densities (3.0 to 4.7 mi/sq mi) present in these subwatersheds. Lower Trout Creek (10501) is also rated as moderately impaired, again due to high road densities (4.7 mi/sq mi). Remaining subwatersheds in these drainages are rated as functional. Over 90% of the land area in this portion of the watershed is in public lands, with significant portions of the Trout Creek drainage in the Wind River experimental forest. Trout Creek and Panther Creek have moderate to high proportion of total area in the rain-on-snow zone (ranging from 36-74%). These subwatersheds have the largest amount of rain-on-snow area, with upstream watersheds increasingly snow-dominated and downstream subwatersheds more rain-dominated.

Local level hydrologic conditions in the mainstem subwatersheds of the lower Wind River watershed and its tributaries are mixed. For example, the second upstream subwatershed of the lower middle Wind River (10802) is rated as functional while the lower mainstem (10801) is rated as moderately impaired. The Little Wind River (10803), which enters the lower Wind River approximately one mile above its mouth, is rated as moderately impaired. Approximately 3 miles upstream at RM 4 is the confluence of Bear Creek, with two subwatersheds (10701 and 10702) rated as hydrologically functional. Extensive private land holdings can be found in several of these subwatersheds, such as the Little Wind River (10803) and the lower mainstem (10801 and 10802) which average approximately 50% private lands. Private lands in this part of the watershed include rangelands, agriculture, residential development, and timber. Land uses on public and private lands in these subwatersheds are within the Columbia Gorge National Scenic Area and are subject to stricter land use and development regulations, thereby dampening the effects of land management in these areas.

When interpreting the hydrologic condition ratings for the mainstem subwatersheds (10802 and 10801), it is important to recognize that the local level hydrologic conditions do not reflect the influence of the upstream portions of the watershed. Watershed level conditions will consider both the local and the upstream effects, and may be quite different than the local conditions alone.

16.7.1.2 Sediment

As with hydrologic conditions, the local level sediment conditions in the upper Wind River are mixed. Functional sediment ratings are concentrated in the Wind River headwaters (10103), Upper Falls Creek (10202), Dry Creek (10302), the upper mainstem (10101), Ninemile Creek (10403), and the middle mainstem (10401 and 10402). Moderately impaired ratings for local level sediment conditions are found in Paradise Creek (10104), the upper Wind River (10102), Falls Creek (10201 and 10203), and Trapper Creek (10304). Watershed level ratings are identical to the local level conditions with one exception. The upper mainstem (10101) is rated functional and appears to benefit from functional conditions in the Wind River headwaters (10103). Natural erodability ratings in this part of the watershed range from low to moderate (5-30 on a scale of 0-126), with the more erodable subwatersheds including Dry Creek, Trapper Creek, Ninemile Creek and the middle mainstem subwatersheds of the Wind River. The functional watershed level ratings for the upper and middle mainstem (10101, 10401, 10402) are determined both by locally functional conditions and the buffering effect from upstream subwatersheds. The functional conditions in upstream subwatersheds appear to provide a buffering effect that balances the effect of moderately impaired subwatersheds at the watershed level.

Trapper Creek (10301 – moderately impaired) has relatively pristine forest cover and riparian conditions (USFS 1996). Road densities in this subwatershed are relatively low (<2.0 mi/sq mi), and the density of streamside roads is also moderately low (0.45 miles/stream mile). However, sediment conditions in this subwatershed are rated as moderately impaired due to the intersection of forest roads, steep slopes, and more erodable geology. While rain-on-snow zone density in Trapper Creek is moderate (43%), the combination of roads in sensitive areas with the potential for rapid runoff under rain-on-snow conditions may create significant sediment loading.

Lower Falls Creek (10201 - moderately impaired) has a low natural erodability rate (7 on the 0-126 scale), but has moderately impaired sediment conditions due to high rain-on-snow area (83%) and high streamside road densities (>2 miles/stream mile). Streamside roads are relatively large sources of sediment relative to overall unsurfaced road density.

Local level sediment conditions in Trout Creek subwatersheds are rated as moderately impaired at the headwaters and the mouth (10504 and 10501). The middle two watersheds in the Trout Creek drainage (10502 and 10503) are rated as functional for sediment conditions. In contrast, watershed level conditions in all four subwatersheds in this drainage are rated as moderately impaired. Based on this information, the moderately impaired conditions in the headwaters of Trout Large are strongly influencing downstream subwatersheds. Natural erodability rates for the Trout Creek drainage are moderate (13-31 on a scale of 0-126), with erodability ratings increasing on an upstream gradient. The watershed level effects of moderately impaired conditions in the headwaters suggests that the relatively high road densities in this subwatershed (>4 mi/sq mi) are concentrated in more erodable areas. Similarly, while erodability ratings at the lower end of Trout Creek (10501) are relatively low, the high road densities in this subwatershed (4.7 mi/sq mi) are concentrated in more erodable areas.

Sediment conditions in the Panther Creek drainage are functional at the local level in all subwatersheds except lower Panther Creek (10601). Watershed level conditions are functional in all subwatersheds, suggesting that the functional conditions in the headwaters and middle subwatersheds of the drainage provide a buffering effect on sediment conditions in the most downstream subwatersheds. Lower and middle Panther Creek (10601 and 10602) are important subwatersheds for summer steelhead. Natural erodability ratings in these areas are low to moderate (ranging from 18-30 on the 0-126 scale), suggesting that moderately impaired ratings are indicative of detrimental effects on instream habitat conditions.

Sediment conditions in the lower Wind River are strongly influenced by watershed level effects from upstream drainages. Sediment conditions in the lower middle Wind River (10802) and the lower Wind River (10801) are rated as functional and moderately impaired at the local level, respectively. These ratings reverse at the watershed level. The lower middle Wind (10802) is rated as moderately impaired at the watershed level due predominantly to the influence of watershed level degradation in the Trout Creek drainage. In contrast, the lower Wind River (10801) is rated as functional at the watershed level, due to the influence of generally functional sediment conditions in the Panther and Bear Creek drainages. The moderately impaired local level rating for the lower Wind River is borderline, suggesting that local level effects are relatively modest contributors of sediment relative to watershed level effects.

Sediment conditions in the Bear Creek drainage (10701 and 10702) are rated as functional at both local and watershed levels. Bear Creek has moderately low overall road densities (averaging 2.0 mi/sq mi). Streamside road densities are moderate, averaging 0.48 miles/stream mile, and rain-on-snow area ranges from 35% in lower Bear Creek (10701) to over 60% in upper Bear Creek (10702). Natural erodability rates are in the moderate range, averaging over 30 on the scale of 0-126. The functional rating for the headwaters of Bear Creek is borderline moderately impaired. This suggests that some roads may be located in particularly sensitive areas.

The moderately impaired rating for sediment conditions in the Little Wind River (10803) is driven by the relatively high level of natural erodability for this watershed (36 on the 0-126 scale) and moderately high road densities (3.1 mi/sq mi). In addition, the headwaters of this subwatershed are in the rain-on-snow zone. This subwatershed has significant area in private land ownership (41%); however, the proximity of this subwatershed to the Columbia Gorge National Scenic Area limits land uses and development on both public and private lands. Streamside road densities are high, exceeding 0.9 miles/stream mile.

16.7.1.3 Riparian

Riparian conditions are rated in the USFS watershed analysis based on various measures of the riparian zone seral stage in selected stream reaches (USFS 1996). Thresholds of concern for riparian vegetation are not defined in the watershed analysis and no definitive ratings are provided. While the data in the watershed analysis cannot be directly evaluated using IWA thresholds, a general rating of riparian condition can be qualitatively derived using arbitrary thresholds for the proportion of the riparian zone in large (successionally mature) trees. For the purpose of this qualitative analysis, riparian ratings are defined as follows:

- Functional: riparian zone >50% large trees
- Moderately Impaired: riparian zone between 20-50% large trees
- Impaired: riparian zone <20% large trees

Based on this information, riparian conditions appear to vary widely across the Wind River watershed, with a general trend towards moderately impaired to impaired conditions. Functional riparian conditions are found in the Little Wind River (10803), the Bear Creek drainage (10701 and 10702), lower and upper middle Panther Creek (10701 and 10703), Trapper

Creek (10301), and Dry Creek (10302). Riparian conditions are rated as impaired in the upper middle Wind River (10401 and 10401) and lower and middle Trout Creek (10501 and 10502). All remaining subwatersheds are rated as moderately impaired, with borderline impaired conditions present in lower middle Panther Creek (10602) and upper middle Trout Creek (10503).

16.7.2 Predicted Future Trends

16.7.2.1 Hydrology

Because of the high proportion of area under public ownership, relatively high levels of mature vegetation, low development expectations, and the extent of restoration actions being implemented on federal lands in the watershed, overall hydrologic conditions in the Wind River Watershed are predicted to trend stable over the next 20 years, with gradual improvement as vegetation matures. Road and road-crossing removal as well as riparian restoration are likely to provide substantial hydrologic benefits.

Most of the upper watershed lies within the GPNF, and can be characterized by fairly good mature vegetation cover. Because of the high proportion of area in public ownership, and the extent of restoration actions being implemented on federal lands in the watershed, hydrologic conditions in the upper Wind River are predicted to trend stable over the next 20 years, with gradual improvement as vegetation matures. High road densities (in excess of 3 mi/sq mi) in subwatersheds within the rain-on-snow zone, such as the upper mainstem (10102) and lower Falls Creek (102 10202), may impede hydrologic recovery in affected reaches.

Given the high percentage of public lands in the Trout Creek and Panther Creek drainages, hydrologic conditions are predicted to trend stable in these subwatersheds over the next 20 years with some gradual improvement as vegetation matures.

While the influence of watershed level conditions in the lower mainstem Wind River (10801 and 10802) have not been analyzed, the general trends predicted for the upstream areas of the watershed will strongly influence conditions in these mainstem reaches. In general, the extensive coverage of hydrologically mature vegetation and the emphasis on habitat restoration on public lands in the watershed would suggest that hydrologic conditions in the watershed as a whole will trend towards improvement. Hydrologic conditions are predicted to trend stable over the next 20 years, given the higher proportion of private lands in these watersheds, the likelihood of ongoing land management activities under existing regulatory constraints, and the existing road densities. Some gradual improvement will occur as areas with immature vegetation recover, but these positive influences may be outweighed by the effects of road conditions.

Other important portions of the Wind River watershed include Bear Creek and the Little Wind River drainages. Hydrologic conditions for the Bear Creek drainage are predicted to remain stable over the next 20 years, based on the currently functional rating and the high proportion of public lands in the drainage. Road densities in the Bear Creek drainage are relatively low (averaging 2.0 mi/sq mi), with a relatively high proportion of mature vegetation. The hydrologic conditions in the Little Wind River (10803) are predicted to remain moderately impaired due to high road densities, with some moderation due to existing land use restrictions. Road densities in this subwatershed just exceed the threshold for hydrologic effects, by 0.1 mi/sq mi (3.1 mi/sq mi total).

16.7.2.2 Sediment Supply

Sediment conditions in the upper Wind River, Trout Creek, and Panther Creek are predicted to trend stable or to gradually improve over the next 20 years due to federal management that places emphasis on habitat preservation and restoration. Forest road maintenance and removal projects, as well as continued vegetation recovery from past clear cutting, will reduce sediment generation and delivery to stream channels. In moderately impaired subwatersheds where roads are not targeted for restoration, degraded conditions are expected to persist.

Sediment conditions in the lower middle (10802) and lower mainstem (10801) Wind River are expected to trend stable. Vegetation recovery and road maintenance/removal projects will improve sediment conditions in some areas, but these improvements will be offset by continued heavy logging practices on private timberlands. Given these balancing factors, the predicted trend over the next 20 years is for sediment conditions in these drainages to remain in their current condition.

The Bear Creek subwatersheds (10701, 10702) are predicted to trend stable for sediment conditions over the next 20 years, due to the high proportion of area in federal lands (approximately 95%). However, the borderline sediment conditions in the headwaters and the high rain-on-snow area suggest the potential for episodic sediment loading.

Given the protections offered by the Columbia Gorge National Scenic Area, sediment conditions in the Little Wind River subwatershed (10803) are predicted to trend generally stable over the next 20 years due to the natural erodability of the drainage and moderately high unsurfaced road and streamside road densities.

16.7.2.3 Riparian Condition

Riparian protections are in place throughout the private and public lands in the basin. However, indiscriminate historical logging practices removed significant amounts of riparian vegetation over the last century, particularly along the middle and upper mainstem Wind River, the Wind River headwaters, Trout Creek and Panther Creek. In some areas (e.g. lower mainstem, middle mainstem), residential, agricultural, and transportation corridor impacts have denuded riparian vegetation. Although many riparian areas, especially those impacted by past timber harvests, are recovering, other areas continue to suffer from degraded conditions. In some places, riparian restoration efforts are restoring natural vegetation assemblages. Based on this information, riparian conditions are predicted to trend toward gradual recovery in most areas. This general trend must be considered against existing limitations. Some riparian areas suffer from residential development and/or streamside roads. High streamside road densities (exceeding 0.7 miles/stream mile) are present in all subwatersheds with impaired ratings for riparian conditions, with some subwatersheds including lower Trout Creek (10501) and the middle mainstem Wind River (10401) approaching 1.5 miles/stream mile. The potential for full recovery of riparian vegetation in these subwatersheds will be somewhat limited, unless road retirement projects are implemented with a goal of riparian restoration.

High streamside road densities are also present in subwatersheds rated moderately impaired for riparian condition. Lower Falls Creek (10201) has road densities exceeding 2 miles/stream mile, i.e., many stream reaches are effectively bracketed on both sides by roads. Streamside road densities in upper Wind River subwatersheds 10101 and 10102 are 0.74 and 1.31 miles/stream mile, respectively. Moderately impaired riparian conditions in these subwatersheds tend to indicate that there is some potential for additional recovery over time, again within the limits imposed by existing roads.

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Little White Salmon Subbasin

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17.0 Little White Salmon Subbasin

17.1 Subbasin Description

17.1.1 Topography & Geology

The headwaters of the Little White Salmon River originate just east of the Cascade crest in south central Washington. The basin encompasses approximately 136 square miles and enters the Columbia River at Drano Lake at RM 162. Anadromous fish use is limited in this basin, with only about 500 meters of available habitat in the lower river.

Basin topography varies from gentle slopes formed by lava flows and volcanic cones to steep, rugged landforms (WDW 1990). The basin drains the Indian Heaven Wilderness and the Monte Cristo Range, which lie in the northwest and northeast portions of the basin, respectively. A major feature is the Big Lava Bed, comprising a large area in the western portion of the subbasin. The geology of this area, and the Indian Heaven Wilderness to the north, consists of relatively young quaternary basalt/andesite flows, of which the Big Lava Bed is a recent (8,000 years ago) example. The area in and around the Monte Cristo Range, on the other hand, is made up of older, tertiary deposits of volcanic tuff and pyroclastic flows. This area makes up much of the mainstem of the Little White Salmon and is susceptible to large, deep seated landslides due to decomposition of the older deposits into silts and clays (USFS 1995). Deep soils of glacial origin are present in alluvial deposits in valley bottoms. These soils also tend to be susceptible to deep-seated landslides. Elevation in the basin ranges from 5,300 feet to 50 feet at the mouth. The major tributaries to the Little White Salmon are Rock Creek, Lava Creek, Moss Creek, Wilson Creek, Cabbage Creek, Berry Creek, Homes Creek, Lusk Creek, and Beetle Creek.

17.1.2 Climate

Situated near the Cascade crest, the subbasin has characteristics of both continental and marine climates. Winters are wet and mild, while summers are warm and dry. Mean annual precipitation is 65 inches – 75% of which falls October through March. Most of the basin above 3,000 feet receives winter snowfall.

17.1.3 Land Use/Land Cover

Nearly the entire basin is forested, with timber harvest being the primary land use. The northern 3/4 of the basin is within the Gifford Pinchot National Forest (GPNF). The southern portion is privately owned, with scattered rural residential development and small-scale agriculture. The major population centers are Willard, Cook, and Mill A. The year 2000 population, estimated at 513 persons, is forecasted to increase to 753 by 2020 (Greenberg and Callahan 2002). The southeastern half of the subbasin is within the grand fir/Douglas fir ecological zone; the northwest portion is within the Pacific silver fir zone except for the Big Lava Bed, composed of scattered lodgepole pine, subalpine fir, western white pine, and Douglas fir. Approximately 20% of the basin is in early-seral vegetation.

A long history of fire suppression has resulted in no large (>100 acre) fires since the 1930s. Timber harvest has replaced fire as the dominant disturbance agent affecting basin hydrology (USFS 1995). A breakdown of land ownership and land cover in the Little White Salmon basin is presented in Figure 17-1 and Figure 17-2. Figure 17-3 displays the pattern of landownership for the basin. Figure 17-4 displays the pattern of land cover / land-use.

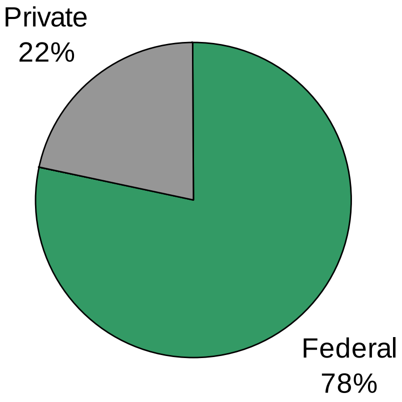


Figure 17-1. Little White Salmon River subbasin land ownership

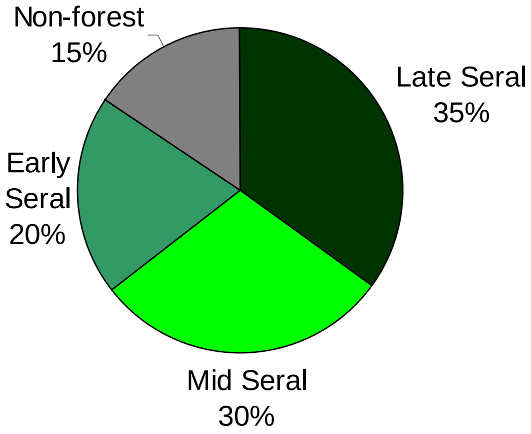


Figure 17-2. Little White Salmon River subbasin land cover

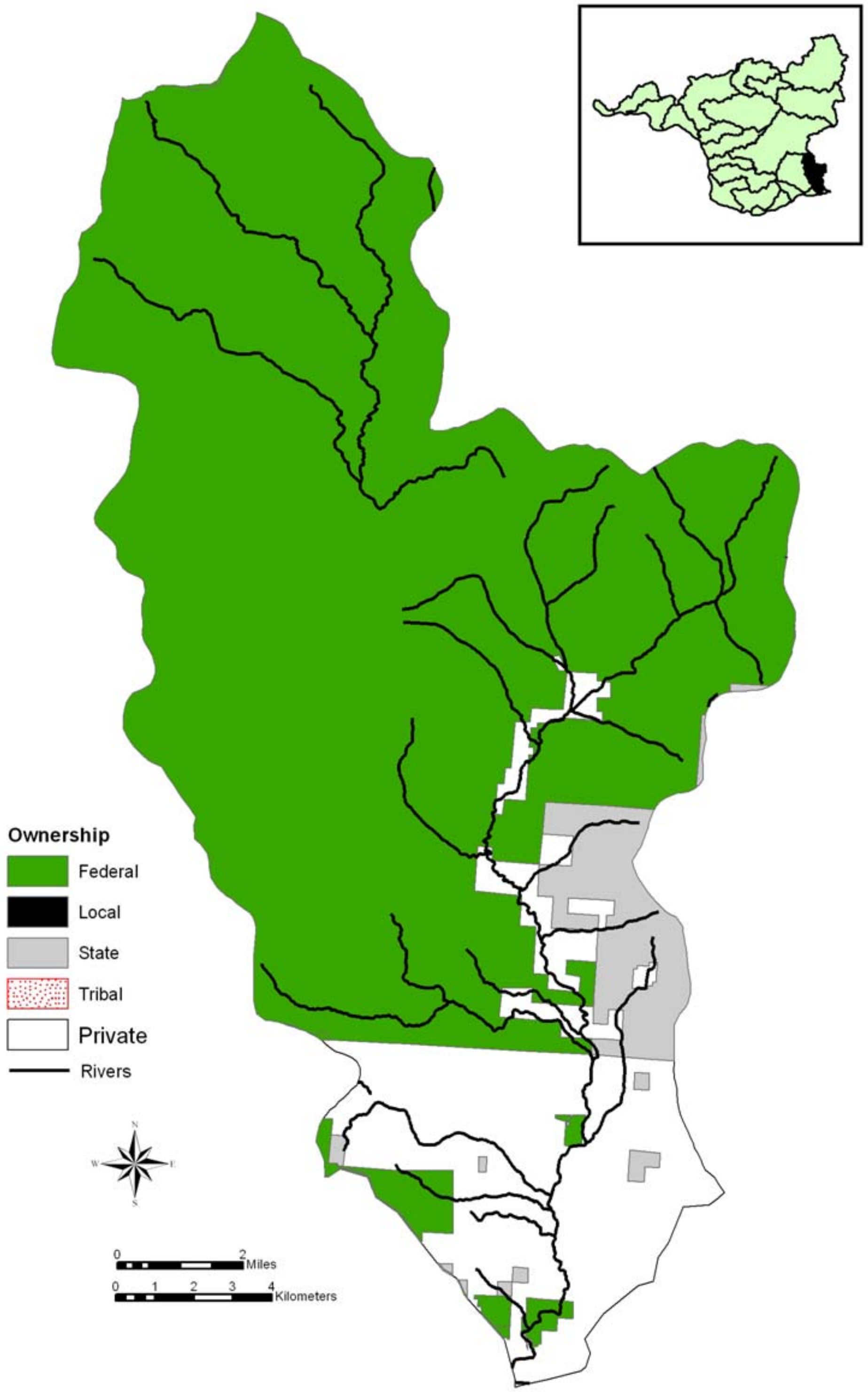


Figure 17-3. Landownership within the Little White Salmon basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

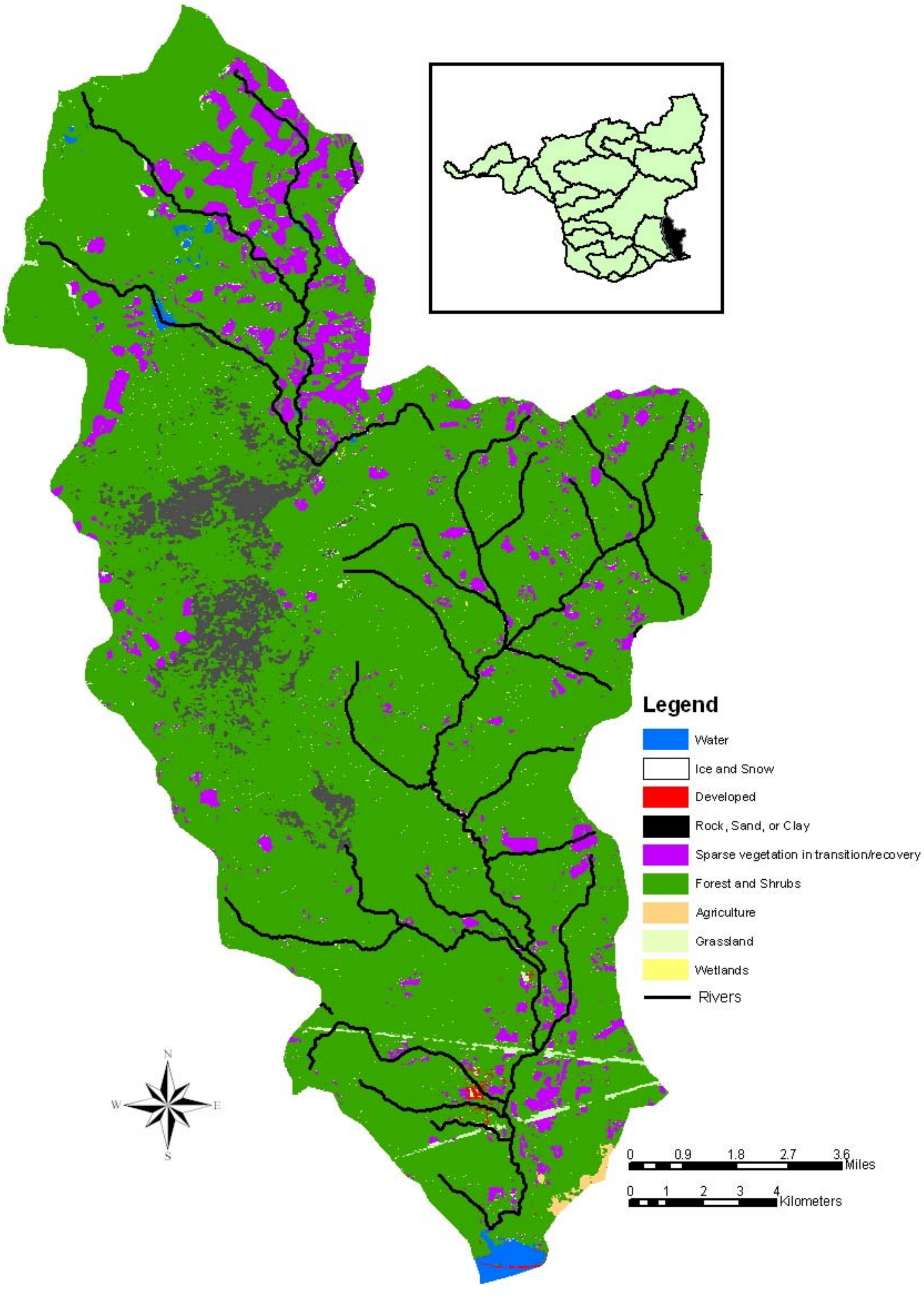
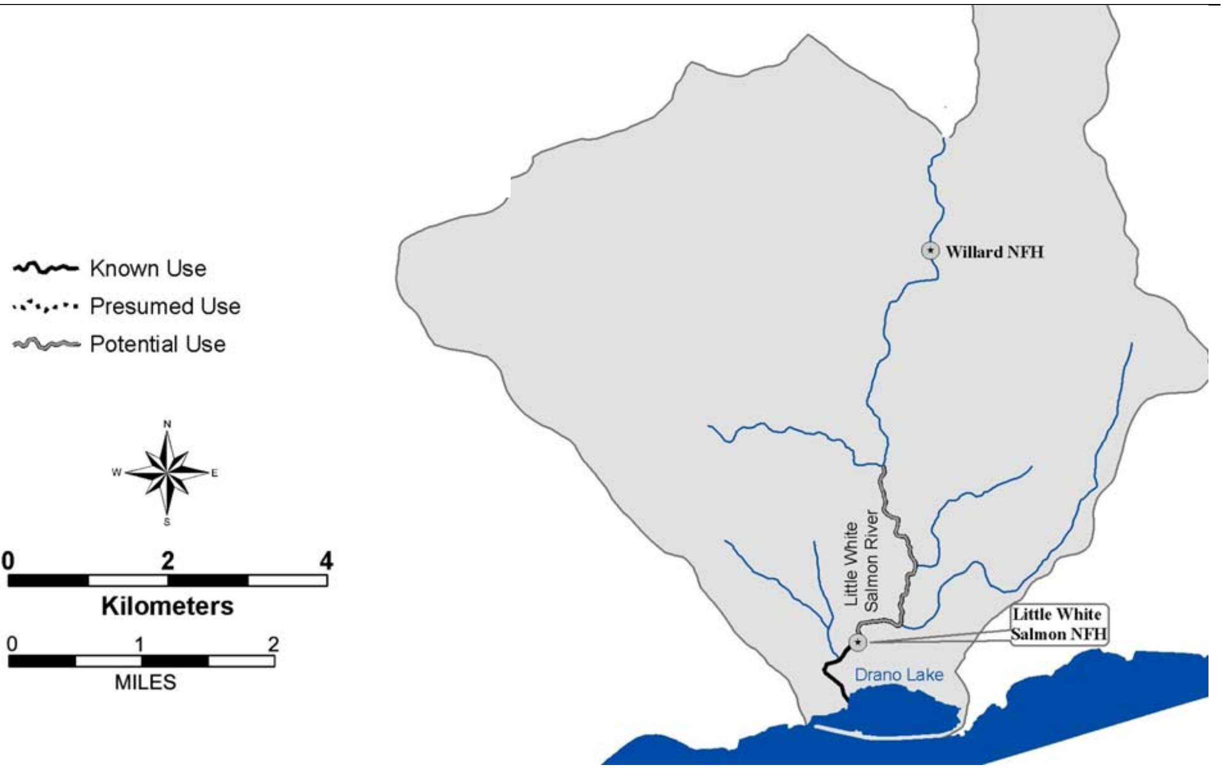


Figure 17-4. Land cover within the Little White Salmon basin. Data was obtained from the National Land Cover Dataset (NLCD).

17.2 Focal Fish Species

17.2.1 Spring Chinook—Little White Salmon Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

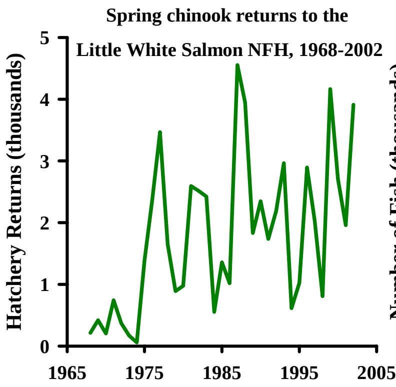
- Historically, few spring chinook were found in the Little White Salmon River basin; spring chinook were limited to the lower river below a barrier falls at about RM 2
- Completion of Bonneville Dam (1938) inundated the primary spring chinook spawning areas in the lower river

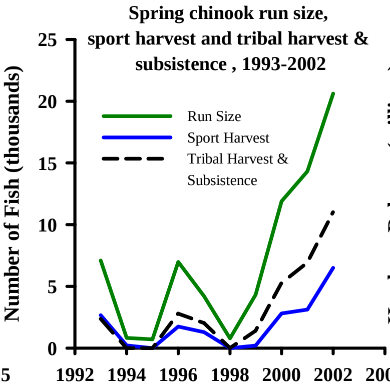
Life History

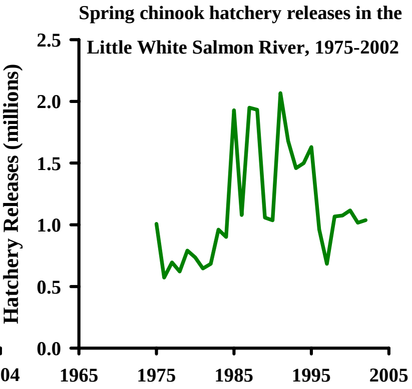
- Spring chinook return to the Little White Salmon River from April through July; spring chinook counts peak at Bonneville Dam in late April
- Natural spawning in the Little White Salmon River is Limited to a small area immediately below the salmon hatchery; spawning at the Little White Salmon Hatchery occurs in July and August
- Age ranges from 3 year old jacks to 6 year old adults, with 4 and 5 year olds usually the dominant age class (averages are 72.0% and 21.9%, respectively)
- No natural fry emergence data are available

Diversity

- One of four spring chinook populations in the Columbia River Evolutionarily Significant Unit (ESU)
- Spring chinook in the Little White Salmon River basin are hatchery fish of mixed origin







Abundance

- In 1936, chinook were reported in the Little White Salmon River during escapement surveys
- Hatchery production accounts for all spring chinook returning to the Little White Salmon River; from 1970-2002, spring chinook total returns ranged from 58 in 1974 to 20,601 in 2002

Productivity & Persistence

- Smolt density model predicted natural production potential for the Little White Salmon River was 32,350 smolts
- Juvenile production from natural spawning is presumed to be low; the run is not considered to be self-sustaining

Hatchery

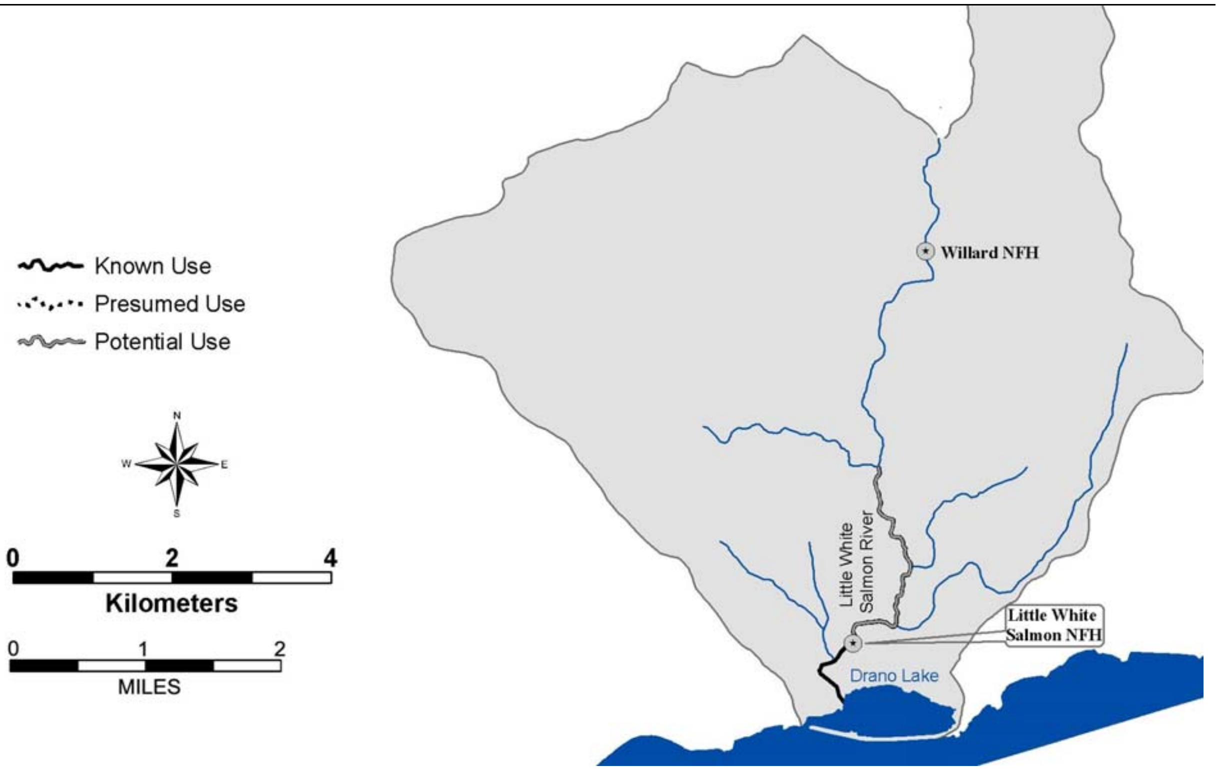
- The Little White Salmon (RM 1) and the Willard National Fish Hatcheries (RM 5) are located in the basin; spring chinook releases began in the 1960s
- Current spring chinook releases into the Little White Salmon River are just over 1 million smolts annually

Harvest

- Spring chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial and sport fisheries
- CWT analysis indicated that upriver spring chinook are impacted less by ocean fisheries than lower Columbia River chinook stocks
- From 1938-1973, about 55% of upriver spring chinook runs were harvested in directed Columbia River commercial and sport fisheries; from 1975-2000 (excluding 1977), no lower river fisheries have targeted upriver stocks and the combined Indian and non-Indian harvest rate was limited to 11% or less
- Beginning in 2001, selective fisheries and abundance based management agreement through *US v. Oregon*, has enabled an increase in Columbia harvest of hatchery spring chinook
- WDF and the Yakama Indian Nation negotiate an annual harvest plan for sharing the Little White Salmon Hatchery surplus between the sport fishery and tribal commercial and subsistence fisheries in Drano Lake
- Sport harvest in Drano Lake from 1993-2002 averaged 1,847, with a record 6,495 harvested in 2002
- Tribal harvest and hatchery subsistence distributions have averaged 3,175 during 1993-2002

17.2.2 Fall Chinook—Little White Salmon Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

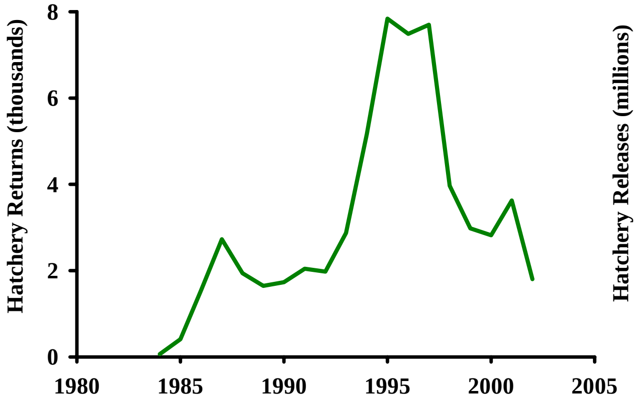
- Historically, fall chinook were limited to the lower river below a barrier falls at about RM 2; currently, very limited natural production occurs in this area
- Completion of Bonneville Dam (1938) inundated the primary fall chinook spawning areas in the lower river

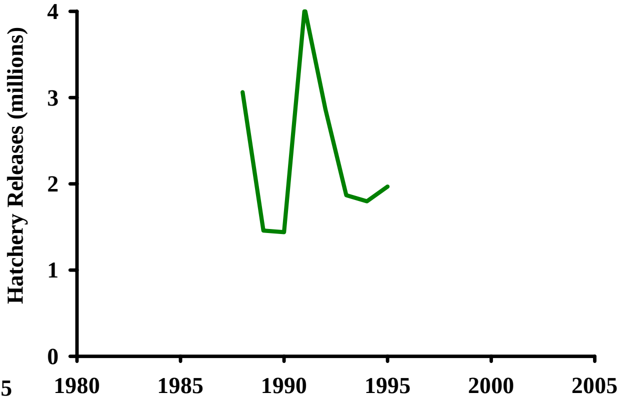
Life History

- Mid Columbia bright fall chinook upstream migration in the Columbia River occurs from August to October; peak counts at Bonneville Dam occur around September 4-9
- Spawning of bright fall chinook at the Little White Salmon National Fish Hatchery occurs in November; natural spawning timing in the Little White Salmon River occurs in late October and November
- Historically, the Little White Salmon fall chinook population was earlier spawning tule stock and was substantial, but the population has not persisted
- Age ranges from 2-year-old jacks to 5-year-old adults, with dominant adult ages of 3 and 4 (averages are 46.1% and 46.1%, respectively)
- Emergence and emigration timing of naturally produced fry is unknown; hatchery fry emerge in March; emigration timing is based on hatchery release timing

Diversity

- Considered an upriver bright stock in the lower Columbia River ESU
- Current bright fall chinook production is a result of hatchery strays


Upriver bright fall chinook adult returns to the Little White Salmon NFH, 1984-2002


Little White Salmon NFH upriver bright fall chinook releases into the Little White Salmon River, 1988-1995

Abundance
- Fall chinook eggs taken from the Little White Salmon River between 1897 and 1920 (as high as 40 million) indicate a very large historical abundance of naturally produced early spawning tule fall chinook
- In the late 1930s, fall chinook were reported in the Little White Salmon River during escapement surveys
- Fall chinook returns to the Little White Salmon NFH ranged from 238-2,653 from 1979-83 (average 981)

Productivity & Persistence
- A smolt capacity model estimated that 73,652 fall chinook fingerlings could be produced in the Little White Salmon River basin
- The White Salmon River tule fall chinook stock is currently produced at Spring Creek NFH

Hatchery
- The Little White Salmon (RM 1) and the Willard National Fish Hatcheries (RM 5) are located in the basin; hatchery production began in 1896
- Annual hatchery egg take of fall chinook during 1897-1920 were typically 10-30 million and as high as 40 million
- Hatchery production shifted from tules to upriver bright (URB) late fall chinook as part of the John Day Dam mitigation and a *US v. Oregon* Agreement in 1988
- The current Little White Salmon Hatchery fall chinook program includes 5.4 million URB fall chinook, with 2.0 million released into the Little White Salmon River and the remainder transferred to Ringold Hatchery, Yakima River, and Priest Rapids Hatchery as part of John Day Dam mitigation

Harvest
- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- URB fall chinook migrate farther North in the ocean than lower Columbia chinook, with most ocean harvest occurring in Alaska and Canada
- URB fall chinook are also an important sport fish in the mainstem Columbia from the mouth upstream to the Hanford Reach, and an important commercial fish from August-early October

- Fall chinook originating upstream of Bonneville Dam are subject to Federal Court Agreements regarding Indian and non-Indian harvest sharing
- CWT data analysis of the 1989-1994 brood years suggests that the majority of the URB fall chinook harvest occurred in Alaska (24%), British Columbia (23%), and mainstem Columbia River (42%) fisheries
- Columbia River harvest of URB fall chinook is limited to 31.29% (23.04% Indian/ 8.25% non-Indian) based on by ESA limits for Snake River wild chinook
- Fall chinook that pass Bonneville Dam are also harvested in Treaty Indian commercial and subsistence fisheries in August and September
- Sport harvest in the Little White Salmon River averaged 45 fall chinook annually from 1985-1987

17.3 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. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin

- Loss of tributary habitat quantity and quality is an important relative impact on all species, while estuary habitat impacts appear to be of lesser importance.
- The impact of hydrosystem access and passage is one of the more important factors for chum and fall chinook. Hydrosystem effects on chum are substantial enough to minimize the relative importance of all other potentially manageable impact factors.
- Harvest has relatively high impacts on fall chinook, while harvest impacts to steelhead and coho salmon are moderate. The relative impact of harvest on chum is minor.
- Hatchery impacts are relatively moderate for coho salmon and summer steelhead. Hatchery impacts on chum salmon, fall chinook, and winter steelhead are low.
- Impacts of predation are moderate for winter steelhead, summer steelhead, and coho salmon, but are low for fall chinook and chum.

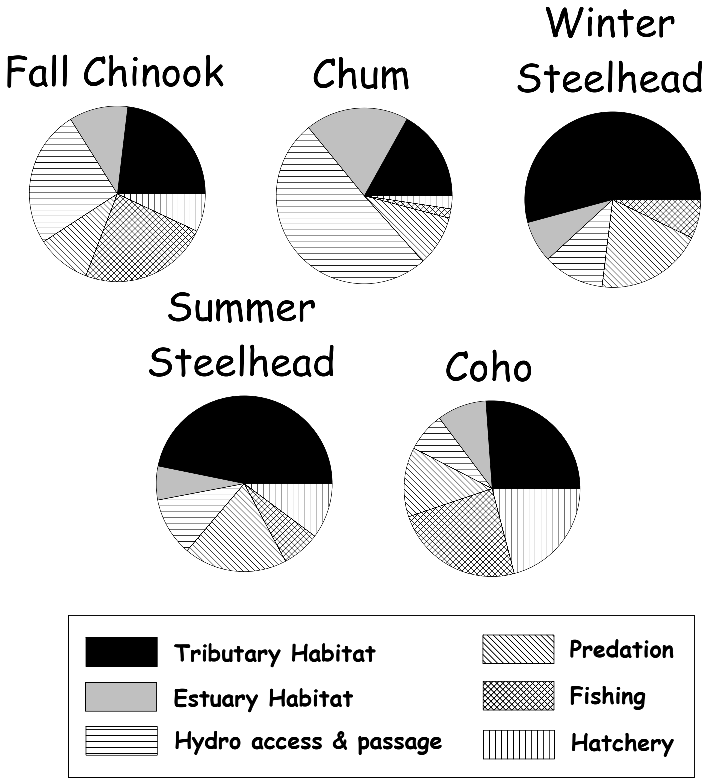


Figure 17-5. Relative index of potentially manageable mortality factors for each species in the Upper Gorge subbasin.

17.4 Hatchery Programs

The Little White Salmon River basin has two hatcheries: the Little White Salmon NFH, constructed in the late 1800s, is located above RM 1 and the Willard NFH, constructed in 1952, is located above RM 5. The two hatcheries coordinate efforts and are referred to as the Little White Salmon River Hatchery Complex. The hatchery complex produces upriver bright fall chinook, spring chinook, and coho salmon; annual production goals are 2 million fingerling fall chinook, 1 million yearling spring chinook smolts, and 1 million yearling coho smolts for release in the Little White Salmon River (Figure 17-6). The hatchery also rears 350,000 spring chinook for release into the Umatilla River and 1.0 million coho for release into the Yakima River (500,000) and the Wenatchee River (500,000) as part of tribal restoration programs.

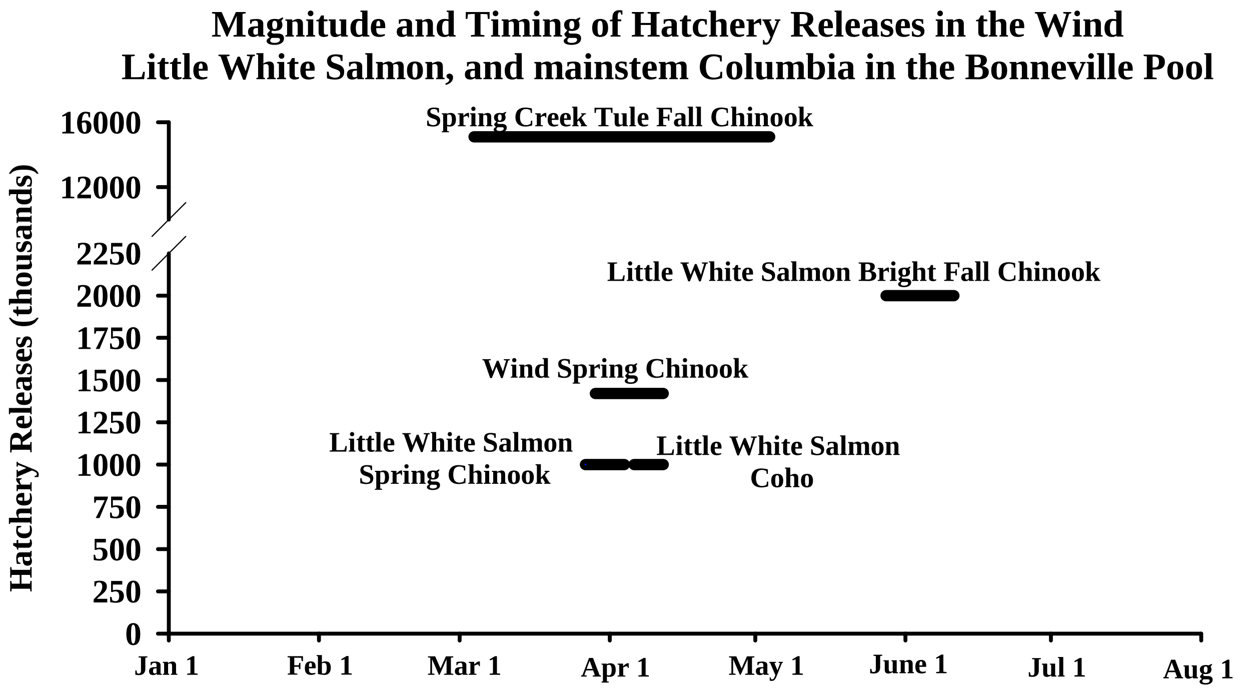


Figure 17-6. Magnitude and timing of hatchery releases in the Wind and Little White Salmon rivers and mainstem Columbia by species, based on 2003 brood production goals.

Fall chinook releases in the basin began in the late 1890s; the program historically produced tule fall chinook, with egg takes as high as 40 million. The fall chinook program shifted to upriver bright fall chinook production in 1988 as part of the John Day Dam mitigation program and the *US v. Oregon Columbia River Fish Management Plan*. The spring chinook hatchery program in the Little White Salmon River basin began in 1967. The coho hatchery program in the Little White Salmon River began in 1919 with unsuccessful attempts to rear late-run coho. During the 1930s–1950s, coho rearing efforts focused on early-run coho, which finally established a consistent run by the mid-1960s.

Genetics—The upriver bright fall chinook broodstock originated from Bonneville Hatchery stocks. Current broodstock is from fall chinook adults returning to the hatchery complex. In years when hatchery returns do not satisfy hatchery complex production goals, stocks are transferred from other hatcheries producing upriver bright fall chinook. The only recent egg transfers to the hatchery complex occurred in 1998 with 2,054,000 from the Bonneville Hatchery, 200,000 from the Umatilla Hatchery in Oregon, 1,213,000 from the Klickitat Hatchery, 600,000 from the Priest Rapids Hatchery, and 13,168 from the Lyons Ferry Hatchery in Washington.

Spawning of spring chinook occurred at the hatchery complex in 1967 when fish of unknown origin returned to the Little White Salmon River. These fish could have been strays or from previous attempts to rear fish in the basin. Multiple out-of-basin spring chinook stocks have been released in the Little White Salmon River, including Willamette stock (Eagle Creek NFH), South Santiam Hatchery stock, Klickitat River stock, Ringold Springs stock, Carson NFH stock, McKenzie River stock, and Salmon River stock. The Little White Salmon spring chinook stock is considered a derivative of the Carson stock. Current broodstock comes from adults returning to the hatchery complex, except for 1995 when part of the brood included adult fish trapped on the Big White Salmon River (Carson stock progeny).

Initial attempts to rear early run coho in the Little White Salmon River basin included stocks from the Quinault, Quilcene, Dungeness, and Toutle rivers. The stock that eventually was successfully developed was derived from Toutle River coho. Adults collected at the hatchery complex are the current source of broodstock, although transfers occur in years of hatchery production shortfalls. In the last 5 years, early-run coho stock transfers from the following facilities have occurred based only on availability: Lower Kalama Hatchery and Speelyai Hatchery in Washington and Cascade Hatchery, Bonneville Hatchery, and Eagle Creek NFH in Oregon.

Interactions—An impassable falls lies just upstream of the Little White Salmon NFH. Historically, anadromous salmonids spawned and reared in habitat from the falls to the mouth of the river, but this habitat was inundated by Bonneville Pool. There is very little, if any, spawning or rearing habitat available to anadromous salmonids below the hatchery barrier and any production in the basin is expected to be from the hatchery programs. The magnitude of hatchery releases in the basin is similar among the three hatchery programs. Based on these conditions, ecological interactions between wild and hatchery fish are expected to be similar for fall chinook, spring chinook, and coho salmon in the Little White Salmon River and are discussed collectively.

Natural spawning has not been observed recently in the Little White Salmon River, except for some minor fall chinook spawning activity (Figure 17-7). Because very little suitable spawning habitat exists, natural production is minimal if it is successful at all. The fall chinook natural spawners are hatchery strays from the Little White Salmon NFH. Hatchery fish returning to the Little White Salmon River volitionally enter the fish collection facility, so substantial numbers of hatchery fish could remain in the river below the barrier dam. However, because no wild fish are thought to be present, interaction between wild and hatchery adults is not a concern. Hatchery fish surplus to broodstock needs are not returned to the river above the falls to promote natural production.

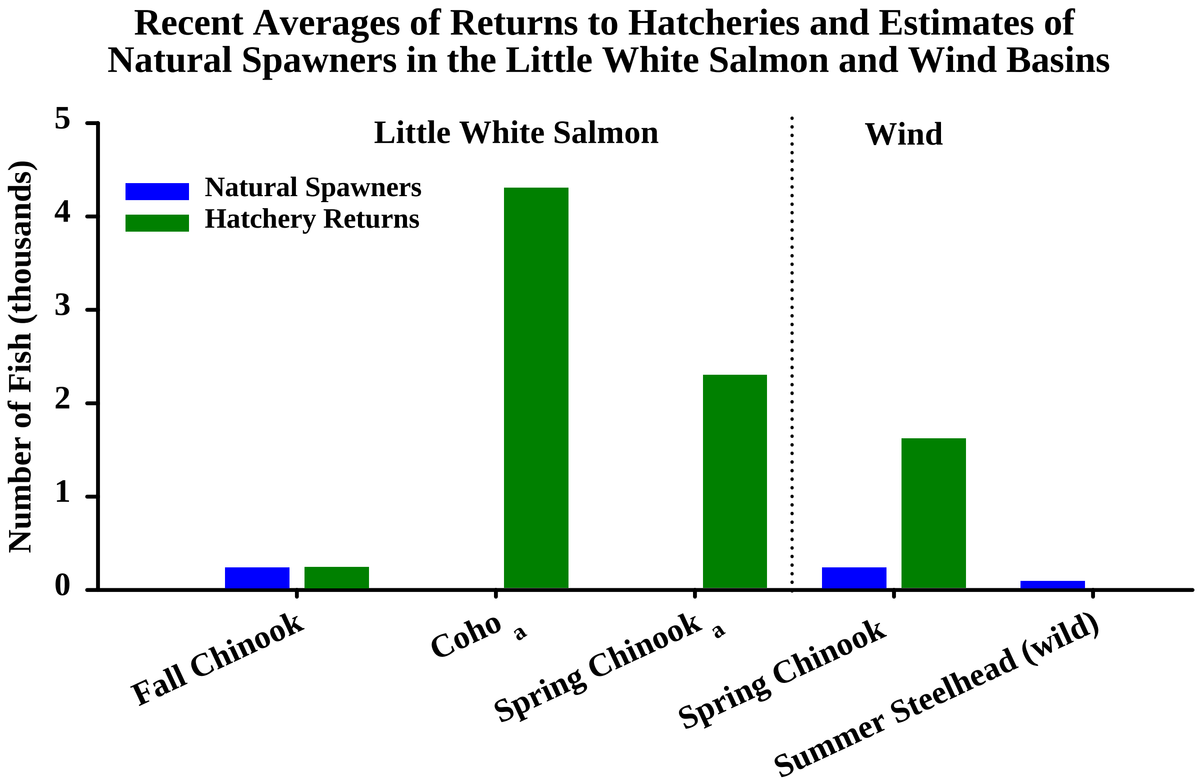


Figure 17-7. Recent year average hatchery returns and estimates of natural spawning escapement in the Wind and Little White Salmon River basins by species.

Juvenile hatchery fish in the Little White Salmon River are released as smolts and are assumed to migrate through the system quickly. Competition impacts are assumed to be greatest in the spawning and nursery areas at the point of release, but because there is no documented natural production in the Little White Salmon River, no anticipated competition or predation by hatchery smolts on wild juvenile salmonids within the basin is expected.

The potential for genetic introgression from straying adults is a possible interaction issue unique to upriver bright fall chinook hatchery fish from the Little White Salmon River. Upriver bright fall chinook from the hatchery complex are colonizing the nearby Wind and Big White Salmon rivers. However, the potential for genetic introgression with existing tule fall chinook populations in the Wind and Big White Salmon rivers is reduced by the separation in the spawn timing of the two stocks. The tule populations in the Wind and Big White Salmon rivers spawn in mid-September to early October and upriver brights spawn in late October through November. Also, the tule populations on the Wind and Big White Salmon Rivers have been heavily influenced by hatchery strays, likely from the Spring Creek NFH. The naturally spawning tule fall chinook are considered part of the listed LCR chinook salmon ESU, whereas the upriver bright fall chinook are not. There is a concern that upriver bright fall chinook can impact tule fall chinook by spawning on top of tule fall chinook redds.

Water Quality/Disease—The Little White Salmon River NFH has a total water right of 33,868 gpm from the Little White Salmon River, a small well, and springs. Eggs are incubated at this facility until the eye-up stage, then transferred to the Willard NFH; water use during production ranges from 11,221 to 28,232 gpm; most comes from the Little White Salmon River.

A water re-use system built at the facility in 1967 was used to supplement water supplies during low water years but has not been used in recent years because of concerns with disease transmission.

The Willard NFH utilizes water from three sources; water rights include 22,440 gpm from the Little White Salmon River and 500 and 1,000 gpm from two separate water wells. Incubation and early rearing are done primarily with well water while river water is used for outside rearing. Both hatcheries monitor facility effluent, which remains in compliance with the complex's NPDES permit.

The Lower Columbia River FHC provides fish health care for the Little White Salmon River hatchery complex under guidance of the Fish and Wildlife Service Manual, the Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries, and the Co-Managers Salmonid Disease Control Policy. A pathologist from the FHC examines fish at various times throughout the hatchery operation. Adult certification examinations are performed at spawning; adult fish tissues are collected to ascertain viral, bacterial, and parasite infections and to provide a brood health profile for the progeny. During holding for broodstock collection, spring chinook are injected with 10 mg/kg erythromycin to prevent mortality by BKD; formalin treatments at 167 ppm for 1 hour, 3-5 times per week are used to control fungus and external parasites during the holding period. To prevent the growth of fungus during incubation at the Little White Salmon River NFH, eggs of all species are treated with 1,667 ppm formalin for 15 minutes, 3-5 times per week. At the Willard NFH, egg trays are opened regularly and dead eggs are removed; formalin is not administered. A ponding examination for viral infections is performed on newly hatched fish when approximately 50% of the fish are beyond the yolk-sac stage and begin feeding. Randomly-chosen rearing fish are examined monthly to determine general health. These exams generally include a necropsy with detailed external and internal exams and tests for bacterial and viral infections. Diagnostic exams are performed on rearing fish as needed, depending on unusual fish behavior or higher than normal mortality. Spring chinook are given prophylactic medicated feedings once in July at a rate of 100 mg erythromycin/kg fish/day for 21 days; this treatment appears to control outbreaks of BKD later in the rearing cycle. Pre-release examinations are performed before fish are released or transferred from the hatchery; these exams focus on testing for listed pathogens.

Disease outbreaks in Willard NFH coho salmon have included BKD, BCWD, and sunburn (steatites). BKD and BCWD have successfully been treated with antibiotics or changes in fish culture practices and have not resulted in significant losses, except for one instance. In 1993, Speelyai coho from the North Toutle Hatchery were transferred to the Willard NFH because of low adult returns. These fish developed epizootic levels of BKD, with monthly mortalities up to 3.4%. The disease could not be controlled by reducing densities and this lot of fish was destroyed—rather than released—to prevent possible transmission of the disease.

Mixed Harvest—At the Little White Salmon River hatchery complex, the upriver bright fall chinook program provides fish production for harvest opportunity to mitigate for federal hydroelectric construction and other development in the Columbia River basin. The upriver bright fall chinook program contributes to fisheries along the West coast of the US and Canada. Upriver bright fall chinook migrate further north than other Columbia River chinook stocks and are more prevalent in Alaska and Canada fisheries; they are also very important to Columbia River commercial, sport, and tribal fisheries. CWT recoveries of Little White Salmon NFH upriver bright fall chinook since the 1980 brood indicate that approximately 42% are accounted for in escapement, 21% are harvested in Columbia River commercial gill-net fisheries (treaty

Indian and non-Indian), 17% are harvested in Alaska commercial fisheries, and 13% are harvested in British Columbia commercial fisheries; the remaining percentage of tag recoveries are distributed among numerous sport and commercial fisheries from Alaska to California. Hatchery and wild fall chinook harvest rates remain similar but are constrained by ESA harvest limitations.

The main purpose of the spring chinook program at the complex is to provide fish production for harvest opportunity to mitigate for federal hydroelectric construction and other development in the Columbia River basin. The spring chinook program contributes to commercial and recreational fisheries from Oregon to Alaska; however, Carson stock spring chinook are impacted less by ocean fisheries than are other lower Columbia River chinook stocks. CWT recoveries of Little White Salmon NFH spring chinook since the 1980 brood indicate that approximately 78% are accounted for in escapement, 16% are harvested in Columbia River sport fisheries, and 5% are harvested in Columbia River treaty Indian fisheries. The majority of harvest occurs in sport and tribal fisheries occurring in Drano Lake, the inundated lower end of the Little White Salmon River

The coho salmon program at the complex provides fish production for harvest opportunity to mitigate for fish losses resulting from federal hydroelectric construction and other development in the Columbia River basin. The coho salmon program contributes to fisheries along the West Coast of the US and Canada, including Columbia River commercial, recreational, and tribal fisheries. CWT recoveries of Willard NFH coho salmon since the 1980 brood indicate that approximately 59% are accounted for in escapement, 13% are harvested in Washington sport fisheries, 10% are harvested in Oregon sport fisheries, and 7% are harvested in Columbia River commercial gill-net fisheries; the remaining percentage of tag recoveries is distributed among numerous sport and commercial fisheries from British Columbia to California. Until recently, the harvest of wild and hatchery coho salmon likely was similar among the various fisheries. Currently all coho releases at the hatchery are externally marked with an adipose fin-clip to allow for selective fisheries on hatchery fish while minimizing wild fish harvest. Many ocean fisheries use selective fishery regulations. Hatchery-selective fishery regulations have been in effect for Columbia River and tributary sport and commercial fisheries since 1998.

Passage—The adult collection facility at the Little White Salmon NFH consists of a barrier dam across the Little White Salmon River that leads fish toward a fish ladder and trap. Fish enter the fish ladder volitionally and are kept in holding ponds; they are moved from pond to pond and into an anesthetic tank using hydraulically operated mechanical crowders. If fish are able to escape the barrier dam, they encounter a barrier falls shortly upstream of the hatchery facility, so there is no fish access to the watershed above about RM 2.

Supplementation—Supplementation is not the goal of the upriver bright fall chinook, spring chinook, or coho salmon hatchery programs on the Little White Salmon River.

17.5 Fish Habitat Conditions

17.5.1 Passage Obstructions

Anadromous fish passage is naturally blocked on the mainstem by a falls at river mile (RM) 1.5; however, a few fish are believed to ascend to a larger falls at RM 2.5. Most natural anadromous spawning occurs in only approximately 400-500 meters of river habitat that is available downstream of the falls and above Drano Lake. High temperatures and other conditions in Drano Lake might affect passage. Two dams restrict passage in the basin. One is located near the mouth of the Little White Salmon, at the Little White Salmon Fish Hatchery, and the other is located on Lost Creek (north) adjacent to a diversion intake. A culvert survey in 1995 revealed that 15 of 26 culverts presented barriers to resident fish, though more information is needed (USFS 1995).

17.5.2 Stream Flow

Peak flows in the subbasin are typically related to winter rain and rain-on-snow events. The USGS has periodically monitored streamflows in the basin. The stream gage near Cook, Washington has the longest period of record (1957-1977). High flows in 1972 (9,250 cubic feet per second [cfs]), 1974 (8,120 cfs), and 1978 resulted in some large changes to stream channels in the basin (USFS 1995). The hydrology of the northwest portion of the subbasin is not well understood, including the Big Lava Bed. Small streams in this area disappear into the quaternary basalts and subsurface water routing has not been quantified (Welch et al. 2002). Despite the lack of information, it is assumed that the Big Lava Bed provides some level of buffering of stormflows (USFS 1995). Another unique hydrologic feature is the loss of subsurface water to the White Salmon basin due to seepage through eastward dipping geological features (USFS 1995).

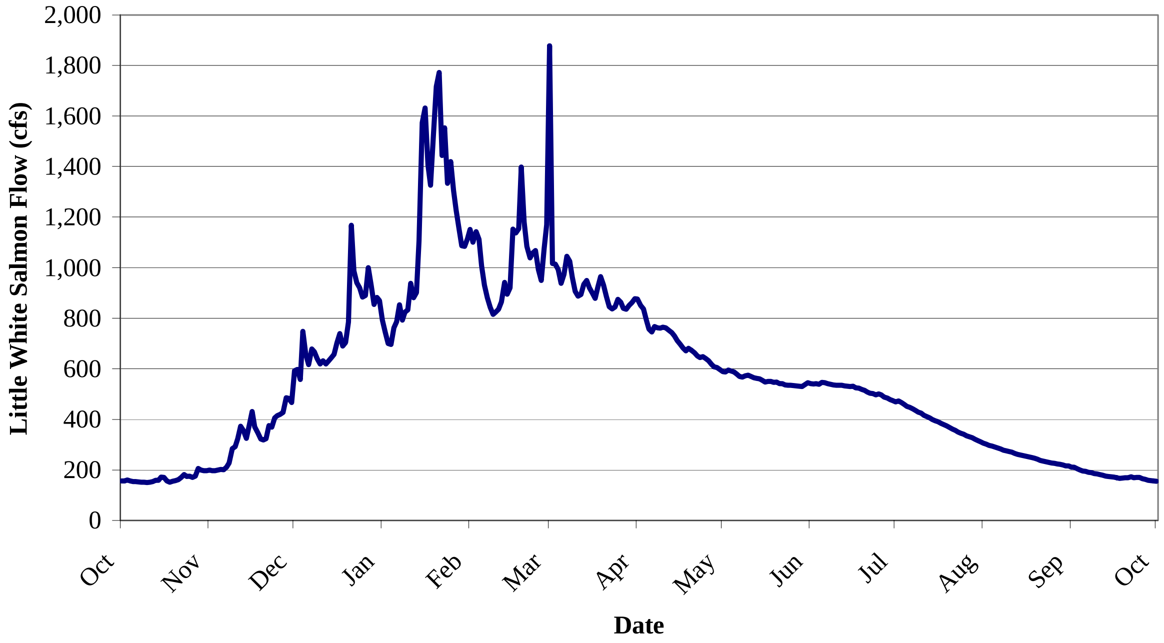


Figure 17-8. Little White Salmon River hydrograph (1968-1977). Peak flows are primarily related to winter rain-on-snow events, with a slight rise in flows due to snowmelt in late May and June. USGS Gage #14125500. Little White Salmon River near Cook, Wash.

Investigations conducted as part of the 1995 watershed analysis (USFS 1995) determined that approximately 19% of the subbasin was hydrologically immature, meaning that these areas had the potential to increase peak streamflows. Using Washington's hydrologic change module, which estimates peak flow changes from changes to vegetation cover, over a 10% increase in the 2-year peak flow was estimated for 11 of the 24 USFS subwatersheds (USFS 1995). The extensive road network may also serve to alter the timing and magnitude of peak flows. The overall road density is approximately 3 mi/mi^2, considered moderately high by most standards. Five of the 24 subwatersheds have road densities greater than 4 mi/mi^2 (USFS 1995).

Hydrologic (runoff) impairment was evaluated as part of IWA watershed process modeling, which is presented in greater detail later in this chapter. The Little White Salmon subbasin did not have the same extent and format of data available to run the hydrology assessment as was done for other portions of the lower Columbia region. Due to the absence of data, hydrology impairment was estimated using USFS data (USFS 1995). Based on vegetation conditions and road densities, the following IWA subwatersheds were estimated as “moderately impaired” with respect to conditions that influence sediment supply: Little White Salmon Headwaters, middle Little White Salmon/Cabbage Creek, middle Little White Salmon/Berry Creek, and the 2 lowermost mainstem subwatersheds. All remaining subwatersheds were estimated as “functional”.

Low flows may also be of concern in the basin, with annual minimums of less than 25 cfs recorded at the Little White Salmon near Willard gage in the 1940s. The mean monthly flow for October over the period of record at the Cook gage is 160 cfs (Welch et al. 2002). A total of approximately 152 cfs is allocated for water rights in the basin; however, the estimated reduction of the minimum summer low flow due to these rights was less than 1% (Greenberg and Callahan 2002). A flow diversion on Lost Creek (north) directs flow into the Coyote Ditch, which transports as much as 5 cfs over to the Trout Lake Creek basin (White Salmon watershed) for livestock watering. This diversion can reduce the flow in lower Lost Creek by one-third during low flow periods (USFS 1995).

17.5.3 Water Quality

Water temperature monitoring from the 1970s into the 1990s on the mainstem near Willard (USFS), and at the Little White Salmon National Fish Hatchery at the mouth (USFWS), indicated no exceedances of the state water temperature standards of 61°F (16°C) for Class AA streams or 64°F (18°C) for Class A streams. However, monitoring in the upper basin in 1994 recorded a temperature of 64°F (18°C) in the mainstem (USFS 1995). More recent water temperature monitoring using continuously recording thermographs has provided greater information on water temperature conditions.

Since 1995, thermographs have been placed in Berry Creek, Cabbage Creek, Dry Creek, East Fork and West Fork Goose Lake Creek, Lost Creek, Lusk Creek, and at several locations on the mainstem. Exceedances of the 61°F (16°C) standard on these streams have occurred on Dry Creek, the mainstem above 201 Road, the mainstem above Lusk Creek, the mainstem at Berry Creek, and the mainstem above Moss Creek. The highest temperatures were measured at the mainstem above Moss Creek site, where 74 days exceeded 61°F (16°C) in 1998 and the maximum recorded temperature was 68°F (20°C) (USFS unpublished data).

USFS monitoring recorded some high lake water temperatures in the 1990s. The highest was 24°C (76°F) (in Forlorn Lake #4), though temperatures are expected to naturally be high due to shallow morphology.

Turbidity monitoring was conducted at 11 locations by the USFS from 1974 to 1975 in response to sediment accumulations at the fish hatcheries during a 1968 flood event. In general, turbidity levels were found to be high throughout the mainstem and in Lusk Creek, and were attributed primarily to bank cutting on the mainstem. Other turbidity monitoring by the USFS is spotty and not very useful for analysis. The USFWS, however, has collected total suspended solid (TSS) data every two weeks since 1975. A general downward trend in TSS is evident over the sampling period. Comparison of this data to estimated streamflow data suggests that the downward trend is attributable more to decreased flow magnitudes than to a true decrease in basin sediment supply (USFS 1995). The 1999 Limiting Factors Analysis identified turbidity problems in the upper basin related to timber harvests (see WCC 1999).

USFS pH monitoring between 1974 and 1987 on the mainstem revealed levels lower than the state standard and the stream was listed on Washington's 303(d) list. However, data collection methods are believed to be suspect (USFS 1995).

17.5.4 Key Habitat

Stream habitat surveys have only been conducted on the Little White Salmon (mainstem), Lost Creek (north), and Goose Lake Creek. Pools per mile were greatest in the mainstem (44.2) and lowest in Goose Lake Creek (10.1). The Range of Natural Conditions (RNC) for this area is 40-60 pools per mile. Width-to-depth ratios in the mainstem were very high (23:1), though conditions were rated good for Goose Lake Creek (5:1) (USFS 1995).

17.5.5 Substrate & Sediment

Information is lacking on substrate conditions in the subbasin. USFS stream surveys revealed that 8.3 of 12.6 surveyed miles of the mainstem (66%) were affected by scour and deposition. In Lost Creek and Goose Lake Creek the rates were 39% and 14%, respectively. Flood related sediment production in the 1970s in Lusk Creek, which followed riparian harvests, increased sediment loading in the mainstem Little White Salmon (USFS 1995).

The same conditions that can alter runoff conditions (i.e. immature vegetation, high road densities) can also alter basin sediment dynamics. The percentage of early-seral vegetation (20%), moderately high road densities (3 mi/mi^2), and the natural instability of the eastern portion of the basin may result in elevated rates of sediment production and delivery to stream channels. Poor road construction has caused numerous shallow landslides and debris flows, especially in steep regions with poor soil conditions. Blocked culverts have also created road erosion, with large volumes of sediment delivered to stream channels in some cases. During a rain-on-snow event in 1968, large volumes of sediment (300 cubic yards) were deposited in the settling basin at the Willard Hatchery. Sediment accumulations created problems in the raceways and similar problems were experienced at the Little White Salmon Hatchery at the mouth. The USFWS suggested that the problems were related to roads, undersized culverts, clear-cut harvesting along streams, and logging debris in stream channels. The USFS subsequently began a turbidity monitoring program to pinpoint the source of sediment. The mainstem Little White and Lusk Creek stood out as the main sources. Despite these concerns, the Little White Salmon basin is considered one of the most stable in the GPNF (USFS 1995).

Sediment supply conditions were evaluated as part of IWA watershed process modeling, which is presented later in this chapter. In summary, the IWA rated 5 of the 13 IWA subwatersheds as "moderately impaired" with respect to landscape conditions that influence sediment supply. The remaining 8 subwatersheds were rated as "functional". The greatest impairments are located in the lower 2 subwatersheds and in the upper western portion of the subbasin (Lava Creek drainage).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

17.5.6 Woody Debris

Recruitment potential of large wood debris (LWD) has been reduced by past forest practices that allowed harvest up to stream channels. Once thought to be an impediment to fish passage, instream LWD was removed from channels during timber harvest operations (USFS 1995). Current LWD levels are low throughout the basin.

Stream surveys in the mainstem, Lost Creek (north), and Goose Lake Creek indicated very poor instream LWD levels. The lowest level was in Goose Lake Creek (6.1 pieces per mile) and the greatest was in Lost Creek (14.5 pieces per mile). Less than 40 pieces per mile is considered poor according to the Columbia River Anadromous Fish Policy Implementation Guide (USFS 1995).

17.5.7 Channel Stability

As part of the 1995 Watershed Analysis (USFS 1995), an air photo investigation was used to assess changes to stream channel conditions since the 1960s. Only a limited number of stream reaches were evaluated due to availability of time and air photos. Large changes including bar development and channel widening were observed in the late 1960s and late 1970s, with conditions recovering in the 1980s. Reaches with the largest changes also tended to have the greatest riparian timber harvest impacts.

Lusk Creek experienced dramatic widening and channel straightening during 1970s peak flow events that followed 1960s clear-cutting of riparian areas. By 1989, vegetation and shade conditions had improved, though channel recovery may take considerably longer. Other streams that experienced bar development and channel widening are Berry Creek, Lost Creek (north), and several reaches of the mainstem, particularly below the southernmost Forest Road 18 crossing.

17.5.8 Riparian Function

Riparian areas have been impacted by past forest practices that allowed harvest of trees up to stream channels. Road building and livestock grazing have also impacted riparian forests. Currently, 21% of the riparian areas are in early-seral vegetation, with nine of the 23 subwatersheds falling outside the “range of natural conditions” (USFS 1995).

Air photo and field review of the upper mainstem has revealed that much of the stream channel is exposed to direct solar radiation during the summer, likely impacting stream temperatures. This is attributed to lack of adequate riparian forests, the presence of unvegetated gravel bars, and high width-to-depth ratios (USFS 1995).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

17.5.9 Floodplain Function

There are very few natural floodplain areas in the subbasin and the bulk of historical floodplain habitats for anadromous species would have been limited to the lower reaches of the mainstem, which are now inundated by the Bonneville Pool (Drano Lake).

17.6 Fish/Habitat Assessments

No Fish/Habitat Assessments have been completed for the Little White Salmon River subbasin.

17.7 Integrated Watershed Assessment (IWA)

Collectively, the Little White Salmon watershed covers approximately 95,700 acres (79 mi/sq mi). The watershed also includes two smaller drainages, Dog Creek to the west and an unnamed tributary to the east. The majority of this watershed (79%) is in public ownership, with approximately 75% in USFS lands and 4% in state forest lands managed by the WDNR. Private forest, rangelands, agriculture, and residential lands cover the rest of the drainage. The watershed comprises fifteen subwatersheds ranging from 4,200 to 9,300 acres. Major tributaries to the Little White Salmon River include Rock Creek, Lava Creek, Lusk Creek, and Cabbage Creek. A prominent feature of the watershed is the Big Lava Bed, a large, relatively recent (8,000 years old) basaltic lava flow, covering and area of approximately 12,000 acres.

The Little White Salmon River watershed is in a transitional zone between marine and continental climate lying along the Cascade Crest, and comprised primarily of mountainous and high meadow terrain. The majority of the watershed is in the snow dominated or rain-on-snow-zone, with rain-dominated areas limited to the river bottoms and low-lying areas near the mouth. Natural erodability rates in the watershed are low to moderately low, ranging from 2-30 on a scale of 0-126.

17.7.1 Results and Discussion

IWA results were calculated only for sediment conditions for subwatersheds in the Little White Salmon River watershed. Geospatial data was unavailable for assessing hydrologic and riparian conditions, however, hydrologic ratings have been inferred from the 1995 USFS watershed analysis. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in Table 16-1. The local and watershed level results are also shown in Figure 17-9 and Figure 17-10, respectively.

Table 16-1. Summary of IWA results for the Little White Salmon watershed.

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
00501	M*	M	ND	ND	M	00101, 00102, 00201, 00202, 00203, 00204, 00205, 00301, 00302, 00401, 00402, 00502
00502	M*	M	ND	ND	M	00101, 00102, 00201, 00202, 00203, 00204, 00205, 00301, 00302, 00401, 00402
00401	M*	F	ND	ND	F	00301, 00302, 00402
00402	M*	F	ND	ND	F	00301, 00302
00301	F*	F	ND	ND	F	00302
00302	M*	F	ND	ND	F	—
00201	F*	F	ND	ND	F	00101, 00102, 00202, 00203, 00204, 00205
00202	ND	M	ND	ND	F	00101, 00102, 00203, 00204, 00205
00203	ND	F	ND	ND	F	00101, 00102, 00204, 00205
00204	ND	M	ND	ND	M	—
00205	ND	F	ND	ND	F	00102
00101	ND	F	ND	ND	F	—
00102	ND	M	ND	ND	M	—

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170701051#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F:	Functional
M:	Moderately impaired
I:	Impaired
ND:	Not evaluated due to lack of data
*	Rating was qualitatively derived from available sources of data for the watershed (USFS 1995).

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

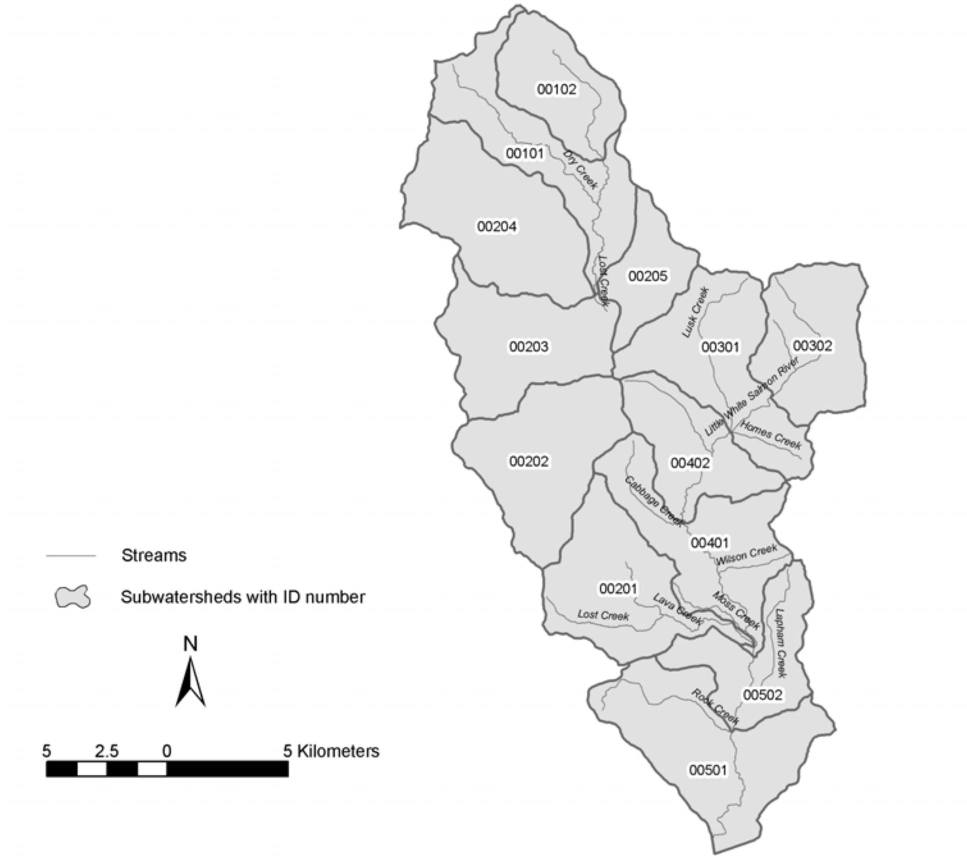


Figure 17-9. Map of the Little White Salmon basin showing the location of the IWA subwatersheds

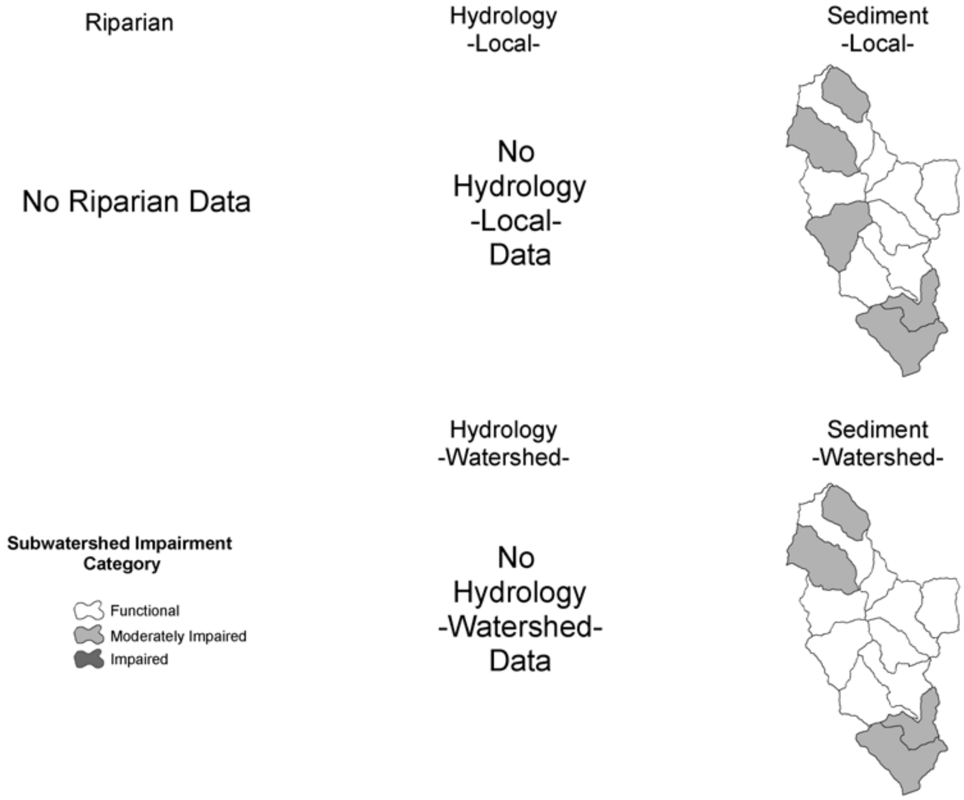


Figure 17-10. IWA subwatershed impairment ratings by category for the Little White Salmon basin

17.7.1.1 Hydrology

IWA results were not developed for hydrologic conditions in the Little White Salmon watershed because of a lack of GIS based data for forest cover.

However, ratings for local hydrologic conditions can be derived from available sources of information. The 1995 watershed analysis conducted by the USFS indicates that 19% of the subbasin features hydrologically immature forest cover. The USFS watershed analysis divided the watershed into 24 subwatersheds (USFS 1995), which is not compatible with the 15 LCFRB recovery planning subwatersheds. Based on the USFS results, all subwatersheds appear to have hydrologically mature vegetation in excess of 50% of the total area. With the IWA method, percent immature hydrologic vegetation and road density are used to rate likely hydrologic condition where impervious surface information is not available. As a result of generally uniform coverage with hydrologically mature vegetation, road densities would be the determinant of hydrologic conditions in the IWA method. The Little White Salmon headwaters (00302), middle Little White Salmon/Cabbage Creek (00401), middle Little White Salmon/Berry Creek, and the lowermost mainstem subwatersheds (00501 and 00502) have road densities in excess of 3 mi/sq mi). These subwatersheds would all be rated as moderately impaired at the local level. All remaining subwatersheds have road densities below 3 mi/sq mi and would be rated as locally functional.

These ratings must be considered against the complex hydrology of the watershed. Much of the surface flow in the Lost Creek drainage and subwatersheds 00204, 00203 and 00202 flows subsurface into the Big Lava Bed and other porous basaltic geology, buffering the hydrology of Lava Creek and the lower Little White Salmon River and resulting in functional hydrology conditions in these portions of the watershed. In addition, some of the subsurface flows in the watershed appear to route to the east, resurfacing in the White Salmon watershed (USFS 1995).

17.7.1.2 Sediment Supply

Local sediment conditions were rated as functional in eight of 15 subwatersheds, with the remaining seven subwatersheds rated as moderately impaired. Watershed level sediment conditions were rated as functional in nine subwatersheds, with six rated as moderately impaired. There are no subwatersheds with impaired sediment conditions at the local or watershed level.

Functional sediment conditions at the local level are distributed throughout the middle subwatersheds while the headwater areas of the Little White Salmon River are rated as functional or moderately impaired. Sediment conditions in these subwatersheds are generally rated functional because of moderate road densities (3 mi/sq mi) and lower concentrations of roads in sensitive areas. These subwatersheds include the Lava Creek drainage (00201) and the subwatersheds along the mainstem, including Cabbage Creek (00401), Berry Creek (00402), Lusk Creek (00301), and streams in the Salmon Creek headwaters (00302). Streamside road densities average less than 1 mile/stream mile in these subwatersheds. Over 90% these subwatersheds are in federal or state lands. Despite the functional ratings, some turbidity problems have been identified as associated with extensive past logging activities in the upper watershed (WCC 1999).

Local sediment conditions in the headwaters of Lost Creek are rated as moderately impaired. Additionally, moderately impaired subwatersheds are concentrated at the downstream end of the watershed and the independent drainages to the east and west.

The distribution of watershed level sediment conditions is similar to the local conditions, with moderately impaired sediment ratings concentrated in the headwaters of the Lost Creek drainage and in subwatersheds at the downstream end of the watershed. It is important to note that moderately impaired sediment ratings in the headwaters of the Lost Creek drainage (00102, 00101) are in subwatersheds that drain to marshlands which feed subsurface flows in the Big Lava Bed. Therefore, sediment conditions in headwaters of the Lost Creek drainage subwatersheds are effectively disconnected from the mainstem Little White Salmon and do not contribute to downstream watershed level sediment conditions.

17.7.1.3 Riparian

IWA results were not developed for hydrologic conditions in the Little White Salmon watershed because of a lack of GIS based data for forest cover.

17.7.2 Predicted Future Trends

17.7.2.1 Hydrology

The predicted trend for Lava Creek, Lost Creek, and the lower Little White Salmon River is for conditions to remain stable or slowly improve based on recovering vegetative cover and the high degree of subsurface flows, which moderate flow variation. Given the large percentage of the watershed that is in public ownership, hydrologic conditions in middle mainstem and headwater areas are predicted to trend towards improvement as vegetation matures.

17.7.2.2 Sediment Supply

Given the coverage of public lands ownership, moderately low erodability, and moderate road densities, sediment conditions in the headwaters and middle mainstem subwatersheds are predicted to trend stable, with turbidity conditions improving over the next 20 years as vegetation matures.

17.7.2.3 Riparian Condition

Riparian conditions in the Little White Salmon River were not analyzed in the IWA analysis because of a lack of available GIS based data.

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Columbia Gorge Tributaries Subbasin

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18.0 Columbia Gorge Tributaries Subbasin

18.1 Subbasin Description

18.1.1 Topography & Geology

For the purposes of this analysis, the Columbia Gorge subbasin includes the tributaries in the Columbia Gorge between Bonneville Dam and the White Salmon River, excluding the Wind River and the Little White Salmon River, which are addressed in separate sections. The subbasin is located within Skamania County and is in Washington State Water Resources Inventory Area (WRIA) 29.

Rock Creek is the largest watershed in this subbasin at 43 mi^2. The headwaters of Rock Creek originate near Lookout Mountain at an elevation of over 4,000 feet. The terrain is generally very steep, with incised drainages (USFS 2000). The river empties into Rock Cove on the Columbia River just west of Stevenson, Washington. A few small tributaries enter the Columbia east of Rock Creek, including LaBong Creek, which is the water source for Stevenson. Carson Creek, which flows through Carson, WA, enters the Columbia just west of the Wind River. Between the Wind and the White Salmon Rivers are also a few tributaries, with Dog Creek being the largest.

Geologic history in the area consists of the extensive flood basalts of the Columbia River Basalt Group, which date back 6-17 million years ago. The stratovolcanoes of the Cascades began to build in the Quaternary Period. Mt. Adams and vicinity was a large site of Quaternary volcanic activity that produced some large lava flows down ancient river valleys in the subbasin. Late Miocene and Pliocene compression created the Yakima fold belt that gave rise to much of the topography of the Columbia Gorge. Syncline and anticline features have shaped the topography of most of the stream systems. Glacial floods (Bretz Floods) dating back 12,700-15,300 years ago funneled through the Columbia Gorge and deposited alluvium in lower elevation areas (Welch et al. 2002). In portions of the Rock Creek and LaBong Creek basins (near Stevenson) there is instability associated with what is known as the Bonneville Landslide. This feature involves the slippage of large blocks of conglomerate material on top of underlying saprolite (soft, clay-rich decomposed rock) (Welch et al. 2002) and contributes to instability in the area.

18.1.2 Climate

The climate is typified by cool, wet winters and warm, dry summers. Air temperatures are moderated by marine air coming through the Columbia Gorge from the Pacific. However, in winter months, cold temperatures result from the influx of cold continental air masses from the east (Welch et al. 2002). Precipitation and temperature vary considerably from the western to the eastern edge of the subbasin. Mean annual precipitation ranges from 77 inches at Bonneville Dam to 30 inches at Hood River, OR (WRCC 2003). Orographic lifting of marine air masses results in high precipitation values near the Cascade crest (western portion of subbasin), whereas eastern regions receive less precipitation due to rainshadow effects.

18.1.3 Land Use/Land Cover

The Rock Creek basin is predominantly forestland (93%), much of it within the Gifford Pinchot National Forest. Western hemlock forest associations dominate the basin, with pacific silver fir forests in the uppermost portion of the watershed. The large Yacolt Burn in 1902 destroyed much of the forest vegetation in the basin. More recently, timber harvests have served to reduce forest cover. Late-successional forests make up only 16% of the basin and early-seral conditions make up 23% of the basin. Rural residential development in the lower basin is increasing.

The smaller stream systems in the basin are mostly within private lands in either rural residential use or small-scale timber production. Lower Rock Creek and smaller streams to the east are impacted by urban development in the town of Stevenson. Carson Creek is impacted by small-scale urban development in and around the town of Carson. A breakdown of land ownership in the basin is presented in Figure 18-1. Figure 18-2 displays the pattern of landownership for the basin. Figure 18-3 displays the pattern of land cover / land-use.

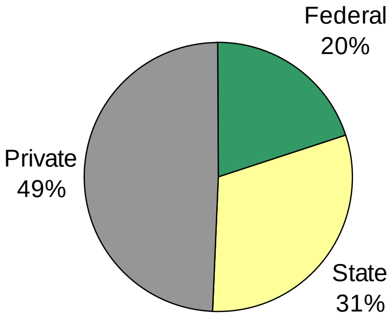

Figure 18-1. Columbia Gorge Tributaries land ownership

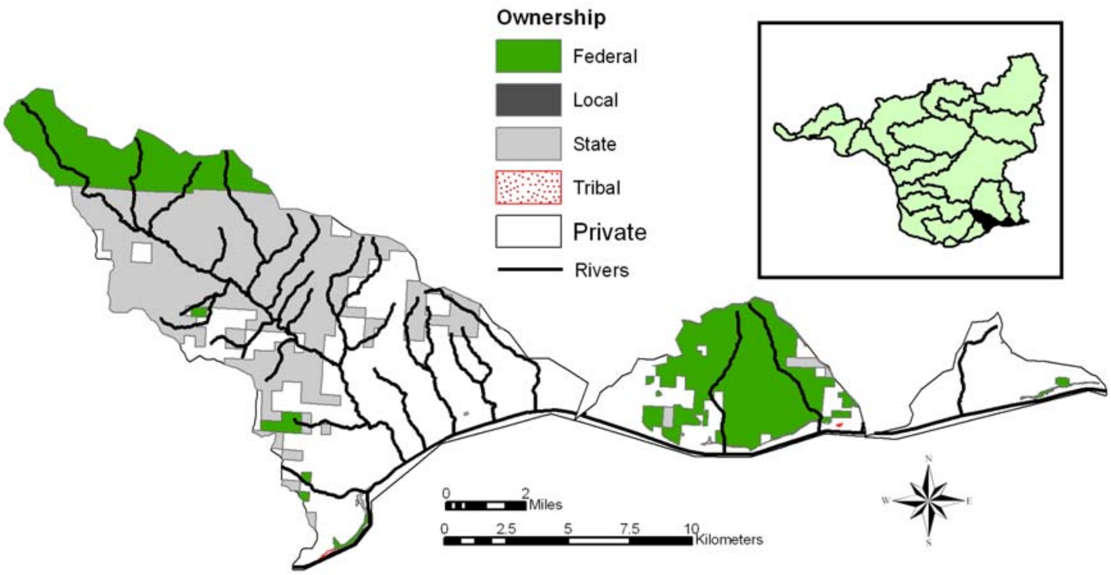

Figure 18-2. Landownership within the Columbia Gorge tributaries basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

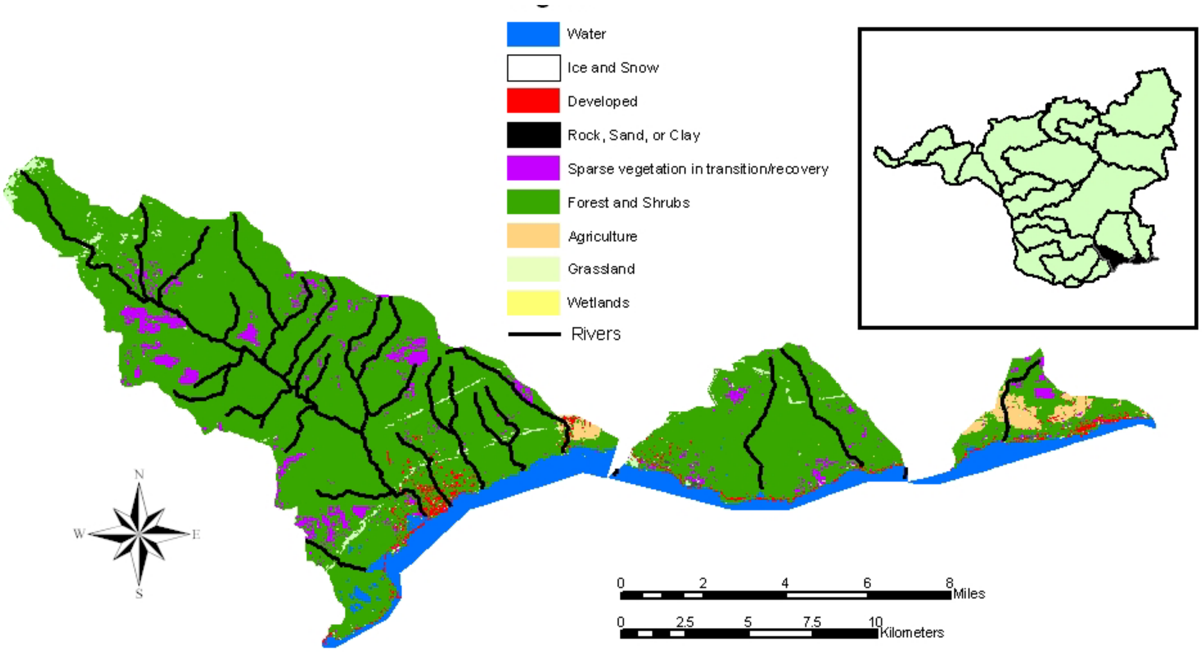

Figure 18-3. Land cover within the Columbia Gorge tributaries basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

18.2 Focal Fish Species

Small numbers of fall chinook and steelhead use the lowermost portions of the large tributaries in this subbasbin. These chinook and steelhead are subcomponents of populations of adjacent large systems.

18.3 Potentially Manageable Impacts

The Potentially Manageable Impacts have not been assessed for the Columbia Gorge Tributaries subbasin.

18.4 Hatchery Programs

There are no hatchery programs in the Columbia Gorge Tributaries subbasin.

18.5 Fish Habitat Conditions

18.5.1 Passage Obstructions

Several passage barriers were identified in the 1999 Limiting Factors Analysis for WRIA 29 (WCC 1999). Lower Rock Creek Falls at river mile (RM) 1 is a natural barrier that restricts passage to all anadromous species. Foster creek, which flows into the western part of Rock Creek Cove, has a culvert and a dam/pond that restrict passage. A natural cascade blocks passage in Carson Creek approximately 100 feet from its mouth. Collins Creek (Columbia RM 157.9) has a culvert under the railroad that may create a passage problem. Passage at the mouth of Dog Creek may be limited due to sediment buildup.

18.5.2 Stream Flow

Annual high flows in the Rock Creek basin typically occur in winter months, related to rain and rain-on-snow events. Based on WDNR classifications, approximately 49% of the basin is in the rain-dominated zone, 44% is in the rain-on-snow zone, and the remainder is in the snow-dominated zone. Coffin (USFS 2000) notes that in reality more of the basin may be within the rain-on-snow zone due to the funneling of cold air masses through the Gorge from the east during winter. There are no streamflow records available for the Rock Creek basin; however, Welch et al. (2002) used streamflow records from the Wind River basin to estimate Rock Creek flows. High flows were estimated at near 280 cu ft per sec (cfs) for December and April, and below 40 cfs in September.

Many of the smaller stream systems have either very low perennial flow, seasonal flow, or ephemeral flow. Information is lacking on specific hydrologic characteristics of these streams.

Information on changes to runoff conditions is only available for the Rock Creek basin. Approximately 30% of the basin is in early successional or non-forest conditions, potentially increasing the amount of snowfall accumulation and melt rates, which can increase peak flow volumes. High road densities is the basin may also have altered runoff conditions. The upper Rock Creek, Spring Creek, and lower Rock Creek basins all have road densities of over 4 mi/mi^2. An analysis of the relative risk of increased peak flows was assessed by the USFS using vegetation condition, road density, and elevation. Based on the results, two of the nine watersheds, upper Rock Creek and Spring Creek, were identified as being susceptible to an increase in peak flows (USFS 2000). Using an analysis developed by the Washington Department of Natural Resources, which models flows using USGS Regional Regression

Equations, current peak flows in the various watersheds were estimated to be 1 to 13 percent higher than those expected under fully forested conditions (USFS 2000).

Information is lacking on runoff conditions for other streams within the subbasin. In general, forest vegetation is younger than historical conditions or has been removed completely. Many of the streams, in particular Carson Creek, have suffered from a dramatic increase in percent of basin area with impervious surfaces, likely increasing runoff rates and peak flow volumes. The Carson / Nelson Creek basin also has a very high road density of 5.25 mi/mi^2.

An assessment of the adequacy of low flows for fish was evaluated using the toe-width method on lower Rock Creek and Carson Creek in 1998. Spot flows measured from late August to early November on Rock Creek were well below optimum flows for salmon and steelhead spawning. Flows were approximately 70% of optimum for salmon and steelhead rearing. Flows in lower Carson Creek for the same time period were even further below optimum levels for spawning and rearing (Caldwell et al. 1999).

18.5.3 Water Quality

Limited water quality data is available throughout the subbasin, and is restricted primarily to Rock Creek. A one-day, spot sampling effort on Rock Creek recorded a temperature of 57ºF (14ºC) 2 miles downstream of the National Forest boundary and 70ºF (21ºC) at the mouth (USFS 2000). It was suggested that low shading or input of geothermal water might be causing high temperatures in the lower river. Another sampling effort, conducted by Fishman Environmental Services (1997), recorded 63ºF (17ºC) at the mouth of Rock Creek and 77ºF (25ºC) at the west end of Rock Cove. Investigators also noted that runoff from the surrounding urban area may be degrading water quality in Rock Cove. There may also be concerns related to the Skamania Lodge Golf Course and the County Dump that was located where the lodge now stands (Michaud 2002). The 1999 Limiting Factors Analysis noted that Nelson Creek, which flows through Stevenson and enters the Columbia at RM 151.5, suffers from water quality degradation related to road runoff and land development.

18.5.4 Key Habitat

Information gathered on the lower mile of Rock Creek as part of a Rock Cove assessment (Fishman Environmental Services 1997) noted that this reach is generally undisturbed by human activities.The habitat is mostly riffles with few pools, though there are side channels that provide rearing habitat. Information on in-stream habitat is lacking for Rock Creek from above the lower falls to the National Forest boundary. Above this, the USFS gathered habitat data in 1997. The survey revealed a pool frequency of 20 pools/mile, lower than reference levels but potentially a natural condition. Nearly half (45%) of the pools were deeper than 3 feet. A total of eight side channels and three braids were observed (USFS 2000).

18.5.5 Substrate & Sediment

Coarse bedload from landslides has been observed in the upper Rock Creek basin (WCC 1999). USFS stream survey data (1997) revealed less than 12% fines in reaches in the upper basin. Overall, in the upper basin, gravel/cobble substrates dominate the upper and lower sections and bedrock substrate dominates the middle section (USFS 2000).

The first mile of Rock Creek has been identified as having limited spawning gravels (Fishman Environmental Services 1997). Grant Lake Creek, which enters the Columbia at RM 158.4 and supports winter steelhead spawning, has sediment accumulations related to natural landslides in the upper basin (WCC 1999).

The same vegetation and road conditions that make a basin susceptible to peak flow alterations can also modify sediment transport dynamics. Rock Creek has high road densities in portions of the basin, especially in the upper basin, which also has many immature forest stands. These conditions may increase sediment production from hillslope sources and can increase delivery rates to stream channels. Stream turbidity and excess coarse bedload volumes have been attributed to landslides in the upper basin, especially along the Washington DNR 2000 Road (WCC 1999).

Sediment supply conditions were evaluated as part of IWA watershed process modeling, which is presented later in this chapter. The IWA indicated that 1 of the 9 subwatersheds rated “impaired” with respect to landscape conditions influencing sediment supply. Six subwatersheds were rated as “moderately impaired” and 2 were rated “functional”. The greatest impairment was in the upper Rock Creek basin and is due to high road densities on steep, erodable slopes on WDNR lands.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

18.5.6 Woody Debris

Only limited information exists for instream LWD and most of it is restricted to the Rock Creek basin. A total of only 6.5 pieces of LWD per mile were measured in the 4.3 miles surveyed in upper Rock Creek in 1997. This is about 8% of the NMFS standard for Properly Functioning Condition (USFS 2000). Poor riparian conditions create lack of LWD recruitment potential.

18.5.7 Channel Stability

Information is lacking on bank stability conditions for most of the subbasin. The Limiting Factors Analysis identified landslides in the Rock Creek basin related to the WDNR 2000 road (WCC 1999). USFS surveys in 1997 measured high width-to-depth ratios (31:1 in the upper Rock Creek basin and 16:1 in the Rock Creek Headwaters basin), revealing potential problems with sediment accumulation and subsequent bank erosion. Overall streambank condition in Rock Creek was rated good to fair (USFS 2000).

18.5.8 Riparian Function

Specific information on riparian conditions is limited to data collected by the USFS as part of the Rock Creek Watershed Analysis. Fire, logging, and splash damming have impacted riparian forests in the Rock Creek basin. Of the riparian reserves, 28% are in early-seral vegetation, with the lower Rock Creek basin having 47% in early-seral conditions. However, it should be noted that hardwoods are included in these early-seral vegetation numbers though they may be well-established hardwoods that colonized riparian areas following the large Yacolt Burn in the early 1900s (USFS 2000). Riparian conditions in other subbasin streams are largely undocumented.

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

18.5.9 Floodplain Function

Most streams in the subbasin have very little natural floodplain habitat due to the steep valley walls of the Columbia Gorge. The Bonneville Pool now covers much of the floodplain habitats that did exist. Floodplain areas are limited to the lower reaches of channels and have been impacted primarily by transportation corridors and residential and industrial development. SR-14 and the Burlington Northern Railroad cross most of the streams in the basin, constricting floodplains and altering natural channel dynamics.

18.6 Fish/Habitat Assessments

No Fish/Habitat Assessments have been completed for the Columbia Gorge Tributaries subbasin.

18.7 Integrated Watershed Assessment (IWA)

The Columbia Gorge Tributaries Watershed includes 9 subwatersheds, comprised of the Rock Creek drainage and several other independent tributaries that flow into the Columbia River between Bonneville Dam and the Little White Salmon River. These smaller drainages include the Nelson – Carson Creek drainage, and the Dog Creek drainage. Just over 50% of the watershed is publicly owned, with over 70% public ownership in the upper subwatersheds of Rock Creek (30202-30204), but less than 15% in the Nelson – Carson subwatershed (30402) and the Ashes Lake subwatershed (30401). Much of the private land in these subwatersheds is within the Columbia River Gorge National Scenic Area.

18.7.1 Results and Discussion

IWA results were calculated only for sediment conditions for subwatersheds in the Columbia Gorge Tributaries watershed. Geospatial data was unavailable for assessing hydrologic and riparian conditions. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in Table 18-1. The local and watershed level results are also shown in Figures ? and ?, respectively.

Table 18-1. Summary of IWA results for the Columbia Gorge Tributaries watershed.

Process Condition	Total Number of Subwatersheds	Local Level Conditions*			Watershed Level Conditions**		
		Functional	Moderately Impaired	Impaired	Functional	Moderately Impaired	Impaired
Hydrology	—	—	—	—	—	—	—
Sediment	9	2	6	1	0	8	1
Riparian	—	—	—	—	NA	NA	NA

Notes:
*Conditions within the subwatershed, not considering upstream effects.
**Conditions within the subwatershed integrating the entire upstream drainage area.
— No result determined because of a lack of available data.
NA Not Applicable

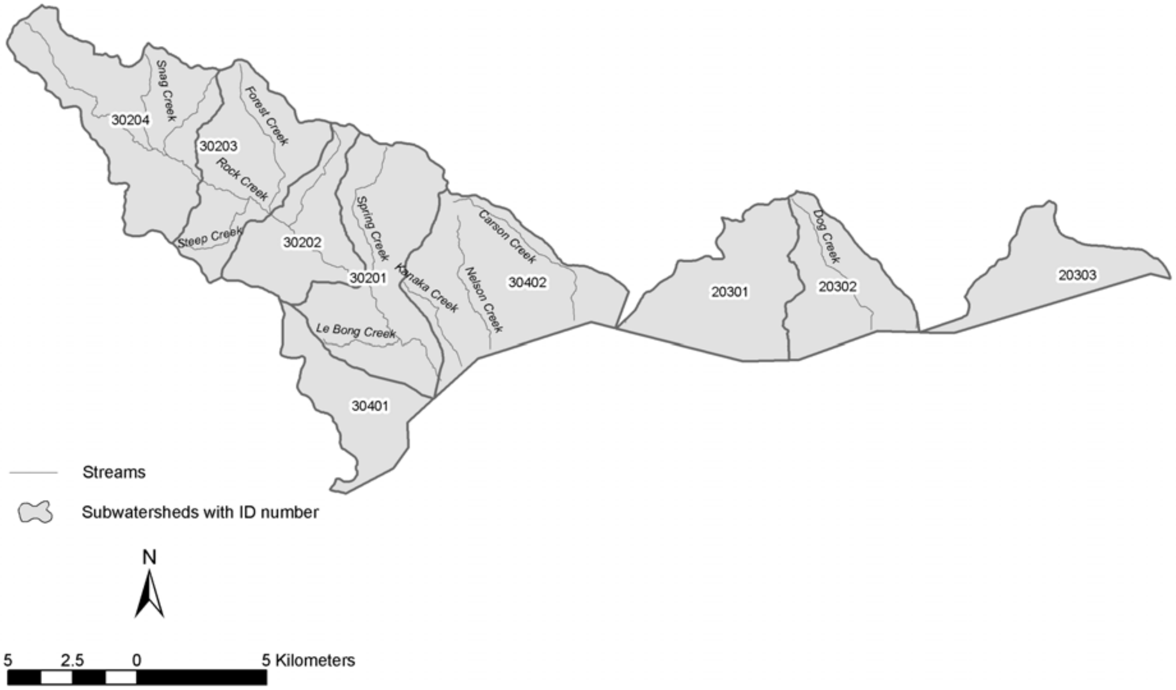

Figure 18-4. Map of the Columbia Gorge Tributaries showing the location of the IWA subwatersheds

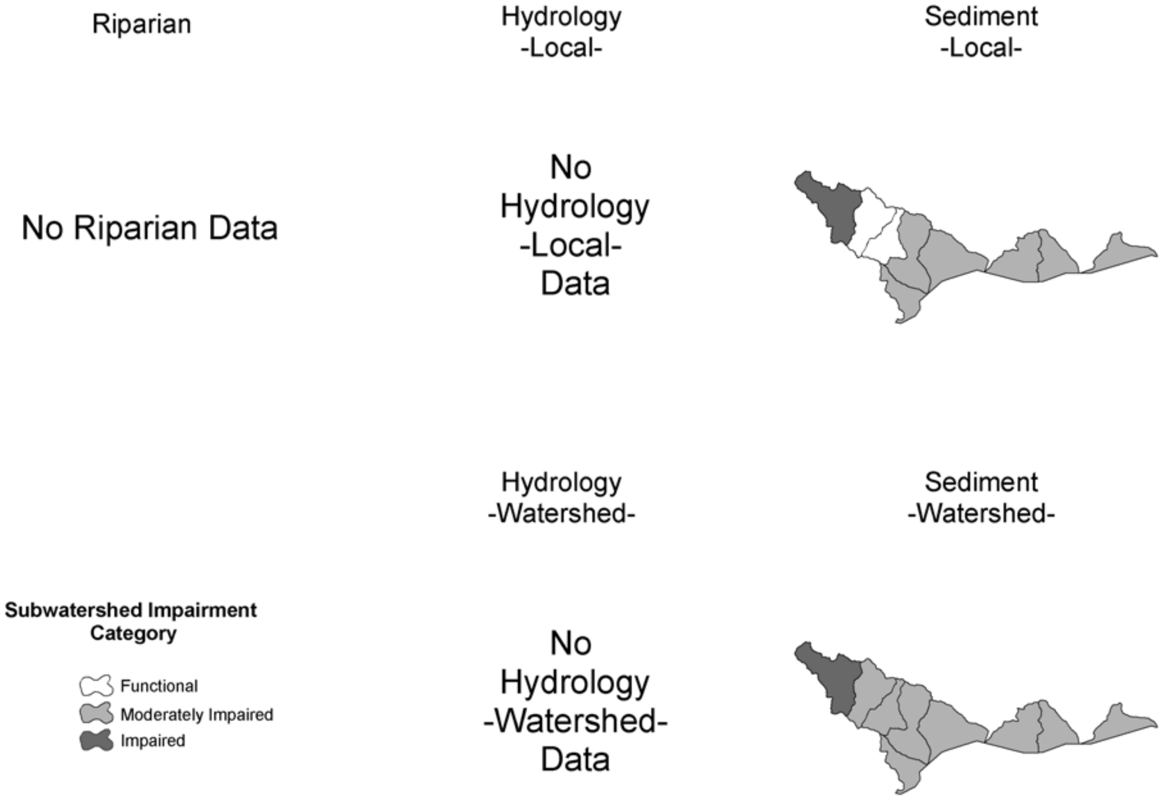

Figure 18-5. IWA subwatershed impairment ratings by category for the EF Lewis basin

18.7.1.1 Hydrology

IWA results were not developed for hydrologic conditions in the Columbia Gorge Tributaries watershed because of a lack of GIS based data for forest cover.

18.7.1.2 Sediment

Local sediment conditions are rated as impaired in one subwatershed, the headwaters of Rock Creek (30204). Impaired conditions in the Rock Creek headwaters are associated with high road densities in sensitive areas (steep, erodable slopes) on WDNR lands. IWA rates the upper and middle Rock Creek subwatersheds (30202 and 30203) as locally functional. When taking watershed level effects into account, the impaired sediment conditions in the Rock Creek headwaters causes degradation in these functional local level conditions, leading to rankings of moderately impaired for the upper and middle mainstem Rock Creek subwatersheds.

All other independent subwatersheds are terminal (i.e., no upstream subwatersheds) and are rated moderately impaired at both the local and watershed levels.

18.7.1.3 Riparian

IWA results were not developed for riparian conditions in the Columbia Gorge Tributaries watershed because of a lack of GIS based data for forest cover.

18.7.2 Predicted Future Trends

18.7.2.1 Hydrology

Public ownership in the upper portions of Rock Creek is high, and much of the lower subwatersheds are under federal management regulations as part of the Columbia River Gorge National Scenic Area. However, the drainage possesses high road densities in the headwaters and lower subwatersheds (greater than 3 mi/mi^2.), and there may be some additional development pressure between the cities of Stevenson and Carson, WA.

Although hydrologic conditions in the Columbia Gorge watershed could not be evaluated using the IWA analysis, overall, hydrologic conditions are expected to remain stable.

18.7.2.2 Sediment Supply

The extent of public lands ownership ranges broadly in these subwatersheds. Terminal, independent drainages have public ownership rates as low as 12%, whereas upper Rock Creek has over 95% of its total area in WDNR and USFS land. Because these subwatersheds all border the Columbia Gorge National Scenic Area, restrictive land use regulations will limit significant development or timber harvest. Given these conditions, the sediment conditions are predicted to trend stable over the next 20 years. Sediment conditions in Rock Creek will remain moderately impaired to impaired until headwaters sediment sources are addressed.

18.7.2.3 Riparian Condition

Streamside road densities exceed 1 mile/stream mile in lower Rock Creek (30201 and 30202), indicating that riparian recovery will be limited by the extent of existing roads.

Although riparian conditions could not be evaluated using the IWA analysis, overall, riparian conditions are expected to remain stable.

18.8 References

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