AQU 18 – APPENDIX G

A CONCEPTUAL FOUNDATION FOR THE MANAGEMENT OF THE LEWIS RIVER SALMONID POPULATIONS

Merwin Hydroelectric Project, FERC No. 935
Yale Hydroelectric Project, FERC No. 2071
Swift No. 1 Hydroelectric Project, FERC No. 2111
Swift No. 2 Hydroelectric Project, FERC No. 2213

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Prepared for

PacifiCorp
Portland, Oregon

and

Public Utility District No. 1 of Cowlitz County
Longview, Washington

Prepared by

George Gilmour, Meridian Environmental, Inc.
Kathy Dubé, Watershed GeoDynamics
Jim Lichatowich, Alder Fork Consulting

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4.18.5 Results and Discussion

4.18.5.1 Conceptual Foundations – What are They and Why are They Important?

For the purposes of this report, a conceptual foundation is a set of scientific theories, principles and assumptions regarding the physical and ecological processes in the Lewis River that influence or determine the capacity and productivity of native and introduced salmonids in the basin. Conceptual foundations determine what information is collected, what problems are identified and the range of appropriate solutions to those problems (Independent Scientific Group (ISG) 2000). They are instrumental in translating fishery management goals into the ecological conditions needed to achieve them (Northwest Power Planning Council (NPPC) 1997). Even though they are a critical part of the planning and implementation of fishery restoration and management programs, conceptual foundations are rarely explicitly stated, discussed or evaluated (Evernden 1993, Botkin 1990).

To help explain their importance and function, the ISG (2000) compared conceptual foundations to the picture on the box of a jigsaw puzzle. Each piece of the puzzle can be thought of as a datum, which can only be interpreted by reference back to the picture. Using the wrong picture to interpret the datum makes it difficult, if not impossible, to complete the puzzle. A conceptual foundation based on false assumptions or principles will lead to the failure of the management program or to inadvertent consequences (Cronon 1995). Ecosystems like the Lewis River are not automatically supplied with a single, clear picture or conceptual foundation. This does not mean that management and restoration programs in the Lewis River are not based on conceptual foundations. Every management program, unless it is composed of entirely random activities, is derived from and guided by a foundational set of assumptions and theories. However, the assumptions and principles that make up a conceptual foundation are often deeply rooted in our experience and training and they are so casually accepted that they are rarely examined or even acknowledged (Evernden 1993). We rarely check to see if we are using the right picture to guide our decisions.

The failure to examine those underlying assumptions is itself a part of the "environmental problem." According to biologist John Livingston, the debates over natural resource management and restoration focus almost exclusively on issues. For example, in the Columbia Basin, the focus is on the effects of dams, the benefits and ecological costs of hatcheries, the effectiveness of barging, the effects of logging, grazing, irrigation, etc. But these issues, like the tips of icebergs, are just the visible part of a much larger entity. The submerged parts of these environmental icebergs are the roots of the problem, the unexamined assumptions, the conceptual foundations that continually reinvent and legitimate programs that perpetuate the supply of environmental issues (Livingston as cited in Evernden 1993).

In recent years, the growing fragmentation of management authority and responsibility for salmon recovery among state, Tribal, federal, county, city entities (Wilkinson and Connor 1983) and the development of strong special interest politics relative to natural resources (Behan 2001 and Cortner and Moote 1999), has intensified the need to examine of conceptual foundations underlying the development of management and restoration plans. Management fragmentation and special interest advocacy means that for every issue, there will be several different organizations, institutions and special interests entering the debate over solutions. Those debates, which at times seem to be intractable, focus on the tip of the iceberg and rarely, if ever, examine the assumptions that underlay the positions of the different organizations and institutions. In other words, the root cause of the differences among participants in those debates goes unexamined, which is one reason why the issues are so difficult to resolve. Institutional fragmentation and issue oriented advocacy makes the examination of conceptual foundations of the participants in the debate an essential step in resolving watershed issues.

Conceptual foundations are not cast in concrete, but should be subject to revision as scientific information increases and our understanding of ecosystems improves. Failure to update conceptual foundations can lead to inadequate programs or programs that have unintended consequences. Lichatowich et al. (1998) gives the following example of a program that failed because it included a false assumption in its conceptual foundation. In the 1970s, the Oregon Legislature authorized the operation of large private sea ranching enterprises for Pacific salmon. An important part of this program was the belief that there was vacant habitat in the ocean for salmon. This belief was derived from the assumption that carrying capacity for salmon was stable and was not being fully occupied because logging, irrigation, grazing, dams, residential development and pollution reduced the number of smolts leaving Oregon's rivers. Stable carrying capacity and fewer smolts equated to vacant habitat that could be filled with smolts from large-scale artificial propagation facilities. Although evidence of highly variable capacity in the ocean was accumulating, the private salmon ranches accepted the assumption that the marine ecosystem was stable. Sea ranches were a large-scale test of that assumption. The failure of private sea ranches suggests the program was based on a false assumption or conceptual foundation. Since that experiment was carried out, information about ocean conditions has continued to show that the ocean's capacity to rear salmon is not stable (e.g., Nickelson 1986 and ISG 2000).

Conceptual foundations are rarely explicitly stated in recovery and management programs (ISG 2000), but that does not mean that they do not exist. They are simply taken for granted and left unstated. But they exert too much influence over the success or failure of a program to let that situation persist. Even the most well-intentioned management programs can have disastrous results if predicated on the wrong assumptions (Cronon 1995). The seemingly intractable and endless debates over management and restoration strategies are often, at their roots, arguments derived from conflicting conceptual foundations. Focusing attention on the fundamental assumptions would at least shift the debate to the real cause of the conflict. False assumptions and outdated science in the conceptual foundation cannot be identified and corrected unless they are explicitly stated and publicly discussed. The purpose of this document is to present a starting point for such an examination.

A Basin-wide Conceptual Foundation

Ecosystems are organized hierarchically (O'Neill et al. 1986). For example, the ecosystem defined as the Columbia River basin has nested within it several subbasins including the Lewis River and, nested in the subbasins are their tributary streams. A hierarchical organization of the Columbia Basin implies a degree of coherence in the ecological and physical processes among the various levels of the ecosystem. It also implies coherence in the conceptual foundations at the basin and subbasin level of organization. The conceptual foundation used to guide the management of the Lewis River must recognize and take into account this basin-wide conceptual foundation. The need for such a foundation was recognized several years ago and some meaningful results are now available.

In 1993, the Northwest Power Planning Council asked the ISG to review the Council's Fish and Wildlife Program (FWP) and evaluate its underlying conceptual foundation. The FWP did not contain an explicitly stated conceptual foundation, so the ISG reviewed the individual measures contained in the program and made its best estimate of the assumptions or principles that underlay them. The result was an estimate of the conceptual foundation implied by the measures.

The program's measures in aggregate implied a conceptual foundation composed of 3 general principles and 29 assumptions (ISG 2000). The 3 principles were[1]:

1. The salmon-bearing ecosystem in the Pacific Northwest and the northeast Pacific Ocean has considerable excess carrying capacity.

2. Abundance of salmon and steelhead in the Columbia River basin has, to a significant degree, declined due to, and is presently limited by, human actions.

3. Ecosystem functions lost as a result of the development of the Columbia River can be replaced by technological solutions to individual problems.

The ISG then examined the scientific evidence in support of those principles and found that the first and third were speculative with little empirical support. The second principle was thoroughly established with good peer review and empirical evidence in its favor. Given the weakness in the implied conceptual foundation, the ISG (2000) proposed an alternative set of 3 principles:

1. The Columbia River is a natural, cultural system. Restoration must consider the whole ecosystem, natural as well as cultural.

2. Salmonid productivity requires a network of complex interconnected habitats that are created, altered and maintained by natural physical processes in freshwater, estuaries and the ocean.

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[1] Consult ISG 2000 for a detailed description of each of the principles.

3. Life history, genetic diversity and metapopulation organization are ways the salmon adapt to their habitat. Diversity is how salmon cope with environmental variation.

Building on the work of the ISG, the Northwest Power Planning Council (NPPC 2000) proposed 8 principles for the basis of recovery programs in the Columbia Basin[2]:

1. The abundance, productivity and diversity of organisms are integrally linked to the characteristics of their ecosystems;

2. Ecosystems are dynamic, resilient and develop over time;

3. Biological systems operate on various spatial and time scales that can be organized hierarchically;

4. Habitats develop, and are maintained by physical and biological processes;

5. Species play key roles in developing and maintaining ecological conditions;

6. Biological diversity allows ecosystems to persist in the face of environmental variation;

7. Ecological management is adaptive and experimental;

8. Ecosystem function, habitat structure and biological performance are affected by human actions.

The Council's 8 principles and the ISG's 3 principles have many elements in common, but there are important ideas contained in only one of the two. For example, the statement that the Columbia River is a natural-cultural system is an important idea that is only in the ISG's set of principles. To retain all the important ideas, we combined the 2 sets and reduced them to 4 principles, which were modified from Lichatowich et al. (1998):

1. The Columbia River is a natural-cultural system characterized by natural environmental variability; natural and man-made disturbance regimens; fluctuations in production; hierarchical organization of its biological subsystems; keystone species that contribute to ecological functions; and, cultural modifications to physical and ecological processes. Salmon restoration and management must consider the whole ecosystem, natural and cultural.

2. Salmonid productivity requires a network of complex interconnected habitats, which are created, altered and maintained by natural physical processes in freshwater, estuaries and the ocean. Species diversity and the biotic community are a reflection of the ecosystem's attributes. To achieve management and restoration goals, suitable ecosystem attributes must be attained.

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[2] Consult NPPC (2000) for more detail on each principle.

3. Life history, genetic diversity and metapopulation organization are ways salmon adapt to their habitat. Diversity and population structure are how salmon cope with spatial and temporal environmental variations. Biological diversity allows ecosystems to persist in the face of environmental variation.

4. Management and restoration at the ecosystem level is adaptive. Human activities must be managed to protect and restore ecological functions and attributes needed for survival of native biota.

We will use the 4 statements above as the basin-wide conceptual foundation. The first principle states that biological systems are hierarchical, which means, as stated earlier, we will seek to achieve coherence between the 4 elements of the Columbia River basin-wide conceptual foundation and the conceptual foundation for the Lewis River developed in this report. To facilitate that goal, we organized the next 4 sections of this report to provide background information relative to the 4 principles of the basin-wide conceptual foundation.

4.18.5.2 The Lewis River as a Natural-Cultural System

Natural-Cultural Systems

The Lewis River and its catchment area is a natural-cultural ecosystem. What does the term natural-cultural mean when applied to a watershed and what does it imply regarding the management and restoration of watersheds? Natural-cultural systems are ecosystems influenced by humans. The ISG (2000) described a natural cultural system as one that "…encompasses all the ecological and social processes that link organisms, including humans, with their environments." Since management itself is an intervention, manipulation or circumvention of natural processes to achieve human goals, all managed watersheds are natural-cultural systems. And, management did not start with Euro-Americans. Native Americans managed watersheds before the first Euro-Americans arrived through activities such as burning. However, since the 1840s and the arrival of Euro-American settlers, cultural changes in watersheds have increased significantly.

The ISG (ISG 2000) believes that an ecosystem with a mix of natural and cultural features can still sustain all life stages of a diverse suite of salmonid populations if the essential ecological conditions and processes necessary to maintain diverse and productive salmonid populations exist within the ecosystem. The ISG calls this ecosystem, with its balanced mix of natural and cultural features, a "normative" ecosystem.

The consideration of both natural processes and cultural activities in watershed management and restoration is an outgrowth of the growing recognition that natural resource management should shift to an ecosystem perspective. For example, Cortner and Moote (1999) list 4 recurring themes used to characterize ecosystem management:

1. "Socially defined goals and objectives;

2. holistic, integrated science;

3. adaptable institutions; and
4. collaborative decision making."

All of these themes imply some consideration and integration of natural and cultural factors.

The current approach to management is a product of the Progressive Era (1870s to 1920s) and the attempt to stop the rampant abuse and waste of natural resources (Hays 1969)[3]. Laissez faire access to natural resources was replaced with management agencies staffed with technical experts who managed natural resources for "the greatest good for the greatest number of people." Experts alone set the goals and objectives of management and those goals focused on single species rather than ecosystems (Hays 1969). Management institutions are slow to adapt to new information (Wright 1992) and they often fail to take a collaborative approach to decision making (Cortner and Moote 1999). Goal setting by experts, inflexible institutions, single species management, and a lack of collaborative decision-making are not compatible with the themes of ecosystem management.

A superficial appraisal of the foregoing might lead one to conclude that the ecosystem approach to salmon management and restoration differs from the current approach by the addition of cultural considerations to what has been a science-based profession. In fact, it is often remarked that salmon management must remain completely science-based and not "tainted" by consideration of cultural factors. However salmon management has been and is dominated by 2 activities, harvest and hatcheries, which are themselves cultural activities that are heavily influenced by social and political factors. The ecosystem approach is really an attempt to give proper recognition and priority to both natural and cultural factors operating in ecosystems.

In the following section, we describe some the natural and cultural attributes of the Lewis River Basin. We focus our description on those attributes that have the greatest potential to affect or influence fish management in the Lewis River ecosystem. Some of that information is summarized in a schematic diagram of the basin (Figure 4.18-1).

It should be noted that the term "upper watershed" refers to the Lewis River watershed upstream of Swift Reservoir. The term "middle watershed" refers to the portion of the Lewis River watershed between Swift Reservoir and Merwin Dam. The term "lower watershed" refers to the Lewis River downstream of Merwin Dam. These designations are different than those used in U.S. Forest Service (USFS) documents, but are consistent with those used in Lewis River relicensing documents.

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[3] The Progressive Era illustrates the ineffectiveness of American society and government in dealing with issues of control over industrial capitalism.

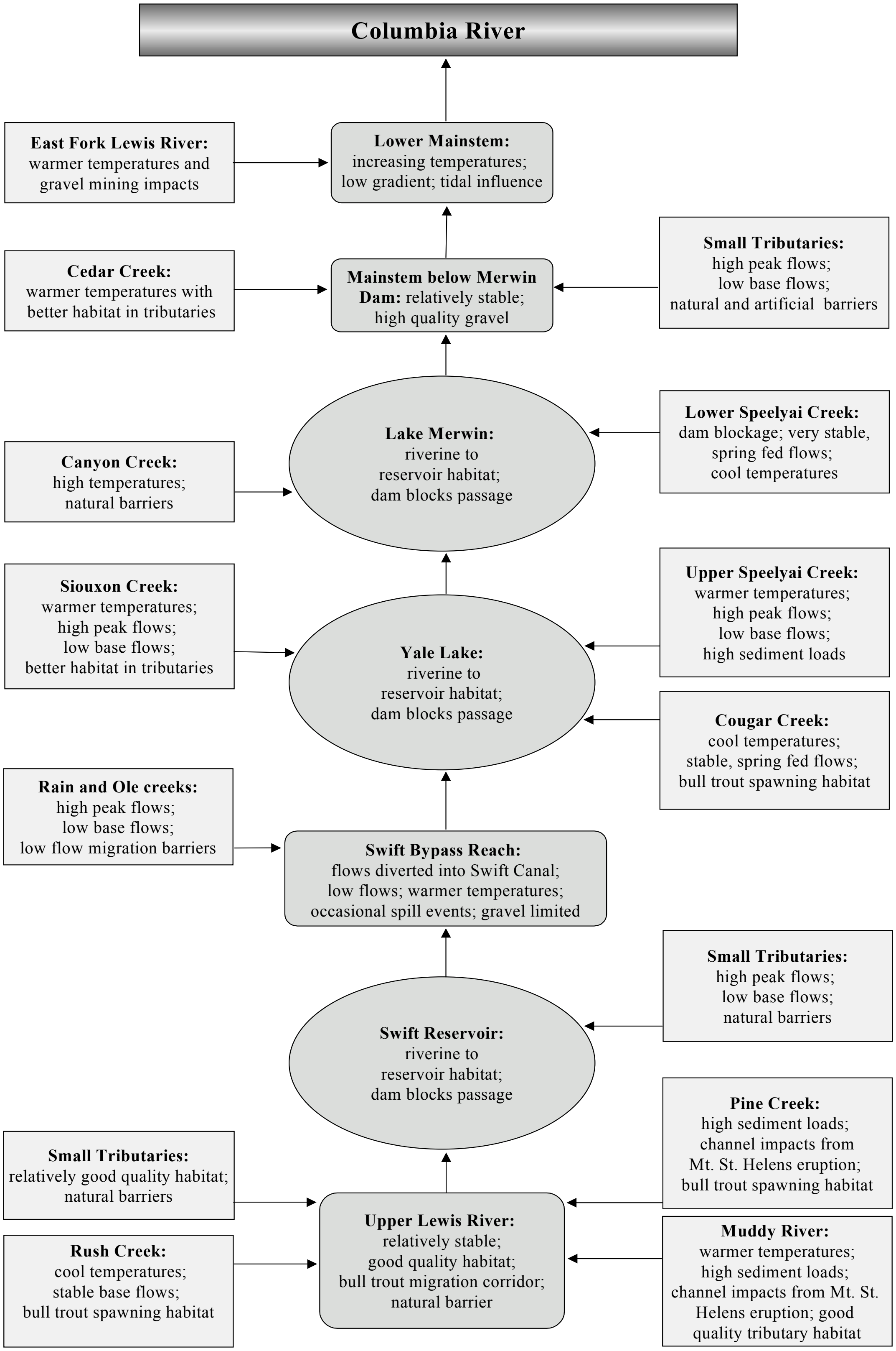

Figure 4.18-1. Schematic diagram of the Lewis River watershed describing environmental gradients.

Lewis River Basin Natural Attributes

The Lewis River basin is located on the western slopes of the Cascade Mountains. Two volcanic peaks, Mount Adams and the recently active Mount St. Helens, lie on the northern and eastern boundaries of the basin. Foothills in the central portion of the watershed are generally steep and forested and range up to approximately 3,000 feet msl. Downstream of Lake Merwin, the Lewis River enters a terrain of rolling hills that eventually transition to the essentially flat "Woodland Bottoms" near the river's confluence with the Columbia River. Forested areas are dominated by conifers, including Douglas-fir (*Pseudotsuga mensiezii*) and western hemlock (*Tsuga heterophylla*) forest types. Upland deciduous and mixed conifer-deciduous forests also occur in the watershed.

Geology – The Lewis River watershed is underlain by primarily volcanic rocks that have been sculpted by subsequent glaciation, recent volcanic activity, and stream processes. Bedrock is comprised of Eocene-Oligocene basaltic-andesite lava flows, Oligocene volcaniclastic rocks, and Quaternary volcaniclastic deposits (Philips 1987a, Philips 1987b, Walsh et al. 1987).

The Lewis River watershed is geologically active, and several large-scale geomorphic processes active during the Holocene (past 10,000 years) shaped the watershed (USFS 1995, 1996, 1997, 1998a). The most obvious of these processes is the active volcanism from Mount St. Helens, Mount Adams, and the Indian Heaven volcanic field. There are 3 main types of volcanic activity that have had a major effect on the watershed: lava flows, debris avalanche/lahars, and tephra (ash) falls (Scott et al. 1995).

Lava flows are probably the least common of the 3 and have most often affected smaller, localized areas near the volcanic vents. Debris avalanches, mudflows, and lahars are more common on Mount St. Helens and Mount Adams. They are rapidly moving slurries of water, rock, soil, and debris. Mudflows swept down Swift Creek, Pine Creek, and the Muddy River during the May 18, 1980 eruption of Mount St. Helens, emptying nearly 18 million cubic yards of water, mud, and debris into Swift Reservoir (Tilling et al. 1990). These events have the ability to alter the streambed and valley characteristics of affected drainages in a matter of hours, and have long-term effects of very high sediment load and altered channel characteristics. Streams affected by recent mudflows are continuing to process the sediment and woody debris and have changed from narrow channels into wide, braided, unstable channels with high sediment and wood loads. Riparian vegetation along these channels was lost, and is slowly recovering as sediment loads decrease with time.

Tephra, ash, and/or pumice falls are the most common and widespread volcanic activity originating from Mount St. Helens and Mount Adams. Thick deposits of tephra can reduce infiltration rates and increase erosion rates. Seven to 8 tephra deposits (including the 1980 eruption) from Mount St. Helens have occurred over the past 10,000 years.

Alpine glacial activity sculpted portions of the Lewis River basin in the past, and is still active to a smaller extent on the tops of Mount Adams and Mount St. Helens. Streams with a large percent of flow from glacial melt carry heavy loads of both fine-grained sediment and bedload, resulting in detectably higher summer turbidities and braided, shifting channels. Past alpine glacial activity has shaped the upper valleys of these same creeks into U-shaped troughs with steep sidewalls, creating areas where mass wasting is now very active.

Climate – The Lewis River basin has the predominantly temperate marine climate typical of the Pacific Northwest. It experiences a narrow range in temperature—a dry summer and a mild but rainy winter. Terrain influences the rainfall and temperature pattern, with lower elevations experiencing warmer temperatures and less rainfall and higher elevations receiving more rain, snow, and cooler temperatures.

Average annual precipitation near the mouth of the watershed is 37 inches, and average annual precipitation on Mount Adams is over 140 inches. Snowfall is minimal at lower elevations, but exceeds 200 inches/yr at elevations over 3,000 feet. In the warmest summer months, afternoon temperatures range from the middle seventies to the lower eighties, with nighttime temperatures in the fifties. Maximum temperatures exceed 90ºF on 5 to 15 days each summer. Temperatures in the foothills and higher elevations are slightly lower than those recorded in the valleys.

Fish Community – The existing resident and anadromous fish community is an important natural attribute of the Lewis River basin, and today the river downstream of Merwin Dam supports populations of wild fall chinook (*Oncorhynchus tshawytscha*) salmon and hatchery stocks of spring chinook, early and late coho (*O. kisutch*), and winter and summer steelhead (*O. mykiss*). White sturgeon (*Acipenser transmontanus*), Pacific lamprey (*Lampetra tridentata*), eulachon (smelt) (*Thaleichthys pacificus*), mountain whitefish (*Prosopium williamsoni*), cutthroat trout (*O. clarki*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), and sockeye salmon (*O. nerka*) are also occasionally observed downstream of Merwin Dam.

The project reservoirs and tributaries upstream of Merwin Dam support kokanee (landlocked *O. nerka*), rainbow trout (*O. mykiss*), mountain whitefish, cutthroat trout, bull trout (*Salvelinus confluentus*), sculpin (*Cottus spp.*), northern pikeminnow (*Ptychocheilus oregonensis*), tiger muskellunge (a sterile northern pike and muskellunge cross), white sturgeon, carp, bluegill (*Lepomis macrochirus*), crappie (*Pomoxis* sp.), threespine stickleback (*Gasterosteus aculeatus)*, largescale sucker (*Catostomus macrocheilus*), residualized coho, chinook, and steelhead. Each of these species, with the exception of kokanee, blue gill, tiger muskellunge, and crappie, are native to the Lewis River basin. Non-native species were introduced following dam construction to enhance the recreation fishery. More detailed information on those species that are the focus of fishery management activities in the Lewis River basin is presented in Section 4.18.5.4.

Cultural Attributes

Cities and Towns – The Lewis River watershed is located in an area dominated by natural resource based land uses, such as forestry, recreation, and agriculture. As a result, population densities are generally low within the basin. The largest urban center, the City of Woodland, is located near the mouth of the Lewis River, approximately 20 miles north of Vancouver, Washington. Woodland was originally established by settlers in the mid-

1850s. As its population grew, lumber mills, agriculture, fishing, and railroad transport became the city's primary industries. Today, it has a population of 3,875, although the number of people living in the greater Woodland area approaches 10,000 residents. In recent years, the community has experienced substantial growth, with an economy driven by industries such as fishing gear manufacturing, manufactured home production, and agriculture. Development in the Woodland area has adversely affected aquatic habitat in the lower Lewis River basin. Residential and agricultural land uses have eliminated most of the riparian vegetation in the lower reaches, and the lower 7 miles of the Lewis River floodplain is almost entirely disconnected from the river due to extensive diking (Wade 2000). In the East Fork Lewis River, over 50 percent of the off-channel habitat and associated wetlands within the floodplains have been disconnected from the river.

Other towns in the Lewis River basin include Cougar, Ariel, Yale, Chelatchie, Amboy, Yacolt and La Center (Wade 2000). None of these settlements have populations exceeding 2,000 and their economies are primarily dependent upon logging, agriculture, and recreation (Lowe 2002). The small town of Cougar, located along the north shore of Yale Lake, was originally established to serve as a staging point for timber harvest activities. However, after hydroelectric development and the creation of the Mount St. Helens National Volcanic Monument, recreation services became the primary industry. The current population of Cougar is under 200. Because these towns were/are largely supported by natural resource extraction (logging), their ecological footprint or impact is much larger than the size of the town would indicate.

There are 3 private communities located around Swift Reservoir. The largest of these is the 206-home Northwoods community on the eastern shore. Yale Lake has private development clustered primarily around the Beaver Bay area, the Town of Cougar, and near Speelyai Canal. Private land ownership is more common around Lake Merwin, where there are several large communities along the shoreline, including a 1,600-lot home/trailer development along the south shore. Scattered private lands are found along the Lewis River adjacent to SR 503, increasing in number as one heads west to the City of Woodland.

Dams – In 1929, the Federal Power Commission issued a 50-year license to Inland Power and Light (the predecessor of PacifiCorp) to construct, operate and maintain the first hydroelectric development in the Lewis River basin. Construction of Ariel Dam at RM 19.4 (now called Merwin Dam) began in 1930 and was completed with a single generating unit in 1932. Two additional units were added to the project in 1949 and 1958.

Merwin Dam is a 314-foot-high concrete arch structure with a total crest length of 1,300 feet. The reservoir formed by Merwin Dam (Lake Merwin) is about 14.5 miles long with a surface area of approximately 4,000 acres at elevation 239.6 feet above msl. The dam's intakes are relatively deep, located approximately 187 feet below full pool.

To help maintain anadromous fish runs in the Lewis River basin and comply with Article 14 of the original project license, Merwin Dam was equipped with an anadromous fish collection facility, also built in 1932 (a trap and haul facility located at the base of the dam) (Hamilton et al. 1970). Volitional fishways were not constructed over Ariel Dam because Inland Power and Light and the WDF and WDG considered them to be “impracticable from the standpoint of properly preserving fish life” (Inland Power and Light Company 1932). During subsequent years, returning adult anadromous fish were collected at the Merwin trap, counted, and either used for hatchery broodstock or transported upstream by truck to spawn naturally in the Lewis River watershed above Merwin Dam. The spillways and turbine outlets of Merwin Dam (and eventually those at Yale Dam) provided the only means of downstream passage for outmigrants (Hamilton et al. 1970). The Merwin Dam Anadromous Fish Collection Facility is still in operation and continues to serve as the main collection facility for hatchery fish returning to the North Fork Lewis River basin.

Yale Dam, located approximately 15.6 miles upstream from Merwin Dam, was constructed between 1951 and 1953. It is a rolled earthfill embankment-type dam with a crest length of 1,305 feet and a height of 323 feet. The reservoir it forms (Yale Lake) is approximately 10.5 miles long with a surface area of approximately 3,800 acres at full pool. The project intake is relatively deep, located approximately 90 feet below full pool. Yale Dam is not equipped with upstream or downstream fish passage facilities; however, fish do pass over its spillway during occasional spill events.

Swift No. 1 is the furthest upstream hydroelectric project in the Lewis River watershed. The project, completed in 1958, is located at RM 45, approximately 10.5 miles upstream from Yale Dam. Swift Dam is an earthfill embankment-type dam with a crest length of 2,100 feet and a height of 512 feet. At the time of its construction, Swift Dam was the tallest embankment dam in the world. Swift Reservoir is about 11.5 miles long and has a surface area of approximately 4,680 acres at elevation 1,000 feet msl (full pool). The Swift No. 1 intake is relatively deep, located at elevation 878 msl (122 feet below full pool). Swift Dam is not equipped with upstream or downstream fish passage facilities.

The Swift No. 2 Project, located 3.2 miles downstream of the Swift No. 1 powerhouse, was completed in 1958. The project does not have its own dam. Instead, it uses a 3.2-mile-long canal to convey water from the tailrace of Swift No. 1 to the Swift No. 2 powerhouse. All water entering the Swift No. 2 powerhouse is discharged into the upper end of Yale Lake.

On April 21, 2002, the Swift No. 2 Project was seriously damaged as a result of a 250-foot breach in the wall of the Swift canal. Following this event, biologists from the USFWS, WDFW and PacifiCorp conducted several fish salvage operations to rescue fish that were trapped in isolated pools located in the dewatered canal. A total of 10 canal salvage operations were conducted from late April through mid-June. Salvaged salmonids included 579 rainbow trout, 510 mountain whitefish, 42 bull trout, 11 coho, 9 cutthroat trout, 5 brook trout, 3 chinook, and 1 bull trout/brook trout hybrid (pers. comm., E. Lesko, PacifiCorp, May 2003). Cowlitz PUD is currently preparing the engineering specifications for repair of all project facilities. It intends to continue the relicensing efforts already underway, and will complete reconstruction of the project in 2005.

Effects resulting from the presence and operation of the 4 projects on aquatic resources and water quality have been examined by numerous studies as part of the relicensing process. A summary of these effects is presented in Table 4.18-1.

Table 4.18-1. Summary of Lewis River Hydroelectric Projects effects on aquatic resources and water quality.

1.0 The projects change the magnitude and timing of water flows in reaches downstream from project facilities (the Lewis River bypass reach, Speelyai Creek downstream of the upper diversion, and the reach downstream of Merwin Dam). The projects also result in fluctuation of reservoir water levels.
1.1 Flows in the Lewis River bypass reach are normally limited to inflow from groundwater/seepage and tributaries except during spill events when large quantities of water are released into the reach.
Normal daily flows between Swift Dam and Ole Creek average 5-10 cfs (See PacifiCorp and Cowlitz PUD 2002, WTS2, Figure 2.2-6). The low daily flows limit the area of available aquatic habitat in this 2.6-mile long reach. These lower flows have caused riparian vegetation to encroach into the channel bed formerly occupied by the river, resulting in channel narrowing (see PacifiCorp and Cowlitz PUD 2002, TER-9, Section 5.9.5.3).
Infrequent spills into the Lewis River bypass reach result in large inputs of water. Spill of several thousand cfs or greater occur every few years (See PacifiCorp and Cowlitz PUD 2002, WTS2, Figure 2.2-31). These large spill events wash away riparian and wetland vegetation, resulting in areas of unconsolidated shoreline for a number of years, and transport wood and sediment through the reach (See PacifiCorp and Cowlitz PUD 2002, WTS3, Figures 2.3 1a through f; TER9, Section 5.9.5.3, Table 5.9-8 and Figure 5.9-1).
The combination of infrequent high spill events and lower base flows has probably increased the proportion of alder in the near channel area o f the bypass reach and reduced the amount of conifer. Periodic high flows also tend to increase the amount of time that the channel is bordered by early successional vegetation. These structural changes have reduced the ability of riparian habitat to contribute LWD to the bypass reach (see PacifiCorp and Cowlitz PUD 2002, TER-9, Section 5.9.5.3).
Breeding amphibian use in the Lewis River bypass reach include northwestern salamanders, red-legged frogs, and Pacific chorus frogs (see PacifiCorp and Cowlitz PUD 2002, TER3). These species use wetlands in the bypass reach that have open, shallow water; most of these wetlands are associated with seepage from Swift Canal through the porous lava/basalt in this area and are above the elevation of the 1995 high flow through the bypass reach. None of these wetlands occur in the existing active channel. Adult chorus and red-legged frogs use the riparian habitat along the bypass reach, and this habitat may be affected by periodic high flows through this area (see PacifiCorp and Cowlitz PUD 2002, TER-9, Section 5.9.5.3). Effects of periodic disturbance of riparian habitat on adult frogs are unknown; but may be minor as long as there is adequate hiding cover near water.
Periodic disturbance by high flows that results in scouring may be colonized by exotic/invasive plant species, reducing riparian habitat quantity and quality for native plants and wildlife (see PacifiCorp and Cowlitz PUD 2002, TER-9, Section 5.9.5.3).

In April 2002, the Swift No. 2 canal failed near the No. 2 powerhouse. As a result of this incident, water from the Swift No. 1 plant is being routed through the canal spillway and enters the bypass reach channel approximately 1 mile downstream of Swift Dam. The Swift No. 1 plant is being operated in a load-shaping mode where units are ramped up during peak load periods and ramped down to zero generation during the evening and other off-peak hours. The project is frequently offline between the hours of midnight and 5 AM. Flows vary between 30-80 cfs (seepage into the canal from the Swift No. 1 plant) and 9,000 cfs. The effects of these higher flows on the aquatic habitat and water quality in the bypass reach have not been documented, but are likely to include an increase in the area of available aquatic habitat, reduced diurnal changes in parameters directly influenced by air temperature (water temperature and dissolved oxygen), and inundation of some small alders and willows in the riparian zone. It is likely that fish and other aquatic species will use the new habitat resulting from the higher flows.

1.2 Flows downstream of the upper diversion on Speelyai Creek are currently limited to groundwater and tributary inflow. The water right for the upper Speelyai diversion includes the provision for 15 cfs (or inflow if less that 15 cfs) to be diverted into lower Speelyai Creek. As a result of concerns for fish health at the hatchery, the upper diversion has only been opened 3 times since 1979 to allow water to flow into lower Speelyai Creek (during extremely dry years). Due to a shift in the upper Speelyai channel away from the diversion structure, water is not currently able to flow into lower Speelyai Creek from upper Speelyai.

Normal daily flows downstream of the upper diversion increase downstream to an average of 15-20 cfs at the hatchery intake and are fairly constant throughout the year as a result of constant groundwater input (See PacifiCorp and Cowlitz PUD 2002, AQU 9, Figure 4.9-16).

The constant flow regime supplies good quality water to the Speelyai Hatchery, but supplies less flow than the current water right at the upper or lower diversion (See PacifiCorp and Cowlitz PUD 2002, AQU 9, Figure 4.9-18). Hatchery personnel have noted increased turbidity and temperature recently and are concerned that water quality may decline in the future as a result of development in the basin.

The constant flow regime results in stable, high quality aquatic habitat in the reach between the 2 Speelyai Creek diversions (See PacifiCorp and Cowlitz PUD 2002, AQU 9, Table 4.9-7 through Table 4.9-10). Riparian habitat is very stable in the reach downstream of the upper diversion as a result of the constant streamflows. Without the diversion in place, lower Speelyai Creek would have a much wider, more active channel and floodplain, and a less stable riparian community, resulting in different ecosystem dynamics. The existing diversity of riparian and wetland habitats throughout this lower reach would probably not occur.

1.3 Flows in the Lewis River downstream from Merwin Dam are altered as a result of project operations to control floods, produce power, and augment late summer flows.

Normal daily flows downstream from Merwin Dam are higher during the late summer, fall, and winter due to flow augmentation (for fish) and reservoir level reductions for peak flow storage. Normal daily flows are lower during the spring as reservoirs are re-filled for the summer recreation season (See PacifiCorp and Cowlitz PUD 2002, WTS 2, Figure 2.2-9).

Operation of the projects reduces the frequency of flows in the 10,000-20,000 cfs range and results in a “stepped” pattern of flows (See PacifiCorp and Cowlitz PUD Final 2001 Technical Report [PacifiCorp and Cowlitz PUD 2003], WTS 2, Figure 2.2-36).

Operation of the projects for flood control has reduced the magnitude of all but the largest peak flows. (See PacifiCorp and Cowlitz PUD Final 2001 Technical Report [PacifiCorp and Cowlitz PUD], FLD 1, Figure 11.1-2).

The more stable flow regime provides additional area of aquatic habitat in the summer months and reduces the frequency of scouring flows during the winter months.

Reduced spring time flows may have an impact on out-migrating smolts.

The stable flow regime reduces the frequency of bedload transport, reduces the disruption of riparian and active bar habitats and alters the formation of riparian habitat. The more stable channel reduces the rate and magnitude of aquatic and riparian habitat disturbance that would take place if the river was not managed, which affects ecosystem processes and may be detrimental to aquatic species and habitats.

The amount of riparian vegetation in the reach below Merwin Dam has increased since 1939 and the amount of riverine habitat has decreased. Both of these effects are the result of channel narrowing due to decreased flows. Although the reduced flooding has probably resulted in changes to the diversity of riparian habitat types below Merwin, the overall amount of habitat has actually increased. (see PacifiCorp and Cowlitz PUD 2002, TER-9, Section 5.9.5.3). The lack of flooding and reduced sediment load has resulted in less unconsolidated shoreline and fewer exposed bars, and thus less available habitat for cottonwood trees, which require bare mineral soil and moist conditions to germinate.

1.4 Rapid decreases in stream flow associated with hydroelectric project operations (i.e., changes in generation, shutdowns associated maintenance, powerhouse failures, or other activities) have the potential to adversely affect aquatic resources.

As water rapidly recedes (faster than what would occur naturally) potential impacts can include the stranding of fish in shallow low gradient areas and off-channel habitat (resulting in immediate or delayed mortality); temporary loss of habitat or loss of habitat access; and the dewatering of fish redds, aquatic insects, and plant life. Relatively rapid changes in streamflow can also affect fish behavior, which could reduce survival or growth. In 1993, PacifiCorp implemented a voluntary 2-inch per hour down-ramping rate below Merwin Dam to protect aquatic resources. While this ramping rate meets WDFW criteria, project related flow fluctuations still have the potential to affect aquatic resources (See PacifiCorp and Cowlitz PUD 2002, AQU3 and PacifiCorp and Cowlitz PUD 2003). In the past, multiple fish losses have occurred in the Lewis River as a result of project-induced changed in river stage. PacifiCorp and Cowlitz PUD (2000) documents 5 separate incidents of rapid flow reductions that resulted in fish kills in a 2-year period.

1.5 Operation of the projects results in changes in reservoir water levels on a daily and seasonal basis. Fluctuations of water levels can affect near shore aquatic habitat, wetlands, and vegetation.

2.0 The project reservoirs trap sediment, limiting the input of sediment to reaches downstream of project facilities (the Lewis River bypass reach, Speelyai Creek downstream of the upper diversion, and the reach downstream of Merwin Dam).

2.1 Input of sediment to the Lewis River bypass reach is limited to input from Ole Creek (2.6 miles downstream of Swift Dam) and re-distribution of stored sediment within the reach (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-9).

The limited input of sediment, coupled with occasional large peak flows results in a coarse-grained streambed with limited spawning habitat in the reach (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-10 and 2.3-11, Figure 2.3-14 and 2.3-15).

2.2 Input of sediment to Speelyai Creek downstream of the upper diversion is limited to tributary input (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-17).

The lack of large peak flows results in a stable streambed with cobble/gravel substrate and spawning-sized gravel distributed through the lower Speelyai reach (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-18 and 2.3-11, Figure 2.3-20).

Sediment inputs include those associated with development and timber harvest in the lower Speelyai basin. Increased development close to the stream can take place since the streamflows are controlled by the upper diversion. Increased development may increase future sediment loads.

2.3 Input of sediment to the Lewis River downstream of Merwin Dam is limited to input from tributaries and side-slope landslides (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-3).

The limited input of sediment, coupled with smaller magnitude peak flows, has resulted in a less active channel in the reach downstream of Merwin Dam (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Figure 2.3-1a through 2.3-1f, Figure 2.3-3, and Table 2.3-5). Some stakeholders feel that the channel has incised. The loss of active bars appears to have slowed down or stopped since the mid 1970's. Some stakeholders feel that the evidence for the slowing of channel change is not definitive.

The extremely low water surface gradient and lower peak flows in the reach downstream of Merwin Dam results in computed very low sediment transport rates (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Figures 2.3-21 and 2.3-22). There is a mix of substrate sizes on the river bed and spawning-sized gravel resources throughout the reach that are used by spawning fish (Figures 2.3-6 through 2.3-10, Table 2.3-8). Some stakeholders feel that the gravel resources are stable in this reach, while other stakeholders feel that the gravel is continuing to be transported downstream at a rate that threatens the viability of spawning resources. There is some uncertainty regarding the rate of gravel and sediment transport in this reach that would best be documented through a monitoring program.

The reduced input of sediment also affects sediment inputs to the Columbia River, estuary, and Pacific Ocean.

3.0 The project reservoirs trap large woody debris, limiting the input of woody debris to reaches downstream of project facilities (the Lewis River bypass reach, Speelyai Creek downstream of the upper diversion, and the reach downstream of Merwin Dam).

3.1 Input of large woody debris to the Lewis River bypass reach is limited to input from Ole Creek.

The limited source of large wood in the riparian area of the Lewis River bypass reach, coupled with occasional large peak flows results in very little large woody debris in the channel (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Section 2.3.5.2). The lack of large wood limits aquatic habitat diversity. Large boulders in the reach provide some habitat diversity and cover.

3.2 Input of large woody debris to Speelyai Creek downstream of the upper diversion is limited to input from within the reach.

There are high levels of large woody debris in the lower Speelyai reach (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-21).

3.3 Input of large woody debris to the Lewis River downstream of Merwin Dam is limited to input from within the reach.
There is currently little large woody debris in the Lewis River between Merwin Dam and Eagle Island (See PacifiCorp and Cowlitz PUD 2002, WTS 3, Table 2.3-7). The lack of wood is the result of cumulative effects of project and non-project actions: removal of wood from the channel long before the projects were constructed, the lack of input from upstream sources (project effect), and low recruitment of large wood from within the reach due to previous harvest of the riparian areas and the more stable channel and peak flow regime (project effect).
LWD in large rivers has been shown to create and maintain floodplain habitat (Sedell and Foggart 1984 in Agee 1988), primarily by forming logs jams on the apex of point bars. These structures are very stable and are therefore able to resist channel migration over time and protect the riparian habitat that develops (Abee and Montgomery 1996). Bar apex jams typically form around very large logs with attached root wad. Although Merwin Dam blocks the movement of LWD from upstream into the lower river, it has been shown that local wood recruitment is important to the formation and jams. Rivers bordered by agricultural areas, development, and clearcuts have fewer log jams than those with intact riparian forests (Collins et al. 2002).
3.4 The trapping of woody debris by project reservoirs reduces the net wood biomass reaching the Columbia River, estuary, and Pacific Ocean.
Cumulative effects of changes to inputs of water, wood, and sediment (1.0, 2.0, and 3.0):
The combined effects of the changes to flow patterns and the trapping of sediment and gravel transported into project reservoirs has resulted in relatively stable channel configurations in lower Speelyai Creek and the Lewis River downstream of Merwin Dam. In the Lewis River bypass reach, the changed regimes have resulted in coarse substrate and a narrower wetted channel with relatively large peak flows relative to low flows. The large peak flows drastically alter aquatic and riparian habitat conditions.
The secondary effects of these changes to water, wood, and sediment inputs include:
Reduced aquatic habitat complexity (loss of in-channel and side-channel habitat).
Reduced chance for the long-term development of riparian habitat since flooding and sediment accumulations of riparian habitats and floodplain areas has been reduced (See: Fetherston et al. 1995; Bisson et al. 1987 and supporting cites; Abbe and Montgomery 1996).
Reduction of spawning habitat for fish, and invertebrates.
Loss of biological diversity.

4.0 Merwin, Yale, and Swift dams have blocked access to a non-field-verified 176 miles[4] of potentially accessible anadromous fish habitat in the upper Lewis River basin, resulting in the extirpation of the preponderance of the population of naturally producing salmon and steelhead of the North Fork Lewis River.

This represents a loss of historical spawning, rearing and migration habitat for anadromous salmonids, sturgeon, smelt, and lamprey, resident salmonids, and other resident fish. It also reduced historical prey abundance for piscivorous fish and wildlife (i.e., eagles, osprey, kingfisher, mergansers, river otter, bull trout, rainbow trout, cutthroat trout) in habitats upstream of Merwin Dam (See PacifiCorp and Cowlitz PUD 2002, AQU1 and AQU4).

The dams block the transport of marine-derived nutrients to upstream areas. This can reduce the productivity of upstream reaches.

5.0 None of the project dams on the Lewis River are equipped with downstream fish passage facilities.

Downstream migrating fish are subject to both spillway and intake entrainment, both of which have the potential to injure or kill migrating fish (See PacifiCorp and Cowlitz PUD 2002, AQU5 and PacifiCorp and Cowlitz PUD 2003).

6.0 The Speelyai Hatchery diversion dam (lower Speelyai Creek diversion) and upper Speelyai Creek diversion block access into Speelyai Creek and divert upper basin flows into Yale Lake (See PacifiCorp and Cowlitz PUD 2002, AQU9 and PacifiCorp and Cowlitz PUD 2003).

7.0 The Lewis River Projects prevent the normal migration of bull trout into, out of, and between river reaches from Merwin Dam to Swift Reservoir, interfering with natural metapopulation processes (i.e. prevents genetic exchange between Yale and Swift populations) (See PacifiCorp and Cowlitz PUD 2002, AQU1 and PacifiCorp and Cowlitz PUD 2003).

8.0 Merwin, Yale, and Swift dams converted approximately 39 miles of mainstem riverine habitat into reservoirs in addition to habitat in the lower reaches of inundated tributaries.

This change from river to reservoir habitat has reduced the production potential of the upper Lewis River basin (See PacifiCorp and Cowlitz PUD 2003).

The inundated channels previously provided an additional source of large woody debris and were a conduit for transport of sediment from upland sources.

9.0 The creation of relatively slow moving reservoir habitat in Lake Merwin and Yale Lake has resulted in the proliferation of northern pikeminnow. Northern pikeminnow are known to prey heavily upon juvenile salmonids (See PacifiCorp and Cowlitz PUD 2002, AQU1).

The increase in the northern pikeminnow population was blamed for the failed efforts to raise coho in Lake Merwin (See PacifiCorp and Cowlitz PUD 2002, AQU8 and PacifiCorp and Cowlitz PUD 2003).

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[4] Estimate based on data from USGS 7.5 minute quads. Field surveys combined with a review of existing USFS data (PacifiCorp and Cowlitz PUD 2002) indicated that approximately 96 miles of potentially accessible anadromous fish habitat existed above Merwin Dam.

10.0 Merwin Project operations, lost access to upper basin habitat, no downstream fish passage facilities, and early hatchery practices contributed to the extinction of the native Lewis River spring chinook stock (See PacifiCorp and Cowlitz PUD 2002, AQU1 and AQU8).

11.0 Operation of the Lewis River Hatchery Complex, and other hatchery facilities in the region, have altered the genetic structure and life history diversity of native anadromous salmonids (chinook, coho and steelhead) in the Lewis River basin and increased the risk of disease transmission between hatchery and wild stocks.

The lack of empirical, historical information makes it impossible to fully describe the extent of these changes (See PacifiCorp and Cowlitz PUD 2002, AQU8 and PacifiCorp and Cowlitz PUD 2003).

12.0 Management of the recreation fishery in the Lewis River reservoirs has resulted in the introduction of several nonnative species including kokanee, tiger muskellunge, and a nonnative stock of rainbow trout, and in some cases, has resulted in the accidental release of species into areas where release was not evaluated or planned (2000 Technical Report [PacifiCorp and Cowlitz PUD 2001] AQU 7-3. p. 7-3).

The presence of these species together with altered habitat has changed the "natural" ecological processes in the basin and created the potential for negative or positive interactions with native species (i.e., increase competition for food, hybridization, loss of genetic fitness, and increased predation) (See PacifiCorp and Cowlitz PUD 2002, AQU8 and PacifiCorp and Cowlitz PUD 2003). However, without the changes to the system, it would have not been possible to implement the recreation fisheries in the Lewis River reservoirs.

13.0 Recreational fishing associated with the project reservoirs increases fishing pressure on native stocks, including endangered species. For example, fishermen in Swift Reservoir and its tributaries occasionally harvest bull trout (See PacifiCorp and Cowlitz PUD 2002, AQU1 and AQU8, PacifiCorp and Cowlitz PUD 2003). The location of the Lewis River and Merwin hatcheries, and the resultant mixed sports fishery near these facilities, may also increase impacts on wild salmon and steelhead.

14.0 Operation of the Lewis River Projects has altered water quality and water temperature in the project-affected reaches of the Lewis River.

Water temperature in the lower portion of the Lewis River bypass reach occasionally exceeds the WDOE water temperature standards (See PacifiCorp and Cowlitz PUD 2002, WAQ1 and PacifiCorp and Cowlitz PUD 2003).

Water temperature in the lower portion of Speelyai Creek is up to 5°C cooler than that observed upstream of the PacifiCorp diversion (See PacifiCorp and Cowlitz PUD 2002, AQU9 Figure 4.9-6).

Water temperature in the Merwin tailrace is consistently higher than that observed at the upstream end of Swift Reservoir. The largest differences in daily mean temperature occurs in September through December, when Merwin tailrace temperatures are generally between 4 and 10°C warmer than the inflow to Swift Reservoir (See PacifiCorp and Cowlitz PUD 2002, WAQ1 Figure 3.1-5, and PacifiCorp and Cowlitz PUD 2003).

Changes in generation at the Yale powerhouse cause fluctuations in water temperature and pH in upper portion of Lake Merwin (surface water temperature can fluctuate as much as 10°C; see PacifiCorp and Cowlitz PUD 2002, WAQ1 Figure 3.1-2 and 3.1-3, PacifiCorp and Cowlitz PUD 2003).
Surface waters warm and thermoclines are developed in project reservoirs (See PacifiCorp and Cowlitz PUD 2002, WAQ1)
Operational effects of the projects have caused exceedences of TDG standards at Swift No. 1, Swift No. 2 and Yale tailraces when the projects are ramped up to full load (see PacifiCorp and Cowlitz PUD 2002, WAQ 2 and WAQ 4).
Concentrations of phototoxic polycyclic aromatic hydrocarbons (PAHs) in Yale Lake approach levels that are toxic to zooplankton and fish, exceeding known no-effects levels, but not exceeding effects concentrations (based on Lake Tahoe data; see PacifiCorp and Cowlitz PUD 2002, WAQ3).
The projects alter the form and quantity of nutrients flowing from upstream habitats to the reach below Merwin Dam, and hatchery operations have affected nutrient levels downstream of the hatcheries (PacifiCorp and Cowlitz PUD 2002, WAQ1). Some stakeholders feel this could affect primary and secondary productivity of the river downstream of the projects and reduce the number, size, and weight of juvenile fish in these habitats.
The lack of anadromous fish access to habitats above the dams has eliminated the input of marine derived nutrients (See PacifiCorp and Cowlitz PUD 2002 AQU8, PacifiCorp and Cowlitz PUD Final 2001 Technical Report WAQ 1, and PacifiCorp and Cowlitz PUD 2003). It is likely that several hundred tons of marine derived nutrients, in the form of salmon and steelhead carcasses, entered the upper Lewis River basin prior to the completion of Merwin, Yale, and Swift dams.
15.0 Operation of the Lewis River Projects affects wetlands that are hydrologically connected to project reservoirs.
There are 7 wetlands that are hydrologically connected to the reservoirs—3 at Merwin, 3 at Yale, and 1 at Swift. Of these, all 3 wetlands at Merwin and 1 at Yale do not have other sources of water and are affected by drawdown. These wetlands are not likely to attract breeding amphibians because they do not contain water during the breeding season. Amphibians successfully breed in the other 4 hydrologically connected wetlands.

Logging – Timber harvesting is one of the most important industries in southwestern Washington, and the majority of the land in the Lewis River basin is devoted to this use. Since settlers first arrived in the area in the mid-1850s, logging and road building have been the dominant activity in the landscape. By the late 1890s, formal logging operations were established at Speelyai (near lake Merwin) and other locations. Over time, the logging industry expanded greatly in the area and there are now numerous public and private logging interests operating in the watershed.

Today, the USFS, the largest public landholder in the Lewis River watershed, manages approximately 321,000 acres of non-wilderness Federal forest lands. Since about 1940, approximately 31 percent of the National Forest land within the agency's 166,000-acre Lower Lewis River Watershed Analysis area has been subject to intensive timber harvest (USFS 1996). This area includes lands drained by Panamaker, Cougar, Swift, Marble, Pine, Drift, Siouxon, and Canyon creeks, and several smaller streams (Figure 4.18-2). All of these streams are located above Merwin Dam. Overall harvest rates for the Pine Creek drainage, a major tributary to the North Fork Lewis River above Swift Dam, were calculated at 75 percent for the upper basin, 69 percent for the middle basin, and 52 percent for the lower basin (USFS 1996). The riparian areas or "riparian reserves" surrounding the vast majority of the tributaries in the USFS Lower Lewis River Watershed Analysis Area are impaired and have been severely affected by timber harvest, volcanism, fire and floods. According to this same document, it could take "a century or more before historic levels are reached." It is important to note that the Pine Creek and Swift Creek drainages previously were privately owned and were acquired by the USFS in an effort to consolidate its ownership south of Mount St. Helens.

Approximately 28 percent of the land in the USFS's "Middle Lewis River Watershed Analysis" area has been harvested since 1950, with a much higher proportion of that harvest occurring on privately owned lands (USFS 1995). The 102,000-acre "Middle Lewis River Watershed Analysis Area" begins at the confluence of the Muddy River and includes lands drained by Alec Creek, Chickoon Creek, Crab Creek, Big Creek, Little Creek, Meadow Creek, Rush Creek, Curley Creek, Outlaw Creek, Hardtime Creek, Miller Creek, Drift Creek, Range Creek and several smaller streams. All of these streams are located upstream of Swift Dam. The riparian reserves in this portion of the basin have been severely impacted by timber harvest activities; however, they are not as heavily impacted as the USFS Lower Lewis River Watershed Analysis Area. The Upper Lewis River Watershed Analysis (USFS 1998a) provides detailed information regarding habitat in the Lewis River and tributaries upstream of Lower Falls (outside of the potential anadromous fish reintroduction zone).

In addition to lands managed by the USFS, the upper portion of the Lewis River basin contains large private and public land holdings actively managed for timber production. The Washington State Department of Natural Resources (DNR) owns approximately 87,000 acres of forestland and has extensive holdings within and adjacent to the Lewis River Projects. Private industrial forest landowners (Weyerhaeuser, Pope Resources, and Longview Fibre) own approximately 98,000 acres of land in the watershed. A large percentage of these state and private lands, including riparian areas adjacent to streams, have been subject to intensive timber harvest and roading, at levels that are higher than

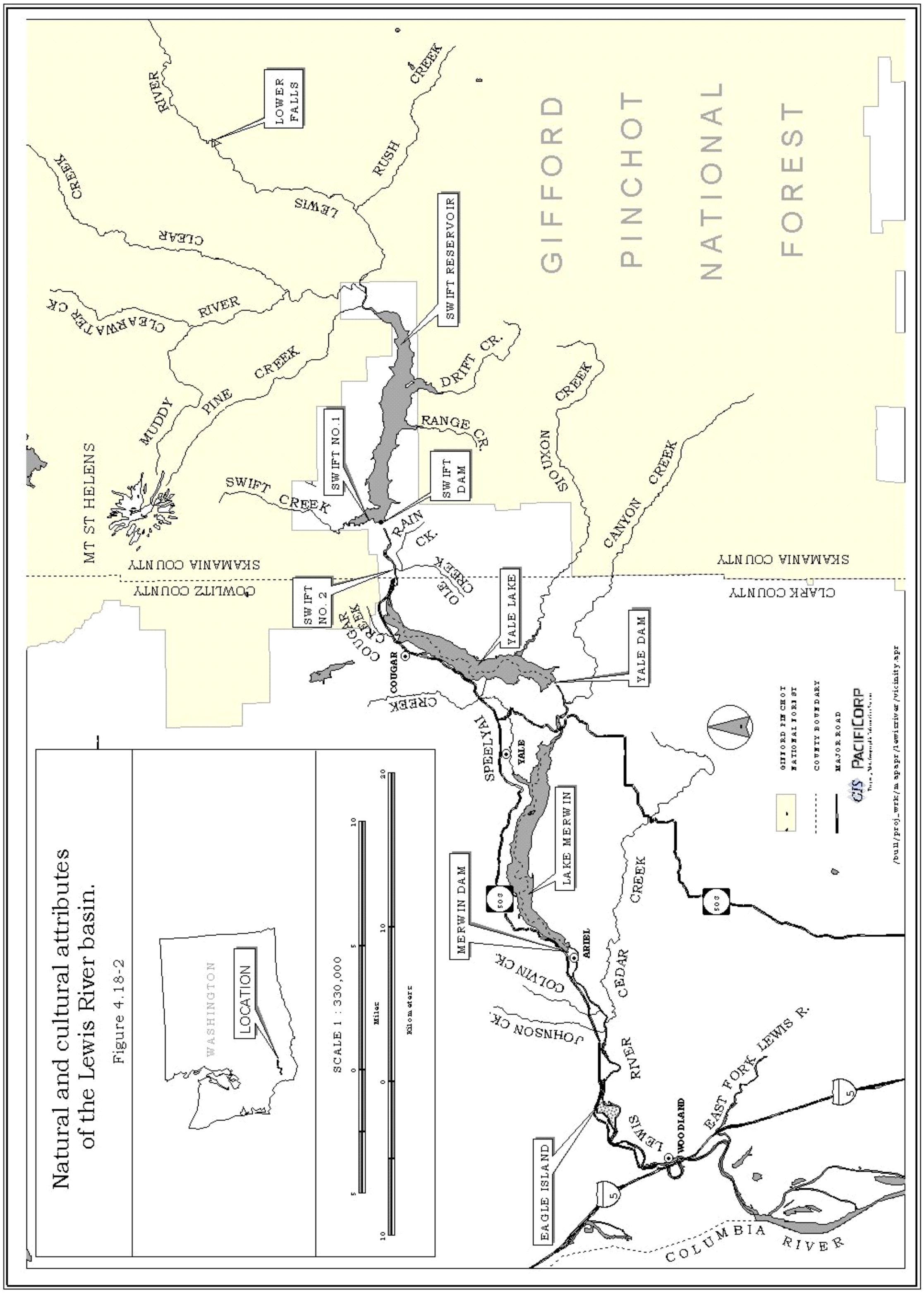


Figure 4.18-2. Natural and cultural attributes of the Lewis River basin.

those on National Forest lands. Most clearcutting in the Lewis River basin currently occurs on private lands located adjacent to the reservoirs.

In the past 150 years, logging activities have altered the vegetation structure of the Lewis River watershed. Old growth forests, with some fire-induced young and intermediate aged stands, once dominated the area. Currently the age classes of vegetation in the watershed are much more fragmented, with many small blocks of young, intermediate, and mature stands (PacifiCorp and Cowlitz PUD 2002).

Prior to active state and federal regulation of forest practices, fishery habitat was damaged throughout the Lewis River basin. Indiscriminate logging around and through streams, the use of splash dams to transport logs, poor road construction and inadequate culverts reduced or eliminated anadromous fish from many streams (WDW 1990). In addition, logging in riparian zones and hillslopes decreases shade, increases water temperatures, decreases the supply of large woody debris, alters streamflows, and increases streambank erosion (Murphy 1995). As described above, many of these impacts to aquatic habitat have been documented in both the upper and lower Lewis River basin (USFS 1996, USFS 1995, Wade 2000). Such effects are important to consider as plans for anadromous fish reintroduction move forward. The potentially accessible streams above Merwin Dam with the highest quality habitat (the least amount of impacts) should be the focus of initial reintroduction efforts. As riparian and instream habitat conditions begin to improve in the more degraded streams over time, either natural colonization or supplementation (coupled with monitoring) may lead to an overall increase in natural production. However, it can take years, and possibly decades for instream and riparian habitat conditions to improve over baseline conditions.

Roads – Interstate 5 bisects the lower Lewis River watershed. In addition, numerous arterials and local access roads have been constructed to serve the small towns and residential developments throughout the basin. State Route (SR) 503, also known as the Lewis River Road, is the major east-west transportation route along the Lewis River. Use of this road has increased substantially since the creation of the Mount St. Helens National Volcanic Monument. As mentioned previously, much of the Lewis River basin is managed as commercial forest, and as a result, it contains numerous logging roads managed by the counties, DNR, USFS, and private landowners.

According to Wade (2000), road densities in the Lewis River basin (up to Merwin Dam) average 4.48 miles per square mile. In the East Fork Lewis River basin, road densities average 4.13 miles per square mile (WDFW 1998a). The average road density within the USFS Lower Lewis River Watershed Analysis Area, between the upper portions of Yale Lake (RM 42.4) to just above Pine Creek (RM 59.5), is 3.41 miles per square mile (USFS 1995). Pine Creek is one of the most densely roaded subbasins within the analysis area with 6.44 miles of road per square mile. In the USFS Middle Lewis River Watershed Analysis area, from above Pine Creek (RM 59.5) to just above Alec Creek (RM 74.7), the average road density is 2.53 miles per square mile. These road densities on National Forest System lands are significant, as areas exceeding 3.0 miles of road per square mile are thought to have high potential for road-related environmental degradation (USFS 1996). Information regarding road densities on private and state forest lands could not be found, although the USFS suspects that they would be equal to, or higher than those on federal lands (USFS 1996). Furthermore, stream crossings on USFS lands range from 0.8 to 1.7 per mile, while values of 1.5 stream crossings per mile can result in high levels of aquatic and riparian habitat fragmentation (USFS 1996).

Recently, federal and state funding have been made available to improve fish passage associated with stream crossings and also to decommission unused logging roads. Such efforts are guided by applicable federal and state forest management regulations.

Tribal Uses –The 2 predominant Native American groups that originally resided in the Lewis River watershed were the Cowlitz Tribe and the Yakama Nation. A Native American group of several dozen people resided along the Lewis River until at least the 1880s, but information regarding this group is incomplete. No village locations or other resource use areas are known within the immediate Lewis River Project area; however, the region is known to have been used by Native Americans for deer hunting and fishing (PacifiCorp 1999). In addition, the Klickitat Trail, a major Indian travel and trade route, crossed the upper Lewis River near Yale Lake and continued east along the river for approximately 30 miles. Along this route were villages, camps, and resource sites used by the Klickitat.

The current tribal fishery in the Columbia River basin has little or no affect on Lewis River stocks, since this fishery occurs on the Columbia River above the Lower Columbia River Management Area (WDFW 2001a).

Recreation – Recreation is one of the most important land uses in the Lewis River watershed. There are numerous recreational land managers in the basin including PacifiCorp and Cowlitz PUD, DNR, WDFW, USFS, Clark County, and private entities. Primary recreation activities include camping, hunting, fishing, hiking, biking, boating, and other outdoor activities. In the Lewis-Kalama River watershed there are over 126 developed recreational access sites (WDFW 1998a). Creation of the Mount St. Helens National Volcanic Monument substantially increased the number of visitors to the Lewis River watershed.

As would be expected, peak use of the Lewis River watershed’s recreation facilities occurs during the summer. Summer campground occupancy ranges from about 35 to 52 percent, while day use sites operate at about 35 to 52 percent of maximum capacity (PacifiCorp and Cowlitz PUD 2002). To meet recreation demand in the watershed, projections suggest that over the next 30 years there will need to be additional campsites, day use or picnic areas, and boat launches. In addition, expansion of existing swimming areas, interpretation and education sites, and trails may be needed (PacifiCorp and Cowlitz PUD 2002).

Recreation anglers currently target Lewis River stocks in the lower mainstem Columbia River, mainstem Lewis River and tributaries, and project reservoirs. Between 1980 and 1998, an average of approximately 4,300 spring chinook, 1,400 fall chinook, 3,500 coho, and 7,500 steelhead were harvested in the Lewis River and its tributaries annually (PacifiCorp and Cowlitz PUD 2002). In addition, the Lewis River reservoirs support very popular rainbow trout, cutthroat trout and kokanee fisheries. The stocking of fish in the Project reservoirs likely increases traffic and the number of visitor days in the basin.

<u>Harvest and Hatcheries</u> – Sport and commercial harvest are 2 cultural activities that have a direct effect on native fishes in the Lewis River.

Harvest – Prior to the completion of Merwin Dam, Lewis River salmon and steelhead were relatively unaffected by hatchery or hydropower operations (PacifiCorp and Cowlitz PUD 2002). However, beginning in the late-1800s, the number of salmon and steelhead returning to the Columbia River was severely reduced by an intensive in-river and ocean commercial harvest (Lichatowich and Mobrand 1995, NRC 1996, ISG 2000). The harvest of Columbia River chinook salmon peaked in 1883 at 42,799,000 pounds, and from 1884 through 1920, an estimated 20 to 50 million pounds of chinook, coho, chum and steelhead were removed from the system annually (Craig and Hacker 1940, ISG 2000) (Figure 4.18-3). As catches of chinook began to decline in the early 1920s, the industry shifted to different species to maintain production (Lichatowich and Mobrand 1995).

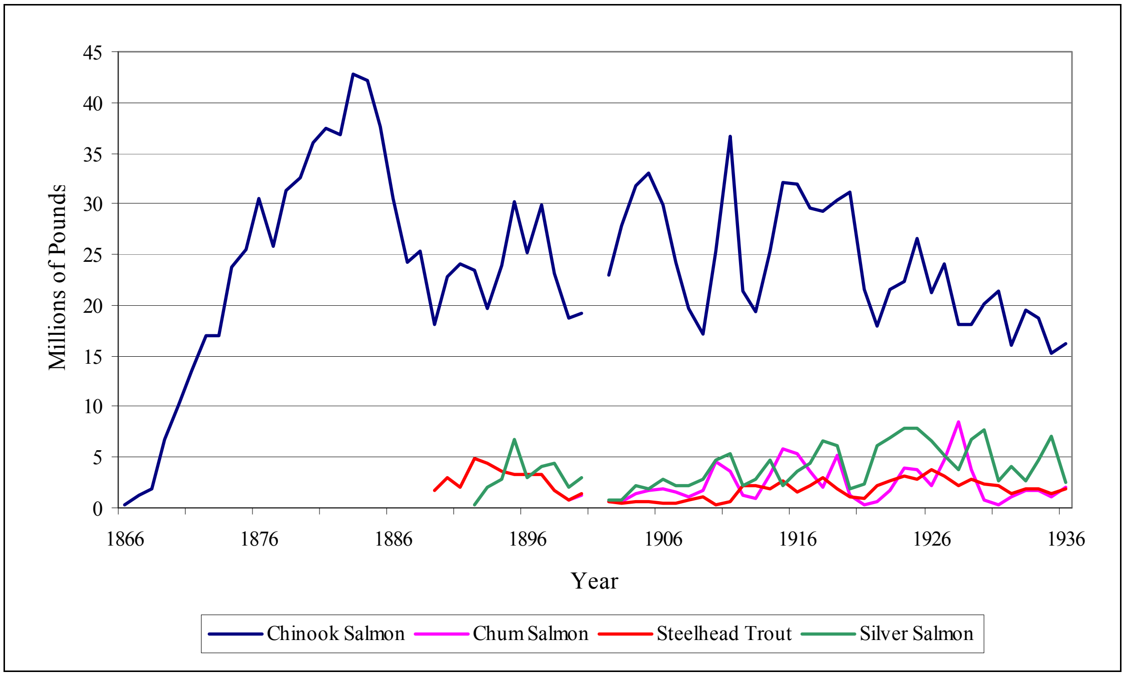


Figure 4.18-3. Columbia River salmon and steelhead harvest in millions of pounds (1866 through 1936).

The early fishery occurred throughout the Columbia Basin, but it was concentrated in the lower 20 miles of the mainstem. The amount of gear (gill nets and traps) employed and the intensity of the fishing were so great that at times canneries just 20 miles upriver could not obtain enough fish. They had to send their fishermen to the mouth of the Columbia to obtain their supply of fish (Lichatowich et al. 1999).

This excessive harvest combined with widespread habitat loss and/or degradation acted synergistically to reduce abundance of Columbia River basin salmon stocks, and it undoubtedly reduced the abundance of salmon and steelhead in the Lewis River basin prior to the construction of Merwin Dam. Unfortunately, the magnitude of these impacts is unknown.

Today, Lewis River salmon and steelhead continue to be exploited by commercial and recreation fisheries. Lewis River spring chinook are taken in the commercial fisheries in the Pacific Ocean off Alaska, Canada, and the northwestern U.S. In past years, these fish were also subject to significant harvest in the mainstem Columbia River. According to NMFS, BIA and USFWS (2000), the ocean fisheries' exploitation rate of lower Columbia River spring chinook, including Lewis River spring chinook, is 15.6 percent (based on 2000 model estimates). The Lewis River spring chinook sport fishery harvest rate has averaged about 60 percent of the total basin return (1988 to 1999 data) (WDFW 2001a). The actual number of spring chinook taken in the Lewis River recreation fishery from 1980 to 1998 has ranged from 394 fish in 1996 to 10,382 in 1987, and averaging approximately 4,300 (Table 4.18-2) (PacifiCorp and Cowlitz PUD 2002).

Table 4.18-2. The average number of salmon and steelhead harvested in the Lewis River recreation fishery based on punch card returns to WDFW.

Species/Stock	Average Annual Recreation Harvest	Data Range
Spring Chinook	4,300	1980 through 1998
Fall Chinook	1,400	1980 through 1998
Coho	3,500	1980 through 1998
Winter Steelhead	3,400	1962 through 1998
Summer Steelhead	3,600	1962 through 1998

Native Lewis River fall chinook are harvested primarily off Alaska and Canada. Total commercial harvest rates of this stock averaged 49 percent from 1977 through 1990 and 28 percent in 1991 and 1992 (NMFS, BIA and USFWS. 2000). The Lewis River fall chinook recreation fishery is managed for an escapement goal of 5,700 adult spawners. In years where tributary run size is expected to exceed the escapement goal, a sport fishery is open. From 1996 through 2000 the recreation fishery was closed for all or part of the season due to low escapement (< 5,700 fish). The number of fall chinook harvested in the Lewis River recreation fishery from 1980 to 1998 based on punch card returns has ranged from 8 in 1998 to 3,057 in 1988, averaging approximately 1,400 (Table 4.18-2) (PacifiCorp and Cowlitz PUD 2002).

The majority of Lewis River coho are harvested off the Oregon and Washington coasts. For the 1991 through 1994 broods, contribution rates of Lewis River Type-N coho were approximately 13 percent to Washington coastal fisheries, 8 percent to the Canadian troll, and 6 percent to the Columbia River net fisheries. Escapement accounted for about 66 percent of the total survival (Byrne and Fuss 1999). Contribution rates for Type-S coho were 8 percent to the Washington coastal fishery, and 5 percent to the Oregon sport fishery. Escapement accounted for the majority (85 percent) of the total Type-S coho survival. The number of coho salmon harvested in the Lewis River recreation fishery from 1980 through 1998 based on punch card returns has ranged from 739 in 1994 to 8,673 in 1991, and averaged approximately 3,500 (Table 4.18-2) (PacifiCorp and Cowlitz PUD 2002).

Steelhead retention is prohibited in commercial ocean fisheries and as a result, they are rarely caught in the marine environment (WDFW 2001a; NMFS, BIA, and USFWS 2000); however, Lewis River steelhead support a popular in-river recreation fishery. Between 1962 and 1998 the annual recreation harvest of winter steelhead in the Lewis basin ranged from 403 in 1997 to 6,869 in 1980, and averaged approximately 3,400 (Table 4.18-2). Annual harvest of summer steelhead has ranged from 359 in 1962 to 8,714 in 1986, averaging approximately 3,600 (PacifiCorp and Cowlitz PUD 2002).

Hatcheries – Hatchery production of Pacific salmon began in the late nineteenth century and ever since it has played a pivotal role in the management of anadromous salmonids in the Columbia River basin. Early hatchery programs focused almost exclusively on increasing the abundance of adult salmon for harvest (ISG 2000). More recently, the goal of most hatchery programs has been mitigation. The prevailing belief was that hatchery production, a relatively new and untested technology, would more than compensate for over-harvest and lost habitat. Fish hatchery management in the Lewis River basin dates back to 1909.

<u>Johnson Creek Hatchery</u> - From 1909 through 1917, a salmon hatchery was operated on Johnson Creek at Lewis River Mile (RM) 15 to “handle” fall chinook and chum salmon (WDF and USFWS 1951). Between 1918 and 1930, there were no known hatchery operations in the Lewis River basin, although a fish rack was maintained on Cedar Creek “for some years” (WDF and USFWS 1951). It is unclear from existing literature why the Johnson Creek facility was closed in 1917.

<u>Lewis River Hatchery</u> – When Merwin Dam was completed in 1932, natural upstream resident and anadromous fish passage was blocked at River Mile [RM] 19.4 (PacifiCorp and Cowlitz PUD 2002). To help maintain anadromous fish runs and to mitigate for lost natural production, Inland Power and Light, the Washington Department of Fisheries and the Washington Department of Game built the Lewis River Hatchery and Merwin Dam Anadromous Fish Collection Facility (Inland Power and Light Company 1932, Hamilton et al. 1970). Inland Power and Light funded the construction of both facilities, although they were, and continue to be, operated by WDFW. The original goal of the Lewis River hatchery program, as written in the initial project license, was to “maintain existing conditions of fish migration and fish culture in the Lewis River as the Secretary of Commerce may consider necessary.” The belief was that the Lewis River Hatchery would fully mitigate for the habitat losses associated with completion of Merwin Dam.

Theses facilities became fully operational in 1932, although juvenile salmon stocking began as early as 1930. During subsequent years, returning adult anadromous fish were collected at the Merwin trap, counted, and either used for hatchery broodstock or transported upstream by truck to spawn naturally in the upper Lewis River and its tributaries.

Between 1933 and 1953, Lewis River Hatchery practices were generally poor and adult spring and fall chinook returns to the Merwin Dam trap declined dramatically (Section 4.18.5.4). According to Smith (1937), “poor water supply, disease, faulty technique and inherent weakness of the spawning fish themselves” were responsible for the decline in abundance. The number of coho caught in the trap also decreased in 1935 and 1938, but then recovered and remained relatively stable through 1953 (Section 4.18.5.4). The decrease in coho returns during the late 1930s was blamed on "poor or intermittent spilling" over Merwin Dam during the outmigration period (Smoker et al. 1951). According to Smoker et al. (1951), this lack of regular spill at Merwin Dam resulted in extensive mortality by either preventing downstream migration or forcing migration through the turbines (where juvenile salmonids were subject to turbine related injury or mortality). While the reduced coho runs were blamed on a lack of spill, operator logs for this period show that spill occurred at Merwin Dam nearly every day during the late winter and early spring (PacifiCorp unpublished data). Unlike chinook and coho, steelhead returns to the Lewis River remained relatively consistent from 1932 through 1951 (Section 4.18.5.4).

In an attempt to minimize Lewis River Hatchery-related mortality, the WDF constructed a hatchery facility near the mouth of Cougar Creek, located approximately 18 miles upstream from Merwin Dam. Completed in 1938, the Cougar Creek facility consisted of a small hatchery building, a residence, 2 holding ponds and 4 rearing ponds. All ponds were formed of earth with gravel bottoms (WDF and USFWS 1951). With improved water quality conditions, spring chinook survival increased dramatically during holding; however, this facility eventually was decommissioned in the late 1950s during the construction of Yale Dam. Operations were relocated to Speelyai Creek.

<u>Speelyai Hatchery</u> – During the planning phases for the Swift No. 1 and Swift No. 2 projects in the mid-1950s, an investigation was conducted by the WDF to predict the effects of the new hydroelectric projects on coho salmon in the Lewis River. Based on the results of this examination, WDF decided to discontinue transporting and releasing coho salmon into the upper watershed for natural spawning. It was further proposed that all the coho salmon be spawned artificially at a new hatchery to be built on Speelyai Creek (Speelyai Hatchery). The transportation of coho into the upper watershed was discontinued in 1957, 2 years prior to the completion of Swift Dam (Hamilton et al. 1970). Again, it was believed that additional hatchery production would mitigate for the subsequent loss of habitat.

Speelyai Hatchery was completed in 1958 at the confluence of Speelyai Creek and Lake Merwin. Initially, the facility consisted of 2 holding ponds (each measuring 60 by 30 feet) and an incubation station.

In addition to funding the construction and operation of Speelyai Hatchery, PacifiCorp and Cowlitz PUD funded a series of studies to determine if it was feasible to rear coho salmon in Lake Merwin (Hamilton et al. 1970). From 1958 through 1964, coho fry and fingerlings reared at Speelyai Hatchery were released into Lake Merwin and Speelyai Creek. After 6 years of study, it was concluded that Lake Merwin could not be used "under present conditions" as a substitute for the in-river environment for coho salmon (Hamilton et al. 1970). As a result, rearing of coho in Lake Merwin was abandoned in favor of additional hatchery production.

Speelyai Hatchery was expanded in 1970 under conditions set forth in Article 32 of the Swift No. 1 Project and Article 23 of the Swift No. 2 Project licenses. The hatchery diversion, located near the mouth of Speelyai Creek blocks fish access into the creek. A second diversion at RM 4.3 diverts all flow from Speelyai Creek into a canal that discharges to Yale Lake.

Although not part of PacifiCorp's and Cowlitz PUD's mitigation program, there are also 7 net pens located in the Echo Park Cove at RM 10 on the North Fork Lewis River that provide approximately 50,000 cubic feet of rearing space. These net pens are owned and operated by Fish First. WDFW also operates net pens in Lake Merwin near the mouth of Speelyai Creek (Speelyai Bay). These WDFW net pens contain enough rearing space for approximately 60,000 fish

<u>Merwin Hatchery</u> – In 1983, FERC issued a license for the continued operation of the Merwin Hydroelectric Project. Article 50 of the new license required PacifiCorp to fund the construction, operation and maintenance of a new steelhead and sea-run cutthroat trout hatchery on the Lewis River and to make the following provisions for anadromous fish:

> **Spring Chinook Salmon:** The Licensee shall pay all expenses for the annual hatchery production of approximately 250,000 juvenile spring chinook (to produce 12,800 adult fish). This production will take place in existing hatcheries.
>
> **Coho Salmon:** The Licensee shall pay all expenses for the annual hatchery production of approximately 2,100,000 juveniles (to produce 71,000 adult fish). This production will take place in existing hatcheries.
>
> **Steelhead and Sea-Run Cutthroat Trout:** The Licensee shall construct and pay all operating and maintenance expenses of a hatchery to produce annually approximately 250,000 juvenile steelhead (about 41,600 pounds) and approximately 25,000 juvenile sea-run cutthroat trout (up to 6,250 pounds).

Article 51 of the 1983 Merwin Project license also required PacifiCorp to pay the costs associated with the operation and maintenance of such facilities to provide for the following resident fisheries:

> **Lake Merwin:** Annual release of 100,000 kokanee at 7-8 fish per pound. Kokanee releases can be supplemented partially or completely with rainbow trout (same poundage) if insufficient numbers of kokanee are available.
>
> **Yale Lake:** Protection of habitat on that portion of Cougar Creek under control of the licensee, which provides spawning for resident sockeye (kokanee) salmon.
>
> **Swift Reservoir:** Annual release of 800,000 rainbow trout fry at 25-30 fish per pound.

In 1988, WDF and WDW and PacifiCorp entered into an agreement leading to the development and operation of the Merwin Hatchery, the third hatchery facility operating in the Lewis River basin. The Merwin Hatchery became fully operational in 1993 and includes 4 adult holding ponds, 10 concrete fingerling raceways, 6 intermediate raceways, 4 rearing ponds, and incubation facilities. The original goal of the Merwin Hatchery program was to provide winter and summer steelhead, sea-run cutthroat trout, and rainbow trout for harvest by sport anglers (Montgomery Watson 1997); however, the sea-run cutthroat trout program was eliminated in 1999. Prior to 1993, steelhead released in the North Fork Lewis River were reared at other hatcheries (Hymer et al. 1993).

The 3 facilities comprising the Lewis River Hatchery Complex have been releasing chinook, coho, steelhead, and other species into the Lewis River basin for over 70 years (Section 4.18.5.4). Although hatchery production and management strategies have changed over time, the ultimate goal of this program has been to provide adult anadromous fish for commercial and recreation harvest (in the absence of historical habitat). For the most part, the Lewis River Hatchery Complex has been able to do this; however, early hatchery practices, out-of-basin stock releases, mixed-stock fisheries, lost historical habitat due to dam construction, and habitat degradation have adversely affected a number of native Lewis River salmon and steelhead stocks (Section 4.18.5.4). For example, native Lewis River spring chinook disappeared from the basin in the early 1950s, and today the spring chinook population in the Lewis River is a mixture of Carson (upper Columbia River), Cowlitz, Kalama, and Klickitat stocks. The native Lewis River coho population was also altered by extensive stock introductions and early hatchery practices, and is currently a mixture of Cowlitz, Toutle, and Lewis River stocks. Lewis River steelhead are thought to be native, although interbreeding has undoubtedly occurred with introduced stocks from the Cowlitz, Washougal, Elochoman, and Klickitat rivers. Fortunately, native Lewis River fall chinook have remained relatively unaffected by hatchery operations and are one of the few healthy fall chinook stocks in the lower Columbia River. The effects of hatchery fish on other species such as native bull trout and cutthroat trout are largely unknown.

While impacts to most native Lewis River stocks have been substantial, more recent hatchery management goals and practices have focused on reducing hatchery impacts on native and wild (naturally spawning) fish. These goals and management directions, as outlined in the Merwin Hatchery agreement, WDFW’s recent draft Hatchery and Genetic Management Plans (HGMPs) for chinook and steelhead, and in policy documents such as WDFW’s Wild Salmonid Policy, should help to reduce or eliminate the negative effects of hatchery production and operation, and contribute to the conservation and potential recovery of ESA-listed salmon and steelhead (see Section 4.18.5.7). However, continued monitoring and reevaluation of program goals is critical to the success of current and future hatchery programs.

For years, hatchery production mitigated for lost habitat due to dam construction, and it is likely that the Lewis River complex will continue to produce salmon and steelhead. It will also likely play a major role in the potential reintroduction effort. However, if reintroduction succeeds, the existing reliance on hatchery production should diminish as populations of naturally produced salmon and steelhead become established. Defining reintroduction success, implementing measures designed to increase the potential for success, and outlining the steps leading to a potential reduction in future hatchery production are the next logical steps in the process.

4.18.5.3 Historical and Current Habitat Forming Processes

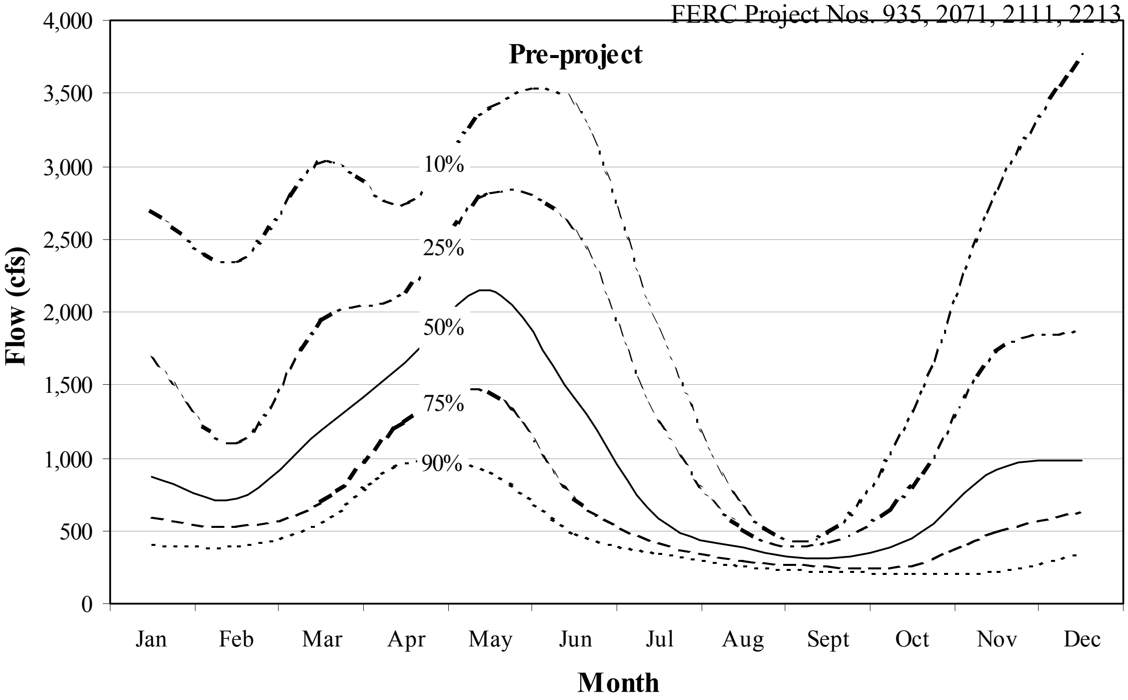
The climate, underlying geology, and vegetation characteristics of a watershed influence the input, transport, and storage of water, sediment, wood, nutrients, heat, and other elements that form aquatic habitat. In addition, human influences (cultural systems) can alter the rate of input, transport, and storage of these elements and alter aquatic habitat. The primary cultural systems in the Lewis River watershed upstream of Swift Dam affecting aquatic habitat are timber harvest and recreation activities. Regulation of the movement of water, sediment, wood, and nutrients by the Lewis River hydroelectric projects, past gravel mining, and urbanization have affected aquatic habitat in the lower river.

There are few, if any, measurements of aquatic habitat conditions prior to the influence of cultural systems in the watershed. However, based on information from similar river systems and our knowledge of watershed processes, the general effects of human influences on aquatic habitat in the Lewis River can be described.

Flow

Historical Flows – The natural flow characteristics of streams in the Lewis River watershed are responsive to the regional precipitation patterns, elevation and geologic features of each stream basin. The moist maritime climate includes a wet season from late fall through spring and a much drier summer, with little precipitation during July, August, and September. Total precipitation, as well as the percentage of precipitation that falls as snow, increases with elevation in the basin. Streamflow patterns of upper basin reaches show a marked spring runoff peak, very low flows in summer and early fall, and a secondary peak resulting from fall and early winter rainstorms (Figures 4.18-4 and 4.18-5). Streams in the lower elevations of the watershed, where a snow pack does not develop, have a fall/winter rainfall peak and low summer flows (Figure 4.18-6). Smaller tributaries in the watershed often show a “flashier” runoff pattern than larger streams. They are more responsive to changes in precipitation, with relatively higher peak to mean flow ratios and lower baseflow to mean flow ratios, as shown by analysis of the Speelyai Creek gage data (Table 4.18-3). Baseflows for most streams in the watershed occur during August, September, and October when little rain falls in the area. Baseflows vary with stream size, but are generally 1/3 to 1/4 of the average annual flow (Table 4.18-3). The exception to this is Speelyai Creek, a small tributary to the Lewis River that has very low baseflows (about 14 times lower than average annual flow).

Note that on Figures 4.18-4 through 4.18-7, the pre-project (upper graph) and with-project (lower graph) periods for these gages show different patterns despite the fact that the gages are upstream of the projects and not affected by project operations or facilities. The median (50 percent exceedence) patterns are similar, although slightly different, between analysis periods, but the higher magnitude flow patterns (lower exceedence values) are quite different. These differences point out the challenges associated with comparing hydrologic data over different time periods, particularly if only short periods of record are available.



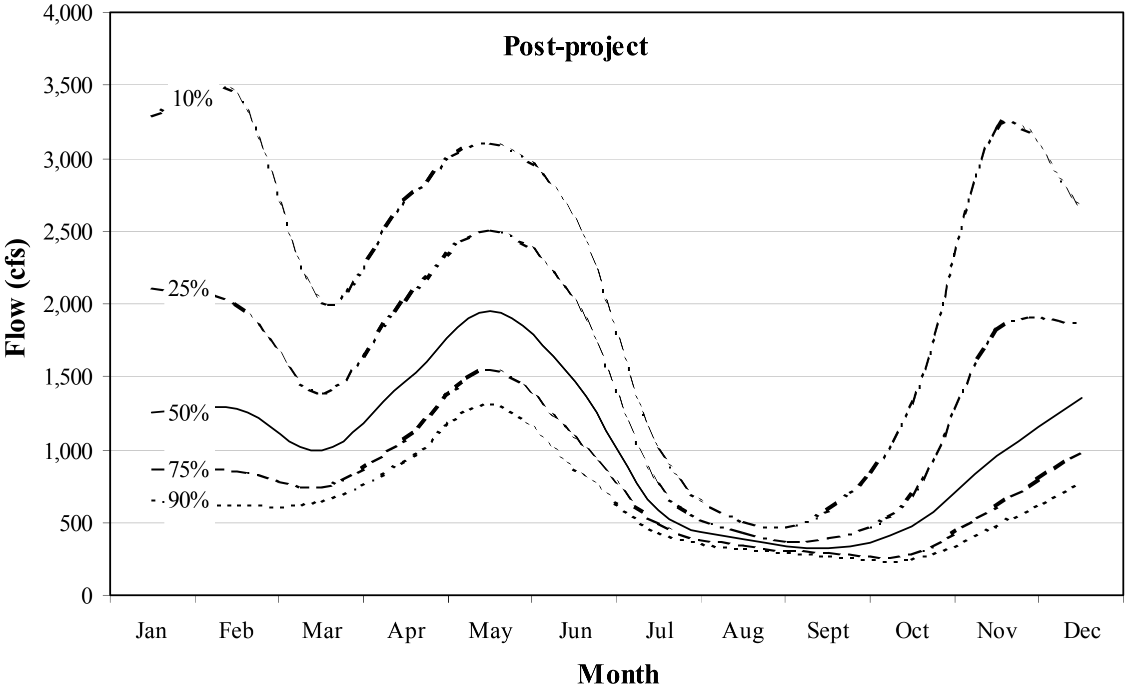


Figure 4.18-4. Daily flow exceedence curves for Lewis River above Muddy River near Cougar.[5]

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[5] USGS Gage 14216000: pre-project data is from 9/1/27 to 9/30/34 and 10/1/54 to 9/31/57; post-project is from 10/1/58 to 9/30/70. Note that differences between two periods are likely the result of the different periods of record.

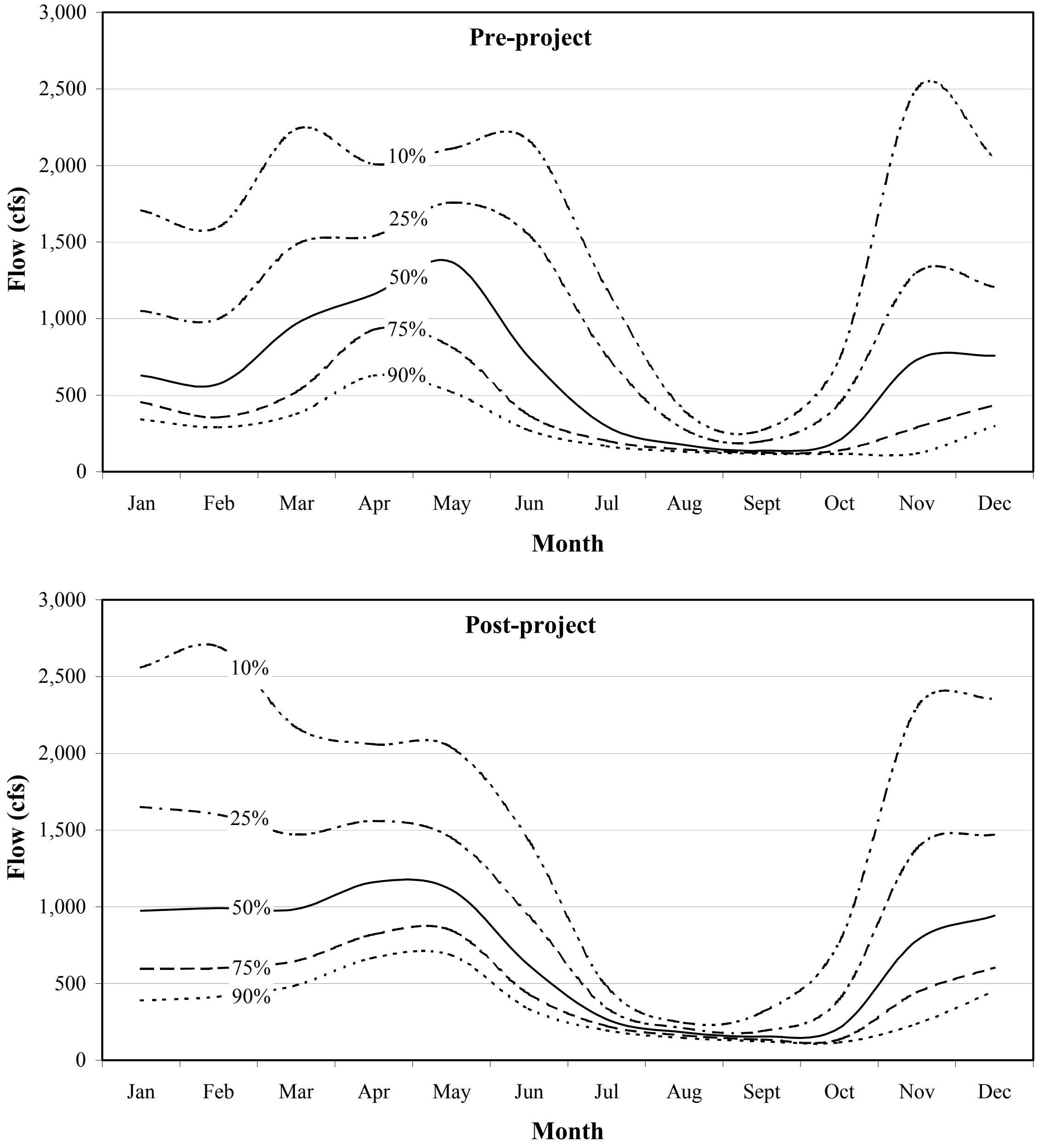

Figure 4.18-5. Daily flow exceedence curves for Muddy River below Clear Creek near Cougar.[6]

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[6] USGS Gage 1426500: pre-project data is from 10/1/27 to 9/30/34 and 10/1/54 to 9/31/57; post-project data is from 10/1/58 to 12/31/73 and 10/1/83 to 9/30/98. Note that differences between two periods are likely the result of the different periods of record.

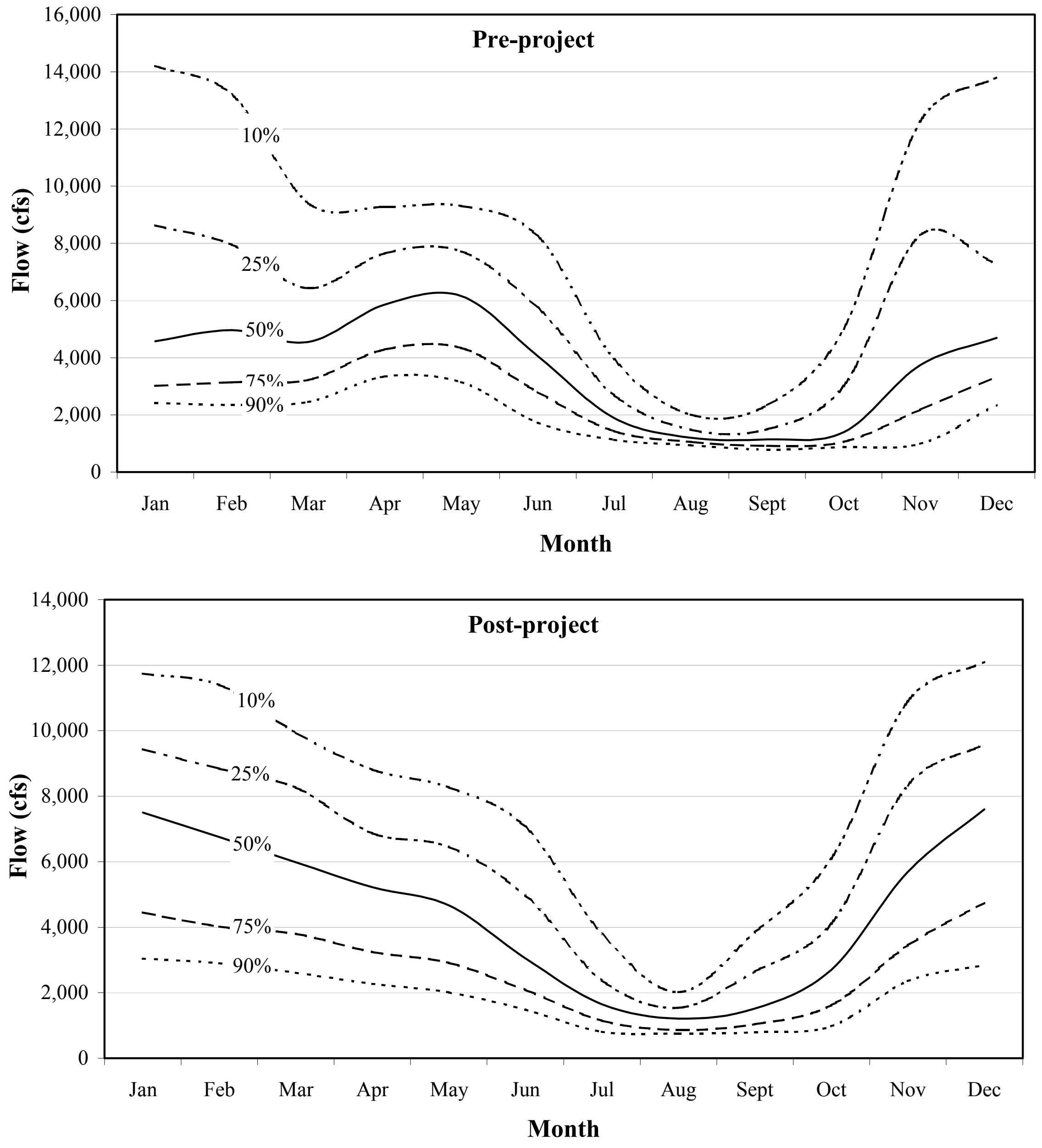

Figure 4.18-6. Daily flow exceedence curve for Lewis River at Ariel (below Merwin Dam).[7]

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[7] USGS Gage 14220500: pre-project data is from 1909 through 1930 and post-project data is from 1932 through 1998. Daily flow from 1910 through 1923 was estimated based on Lewis River flow at USGS Gage 14219500 near Amboy.

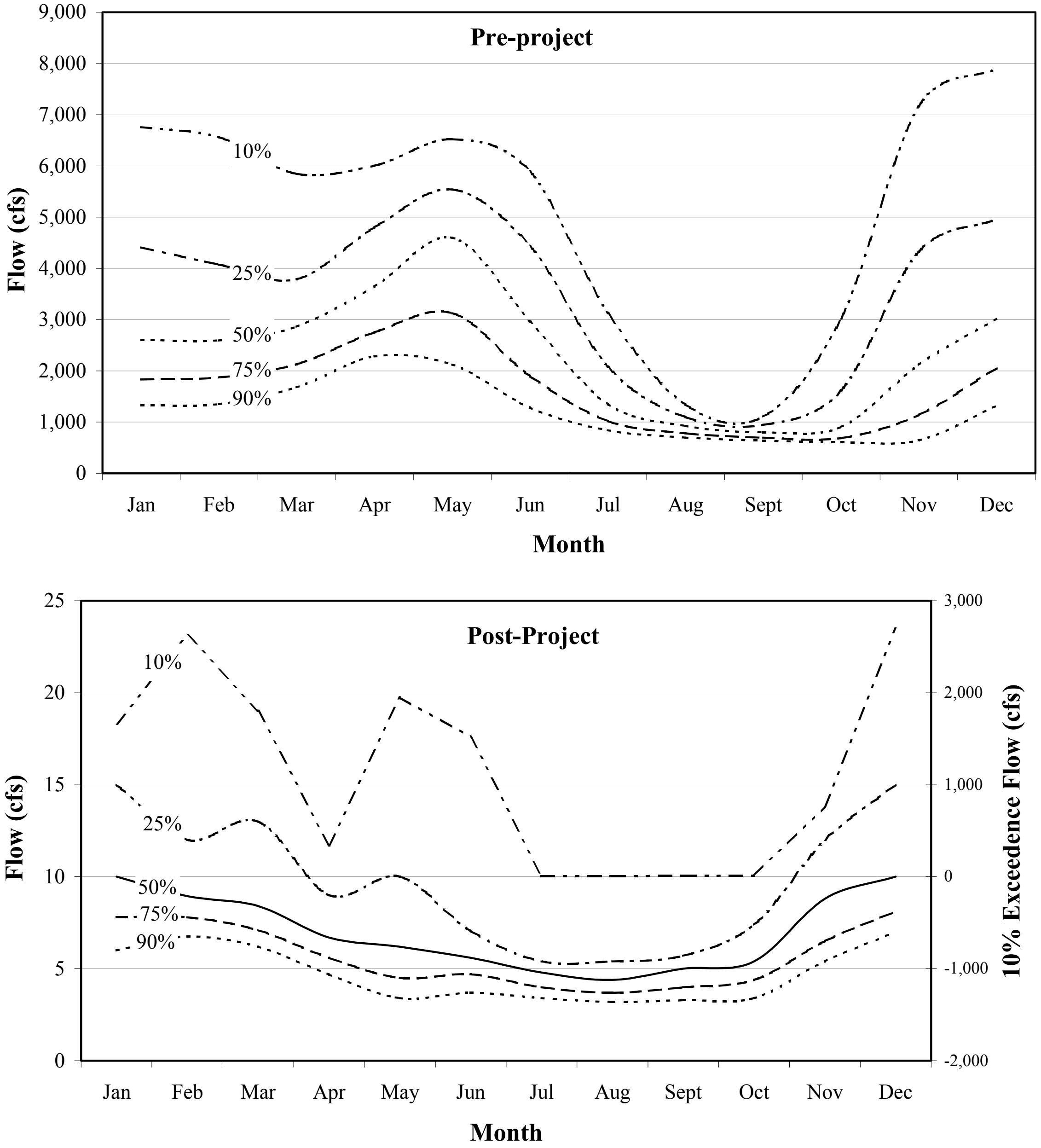

Figure 4.18-7. Daily flow exceedence curve for Lewis River near Cougar.[8]

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[8] Swift No. 2 bypass reach, USGS Gage 14218000: pre-project 7/1/24 to 9/31/57; post-project 10/1/58 to 12/31/77). Note: On the post-project graph, the 10% exceedence flow curve is plotted on a different scale.

Table 4.18-3. Summary of streamflow statistics for Lewis River stream gages.

Stream Gage	Annual 50% exceedence flow (cfs)	Average 1-day baseflow (cfs)	2-year peak flow (cfs)	Baseflow: annual flow ratio	Peak: annual flow ratio
Lewis River near Trout Lake	500	113	5,890	0.23	12
Lewis River above Muddy River	917	283	9,240	0.31	10
Muddy River below Clear Creek	620	144	6,720	0.23	11
Lewis River near Cougar (pre-project)	2,185	687	18,100	0.31	8
Speelyai Creek	56	4	1,680	0.07	30
Lewis River at Ariel (pre-project)	3,370	1,051	42,000	0.31	12
Lewis River at Ariel (with-project)	3,790	767	22,000	0.20	6

<u>Current Flows</u> – Timber harvest is the primary potential cultural influence on streamflows in the upper watershed (upstream of Swift Reservoir). Research on the effects of timber harvest on streamflow has resulted in conflicting conclusions. Some studies suggest that harvesting and road building increase peak flows and summer water yields, while other studies find no significant changes once climatic variability is taken into account (see summary in Bowling et al. 2000). All of the studies have concluded that in order to detect differences, large portions of a watershed must be harvested; changes were less noticeable in large watersheds and as trees grew back. Therefore, in the Lewis River watershed, it is possible that timber harvest has altered streamflows in very small catchments, but unlikely that measurable changes have occurred in larger streams used by fish.

Streamflows in reaches downstream of project facilities are affected by storage or diversion of water, including the Lewis River bypass reach (between Swift Dam and Yale Lake), lower Speelyai Creek, and the Lewis River downstream of Merwin Dam. Under current conditions, flows from the Lewis River are diverted into the Swift Canal and do not enter the 3-mile-long Lewis River bypass reach except during spill events. As a result, the only flow in the bypass reach is a result of inflow from tributaries, groundwater, and canal leakage. Flows downstream of Ole Creek, near the downstream end of the reach, are higher as a result of inflows from the creek. During high runoff conditions, when the projects are operating to control floods in the basin or during operational emergencies, water is spilled into the reach from either the Swift Dam spillway or the Swift Canal spillway, located 1.25 miles downstream of Swift Dam. As a result of these operational regimes, flow in the Lewis River bypass reach is very low (5-10 cfs) most of the time. Spill events occur sporadically, but in general, spills of several thousand cfs or greater occur every few years. The largest spill since Swift Dam was constructed was about 64,000 cfs during February 1996.

Speelyai Creek is a tributary to Lake Merwin. A diversion structure 4.3 miles upstream of the mouth of the creek currently diverts water from the upper watershed into a canal that carries flow into Yale Lake. A second diversion structure, which supplies water to Speelyai Hatchery, is located 0.1 miles upstream of the mouth. Under current conditions, flows in lower Speelyai Creek gradually increase downstream from the upper diversion from spring flows and small tributary inflows. Flow measured at the hatchery averages 17 cfs in the summer months (July-September), and 21-28 cfs during the spring and winter.

Flows in the Lewis River downstream of Merwin Dam are also affected by project operations. Flows in this reach are highest during the winter, decreasing gradually in the spring, and are lowest during summer months (Figure 4.18-6). Storage of water in project reservoirs and operation of the turbines result in lower peak flows and a step-wise flow pattern as units are turned on and off for power generation.

An analysis of changes in flow patterns downstream from Merwin Dam using the Indicators of Hydrologic Alteration (IHA) method (Richter et al. 1996) was completed to compare pre-project and with-project conditions (Kaje 2002). The results were similar to those reported in the Streamflow Study (PacifiCorp and Cowlitz PUD 2002a: WTS 2). The project storage and flood control operations result in higher median flows during fall and winter months (September-March) as the reservoirs are drawn down and then regulate winter peak flow events. Median flows are lower between April and July as the reservoirs are refilled for the summer recreation season. Project operations have slightly lowered minimum flows (2-9 percent lower) and daily maximum flows (13-14 percent lower) and shifted the timing of low flows from September to August. The timing of the one-day maximum daily flow has shifted from December to January. Flows rise and fall more frequently under regulated conditions, with more gradual flow increases and more rapid flow decreases.

These flow changes have resulted in more wetted area in the Lewis River downstream from Merwin Dam during the summer and early fall months than prior to construction of the projects, inundating more potential aquatic habitat and likely more side channel habitat. The reduction in peak flows has resulted in a more stable channel with less scour of redds and less sediment transport than prior to project operation. These conditions are different than a “natural” system that is often quite dynamic. Reduced springtime flows may also have an impact on out-migrating smolts.

While PacifiCorp currently complies with WDFW-recommended ramping rate criteria for flows below Merwin Dam (Hunter 1992), project-related flow fluctuations still have the potential to adversely affect aquatic resources. In the past, multiple fish losses have occurred in the Lewis River as a result of project-induced changes in river stage. PacifiCorp and Cowlitz PUD (2000) documents 5 separate incidents of rapid flow reductions that resulted in fish kills in a 2-year period.

Sediment

The amount of sediment supplied to a river has a major influence on the form and stability of the river channel. Streams carrying high sediment loads are generally braided, with many shifting and anastamosing channels and often show signs of aggradation. Streams with very limited sediment loads are often armored with large particles, and may exhibit signs of incision.

Historical Sediment Inputs – There are no data on the sediment loads of streams in the Lewis River watershed prior to cultural disturbances. However, an estimate of sediment inputs from natural background sources were computed for several sub-basins in the watershed downstream of the projects during relicensing studies. The inputs were separated into “background” inputs, those that would be expected to occur with no cultural influences in the basin, and management-related sources, primarily relating to timber harvest and forest roads (Table 4.18-4). The inputs are expressed as average tons/square mile of drainage area/year for comparison between drainages. It is understood that the majority of inputs are from mass wasting events that are episodic and provide large quantities of sediment during occasional large storm events and little sediment for the remainder of the time. (Note that the sediment inputs were computed only for the drainage areas indicated and did not include potential inputs from upstream sources that are currently blocked by dams.)

Table 4.18-4. Average annual sediment input to selected Lewis River sub-basins under background and current conditions (all values in tons/sq mi/yr)**.**

Source	**Upper Speelyai Creek (13 sq mi)**	**Lower Speelyai Creek (4 sq mi)**	**Rain Creek (2.4 sq mi)**	**Ole Creek (5 sq mi)**	**Swift bypass (w/o Ole; 2 sq mi)[9]**	**Lewis River from Merwin Dam to Eagle Island (32 sq mi)[1]**	**Cedar Creek (55 sq mi)**
Background	40	60	4,067	117	10	25	20
Management-related sources	714	1	40	200	0	181	8
Percent Increase over Background	1790%	0%	0%	170%	0%	720%	40%
Upstream Sediment Blocked by Dams?	N	Y	N	N	Y	Y	N

The estimated background sediment input to the study basins ranged from 10 to 117 tons/mi^2/yr with the exception of the small Rain Creek watershed that experienced several large landslides and had an average of 4,067 tons/mi^2/yr.

Historically, it is likely that input of sediment to the Lewis River upstream of Swift Dam included periodic large inputs from lahars and ash fall associated with volcanic activity at Mount St. Helens, Mt. Hood, and the Indian Heaven volcanic field. This sediment would have been transported through the watershed into the lower Lewis River and Columbia River.

<u>Current Sediment Inputs</u> – Current sediment inputs to streams in the Lewis River watershed are due to natural processes and land management practices that have increased the erosion potential of managed areas, and to the construction of dams or barriers that block downstream transport of sediment.

The eruption of Mount St. Helens provided an overwhelming recent source of sediment to several streams in the upper watershed, instantaneously contributing large amounts of sediment via mudflows, and providing a source of easily erodible ash to streams in portions of the upper watershed. Mudflows during the initial eruptions swept nearly 18 million cubic yards of water, wood, and debris down these streams and into Swift Reservoir (Tilling et al. 1990). These streams, primarily the Muddy River, Pine Creek, and Swift

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[9] Note that the Lewis River bypass reach and Lewis River from Merwin Dam to Eagle Island sections include only sediment inputs from within the small drainage areas downstream from Swift or Merwin dams, respectively.

Creek, are still carrying large volumes of sediment into the reservoir; over 15 million tons of sediment were transported from 1982 through 1990 (Dinehart 1997). Thick deposits of tephra covered the upper portions of Smith Creek and Clearwater Creek, reducing infiltration rates and increasing erosion following the 1980 eruption (Dinehart 1997).

Several large fires burned in the East Fork Lewis River watershed in the past century (Wade 2000). The Yacolt Fire of 1902 covered 238,900 acres and was a particularly hot burn, leaving little live vegetation. Portions of the area were re-burned in subsequent fires in 1927, 1929, and the 1950s. These fires likely increased sediment inputs for several years until vegetation was re-established. Associated timber salvage operations also likely greatly increased sediment inputs as wood was pulled from riparian areas and stream channels.

Road building, timber harvest, farming/grazing, or urbanization have taken place in nearly all portions of the Lewis River watershed. These activities have the potential to increase the sediment supply to streams through associated mass wasting, surface erosion, or bank erosion. Quantitative estimates of the amount of sediment input to streams from management-related sources have been made for a few portions of the watershed (Table 4.18-4). In these sub-basins, sediment input ranged from very little in Lower Speelyai, Cedar Creek, and the Lewis River bypass reach, to several hundred tons/mi^2/yr in Upper Speelyai, Ole Creek, and the Lewis River downstream of Merwin Dam. Similar ranges of cultural inputs are likely in other areas of the watershed, with disturbances on steep slopes (primarily road or timber harvest activities, predominantly in the middle and upper portions of the watershed) or directly adjacent to streams (grazing or urbanization, primarily in the lower portions of the watershed) most likely to cause the largest inputs.

Other disturbances in the watershed that affect the movement of sediment through the river system included construction of dams and diversions and gravel mining. In lower Speelyai Creek, the Lewis River bypass reach, and the Lewis River downstream of Merwin Dam, sediment from upstream sources has been blocked by the dams. In each of these 3 reaches, the channels would have carried much higher loads of sediment from either management-related inputs (e.g., Speelyai Creek) or from Mount St. Helens (the Lewis River reaches) than under current conditions if the dams had not been in place. In the past, gravel mining activities have occurred in the Lewis River downstream of Merwin Dam and in the East Fork Lewis River. Gravel was also mined in the Lewis River bypass reach to provide materials for dam construction. Gravel mining operations reduce the in-channel amount of gravel, and often results in reduced spawning habitat availability.

Sediment from reaches upstream of project dams is blocked from being transported to downstream reaches. As a result, the Lewis River bypass reach, lower Speelyai Creek, the Lewis River downstream from Merwin Dam, and the Columbia River and estuary have a much lower rate of sediment movement than would have occurred if the project dams were not in place. The high peak flows and high gradient in the Lewis River bypass reach result in a cobble-boulder bed, with little gravel except downstream from Rain and Ole creeks. Lower Speelyai Creek has a stable channel, with a variety of grain sizes; if the upper Speelyai diversion were not in place, the channel would be very wide and active, with a cobble bed similar to the creek upstream of the diversion structure. The Lewis River downstream from Merwin Dam has a mix of substrate sizes, and has retained spawning-sized gravel, likely as a result of the very low gradient. If the project facilities were not in place, the river downstream from Merwin Dam would be much different, with a very active channel and abundant sediment and large woody debris as a result of the huge influx of sediment and debris following the Mount St. Helens eruptions.

Large Woody Debris

The role of large woody debris in shaping the geomorphology and aquatic habitat in large river systems has been a topic of much recent research (Abbe and Montgomery 1996, Bilby and Bisson 1998, Collins et al. 2002). Compared to small streams, single pieces of large woody debris in large river systems (>60 feet wide) are less of an influence on channel dynamics because the pieces are not very stable in large flows, are usually confined to the banks instead of within the wetted channel, and are so small compared to the size of the river they do not have enough influence on channel hydraulics to form reach-scale elements of habitat complexity (Bilby and Bisson 1998, Lassettre and Harris 2001). Recent investigations of the historical role of large woody debris in large river systems have confirmed that single pieces do not have the same function as they do in smaller systems (Collins et al. 2002).

Large woody debris performs additional ecosystem functions, including trapping sediment and smaller pieces of wood and debris that can retain nutrients in the ecosystem and influence the development of riparian habitat communities, and trapping salmon carcasses. Large woody debris also provides habitat for fish, macroinvertebrates, and other aquatic species.

Historical Large Woody Debris – Historically, wood formed large log jams or log rafts that influenced the morphology of large rivers on many scales (Collins et al. 2002). At a local scale, the wood formed pools and provided cover. At the reach scale, the jams formed and maintained multiple channels and floodplain sloughs. At a valley bottom scale, the large log jams influenced water, sediment, and wood routing during high flows by increasing flooding and recharge of floodplains and associated wetlands, and trapping sediment and additional wood. Historic wood loading levels in the Lewis River watershed are not known; however, it is likely that there was much more wood than under present conditions, including log jams and single pieces of wood.

Current Large Woody Debris – Large woody debris and log jams were removed from most large western Washington streams in the late 1800s and early 1900s by settlers and the Corps of Engineers to decrease flooding and improve navigation. The combination of instream wood removal and harvesting of lowland riparian forests resulted in very little large woody debris in or being recruited to most large western Washington streams by the early-to mid-1900s (Collins et al. 2002). It is very likely that log jams in the lower Lewis River were removed in the late 1800s since there was very little wood in the river in the earliest (1939) aerial photographs, even as far downstream as the confluence with the Columbia River. Timber salvage associated with the Yacolt Fire (1902) included removing wood from the riparian areas and streams in the East Fork Lewis River, and removal of log jams was undertaken as recently as the 1980s to improve fish passage (Wade 2000). Mudflows associated with the eruption of Mount St. Helens in 1980 and subsequent channel migration in Pine Creek, Swift Creek, and the Muddy River transported large volumes of wood downstream. Much of this wood was removed from Swift Reservoir; some is stored in the channels upstream of the reservoir.

Current levels of large woody debris were measured during field surveys of the Lewis River in the Lewis River bypass reach, downstream of Merwin Dam, and Speelyai Creek. Lower Speelyai Creek had the highest density of large wood, with 108 pieces/mile; upper Speelyai had 77 pieces/mile. The Lewis River bypass reach had an average of 21 pieces/mile, with most of the wood in the lower end of the reach downstream from Ole Creek. The Lewis River downstream of Merwin Dam had 15 pieces/mile. Rating of large woody debris in the rest of the watershed was considered “poor” in the WRIA 27 limiting factors report (Wade 2000). The lack of wood downstream of Merwin Dam is the result of cumulative effects of project and non-project actions: removal of wood from the channel long before the projects were constructed, the lack of input from upstream sources (project effect), and low recruitment of large wood from within the reach due to previous harvest of the riparian areas, and the more stable channel and peak flow regime (project effect).

Past harvest of riparian areas, removal of large wood from streams, and road building along some streams have resulted in relatively little instream wood in most of the watershed. Current harvest practices and an awareness of the importance of mature riparian stands as the source of large wood in rivers will result in gradually improving conditions over the long term as riparian stands age. The eruption of Mount St. Helens resulted in the input of wood to several streams in the upper watershed. This wood was caught in Swift Reservoir and removed from the river system. Continued capture of large woody debris by the Lewis River dams will result in no large wood transport into the lower Lewis River from upstream sources, except under extremely high flow conditions such as the flood of 1996, when the gates are fully opened and wood can pass through. The small to moderate size of trees in current lower river riparian stands and limited lateral migration of the river restricts the potential for recruitment of woody debris large enough to be stable or function in log jams in the lower river. The decreased input and transport of large woody debris through the Lewis River system also results in a decreased supply of large wood to the Columbia River and Pacific Ocean.

Riparian Habitat

In the most general terms, riparian ecosystems are defined as ecotones between aquatic and upland ecosystems (Mitsch and Gosselink 1986). Riparian habitat starts at the ordinary high water line of a stream or river and includes that portion of the adjacent terrestrial landscape that influences the aquatic habitat by providing shade, nutrients, woody material, insects, or habitat for riparian-associated species (Knutson and Naef 1997). Riparian habitat also encompasses floodplains because these areas influence and are influenced by high water events. Riparian areas can include wetlands as well as upland plant communities that directly influence streams. Riparian habitat provides a number of important contributions to both aquatic and terrestrial ecosystems and is designated by the WDFW as a priority habitat in Washington.

Historical Riparian Conditions – Riparian habitats are created and maintained by changes in flow and associated disturbances (Poff et al. 1997; Hall 1988). Prior to the influence of cultural systems in the Lewis River watershed, the majority of riparian stands along river reaches with comparatively stable channel structure were dominated by coniferous or mixed coniferous/deciduous stands. Riparian areas that are frequently disrupted by high flows or channel shifting along streams with high sediment loads do not support conifer species and are dominated by alder (Diaz and Mellen 1996). Disturbed sites and newly developed stream bars are usually quickly colonized by red alder, a pioneer species that can survive periods of low-intensity inundation (Agee 1988). These types of riparian communities were, and still are, found along stream reaches with a large influence of glacial flow, such as streams draining glaciers on Mount Adams and Mount St. Helens, and reaches that experienced mudflows from the recent eruption of Mount St. Helens.

Current Riparian Conditions – Expansion of timber harvest, agriculture, and communities into the lower Lewis River began in the mid-1800s and progressively moved into the upper watershed. Timber harvest practices in the past resulted in removal of riparian vegetation, and often disturbance of aquatic ecosystems as logs were skidded across or along stream channels, or splash dams were constructed and channels were used to transport logs downstream. Changes to timber harvest regulations in the past few decades are aimed at minimizing disturbance to riparian areas and aquatic ecosystems. However, after a century of timber harvest activities, many of the riparian communities in the basin have been disturbed at least once by harvest and are in the process of re-growth and recovery.

Operation of the Lewis River projects has altered the flow and sediment supply regimes of downstream reaches, which has affected riparian communities to some extent as described in the following paragraphs.

Lewis River Bypass Reach – Spills through the Lewis River bypass reach have contributed to a riparian community along the active channel that is and will likely always be dominated by red alder. In fact, deciduous forests consisting mostly of alder currently represent 67 percent of the riparian vegetation in the reach, with mixed conifer-deciduous stands representing only 14 percent. The few stands of mixed riparian conifer-deciduous or upland conifer that occur near the active channel are found above steep banks in areas where the bypass reach is confined and have probably not been flooded since the dam was constructed.

Another result of high flow events is that scoured areas, particularly those at higher elevations outside the active channel, are susceptible to colonization by weedy, invasive species. There are a number of sites in the bypass reach that currently support monocultures of Scot's broom, an introduced species that can quickly establish on dry sunny sites. In addition, deciduous shrub cover in many of the alder-dominated forest stands consists primarily of Himalayan blackberry, another introduced species that invades moist, disturbed substrates. Shrub cover is relatively low and native hydrophytic shrub species are almost completely lacking. Reduced flows in the Lewis River bypass reach likely have also affected riparian vegetation by changing the groundwater table.

Lewis River Downstream of Merwin Dam – Riparian habitat in the Lewis River downstream from Merwin Dam has been affected by many activities, so the specific effects of project operations are difficult to determine separately. The projects have decreased the sediment load, decreased the magnitude of peak flow events, and decreased the supply of large woody debris from upstream areas. Timber harvest, farming, and urbanization along the lower river have also affected riparian communities. A study of 1939 through 2001 aerial photographs along the lower river shows several trends:

- Riparian vegetation increased by about 306 acres between 1939 and 2001, with the greatest change seen in the riparian deciduous forest types, which gained 279 acres (113 ha) in this period. While some of this acreage increase may have resulted from the succession of riparian grassland and shrub types to forest, it is apparent from the photographs that a large amount of this area had been logged and was being farmed in 1939.

- Between 1939 and 2001, riverine unconsolidated shore decreased from 186 to 7 acres (75 to 2.8 ha), a loss of 179 acres (72 ha). A large amount of this area now supports riparian shrubs, which increased by 153 acres (62 ha) in this period.

- In 1939, the main channel of the river was on the north side of Eagle Island; in 2001 the main channel is on the south side. In 1939, much of the south side of the island was occupied by a large, unvegetated gravel bar. By 1963 there was a gravel mining operation on the island. Currently, most of this area is covered by riparian mixed conifer-deciduous forest stands. The old channel between the north and south half of the island had filled in by 1974 and by 2001 was barely discernable through a dense stand of riparian forest.

- Conifer forests declined substantially (79 percent) along the Lewis River between 1939 and 1963, primarily due to logging and conversion to agriculture. Between 1963 and 2001, the area of conifer increased, as some stands replanted with conifers grew to pole size. Other regenerating areas supported mixed or deciduous stands in 2001.

- Like many other rural areas in western Washington, the amount of land in agriculture decreased along the Lewis River. In 1939, 45 percent of the land within the 240-foot contour along the both sides of the river was farmed, with another 5 percent in pasture. By 2001, only 22 percent of the land in this area was classified as agriculture; 9 percent is now pasture. Much of the agricultural land has reconverted to forest and now supports deciduous and mixed conifer-deciduous stands.

- As expected, development between the dam and Eagle Island increased between 1939 and 1963, although not substantially. Developed and residential lands in 1939 represented less than 1 percent of the land along the lower river, and there was very little change over the next 24 years. By 2001, however, the combined acreage of developed, recreational, and residential had increased to 6 percent of the land in the reach, with 2 percent represented by the Lewis River Golf Course. Most of this development is concentrated in the 2 miles or so upstream of Eagle Island.

The pre-cultural riparian communities along rivers in the Lewis River watershed contributed to aquatic habitat values by providing shade to reduce stream temperatures, a source for large woody debris and smaller wood/litter material, and bank stabilization. Harvest and disturbance of riparian areas throughout the watershed has reduced the ability of riparian vegetation to provide these functions, but recent regulations are aimed at improving riparian communities over time.

Water Temperature

Water temperature is a critical component of aquatic habitat and a major factor influencing the composition and productivity of aquatic ecosystems. In undisturbed rivers and streams, "normal" water temperatures vary daily, seasonally, annually, and spatially. For salmonids, these variations influence the timing of migration, spawning, incubation rate, growth, distribution, resistance to parasites, food supply, and tolerances to diseases and pollutants (Bjornn and Reiser 1991). Although not fully understood, changes in water temperature, outside of the normal natural range, can alter the development, growth, and timing of locally adapted life history events (Murphy 1995).

Generally, water temperatures ranging from 3 to 16°C are considered suitable for both resident and anadromous salmonids (Table 4.18-5). Most salmonids are placed in life-threatening conditions when temperatures exceed 23 to 25°C, and they usually try to avoid such temperatures by moving to other areas (Bjornn and Reiser 1991). While the temperatures shown in Table 4.18-5 are the generalized preferred range, the life histories of native populations of salmonids are adapted to the natural temperature regimes in their specific watershed.

Table 4.18-5. Preferred temperature ranges, and upper lethal temperature ranges for various life stages of resident and anadromous salmonids found in the Lewis River basin.

Species	Preferred Temperature Range (°C)				Upper Lethal Temperature (°C)
	Upstream Migration	Spawning	Incubation	Freshwater Rearing	
Fall Chinook	10.6–19.4	5.6-13.9	5.0-14.4	12-14	26.2
Spring Chinook	3.3–13.3	5.6-13.9	5.0-14.4	12-14	26.2
Coho	7.2-15.6	4.4-9.4	4.4-13.3	12-14	26.0
Steelhead		3.9-9.4		10-13	23.9
Bull Trout	10-12	5-6		8-14	
Kokanee		5.0-12.8			
Cutthroat Trout		6.1-17.2		12.0-15.0	22.8
Rainbow Trout		2.2-20.0		10-22.0	29.4

Source: Bjornn and Reiser 1991, Goetz 1989, BioAnalysts, Inc. 1998.

Historical Water Temperature – Prior to the completion of Merwin Dam in 1932, water temperatures in the Lewis River basin were unaffected by large impoundments or water diversions. Water flowed unobstructed from the Lewis River headwaters near Mount St. Helens to the Columbia River. The thermal regimes in tributaries differed widely with location, elevation, and input from rainfall, snowmelt, and spring flow. Data describing pre-project (pre-1932) Lewis River water temperature regime are not available. According to Smith (circa 1943), "the permit for the dam was issued on June 25, 1929, so there was not time for experimental work with fish, and there was no preliminary investigation comparable to the fine surveys made incidental to the construction of Grand Coulee Dam and Shasta Dam." While there are no quantitative data describing temperature conditions prior to dam construction, this same report states that one of the "striking effects" that Merwin Dam had on temperatures of the lower river has been that:

> *The maximum and minimum temperatures are much lower below the lake than above throughout the greater portion of the summer. The summer condition is reversed in the cooler fall weather and the river waters below the lake are warmer than those above.*

Between September 1937 and July 1939, 5 to 7 years after the completion of Merwin Dam, water temperatures were recorded periodically at the Lewis River gaging station above Cougar and in the Lewis River below Merwin Dam (Lewis River Hatchery) (Figure 4.18-8) (Smith circa 1943). Water temperatures recorded during this period ranged from 2.5 to 14.5°C. While these water temperature data are not pre-project, and reflect the influence of Lake Merwin and possibly the influence of logging, they are the earliest available water temperature data for the mainstem Lewis River.

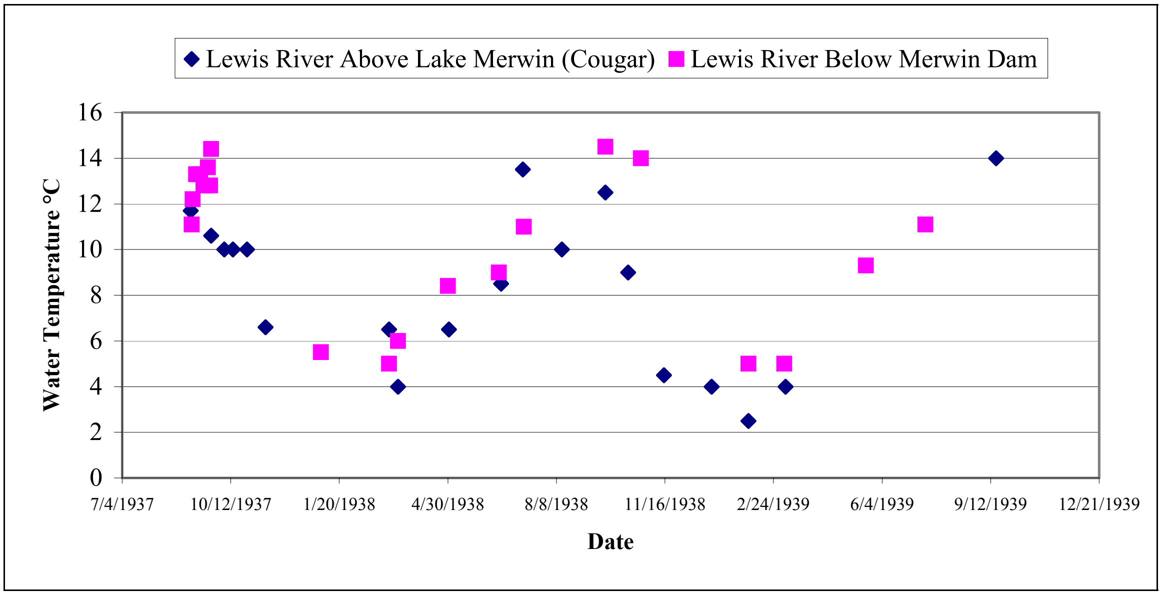

Figure 4.18-8. Water temperatures recorded above Lake Merwin (Cougar) and below Merwin Dam (September 1937 through July 1939).

The water temperature data collected in 1937, 1938, and 1939 were collected randomly, and very few measurements were taken during the warmer periods of the year (July and August). Because of this, it is difficult to compare these "historical" water temperatures to current conditions in the lower river.

<u>Current Water Temperature</u> – The completion of Merwin, Yale and Swift dams converted approximately 39 miles of free flowing mainstem riverine habitat into relatively slow moving reservoir habitat, altering the natural thermal regime downstream of the dams. Concurrently, basin wide stream canopy removal associated with extensive timber harvest and other land use activities (i.e. agricultural and urban development) reduced

tributary stream shading and contributed to an overall increase in solar heating. While a lack of historical data makes it difficult to quantify these effects, a substantial amount of "current" water temperature data has been collected in the Lewis River basin (PacifiCorp and Cowlitz PUD 2002, Wade 2000, USFS 1996). Typically, these data were collected in a regulatory context and compared against Washington Department of Ecology (WDOE) criteria for Class AA (temperatures must not exceed 16°C) and Class A (temperatures must not exceed 18°C) streams. WDOE has defined classes of water quality, ranging from Class AA (extraordinary) to Class C (fair). All mainstem Lewis River reaches within the project area (downstream of the boundary of the Gifford Pinchot National Forest) are designated Class A; however, most tributary streams to the project reservoirs are designated Class AA. These criteria are designed to protect "beneficial uses" including salmonid and other fish migration, rearing, spawning, and harvesting.

As part of relicensing, PacifiCorp and Cowlitz PUD monitored water temperatures at 14 stream locations in the Lewis River basin. Hourly water temperatures were recorded from May 1999 through April 2000 at the inflow to Swift Reservoir, the upstream and downstream ends of the Lewis River bypass reach, in all 4 project tailraces (Swift No. 1, Swift No. 2, Yale, and Merwin), in the Lewis River below Merwin Dam, and in Pine, Drift, Swift, Canyon, Speelyai, and Ole creeks (Table 4.18-6) (PacifiCorp and Cowlitz PUD 2002). Exceedences of the standard are depicted in bold type.

Table 4.18-6. Maximum of daily maximum, minimum of daily minimum, and 7-day running mean of daily maximum water temperatures by site.

Site	Min. Temp. (°C)	Max. Temp. (°C)	Number of Days > WDOE Criteria	Max. 7-Day Mean Max (°C)
Class AA (16°C maximum)				
Pine Creek near mouth (RM 0.1)	5.3	14.3	0	13.7
Drift Creek near mouth (RM 1.5)	7.6	**16.3**	**1**	15.8
Swift Creek near mouth (RM 2.0)	4.6	10.5	0	10.2
Canyon Creek near mouth (RM 1.0)	3.9	**19.5**	**43**	**18.8**
Upper Speelyai Creek (RM4.3)	0.3	**18.7**	**35**	**18.2**
Lower Speelyai Creek near hatchery (RM 2.0)	6.2	14.3	0	13.6
Lewis River inflow to Swift Reservoir	2.3	15.1	0	14.6
Class A (18°C maximum)				
Ole Creek near mouth (RM 0.5)	4.0	16.6	0	16.1
Swift No. 1 tailrace	4.3	13.9	0	13.3
Lower Lewis River bypass reach	4.3	**18.2**	**1**	17.5
Swift No. 2 tailrace	4.1	15.4	0	13.9
Lewis River near Yale Powerhouse tailrace	4.5	17.0	0	15.3
Lewis River near Merwin Powerhouse tailrace	5.3	15.5	0	15.5
Lewis River near Eagle Island	9.4	16.3	0	15.7

Water temperatures in project area Class AA and Class A tributaries and stream reaches during this period ranged from 0.3°C in upper Speelyai Creek to 19.5°C in lower Canyon Creek. Maximum water temperatures were recorded at most sites in August. Minimum water temperatures were typically recorded in January and February.

Exceedences of the Class AA criteria (16°C) were observed at the mouths of Drift Creek and Canyon Creek, and in Speelyai Creek above the diversion. A single measurement of 16.3°C recorded on August 4, 1999 was the only value recorded in Drift Creek that was greater than the 16.0°C criterion. In contrast, temperatures greater than 16.0°C persisted during much of July and August 1999 in both Canyon Creek and upper Speelyai Creek (PacifiCorp and Cowlitz PUD 2002). Maximum temperatures of about 19°C were recorded in both creeks, and each creek's maximum 7-day mean maximum temperature was greater than 18.0°C. The only exceedence of the 18.0°C Class A criterion was a value of 18.2°C recorded at the lower end of the Lewis River bypass reach on August 4, 1999.

Comparison of Lewis River temperatures downstream of Lake Merwin to the Swift Reservoir inflow reveals that the river was generally warmer below Lake Merwin than above Swift Reservoir. Water temperatures recorded at the inflow to Swift Reservoir ranged from 2.3°C to 15.1°C and water temperatures near the Merwin powerhouse tailrace ranged from 5.3°C to 15.5°C (Table 4.18-6). The largest differences in daily mean temperatures occurred in September through December, when Merwin tailrace temperatures were generally between 4 and 10°C warmer than the inflow to Swift Reservoir. From January through August, Merwin tailrace temperatures were within 4°C of the inflow to Swift Reservoir (Figure 4.18-9) (PacifiCorp and Cowlitz PUD 2002). According to PacifiCorp and Cowlitz PUD (2002), much of the difference in temperature is due to differences that occur between the inflow and outflow of Swift Reservoir itself. Swift outflow temperatures exceeded inflow temperatures by approximately 6°C in November.

A similar change in the seasonal temperature pattern was observed in the Rogue River, Oregon following construction of Lost Creek Dam. Stream temperatures below the dam in November and December exceeded natural temperature by an estimated 1.4 to 1.7°C. The increased temperature caused spring chinook fry immediately below the dam to emerge from the gravel 52 days earlier than the pre-dam emergence. The negative effect of early emergence was somewhat offset by the beneficial effect of reduced peak flows. The net effect was slightly negative (Cramer et al. 1985).

In addition to the water temperature data collected during the relicensing of the Lewis River projects, recent data have also been collected in Cedar Creek, North Fork Chelatchie Creek, the East Fork Lewis River, Siouxon Creek, and Cougar Creek (Wade 2000, PacifiCorp 1999b, USFS 1996). Water temperature information is generally lacking for other tributaries within the lower North Fork Lewis River basin.

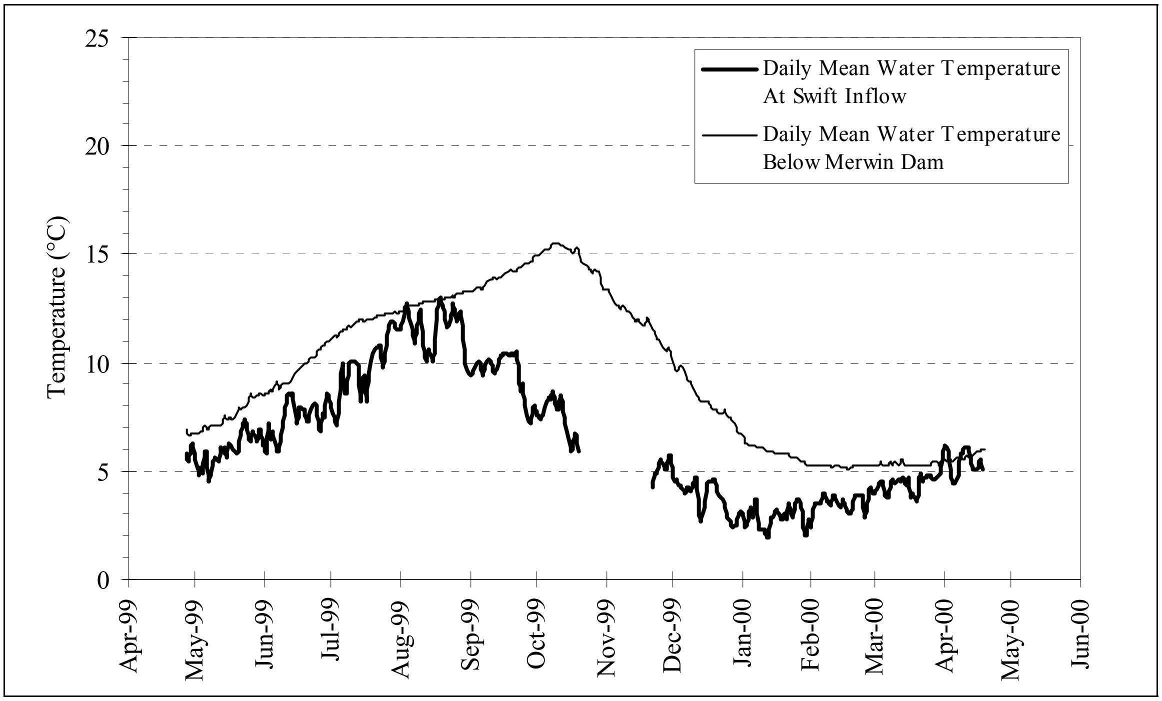

Figure 4.18-9. Comparison of daily mean temperatures in the Lewis River below the Merwin Dam (Merwin Powerhouse tailrace) and above Swift Reservoir (Swift inflow).

According to Wade (2000), Cedar Creek has some problems with high water temperatures during the summer months. Both at Amboy and at the mouth, water temperatures often exceed 16°C during July and August, and sometimes reach near lethal temperatures for salmonids (23 to 25°C). Water temperatures in the North Fork Chelatchie Creek are generally “good,” even during the summer months. Various land use activities may be affecting water temperature within the Cedar Creek basin, including agriculture and grazing, water withdrawals, surface runoff, and riparian impacts from residential development and forestry operations, and the construction of illegal dams and diversions on tributaries to Cedar Creek (Wade 2000).

High water temperatures during the summer months are one of the most important water quality issues on the lower East Fork Lewis River (Wade 2000). In 1996 and 1998, the East Fork, from the mouth to Mouton Falls (RM 24.6), was listed under Section 303(d) of the Clean Water Act as an impaired water body due to water quality exceedances for temperature and other parameters (WDOE 1996, WDOE 1998). For Washington State Class A waters, like the East Fork, the temperature standard is 18°C, a level commonly exceeded in the East Fork during the summer (Wade 2000). In the upper East Fork Lewis River, Forest Service surveys show that maximum daily water temperatures in the East Fork near Sunset Falls exceeded 16°C on more than 40 days between June and September in 1997 and 1998 (USFS 1999a).

Water temperatures in Siouxon Creek also exceed the WDOE standards (USFS 1996, PacifiCorp 1999b). In 1996, the Siouxon Creek 7-day average maximum temperature was 19.9°C and in 1997, it was 18.7°C (PacifiCorp 1999b). High temperatures in

Siouxon Creek, below the mouth of North Fork Siouxon Creek, were determined to be caused by "insufficient streamside shade protection" left after logging (USFS 1996).

From May 1996 through February 1998, monthly median water temperatures in Cougar Creek varied little (5.3 to 7.5°C) and were well within WDOE standards.

According to USFS (1995), stream temperatures above 16°C have also been measured in Pine Creek. The causes of these elevated stream temperatures are not well understood. It is suspected that channel widening from high levels of timber harvest, and the 1980 mudflows and loss of riparian vegetation from the Mount St. Helens eruption, have all contributed to elevated stream temperatures in Pine Creek.

In an effort to assist PacifiCorp and Cowlitz PUD in their relicensing effort, USFS fishery personnel conducted a "file search" to identify and summarize available aquatic habitat and fishery data for streams in the Lewis River basin above Merwin Dam. The data in these files, including water temperature data, were collected during stream surveys conducted between 1983 and 1998 (USFS 2002a). Water temperature data collection in these streams typically began in late May to early June and continued through late September to early October. "Mean" water temperature data for the surveyed streams are shown in Figure 4.18-10.

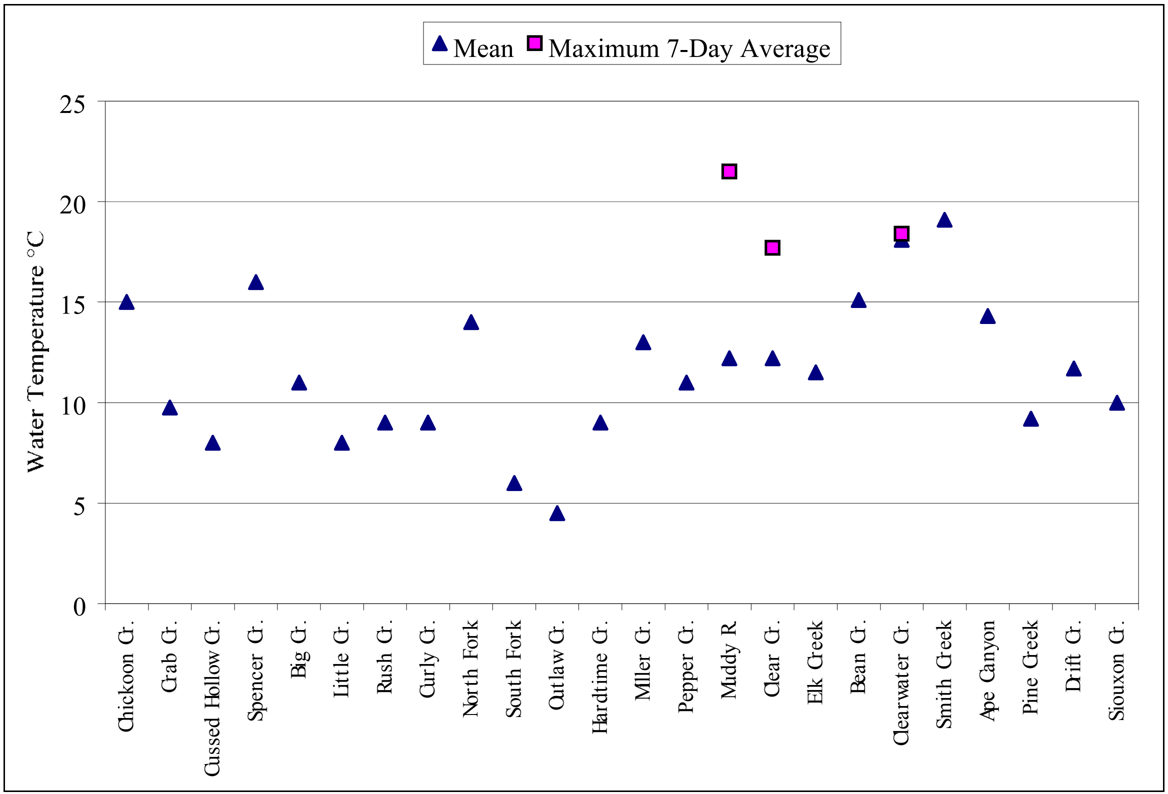

Figure 4.18-10. Water temperature data for tributaries of the Lewis River between Lower Falls and Swift Reservoir, Drift and Siouxon creeks.

More recent USFS water quality monitoring data (USFS 1997, USFS 1998b, USFS 1999b, USFS 2000, USFS 2001 and USFS 2002b) show that water temperatures in the upper mainstem Lewis River, Quartz Creek, Clearwater Creek, Muddy River, Clear Creek, Siouxon Creek, Canyon Creek, and East Fork Lewis River regularly exceed 16°C. Water temperatures above 20°C have been recorded in the Muddy River, Clear Creek, Clearwater Creek, East Fork Lewis River, and Siouxon Creek.

Due to the diversion of water from upper Speelyai Creek into Yale Lake, water temperature in the lower portion of Speelyai Creek is up to 5°C cooler than that observed upstream of the upper diversion. Changes in generation at the Yale powerhouse can also cause fluctuations in water temperature in the upper portion of Lake Merwin (surface water temperature can fluctuate as much as 10°C).

Nutrients

Pacific salmon play an important role in regulating aquatic-riparian food web productivity via the energy and nutrients they provide after migrating to fresh water to spawn and die (Wipfli et al. 1998, NRC 1996, Kline et al. 1990, Bilby et al. 1996). Such nutrient input to streams is a fundamental aspect of salmonid ecology and is important to the productivity of waters in which salmon spawn. Reduced inputs of marine-derived nutrients (MDN) can depress stream ecosystem productivity and lead to decreased juvenile salmonid size, reduced over winter and marine survival, and declines of returning adults.

Nitrogen limitation is not uncommon in Pacific Northwest streams (Lauer et al. 1979, Salminen and Beschta 1991), and nitrogen-to-phosphorous (N:P) ratios for sites monitored during relicensing strongly suggest a nitrogen limitation in the tributaries to Swift Reservoir (PacifiCorp and Cowlitz PUD 2002). The current lack of fish passage facilities prevents transfer of MDN upstream of Lake Merwin. In addition, there is no ongoing program of salmon carcass placement in project tributaries.

The lack of MDN from salmon carcasses for more than 70 years is thought to contribute to the current nitrogen limitation in the upper Lewis River. Decaying salmon provide a mechanism for transporting nutrients from the fertile Pacific Ocean to relatively nutrient poor freshwater streams and adjacent terrestrial communities (Kline et al. 1990; Bilby et al. 1996). Helfield and Naiman (2001) present data from Alaska that strongly suggests that MDN creates significantly higher growth rates in trees near spawning streams, thus improving spawning and rearing habitat for subsequent generations. Growth of Sitka spruce (mean annual basal area growth) at spawning sites was 3 times higher than at non-spawning sites, and trees at spawning sites reach a diameter at breast height (dbh) of 50 cm at approximately 86 years, versus 307 years at non-spawning sites (Helfield and Naiman 2001). Similar to riparian vegetation, increased productivity has been observed in stream macroinvertebrates and in terrestrial invertebrates in carcass-enriched streams vs. sites upstream of spawning salmon (Wipfli et al. 1998; Hocking and Reimchen 2002). The effect of MDN as a "nutrient subsidy" would be expected to be no less important and likely of greater importance in the Lewis River watershed, where geochemical influences already act to reduce N:P ratios.

Aquatic Habitat Connectivity

For migratory species of fish, successful completion of their life cycle depends on access to required habitats and safe, effective passage between these habitats. Connectivity between fish spawning, rearing, and overwintering habitats is critical to the survival and persistence of robust populations (Bjornn and Reiser 1991). Non-natural physical barriers (such as improperly designed culverts) impede passage and reduce connectivity by fragmenting habitat. Larger structures, such as dams, constrain or eliminate passage and may entrain or impinge fish within intake structures or spillways (WDFW et al. 2002). Loss of habitat connectivity need not be associated with physical structures such as dams or culverts. High water temperatures can effectively block movement and fragment habitat (Lichatowich and Mobrand 1995).

Historical Connectivity – Prior to the advent of hydroelectric development, resident and anadromous salmonids and other migratory fish (i.e. Pacific lamprey and sturgeon) had unhampered access to abundant high quality spawning and rearing habitat in the upper Lewis River and its tributaries. Smith (circa 1943) noted that chum salmon formerly ascended the Lewis River to the mouth of Speelyai Creek, about 8 miles above the site of Merwin Dam. “Spawning occurred in the main river below that point and in several sloughs that were flooded by Lake Merwin.” The rising water of Lake Merwin completely eliminated the chum salmon spawning grounds above the dam. “Coho salmon spawned in almost every tributary of the Lewis River.” “They were by far the most widely distributed of the 3 species of salmon normally spawning in the Lewis River system.” “Beautiful mountain streams like the Clearwater and Clear Creek whose junction with the Muddy River, a large tributary of the upper Lewis River, are important silver spawning streams.” “Lewis River spring chinook, under natural conditions, was a fish of the headwater streams.” “The tributaries of the Muddy and mainstem Lewis River in its upper reaches were the natural spawning grounds of this fish.” No spring chinook were reported by Smith to spawn in the streams below the Merwin Dam site. Fall chinook were said to have spawned only a little way above where Merwin Dam is located. “The upper spawning areas of this race of chinook salmon in the main river have, therefore, been flooded by Lake Merwin.” Fall chinook were also reported to enter Cedar Creek, Johnson, and Colvin creeks. Little information is available describing steelhead distribution in the basin prior to the completion of Merwin Dam; however, Smith (circa 1943) noted, “many tributaries of the Lewis River had steelhead entering them to spawn.”

Although access to historical habitat was largely unencumbered by man-made blockages, a “fish rack” was operated on Cedar Creek for several years prior to the completion of Merwin Dam. Eggs from the fish collected in Cedar Creek were transferred to salmon and steelhead hatcheries in the region. It is unclear how the operation of this fish rack affected salmon and steelhead runs in Cedar Creek.

Current Connectivity – When Merwin Dam was completed in 1932, “natural” resident and anadromous fish passage into the upper Lewis River basin was blocked at RM 19.4. To mitigate for this loss of historical habitat, PacifiCorp and the WDF (now WDFW) constructed the Lewis River Hatchery and the Merwin Dam anadromous fish collection facility (a trap and haul facility located at the base of the dam) (Hamilton et al. 1970).

The fish collection facility became fully operational in 1932, and for 25 years adult anadromous fish collected at the base of Merwin Dam were counted, and either used for hatchery broodstock or transported upstream by truck to spawn naturally in the watershed above Merwin Dam. The unscreened spillways and turbine outlets at Merwin Dam and eventually Yale Dam (completed in 1953) provided the only means of downstream passage for outmigrants (Hamilton et al. 1970, Smoker et al. 1951, Chambers 1957). Fish ladders were not constructed over Merwin Dam because PacifiCorp and the Washington State Fisheries and Game Commission (now WDFW) considered them to be "impracticable from the standpoint of properly preserving fish life" (Inland Power and Light Company 1932). The perception was that a conventional fish passage facility could not be designed to accommodate the height of Merwin Dam (PacifiCorp and Cowlitz PUD 2000).

Because of declining run sizes (Section 4.18.5.4), the transportation of chinook into the upper Lewis River watershed was discontinued in 1953; from that point on, all captured chinook were held to provide eggs for the Lewis River Hatchery. The transportation of coho into the upper watershed was discontinued in 1957 (Hamilton et al. 1970).

In addition to the habitat blockages created by the Lewis River dams, adult salmon and steelhead "rack traps" were operated on Cedar, Johnson and Colvin creeks. These traps were used to collect broodstock for Lewis River Hatchery. Colvin and Johnson creeks were also impounded with small impassable dams to create holding ponds for the Lewis River Hatchery. Although rack traps are no longer operated in these streams, the small dam in Colvin Creek continues to block fish migration.

Two diversion dams are currently located on Speelyai Creek. The upper diversion (RM 4.3) was originally built with a dual purpose: 1) to divert upper Speelyai Creek into Yale Lake for power generation; and 2) to divert upper Speelyai Creek away from the lower, spring-fed section to improve the quality of the hatchery water supply. The lower diversion, located approximately 200 feet upstream of Lake Merwin, controls the diversion of water into the hatchery. It includes a rotating drum screen to exclude debris and fish from the intake. Both the upper and lower diversions are total barriers to fish migration; however, fish do have access to upper Speelyai Creek via the canal from Yale Lake. Between 1979 and the present, the upper diversion on Speelyai Creek was only opened on 3 occasions to allow water to flow into lower Speelyai Creek. It is normally closed due to fish health concerns. The Speelyai Hatchery intake water is virtually free of any fish pathogens since very few fish species are present in Speelyai Creek between the 2 diversion structures. This provides a disease-free rearing environment at the hatchery, which is important to the hatchery managers. The upper diversion structure was damaged during the 1996 flood, and the stream channel moved northeast and away from the diversion structure. As a result, water cannot be diverted into lower Speelyai Creek under current conditions. It should be noted that prior to the completion of Merwin Dam, a natural anadromous fish migration barrier existed at the mouth of Speelyai Creek (Hamilton 1974).

As mentioned previously, none of the dams on the Lewis River are equipped with downstream fish passage facilities. As a result, downstream migrating fish are subject to both spillway and intake entrainment, both of which have the potential to injure or kill migrating fish.

Several studies have evaluated entrainment at the Lewis River projects. At Merwin Dam, Schoeneman et al. (1954) estimated coho survival through the spillway to be 54 percent (± 7 percent). Hamilton et al. (1970) estimated that approximately 65 percent of the kokanee and coho exiting Merwin through the turbines survived. Hydroacoustic studies conducted during the Yale relicensing effort showed that approximately 780 fish per day (with an estimated mean length of 130 mm) were entrained at Yale Dam (PacifiCorp 1999b). Although the species composition of these fish (acoustic targets) could not be identified from the hydroacoustic data set, attempts to identify species of entrained fish through reservoir trawls yielded samples that were dominated by threespine stickleback and sculpin that were less than 50 mm in length. As a result, it is likely that the majority of the fish entrained during the study were these species. Between February 1, 2002 and November 30, 2002, a total of 1,527 fish representing 10 different species were collected during screw trap sampling in the Swift No. 1 tailrace (PacifiCorp and Cowlitz PUD: AQU 6, in press). Stickleback was the most common species captured during the study, representing over 65 percent of all fish captured, followed by rainbow trout (16.0 percent), sculpin (9.2 percent), coho (4.5 percent), sucker (3.0 percent), chinook (1.0 percent), steelhead (0.3 percent), bull trout (0.3 percent), cutthroat trout (0.1 percent), and whitefish (0.1 percent). Of the 340 salmonids captured during sampling, rainbow trout was the most common salmonid species caught, accounting for 72.1 percent of all trapped salmonids.

Following the catastrophic failure of the Swift canal on April 21, 2002, biologists from the USFWS, WDFW, Cowlitz PUD, and PacifiCorp conduced several fish salvage operations to rescue fish that were trapped in isolated pools located in the dewatered canal. A total of 10 canal salvage operations were conducted from late April through mid-June. All live fish collected were transported out of the canal and released into either Yale Lake or Swift Reservoir. The number and relative abundance of each species salvaged from the canal in 2002 is presented in Table 4.18-7.

Roads have also been identified as an important factor contributing to habitat fragmentation and the decline of fish populations. Culverts can interfere with, or block, fish migration and alter the movement of both large woody debris and sediment (Murphy 1995). As discussed in Section 4.18.5.2, road densities in the Lewis River basin are relatively high, approaching 4 miles of road per square mile. According to the USFS (1996), road densities that exceed 3 miles per square mile are viewed as “red flags” and indicate where road-related problems are likely to occur. This value is based on several years of observation by Gifford Pinchot National Forest hydrologists and fishery biologists. Recently, both federal and state funding has been made available to improve fish passage associated with stream crossings and also to decommission unused logging roads. Such efforts are guided by applicable federal and state forest management regulations.

Table 4.18-7. The total number of fish, and percent of each species salvaged in the Swift canal compared with screw trap catch results.

Species	Number salvaged (n = 2,143)	Percent of total salvaged
All *O. mykiss* (pooled)	579	27.0
Rainbow	229	10.7
Steelhead	13	0.6
Triploid Rainbow	337	15.7
Whitefish	510	23.8
Stickleback	378	17.6
Sculpin	346	16.1
Bull Trout	42	2.0
Cutthroat Trout	9	0.4
Coho	11	0.5
Chinook	3	0.1
Brook Trout	5	0.2
Hybrid Bull Trout x Brook Trout	1	<0.1
Sucker	253	11.8
Dace	6	0.3
Crayfish	339	Excluded

Aquatic Habitat Conditions

Aquatic habitat in a particular stream reach is formed as a function of the interaction of many variables relating to the watershed as a whole (e.g. climate and geology), the location of a particular reach (e.g. local riparian condition, stream gradient), and the supply of water, wood, sediment, nutrients, and heat from upstream sources.

Historic Aquatic Habitat Conditions – There is little quantitative information on the historic condition of aquatic habitat in the Lewis River system. However, it can be assumed that the watershed as a whole provided a variety of habitat types, higher levels of large woody debris loading than under current conditions, and generally good habitat values in most stream reaches. Streams that were subjected to naturally high sediment loads, such as tributaries in the upper watershed draining glaciers or those in steep watersheds prone to mass wasting likely had different habitat characteristics and higher levels of fine sediment inputs than streams in the lower watershed areas with gentler topography. High quality habitat connected from headwaters to the mouth most likely allowed the expression of diverse life histories in Lewis River salmonids.

Current Aquatic Habitat Conditions – There is quantitative information on the current condition of aquatic habitat in some Lewis River reaches and tributaries, and little specific information regarding other streams. In general, harvesting of riparian areas and removal of large woody debris over the past century has resulted in little large wood in most stream reaches. Almost all stream reaches in the lower and middle watershed were rated as “poor” for large woody debris levels (Wade 2000).

Input of sediment from cultural systems (timber harvest, stream-side grazing) and natural processes (Mount St. Helens eruptions) has resulted in high levels of fine sediment, pool filling, and in tributaries affected by Mount St. Helens, shifting channels. These effects have reduced the number and quality (depth) of pools and reduced the quality of spawning habitat in some reaches. Conversely, the trapping or diversion of sediment by dams on the mainstem Lewis River and Speelyai Creek, and gravel mining in the East Fork Lewis River have reduced the input of sediment from upstream sources. There is limited spawning gravel in the Lewis River bypass reach. Gravel availability and quality is good in the Lewis River downstream of Merwin Dam and in lower Speelyai Creek as a result of the low gradient and/or lower flows in these reaches. ·The limited input of sediment, coupled with smaller magnitude peak flows, has resulted in a less active channel in the reach downstream of Merwin Dam. The reduced input of sediment also affects sediment inputs to the Columbia River, estuary, and Pacific Ocean.

Construction of dikes and levees in the lower 7 miles of the Lewis River has limited the formation of side channel habitat in this reach. Side channel habitat is available in other reaches and streams that have low gradient, unconfined reaches.

Stream habitat values that were measured as part of relicensing studies in specific reaches of the Lewis River watershed are summarized in Table 4.18-8. Currently, the 2.7-mile-long Lewis River bypass reach (North Fork Lewis River) has no minimum flow requirement, and prior to the Swift canal failure in April 2002, surface flow at the downstream end of the bypass reach was estimated to be about 10 cfs (during summer low flows). Instream habitat in the Lewis River bypass reach prior to canal failure was dominated by 20- to 60-foot-wide low-gradient riffles and glides, each of which comprised approximately one third of the total wetted habitat area in the bypass reach (Table 4.18-8). Seven relatively large pools comprised most of the remaining mainstem habitat. Numerous side channels are also present in the bypass reach adjacent to Swift canal. Fish habitat quality in the Lewis River bypass reach is limited by low instream flows, a lack of LWD and a lack of adequate spawning gravel. High summer water temperatures are a problem in the Lewis River bypass reach and may limit the production of resident and/or anadromous salmonids (PacifiCorp 1999b).

During the period when Swift No. 2 is inoperable, water exiting the Swift No. 1 powerhouse is routed through the canal spillway entering the bypass reach channel approximately 1 mile downstream of Swift Dam. The Swift No. 1 plant is being operated in a load-shaping mode, where units are ramped up during peak load periods and ramped down to zero generation during the evening and other off-peak hours. The project is frequently offline between the hours of midnight and 5 AM. Flows vary between 30-80 cfs (seepage into the canal from the Swift No. 1 plant) and 9,000 cfs. The effects of these higher flows on the aquatic habitat and water quality in the bypass reach have not been documented, but are likely to include an increase in the area of available aquatic habitat, reduced diurnal changes in parameters directly influenced by air temperature (water temperature and dissolved oxygen), and inundation of some small alders and willows in the riparian zone. It is likely that fish and other aquatic species will use the new habitat resulting from the higher flows.

Table 4.18-8. Current aquatic habitat metrics in measured stream reaches in the Lewis River watershed.

Stream Reach	Riffle (percent by length)	Glide (percent by length)	Pool (percent by length)	Side Channel (percent by length)	Dominant/ sub-dominant substrate	Total area of spawning gravel (sq yd)	Average percent fines (<1mm) in spawning gravel	LWD (pieces/ mile)
Lewis River bypass reach	12%	11%	15%	62%	Small Boulder/ Cobble	Not measured	1-5%	21
Upper Speelyai Creek (1 mile reach)	46%	41%	13%	0%	Cobble/ Boulder	2	Not measured	77
Lower Speelyai Creek	18%	42%	40%	0%	Cobble/ Gravel	730	Not measured	108
Lewis River: Merwin Dam to Lewis River Hatchery (confined)	22%	56%	22%	0%	Cobble/ Gravel	38,600	0-4%	10
Lewis River: Hatchery to Eagle Island (unconfined)	17%	60%	0%	23%	Cobble/ Gravel	40,600	2-10%	20

Two diversion dams are currently located on Speelyai Creek. The upper diversion (RM 4.3) was originally built with a dual purpose: (1) to divert upper Speelyai Creek into Yale Lake for power generation; and (2) to divert upper Speelyai Creek away from the lower, spring-fed section to maintain the quality of the hatchery water supply. The lower diversion, located approximately 200 feet upstream of Lake Merwin, controls the diversion of water into the hatchery. The upper diversion structure was damaged during the 1996 flood, and the stream channel migrated away from the diversion structure. As a result, water cannot be diverted into lower Speelyai Creek under current conditions. Both the upper and lower diversions are total barriers to fish migration; however, fish do have access to upper Speelyai Creek via the canal from Yale Lake.

Speelyai Creek, upstream of the PacifiCorp diversion, is typical of a high-energy stream with large peak flow events. The reach is dominated by riffles and glides, with a few pools and cascades (Table 4.18-8). Average wetted width is 23 feet, and the bankfull:wetted width ratio is 3, indicating large peak flows. Dominant substrate is cobble and boulder, with minor gravel in pools. The riparian zone is dominated by upland species, likely due to the flashy nature of the streamflow. Like the Lewis River bypass reach, high summer water temperatures are a problem in upper Speelyai Creek (PacifiCorp 1999b). Water temperatures are unusually high compared to other tributaries in the system, and may be related to the removal of riparian vegetation in the upper reaches.

Flows downstream of the upper diversion are currently limited to groundwater and tributary inflow. As a result, lower Speelyai Creek has the characteristics of a spring-fed system. During low flows conditions, flow in lower Speelyai Creek increase from only a trickle just below the upper diversion to an estimated 15 to 20 cfs at the Speelyai Hatchery diversion (PacifiCorp and Cowlitz PUD 2002). Wetted channel width is close to 30 feet in the lower reach. The constant flow regime results in stable, high quality aquatic and riparian habitat between the 2 diversions. Aquatic habitat is dominated by glides and pools, with some riffles (Table 4.18-8). Substrate is cobble/gravel, and there is an average of 108 pieces of large woody debris/mile in the reach, the only project-affected reach to meet the USFS objectives for large wood. Without the diversion in place, lower Speelyai Creek would have a much wider, more active channel and floodplain, and a less stable, less diverse riparian community, resulting in different ecosystem dynamics.

The mainstem Lewis River between Merwin Dam and just downstream of the Lewis River Hatchery is confined in a bedrock channel. Aquatic habitat in this reach is characterized by glides (56 percent), riffles (22 percent), and pools (22 percent; Table 4.18-8). No side channels were mapped. Average wetted widths during the field survey were 224-269 feet; average bankfull widths were 305-350 feet. Dominant/subdominant substrate was cobble/gravel in the glides and riffles, and boulder/bedrock/cobble in the pools. A total of 1,042,000 square feet of spawning-sized gravel deposits were mapped during the field survey in this reach.

Downstream of the naturally confined reach, the Lewis River valley widens from 0.5 to 1 mile. In this unconfined reach, historically the river has been able to migrate across its valley. As mentioned previously, human intervention has prevented migration of several meanders in this reach in the past 70 years. Aquatic habitat is dominated by glide habitat (60 percent), side channel habitat (23 percent), and riffles (17 percent). No pools were mapped in this reach. Average wetted widths were 210-232 feet for riffles and glides, respectively, and 87 feet for the side channels. Bankfull widths were 256-296 feet for riffles and glides and 108 feet for side channels. Dominant/subdominant substrate was cobble/gravel in the riffles and glides and gravel/silt/sand in the side channels.

The results of USFS surveys in 26 tributaries of the upper Lewis River above Swift Dam (including Drift and Siouxon creeks) (USFS 2002a) revealed that most of the streams and rivers in the surveyed portion of the watershed do not meet the standards of the Gifford Pinchot National Forest’s Forest Plan (USFS 1990). Although aquatic habitat quality was determined to be lower than Region 6 Forest Service standards, the habitat is thought to be adequate for reintroduction of anadromous fish (USFS 2002a).

Data describing large wood (LW) densities in these 26 tributaries, compared to USFS desired future conditions, is shown in Figure 4.18-11. The USFS uses 80 pieces of LW per mile as a quantity that reflects a loading that would be considered "Functioning Appropriately." Based upon the available information, the accessible aquatic habitat in the surveyed streams was determined to be “Functioning at Unacceptable Risk” for large wood (USFS 2002a). These degraded LW conditions are not the result of the Lewis River projects.

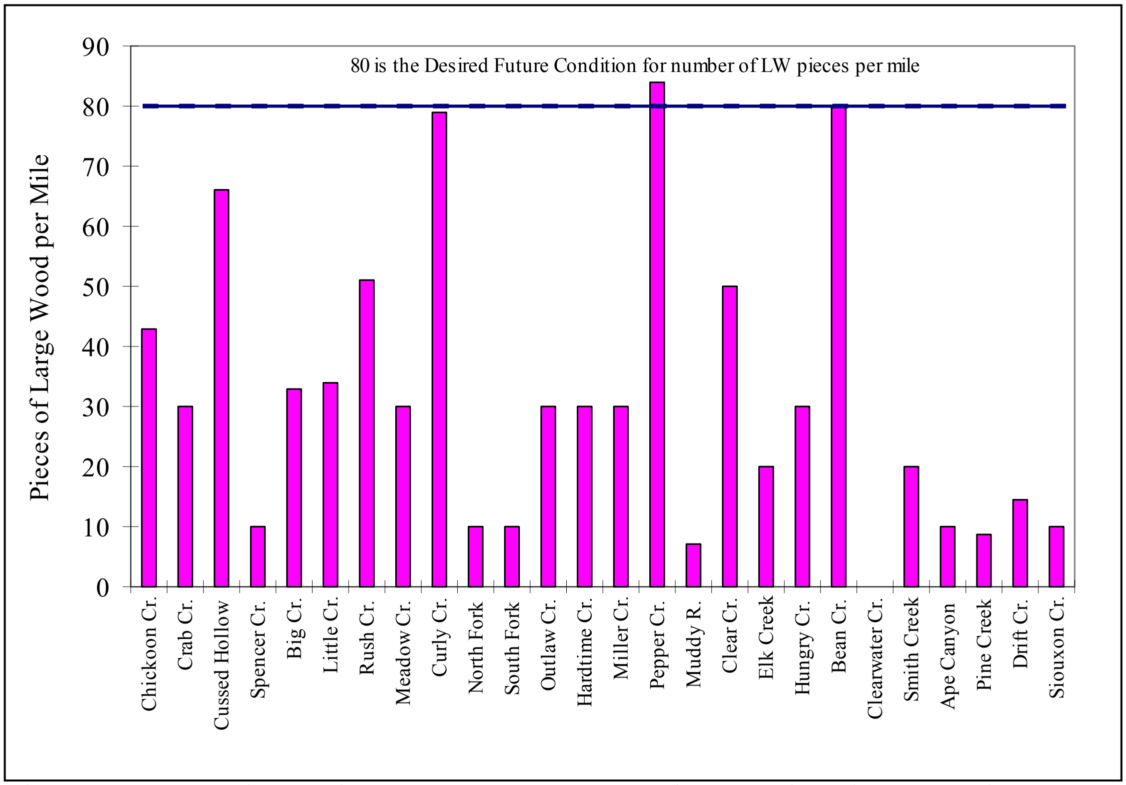

Figure 4.18-11. Pieces of large wood (LW) per mile compiled from multiple year USFS surveys.

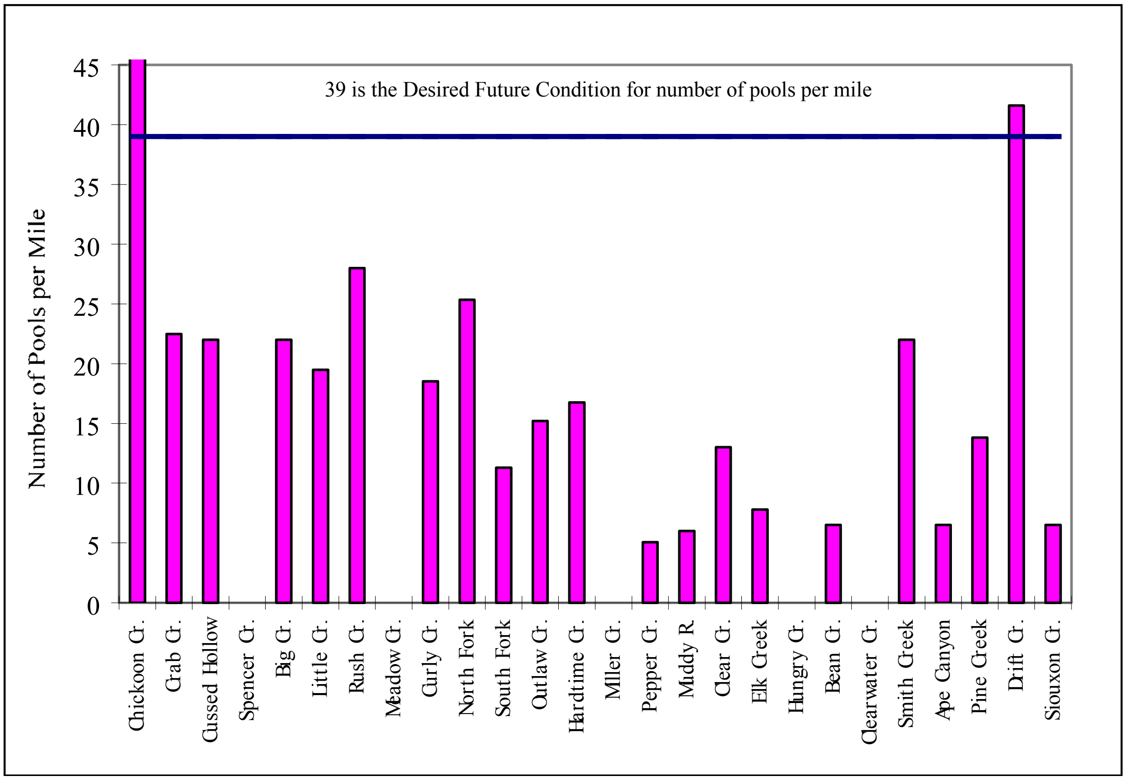

Figure 4.18-12. Number of pools per mile calculated from multiple year USFS surveys.

be approximately 39 pools per mile. According to USFS (2002a), the average pool frequency of 17.5 pools/mile is on average "Functioning at Unacceptable Risk."

Potentially Accessible Anadromous Fish Habitat – As part of anadromous fish reintroduction studies, PacifiCorp and Cowlitz PUD delineated the stream segments in the upper North Fork Lewis River (above Merwin Dam) that would be accessible to anadromous fish under any fish passage option. This review of existing information, combined with field surveys, estimated the length (in miles) and area (in square feet) of potentially accessible anadromous fish habitat above Merwin Dam (PacifiCorp and Cowlitz PUD 2001)[10].

The results of this study indicated that there are approximately 96.1 miles of potentially accessible anadromous fish habitat in the North Fork Lewis River basin upstream from Merwin Dam (Table 4.18-9). Of this potentially accessible habitat, 6.2 miles are located between Merwin Dam and the base of Yale Dam. Approximately 15.8 miles are between Yale Dam and the base of Swift Dam, and the remaining 74.1 miles are upstream from Swift Dam. As expected, the total area and percent area calculations paralleled the length-based calculations. Although the quality of the habitat in these streams is highly variable, the vast majority would likely support anadromous salmonids. More detailed information describing the habitat found in these reaches, including photographs, is available in PacifiCorp and Cowlitz PUD (2001).

Table 4.18-9. The length and area of potentially accessible anadromous fish habitat, and the percent of total accessible habitat in the 3 reaches of the North Fork Lewis River upstream of Merwin Dam.

Reach Name*	Length of Accessible Habitat (miles)	Total Wetted Area of Accessible Habitat (ft^2)	Percent of Total Accessible Habitat (by area)	Percent of Total Accessible Habitat (by length)
Lake Merwin	6.2	361,702	1.8%	6.5%
Yale Lake	15.8	2,753,035	13.4%	16.4%
Swift Reservoir	74.1	17,468,436	84.9%	77.1%
Grand Total	96.1	20,583,173	100.0%	100.0%

* The "Lake Merwin" reach extends from Merwin Dam to the base of Yale Dam, the "Yale Lake" reach extends from Yale Dam to the base of Swift Dam; and the "Swift Reservoir" reach extends from Swift Dam to the lower falls on the North Fork Lewis River.

In addition to the above data, members of the ARG completed an assessment of potentially accessible anadromous fish habitat in the upper basin using information from USGS 7.5 minute quadrangles. Results of this evaluation indicated that as much 176 miles of habitat may exist in the basin during high flow conditions. According to this assessment, 29.4 miles are located between Merwin Dam and the base of Yale Dam. Approximately 29.5 miles are located between Yale Dam and the base of Swift Dam, and 117.1 miles are located upstream from Swift Dam (Table 4.18-10). Unlike the estimates in Table 4.18-9, these estimates include habitat inundated by the project reservoirs.

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[10] Downstream from longstanding natural barriers.

Table 4.18-10. Length of potentially accessible anadromous fish habitat and the percent of total accessible habitat in the three reaches of the North Fork Lewis River upstream of Merwin Dam.

Reach Name*	Length of Potentially Accessible Habitat (miles)	Percent of Total Accessible Habitat (by length)
Lake Merwin	29.4	17%
Yale Lake	29.5	17%
Swift Reservoir	117.1	67%
Grand total	**176.0**	**100%**

* The Lake Merwin reach extends from Merwin Dam to the base of Yale Dam; the Yale Lake reach extends from Yale Dam to the base of Swift Dam; and the Swift Reservoir reach extends from Swift Dam to the lower falls on the North Fork Lewis River.

Source: Based on estimates developed by the ARG.

Habitat in the upper basin above Swift Dam is capable of supporting anadromous salmonids over part of their life history. However, habitat connectivity between the upper and lower basin is nonexistent or severely curtailed by 3 dams and their reservoirs. What life histories will emerge from this fragmented habitat after reintroduction is a crucial question. It will only be answered by implementing a carefully planned reintroduction program followed by adequate monitoring of the emerging life histories. The reintroduction of anadromous salmonids to the upper basin must pay enough attention to nurturing life history-habitat relationships as to the numbers of fish involved.

4.18.5.4 Historical and Current Fish Assemblages

Historical Assemblages

Chinook Salmon – Prior to the completion of Merwin Dam in 1932, the Lewis River basin supported self-sustaining populations of both spring and fall chinook salmon. Early reports of chinook abundance completed by the WDF and the WDG (Smoker et al. 1951) indicate that "at least 3,000" spring chinook were believed to have entered the Lewis River above the Merwin Dam site. The “original” pre-project fall chinook run past the dam site was believed to be "at least 1,300 adults." Unfortunately, these upper basin population estimates do not account for commercial or recreation harvest, nor do they reflect chinook abundance before major freshwater habitat degradation. In addition, the authors noted that these estimates were based on "early trap counts, poor records,” or in some cases "only one brood year.”

Information describing the historical (pre-project) distribution of chinook salmon is limited; however, spring chinook were thought to spawn throughout the "Lewis River headwater" upstream from the Merwin Dam site (Smoker et al. 1951). Smith (1939a) also identified chinook spawning in lower Muddy River, Clearwater Creek, and Clear Creek (Figure 4.18-2). Fall chinook, normally a mainstem spawner, were thought to spawn in "the present Merwin Reservoir area" (McIsaac 1990). In a study designed to quantify the amount of suitable spawning and rearing habitat "above Yale Dam", the WDF, now WDFW, reported that there were approximately one million square feet of suitable chinook spawning habitat in the North Fork Lewis River between Bolt Camp (near Rush Creek) and Swift Creek (Figure 4.18-2) (Chambers 1957). The lower portion of Muddy River was also thought to provide an additional 500,000 square feet of chinook spawning area (Chambers 1957). No other chinook spawning areas were described in the WDF report. Although this historical spawning habitat has likely diminished in quality for a number of reasons, it is likely that the quality of this habitat will improve over time as riparian areas become reestablished, marine derived nutrients are reintroduced into the system and instream habitat conditions increase in complexity.

During project relicensing, a technical work group was appointed by the Settlement Negotiating Group to establish methods and provide estimates of historical (pre-dam) adult anadromous fish production in the Lewis River basin. Estimates were developed using an Ecosystem Diagnosis and Treatment (EDT) analysis (Mobrand Biometrics, Inc, 2003) and a run reconstruction method (Norman and Rawding 2003). EDT estimates of historical production assume pristine (pre-European settlement conditions) for the mainstem Lewis River and tributaries, and Columbia River estuary. Run reconstruction estimates were derived from pre-project terminal escapement and harvest estimates. The run reconstruction method provides an alternative scientific approach to estimating population levels, which enables a comparative analysis between the results of a habitat measuring method and a retrospective fish accounting method.

EDT estimates of historical spring chinook production above the Merwin Dam site (upper basin) range from 10,560 adults during periods of low ocean survival to 20,757 adults during periods of high ocean survival (Table 4.18-11). Fall chinook production estimates range from 5,532 adults during periods of low ocean survival to 11,064 adults during periods of high ocean survival (Table 4.18-11).

Table 4.18-11. Adjusted EDT-based historical production potential estimates for habitat located above Merwin Dam.

Species	**Average Ocean**	**High Ocean**[1]	**Low Ocean**	**Range of Ocean Survival**[2]
Chum	12,105	18,230	5,979	0.12%-0.22%
Fall Chinook	8,298	11,064	5,532	1.2%-2.4%
Spring Chinook	15,659	20,757	10,560	3%-6%
Coho	33,886	44,439	23,332	5%-10%
Winter Steelhead	7,778	10,205	5,350	6%-12%
Summer Steelhead	~500	656	344	--
Sea-Run Cutthroat	3,389	4,444	2,333	--
Total	**81,615**	**109,795**	**53,430**	

[1] Historic (pre-European settlement) survival may be higher than displayed under high marine survival due to higher fitness level associated with fish not affected by harvest or habitat degradation beginning in the late 19th century.

[2] High and low marine survival represent averages for a time period (typically 20-40 years). The survival actually varies significantly within a period. For example:

A. Coho low marine survival averages 5%; however, annual survival rates range from less than 1% to over 10%.
B. Coho high marine survival averages10%; however, annual survival rates range from less than 5% to over 20%.

Run reconstruction estimates of historical adult spring and fall chinook production above the Merwin Dam site are presented in Table 4.18-12. According to this methodology, an estimated 7,000 spring chinook and 6,800 fall chinook were produced in the upper basin prior to dam construction. Comparing the individual species results shows that the EDT analysis and run reconstruction method provide both highest and lowest estimates depending on the species. The fact that one method is not consistently high or low compared to the other supports the notion that these methods may, as an aggregate, reflect the range of potential production estimates (Norman and Rawding 2003).

Table 4.18-12. Lewis salmon and steelhead run reconstruction for above-Merwin production.

Species	Terminal Run	Harvest Rate	Total Production
Chum	3,000	53%	6,400[1]
Fall Chinook	1,300	81%	6,800
Spring Chinook	3,500	50%	7,000
Coho	29,264	63%	78,600
Winter Steelhead	5,250	34%	8,000

[1] Included entire Lewis basin, above Merwin ~ 10%

Coho Salmon – The Lewis River basin historically supported a large spawning population of coho salmon. The WDF and WDW estimated pre-project coho escapement to be about 15,000 fish, with 10,000 entering the North Fork and 5,000 entering the East Fork Lewis River (WDF and WDW 1993). According to Smoker et al. (1951), the 1933 count at Merwin Dam was 29,264 coho. These were the progeny of adults that were not affected by the dam. As with chinook, these estimates do not account for commercial or recreation harvest.

The pre-project coho population was reported to spawn in the Muddy River and in Pine, Clearwater, Clear, Smith, Drift and Cougar creeks (Figure 4.18-2) (WDF and WDW 1993, Chambers 1957). "Limited" coho salmon spawning was also thought to occur in the side channels and smaller tributaries of the mainstem Lewis River, as well as the lower reaches of Range Creek. Smith (1939a) also made reference to a large pool at the mouth of Clearwater Creek containing an estimated 1,500 to 2,000 coho. This pool was located just upstream from the confluence with the Muddy River.

EDT-based estimates of historical coho production above the Merwin Dam site range from 23,332 adults during periods of low ocean survival to 44,439 adults during periods of high ocean survival (Table 4.18-11) (Mobrand Biometrics, Inc, 2003). According to the run reconstruction methodology, the upper basin produced an estimated 78,600 coho (Table 4.18-12) (Norman and Rawding 2003).

Steelhead – Summer and winter steelhead are indigenous to the Lewis River basin. Historically, large numbers of winter steelhead were known to spawn and rear in the North Fork upstream from Merwin Dam. Few summer steelhead spawned in the North Fork (NPPC 1990). Unfortunately, the full extent of their historical distribution in the upper basin is unknown.

Information describing the historical (pre-project) abundance of steelhead in the Lewis River basin is extremely limited, although Smoker et al. (1951) estimated that the total spawning escapement above the Merwin Dam site exceeded 1,000. Lavoy (1983) estimated that the total spawning escapement ranged from 8,000 to 11,000 fish.

EDT based estimates of pre-project winter steelhead production in the upper basin range from 5,350 adults during periods of low ocean survival to 10,205 adults during periods of high ocean survival (Table 4.18-11) (Mobrand Biometrics, Inc, 2003). EDT estimates of historical summer steelhead production range from 344 to 656 adults. According to the run reconstruction methodology, the upper basin produced an estimated 8,000 winter steelhead (Table 4.18-12) (Norman and Rawding 2003). Run reconstruction estimates are not available for summer steelhead.

Chum Salmon – Historically, chum salmon were abundant in the lower Columbia River and its tributaries. Populations were reported to spawn as far upstream as the Walla Walla River. Prior to the completion of Merwin Dam, chum salmon were common in the lower Lewis River basin and were reported to "ascend the main stem above the dam site and spawn in the present reservoir area" (Smoker et al. 1951). During the 10-year period following the construction of Merwin Dam (1930 to 1940), the Lewis River Hatchery supplemented the wild run, but experienced no success (Smoker et al. 1951). In 1951, WDF and WDW estimated the Lewis River chum escapement to be about 3,000 fish. Records of Cedar Creek, located below Merwin Dam, show that at least a thousand adult chum salmon ascended this tributary (Smoker et al. 1951). Chambers (1957) reported 96 chum salmon spawning just downstream from Merwin Dam in mid-November of 1955.

EDT estimates of historical chum salmon production in the entire Lewis River basin (both above and below the Merwin Dam site) range from 5,979 adults during periods of low ocean survival to 18,230 adults during periods of high ocean survival (Table 4.18-11) (Mobrand Biometrics, Inc, 2003). According to the run reconstruction methodology, the upper basin produced an estimated 6,400 chum salmon (Table 4.18-12) (Norman and Rawding 2003).

Current Assemblages

As discussed in Section 4.18.5.4, the Lewis River basin downstream of Merwin Dam currently supports a self-sustaining population of wild fall chinook salmon and hatchery stocks of spring chinook, early and late coho, and winter and summer steelhead. White sturgeon, Pacific lamprey, eulachon (smelt), mountain whitefish, cutthroat trout, chum salmon, pink salmon, and sockeye salmon are also occasionally observed downstream of Merwin Dam (Table 4.18-13).

Species known to occur in the project reservoirs include kokanee, rainbow trout, mountain whitefish, cutthroat trout, bull trout, sculpin, northern pikeminnow, tiger muskellunge, white sturgeon, carp (*Cyprinus carpio*), bluegill, crappie, threespine stickleback, largescale sucker, residualized coho, chinook, and steelhead (Table 4.18-13). Each of these species, with the exception of kokanee, carp, blue gill, tiger muskellunge (*Esox masquinongy X Esox lucius*), and crappie, are native to the Lewis River basin. Non-native species were introduced following dam construction to enhance the recreation fishery.

Table 4.18-13. Fish species present in the Lewis River hydroelectric project area.

Species	Project Reach			
	Lewis River below Merwin Dam	Lake Merwin	Yale Lake	Swift Reservoir and Upper Lewis River
Fall chinook salmon	X			
Spring chinook salmon	X	X*		X**
Coho salmon	X	X*		X**
Winter steelhead	X	X*		
Summer steelhead	X	X*		
Chum salmon	X			
Pink salmon	X			
Sockeye salmon	X			
Sea-run cutthroat trout	X			
White sturgeon	X	X		
Pacific lamprey	X			
Eulachon (smelt)	X			
Kokanee		X	X	
Bull trout	X	X	X	X
Resident rainbow trout	X	X	X	X
Resident cutthroat trout	X	X	X	X
Northern pikeminnow	X	X	X	X
Brook trout			X	
Mountain whitefish	X	X	X	X
Sculpin (spp.)	X	X	X	X
Carp		X		
Bluegill		X		
Crappie		X		
Threespine stickleback	X	X	X	X
Largescale sucker	X	X	X	X
Brown bullhead		X		
Tiger muskellunge	X	X		

* Excess hatchery salmonids are planted into Lake Merwin to supplement the sport fishery.

** Progeny of experimental releases in the upper watershed.

In this section of the report, we focus our discussion on the post-project (1932-present) distribution, abundance, hatchery production, and stock status of those species being evaluated for potential reintroduction above Merwin Dam (spring chinook, coho and steelhead). We also discuss introduced species that have the greatest potential to affect, or interact with, those species targeted for reintroduction. Additional information describing the current and historical abundance and life histories of those species not discussed in this report is available in Study AQU-1 of the Licensee's 2001 Technical Study Status Reports (PacifiCorp and Cowlitz PUD 2002).

Chinook Salmon – For the first 21 years following construction of Merwin Dam and Lewis River Hatchery (1932-1953), spring and fall chinook returns to the Merwin Dam Anadromous Fish Collection Facility decreased dramatically, although a relatively large number of spring chinook did return to the basin in 1940 (Figure 4.18-13). During this same period, Columbia River basin spring chinook returns were increasing in abundance (ODFW and WDFW 2000) (Figure 4.18-13). Lewis River and Columbia River basin fall chinook returns were variable, with some similarities in annual abundance. Early attempts to maintain the native spring chinook stock through hatchery production failed, and by the mid-1950s, only fall chinook were trapped at Merwin Dam. Spring chinook completely disappeared from the trap catches; fall chinook returns were greatly reduced in certain years (Figure 4.18-13). According to Smith (1937), "poor water supply, disease, faulty technique and inherent weakness of the spawning fish themselves" were responsible for the decline in abundance. Smoker et al. (1951) also noted that the native Lewis River spring chinook stock was "undoubtedly injured" by poor hatchery practices and a lack of regular spill at Merwin Dam. In particular, brood years 1931, 1932, 1933 and 1934 were "seriously damaged." Smoker et al. (1951) further states, "Where the original runs were about 3,000 fish per annum, the present run averages only about 100 adults and has been as low as 19 fish in 1949." Because of these declining run sizes, the transportation of chinook into the upper watershed was discontinued in 1953 (Chambers 1957); from that point on, all captured chinook were held to provide eggs for the Lewis River Hatchery program.

In response to collapsing returns and the apparent extinction of native Lewis River spring chinook, the WDF introduced spring chinook from the Cowlitz River, Wind River (Carson Hatchery), and Willamette River, although relatively few were planted until 1972 (PacifiCorp and Cowlitz PUD 2000, Myers et al. 1998). Since then, spring chinook used in the Lewis River Hatchery program have originated from a variety of sources including Cowlitz, Kalama, Carson, and even Klickitat stock, along with in-station returns to the Lewis River (Hymer et al. 1993, Myers et al. 1998).

Between 1972 and 1999, annual spring chinook releases from the Lewis River Hatchery Complex ranged from about 122,000 to over 1.5 million (Figure 4.18-15). Most (91 percent) were released as yearlings. According to Myers et al. (1998), only 4 percent of these releases were made using stocks from basins located outside of the Lower Columbia River Evolutionarily Significant Unit (ESU). Contrary to what is presented in Myers et al. (1998), the Lewis River Hatchery Complex manager believes that the majority of spring chinook returning to the North Fork Lewis River originated from Carson stock (pers. comm. R. Nicolay, WDFW, as cited in Shrier 2000). Carson stock spring chinook are bound for the upper Columbia River and are not considered part of the Lower Columbia River ESU. Recent genetic data compiled by Myers et al. (1998) and Marshall et al. (1995) have shown that Lewis River spring chinook are more closely related to Cowlitz, Kalama and Klickitat stocks (Section 4.18.5.5). WDFW considers Lewis River spring chinook to be a mixed stock of composite production (WDF and WDW 1993).

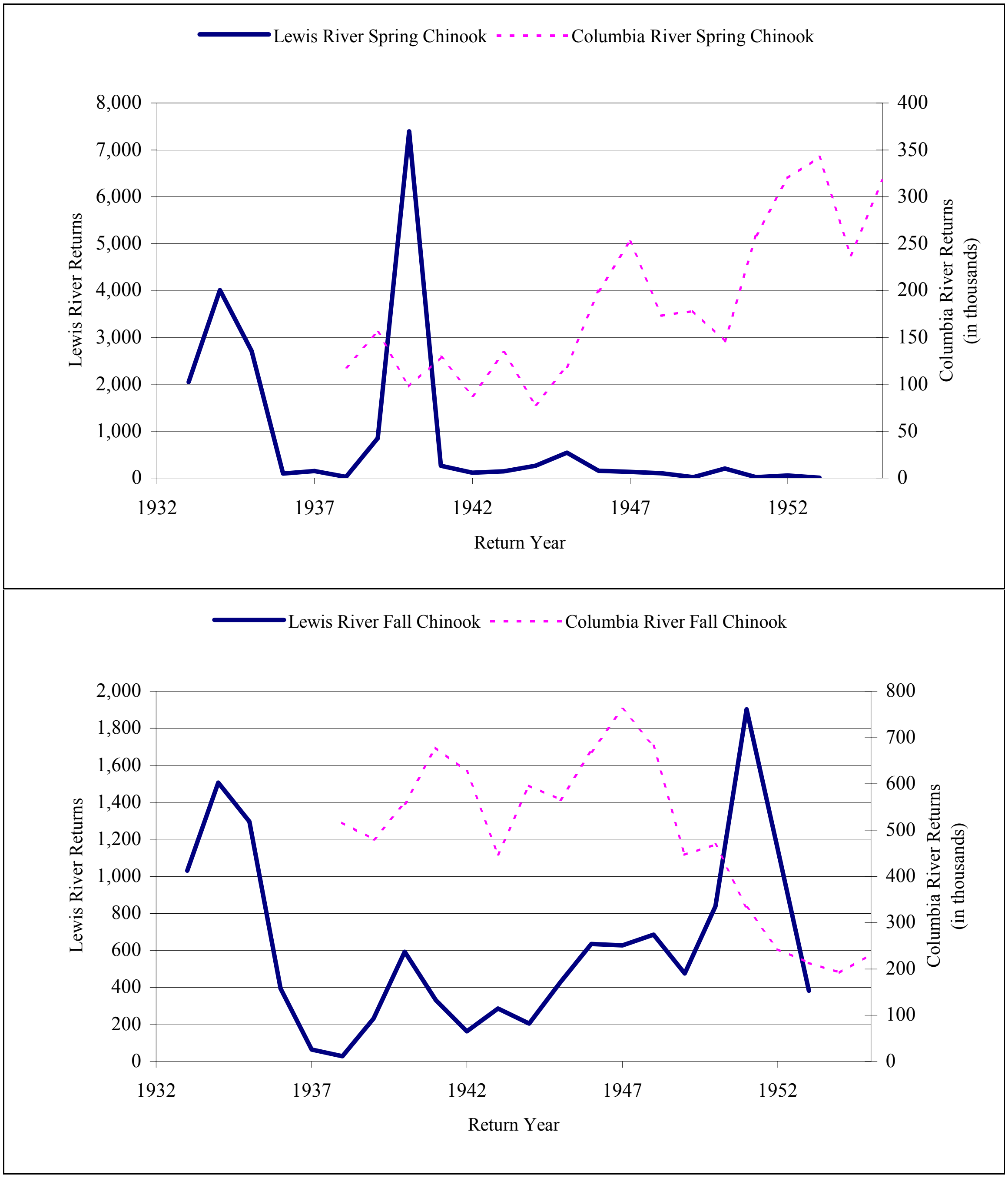

Figure 4.18-13. The number of adult spring and fall chinook collected at the Merwin Dam Anadromous Fish Collection Facility (Lewis River returns) compared with Columbia River basin returns (1933 to 1955).

The current spring chinook production goal at the Lewis River Hatchery Complex is 1.05 million smolts at 5 to 7 per pound (Table 4.18-14). The number of juveniles produced at the hatcheries is adjusted on the basis of a 5-year rolling average of adult returns in an ongoing attempt to provide the number of adult salmon (12,800 spring chinook and

71,000 coho) that are identified in Article 50 of the existing Merwin Project license. According to WDFW (2001b), additional "performance goals" are to:

1. Produce adult fish for harvest;
2. Meet hatchery production goals;
3. Manage for adequate escapement;
4. Minimize interactions with listed fish through proper broodstock management;
5. Minimize interactions with other fish populations through proper rearing and release strategies;
6. Maintain stock integrity and genetic diversity;
7. Maximize in-hatchery survival of broodstock and their progeny; and limit the impact of pathogens associated with hatchery stocks, on listed fish; and
8. Ensure that hatchery operations comply with state and federal water quality standards through environmental monitoring.

Table 4.18-14. Current WDFW fish production goals for the Lewis River basin.

Species	Hatchery	Release Site	Production Goal
Spring Chinook	Lewis River/Speelyai	Lewis River	1,050,000 (5-7/lb) (210,000 pounds)
Early Coho (Type-S)	Lewis River/Speelyai	Lewis River	1,880,000[1]
Late Coho (Type-N)	Lewis River	Lewis River	2,100,000[2]
Summer Steelhead	Merwin	Lewis River	175,000 (5/lb) (35,700 pounds)
Winter Steelhead	Merwin	Lewis River	100,000 (5/lb) (20,400 pounds)
Kokanee	Speelyai	Lake Merwin	45,000 fingerlings, 48,000 yearlings
Tiger Musky	Merwin	Lake Merwin	Approx. 3,000 (4-5/lb)
Rainbow Trout	Merwin	Swift Reservoir	800,000 (25/lb) (30,000 pounds)

[1] 880,000 smolts at 13 to 15 per pound for the Lewis River Hatchery program and 1 million smolts (and 750,000 eyed eggs) for the Tribal component of the program.
[2] 800,000 smolts at 13 to 15 per pound for the Lewis River Hatchery program.

In the last 20 years, adult spring chinook returns to the Lewis River basin have been highly variable. From 1980 through 1997, the total adult spring chinook return (including hatchery returns, natural escapement, and sport harvest) has ranged from a low of 1,600 in 1996 to nearly 17,000 in 1987, with an average of approximately 5,600 fish (Figure 4.18-14) (Pettit 1997; pers. comm., R. Pettit, WDFW 2001; WDF and WDW 1993). Trends in annual abundance were similar to those observed in the Columbia River basin as a whole.

Currently, there is very little natural production of spring chinook in the Lewis River basin. From 1980 through 1997, the natural escapement of adult spring chinook, based on annual spawning ground counts, averaged about 1,700 fish, or approximately 15 to 20 percent of the total run size (Pettit 1997). All of these naturally spawning fish are considered a mixed stock of composite production (WDF and WDW 1993).

The distribution of these naturally spawning spring chinook is limited to the mainstem Lewis River (from RM 0.0 to RM 19.4) and Cedar Creek (from RM 0.0 to RM 18.2)

(Figure 4.18-2). Few, if any, spring chinook return to the East Fork Lewis River (WDF and WDW 1993). In the mainstem Lewis River, most natural spring chinook spawning and rearing occurs between Merwin Dam and the Lewis River Hatchery (RM 15.6 to RM 19.4). Most spawning and rearing in Cedar Creek occurs between RM 11.0 and RM 18.2.

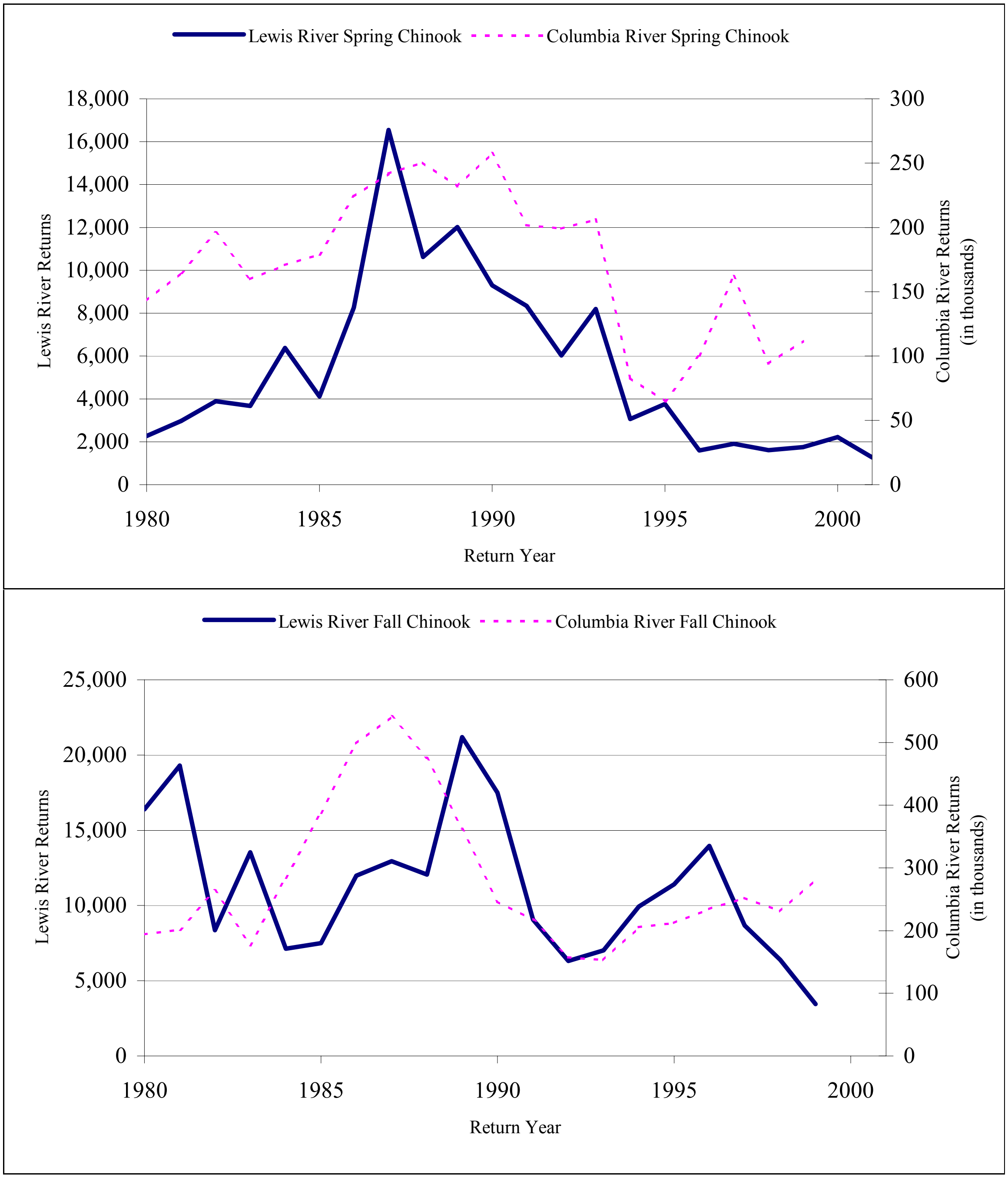

Figure 4.18-14. Adult spring chinook and fall chinook returns to the North Fork Lewis River compared with Columbia River basin returns (1980 to 2001).

Lewis River spring chinook support a popular in-river recreation fishery. Between 1988 and 1999, the in-river harvest rate of spring chinook has averaged about 60 percent of the total return (1988 to 1999 data). During this period, 99.9 percent of the total recreation catch was harvested in the Lewis River and 0.09 percent was harvested in the East Fork Lewis River.

Out-of-basin origin fall chinook were introduced into the Lewis River during and immediately following the construction of Merwin Dam. From 1930 to 1939, between 600,000 and 10.5 million fall chinook eggs were imported annually from the Little White Salmon and Kalama rivers (WDF and USFWS 1951). Smith (1937) also makes reference to “a lot of Cowlitz chinook eggs” being transported to the Lewis River Hatchery in the late 1930s. From the early 1950s through the early 1980s, releases were also made from the Grays River Hatchery, Kalama Falls Hatchery, and the Spring Creek National Fish Hatchery (located 62 miles east of Vancouver on the Columbia River) (PacifiCorp and Cowlitz PUD 2002). Annual releases ranged from 0 in the late 1960s and early 1970s to over 3 million in 1965 (Figure 4.18-16) (PSMFC 2001).

WDFW discontinued the Lewis River Hatchery fall chinook program in 1986 to eliminate negative interactions with wild fall chinook, and despite years of hatchery augmentation, the fall chinook stock in the Lewis River system has “maintained a significant population with negligible hatchery influences” (Hymer et al. 1993). Current production of fall chinook in the Lewis River basin is entirely natural.

Today, Lewis River fall chinook represent about 80 to 85 percent of the wild fall chinook returning to the lower Columbia River (NPPC 1990). The total adult fall chinook return to the Lewis River from 1980 through 1998 has been highly variable, ranging from 6,200 in 1998 to 21,200 in 1989 (Figure 4.18-14). The average over this period was 11,600 fish (Figure 4.18-14) (Hawkins 1998). According to WDFW protocol, fall chinook escapement estimates in the Lewis River are based on a peak spawner count expansion of 5.27 (Hawkins 1998).

The distribution of Lewis River fall chinook is limited to the mainstem Lewis River from RM 0.0 to RM 19.4 (Merwin Dam), in the East Fork Lewis River from RM 0.0 to RM 20.6, and in Cedar Creek from RM 0.0 to RM 8.2 (Figure 4.18-2). In the East Fork Lewis River, most fall chinook spawning and rearing occurs between RM 0.0 and RM 13.9.

The Lewis River fall chinook recreation fishery is managed for an escapement goal of 5,700 adult spawners. In years where tributary run size is expected to exceed the escapement goal, a sport fishery is opened. From 1996 through 2000, the recreation fishery was closed for all or part of the season due to low escapement (< 5,700 fish). The number of fall chinook harvested in the Lewis River recreation fishery from 1980 to 1998 (the latest final data) based on punch card returns has ranged from 8 in 1998 to 3,057 in 1988 (PSMFC 2001, WDFW 1997, WDFW 1999a, WDFW 1999b, WDFW 1999c). During this period, 99.3 percent were harvested in the mainstem Lewis River (bright stock) and 0.70 percent were harvested in the East Fork Lewis River (Tule fall chinook).

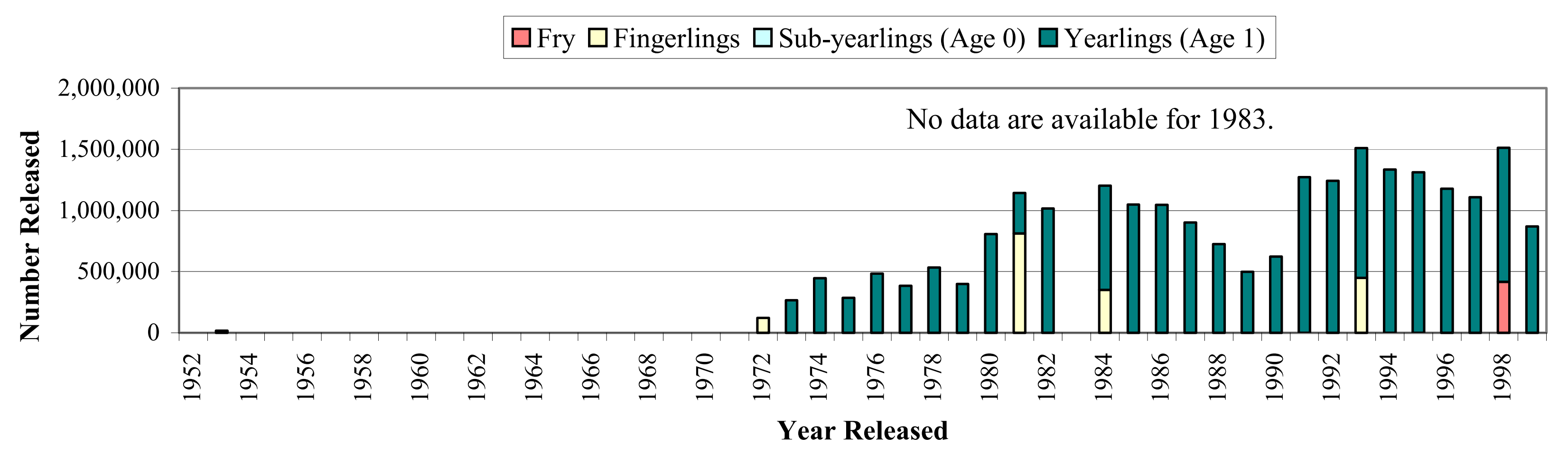

Figure 4.18-15. Hatchery releases of spring chinook salmon yearlings, sub-yearlings, fingerlings and fry from 1952 through 1999.

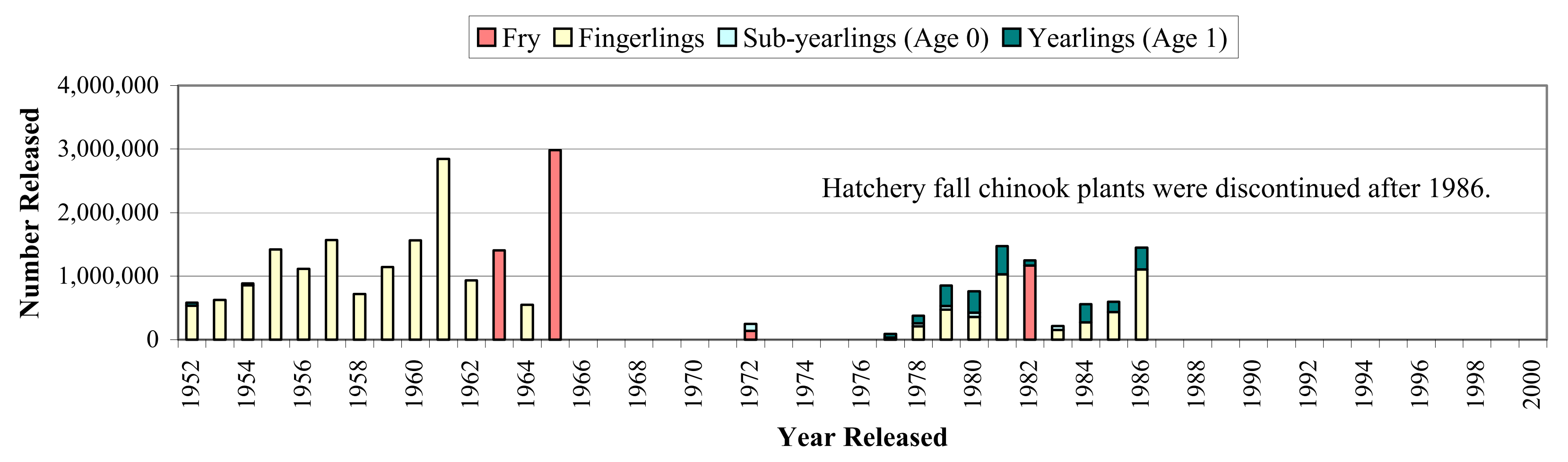

Figure 4.18-16. Hatchery releases of fall chinook salmon yearlings, sub-yearlings, fingerlings and fry from 1952 through 2000.

The overall stock status of spring and fall chinook in the Lewis River basin, as designated by WDFW, is considered "healthy" based on escapement trends (WDF and WDW 1993); however, chinook salmon in the lower Columbia River ESU, including Lewis River fall chinook (both “bright” and “Tule” stocks), were listed as threatened under the Endangered Species Act (ESA) on March 24, 1999 (Federal Register, Vol. 64, No. 56, March 24, 1999). Lewis River spring chinook, a hatchery stock, are a component of the lower Columbia River ESU, but are not considered a listed species (USFW and NMFS 2002).

According to Mobrand Biometrics, Inc, (2003), the existing habitat above Merwin Dam is currently capable of producing 5,559 adult spring chinook during periods of low ocean survival and 14,151 adults during periods of high ocean survival (Table 4.18-15). The estimated upper basin production potential for fall chinook is 3,525 adults during periods of low ocean survival and 7,049 adults during periods of high ocean survival.

Table 4.18-15. EDT estimates of adult anadromous fish production potential under current (patient) conditions in the Lewis River basin above Merwin Dam[1].

Species	Average. Ocean	High Ocean	Low Ocean	Range of Ocean Survival[2]
Chum	2,775	4,469	1,082	0.12%-0.22%
Fall Chinook	5,287	7,049	3,525	1.2%-2.4%
Spring Chinook	9,855	14,151	5,559	3%-6%
Coho	21,753	28,747	14,579	5%-10%
Winter Steelhead	7,018	9,232	4,804	6%-12%
Summer Steelhead	~500	656	344	
Sea-Run Cutthroat	3,101	3,933	2,269	
Total	50,289	68,237	41,900	

[1] Estimates assume current habitat conditions below Merwin Dam, historical habitat under the reservoirs, and Properly Functioning Conditions (NMFS model) in the tributaries above Merwin Dam.

[2] High and low marine survival represent averages for a time period (typically 20-40 years) The survival actually varies significantly within a period. For example:

A. Coho low marine survival averages 5%; however, annual survival rates range from less than 1% to over 10%.
B. Coho high marine survival averages10 percent; however, annual survival rates range from 20% to less than 5%.

<u>Coho Salmon</u> – Coho salmon returns to the Lewis River basin also declined following the completion of Merwin Dam. The initial decrease in the abundance and high degree of annual variability in the late 1930s and early 1940s was believed to be the result of “poor intermittent spilling” over Merwin Dam (Smoker et al. 1951). However, these declines in abundance were also occurring in the Columbia River basin as whole, and may be more closely related to intensive harvest or changes in ocean productivity. During the period mentioned by Smoker et al. (1951), Merwin only had one turbine in place with a capacity of 3,800 cfs. In 1941 and 1942, the Lewis River experienced drought conditions to the point that very little spill occurred. In the years prior to this and after 1942, any flow greater than 3,800 cfs occurred as spill and resulted in the spill gates releasing water throughout most of the Spring in each of those years. A second turbine was added to Merwin in 1949. Investigation by Smith (1939b) also demonstrated that coho salmon fingerlings can survive an unimpeded fall of 190 feet from the crest of Merwin Dam to the pool at its base, and that spill over Merwin Dam was an adequate means of passing

fish downstream en route to the sea. Smith (circa 1943) also noted an increase in the hooking of smolt-sized fish downstream of Merwin by local anglers a short time after spill at Merwin. Despite improvements in project operations, coho returns to the Merwin Dam collection facility continued to decline through the early 1960s, and as a result WDF decided to discontinue transporting and releasing coho salmon into the upper watershed for natural spawning. WDF further decided that all the coho salmon should be spawned artificially at a new hatchery to be built on Speelyai Creek (Speelyai Hatchery). The transportation of coho into the upper watershed was discontinued in 1957 (Hamilton et al. 1970).

In the 1960s and 1970s, the number of coho returning to the Lewis River basin remained relatively low despite increasing returns in the entire Columbia River basin (Figure 4.18-17). Since 1980, trends in Lewis River coho abundance have in large part paralleled coho returns to the Columbia River.

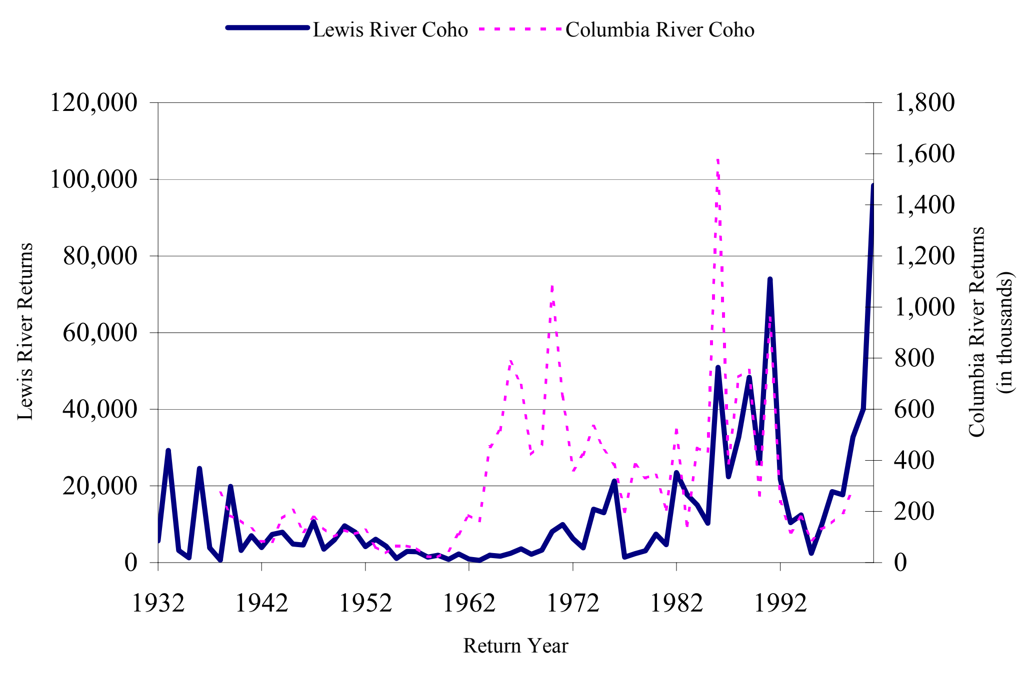

Figure 4.18-17. The number of adult coho collected at the Merwin Dam Anadromous Fish Collection Facility and Lewis River Hatchery (Lewis River returns) compared with Columbia River basin returns (1932 to 2000).[11]

Although the original Lewis River Hatchery coho stock was taken from native coho trapped at the Merwin Dam Anadromous Fish Collection Facility (WDFW 2000a), coho released into the basin in the past 70 years have been augmented using a variety of stock sources (Table 4.18-16). The majority of these releases have been from Cowlitz River (Type-N) and Toutle River (Type-S) stock. Since 1952, annual releases of hatchery coho salmon into the Lewis River basin have ranged from 457,000 in 1959 to over 12.2 million in 1989 (Figure 4.18-18). Most (65 percent) were released as yearlings. Release locations receiving the largest number of coho include the mainstem Lewis River, East

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[11] Lewis River coho returns do not include jacks or fish harvested by recreation anglers.

Fork Lewis River, Cedar Creek, Green Fork, Copper Creek, and North Fork Chelatchie Creek.

Table 4.18-16. Releases of out-of-basin coho salmon stocks in the Lewis River from 1963 through 1992.

Coho Stock	Years Planted	Life-stages Planted	Total Planted	Number of Years Planted
Abernathy	1963	Fry	518,056	1
Big Creek (Oregon)	1965	Yearling	163,548	1
Eagle Creek (Oregon)	1963	Fry	2,624,122	1
Kalama Falls	1963, 1966	Fry, Yearlings	167,152	2
Klaskanine (Oregon)	1962, 1965	Fry, Yearlings	272,148	2
Toutle	1958	Yearlings	15,878	1
Type N (Cowlitz)	1975-1992	Fry, Yearlings	65,681,281	18
Type S (Toutle)	1967-1992	Fry, Yearlings	58,287,123	26
Washougal	1963	Fry	96,110	1

Source: Weitkamp et al. 1995.

Because of these extensive stock transfers, WDFW considers the existing Lewis River coho population to be a mixed stock of composite production (WDF AND WDW 1993). In 1991, NMFS concluded that, as a result of massive and prolonged effects of artificial propagation, harvest, and habitat degradation, the agency could not identify natural populations of coho salmon in the lower Columbia River that qualified for ESA consideration (Shrier 2000).

The current WDFW coho production goal at the Lewis River Hatchery Complex is to produce 880,000 early-coho smolts and 800,000 late-coho as mitigation for the hydroelectric projects in the basin (funded by the licensees) (Table 4.18-14) (WDFW 2000a). Like spring chinook, the number of juvenile coho produced at the hatcheries is adjusted on the basis of a 5-year rolling average of adult returns in an ongoing attempt to provide the number of adult coho (71,000) that are identified in Article 50 of the existing Merwin Project license (WDFW 2003). Other coho program goals are to:

1. Minimize interactions with other fish populations through proper rearing and release strategies;
2. Maintain stock integrity and genetic diversity;
3. Provide maximum survival and fish health using disease control and disease prevention techniques; and
4. Conduct environment monitoring to ensure that hatchery operations comply with water quality standards.

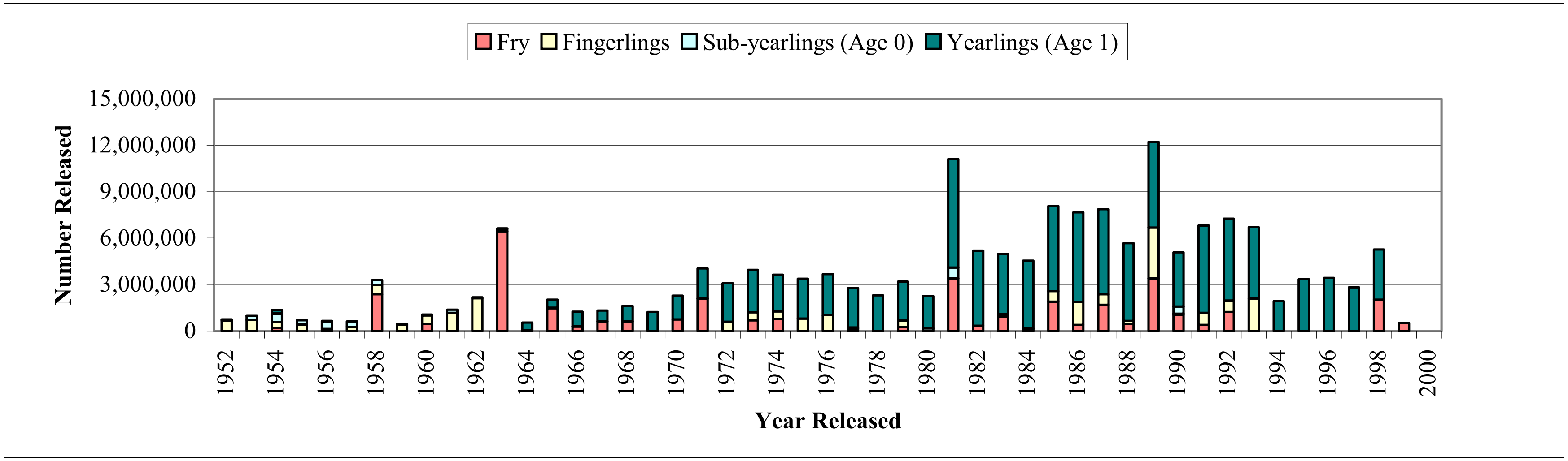

Figure 4.18-18. Hatchery releases of coho salmon yearlings, sub-yearlings, fingerlings and fry from 1952 through 1999.

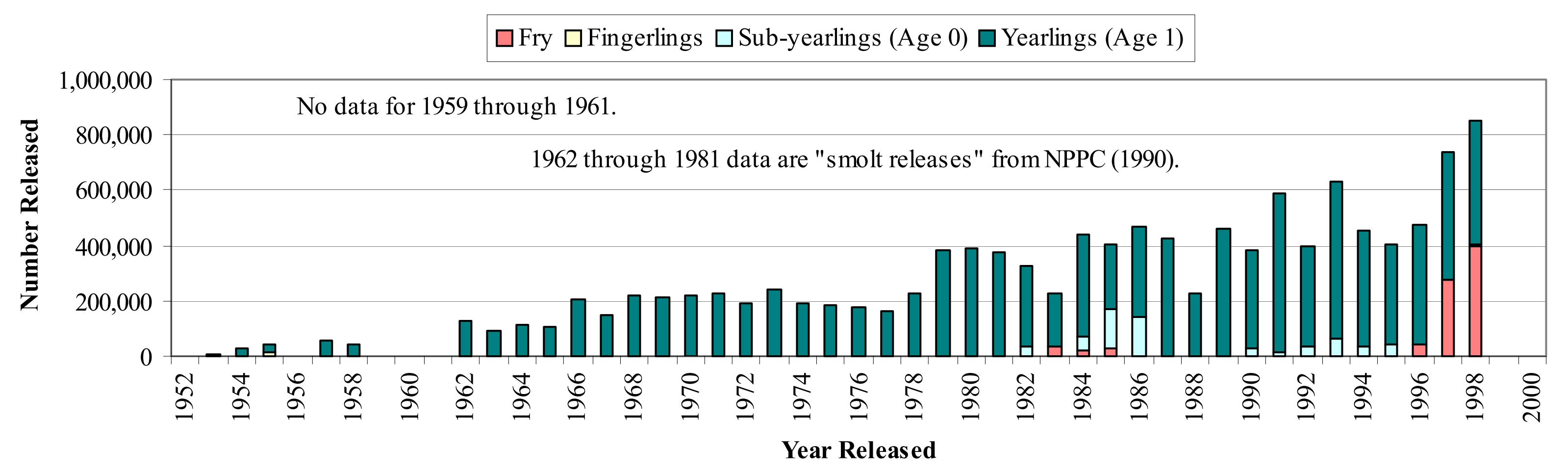

Figure 4.18-19. Hatchery releases of steelhead yearlings, sub-yearlings, fingerlings and fry from 1952 through 1998.

Like spring chinook, there is very little natural production of coho salmon in the Lewis River basin. The majority of coho returning to the basin are captured at the Merwin Hatchery, although an estimated 5 to 10 percent spawn naturally within the mainstem Lewis River below Lake Merwin and in several tributaries including the East Fork Lewis River, Ross, Cedar, Chelatchie, Johnson, and Colvin creeks, and numerous smaller tributaries (Figure 4.18-2) (WDF and WDW 1993, PacifiCorp and Cowlitz PUD 2002).

According to Mobrand Biometrics, Inc, (2003), the existing habitat above Merwin Dam is currently capable of producing 14,579 adult coho during periods of low ocean survival and 28,747 adults during periods of high ocean survival (Table 4.18-15).

The number of coho salmon harvested in the Lewis River recreation fishery from 1980 to 1998 (based on punch card returns) has ranged from 739 in 1994 to 8,673 in 1991 (PacifiCorp and Cowlitz PUD 2002). During this period, 99.4 percent were harvested in the mainstem Lewis River and 0.6 percent were harvested in the East Fork Lewis River.

Steelhead – Prior to large-scale hatchery influences in the basin (1932 through 1949), the number of steelhead returning to the Merwin Dam Anadromous Fish Collection Facility ranged from 47 in 1937 to 1,366 in 1935; however, in most years less than 500 fish returned to the collection facility (Figure 4.18-20).

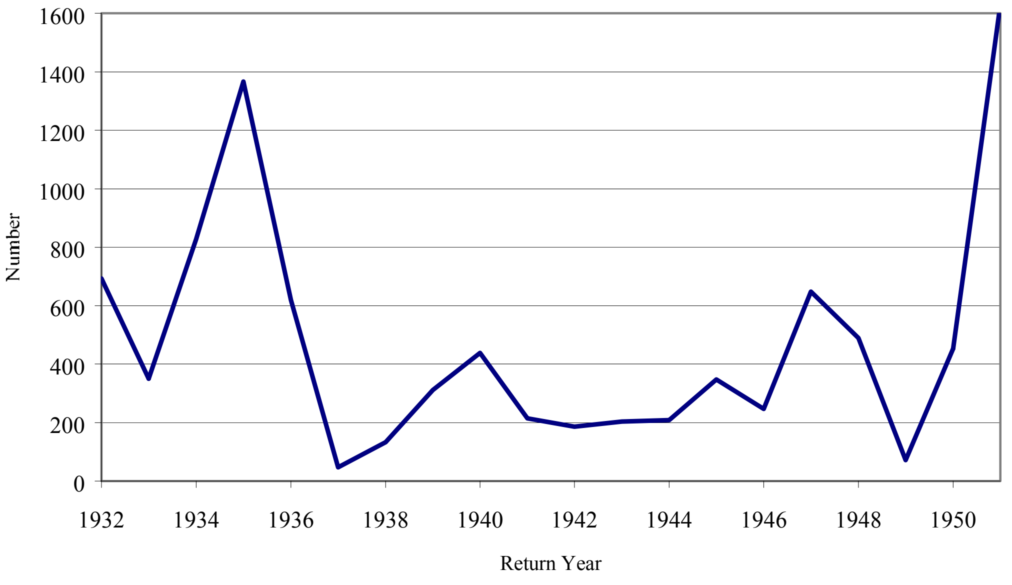

Figure 4.18-20. The number of adult steelhead collected at the Merwin Dam Anadromous Fish Collection Facility (1932 to 1950).

Skamania summer steelhead and Beaver Creek and Skamania winter steelhead were introduced into the Lewis River in the late 1950s, although relatively few were planted prior to the 1960s (PacifiCorp and Cowlitz PUD 2000). Skamania summer steelhead were developed from Washougal River and Klickitat River summer steelhead at the Skamania Hatchery, Washington (Crawford 1979). This stock has been widely used in Washington, Idaho, Oregon, and California to provide recreation angling opportunities. Beaver Creek winter steelhead are a mix of Elochoman River and Chambers Creek (Puget Sound) stocks.

From 1962 to 1980, approximately 200,000 steelhead were released into the Lewis River basin annually (Figure 4.18-19). Annual releases have increased in the past 20 years, averaging just under 500,000 (PSMFC 2001). The majority of the steelhead releases have been yearlings from the Merwin Hatchery (post 1993), as well as from the Skamania, Vancouver, and Beaver Creek hatcheries. Today, North Fork Lewis River winter steelhead are thought to be native, although some interbreeding has probably occurred with the introduced stocks. In addition, steelhead, which abandoned the Cowlitz system following the eruption of Mount St. Helens in 1980, probably strayed into the Lewis River and spawned with native Lewis stock (Hymer et al. 1993).

From 1962 through 1998, annual angler catch of summer steelhead in the mainstem and North Fork Lewis River has averaged just over 3,600 fish. Catch of winter steelhead during this same period has averaged about 3,400 fish (Figure 4.18-21) (PacifiCorp and Cowlitz PUD 2002). In most years, Lewis River catch rates paralleled steelhead returns to the entire Columbia River basin (ODFW and WDFW 2000). Prior to 1994, all steelhead captured at the Lewis River Hatchery were returned to the river for angler harvest. Therefore, hatchery returns are not the best indicator of total run size. Selective harvest regulations allow only the harvest of adipose-fin clipped fish. There is no legal harvest for wild steelhead in the North Fork Lewis River basin.

Currently, there is very little wild steelhead production in the North Fork Lewis River below Merwin Dam; wild steelhead returns account for approximately 7 percent of the total North Fork run size (WDFW 1994). Due to the low return of wild summer steelhead in the North Fork, no escapement goal has been established (PacifiCorp and Cowlitz PUD 2000c). The escapement goal for wild winter steelhead on the North Fork is 698 fish.

Current steelhead distribution in the mainstem North Fork Lewis River occurs from RM 0 to RM 19.4 (below Merwin Dam). Steelhead also spawn and rear in the East Fork Lewis River from RM 0.0 to RM 31.9. A dam located on Cedar Creek (a tributary to the North Fork) was removed in 1946, and in combination with stream improvements, spawning now occurs throughout most of Cedar Creek (from RM 0 to RM 18.2) (Hymer et al. 1993). In addition to these reaches, winter and summer steelhead also utilize portions of Big, Rock, Chelatchie, Cold, Copper, Coyote, and Johnson creeks, and several smaller tributaries.

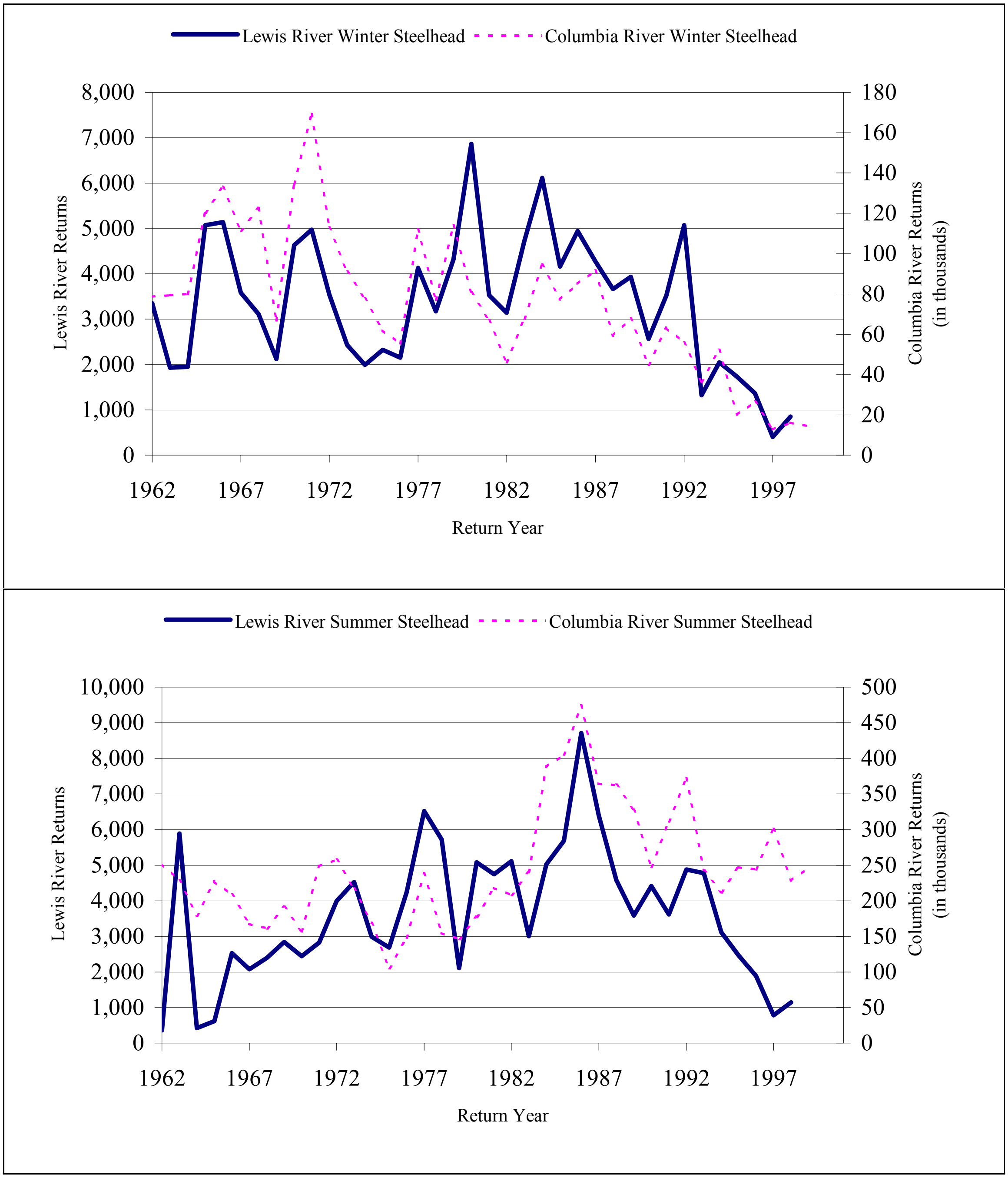

Figure 4.18-21. The number of winter and summer steelhead harvested in the Lewis River basin recreation fishery compared with Columbia River basin returns (1962 through 1998).

According to Mobrand Biometrics, Inc, (2003), the existing habitat above Merwin dam is capable of producing 4,804 adult winter steelhead during periods of low ocean survival and 9,232 adults during periods of high ocean survival (Table 4.18-15). Estimates for summer steelhead production range from 344 during periods of low ocean survival to 656 adults during periods of high ocean survival.

Lewis River steelhead are currently managed for both hatchery and wild production. The overall WDFW management goal is to maximize harvest of hatchery returns while optimizing natural production. WDFW's annual hatchery production goals are 175,000 summer steelhead smolts (5/lb.) and 100,000 winter steelhead smolts (5/lb.) (Table 4.18-14). Present Lewis River steelhead releases are from broodstock collected at the Lewis River Hatchery Complex. In addition to the present hatchery program, 60,000 summer steelhead smolts are released to the lower river from the new Fish First Lake Merwin net pen project. Additional summer and winter steelhead program goals are to:

1. Produce adult fish for harvest;
2. Meet hatchery production goals;
3. Manage for adequate escapement;
4. Minimize interactions with listed fish through proper broodstock management;
5. Minimize interactions with other fish populations through proper rearing and release strategies;
6. Maintain stock integrity and genetic diversity;
7. Maximize in-hatchery survival of broodstock and their progeny and limit the impact of pathogens associated with hatchery stocks on listed fish; and
8. Ensure that hatchery operations comply with state and federal water quality standards through environmental monitoring (WDFW 2001c; WDFW 2001d).

According to WDFW, the stock status of both summer and winter steelhead in the Lewis River basin is "depressed" due to the loss of access to available habitat upstream of Merwin, Yale, and Swift dams (WDF and WDW 1993). Steelhead in the lower Columbia River ESU, which includes naturally spawned populations and their progeny in the North Fork Lewis River below Merwin Dam, were listed as threatened by NMFS on March 19, 1998 (Federal Register, Vol. 63, No. 53, March 19, 1998).

Chum – Currently only a remnant population of chum salmon (of uncertain stocking history) exists in the Columbia River and its tributaries below Bonneville Dam. Most of these chum salmon spawn in the Grays River system near the mouth of the Columbia River and near Bonneville Dam in Hardy and Hamilton creeks (WDF and WDW 1993). Very small numbers of chum salmon have also been observed in the Washougal, Lewis, Kalama, and Cowlitz rivers (Johnson et al. 1997; Tacoma Power 1999). In the lower Lewis River, spawning chum salmon were sighted occasionally during 1998 fall chinook spawning surveys, and 4 adult carcasses were observed in Cedar Creek. In addition, about 45 juvenile chum salmon were captured during seining operations related to a smolt residual study in 1998. Annually, about 3 or 4 adult chum salmon have also been captured at the Merwin fish trap (PacifiCorp and Cowlitz PUD 2000). All of these fish were believed to be wild; hatchery supplementation has not occurred since 1940 (NPPC 1990).

Throughout their range, chum salmon spawn most commonly in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels from just above tidal influence. In the Lewis River basin, much of the lower river mainstem and side channel habitat has been severely degraded or lost due to the construction of dikes and levees (Section 4.18.5.2).

According to Mobrand Biometrics, Inc, (2003), the existing habitat above Merwin Dam is currently capable of producing 4,469 adult chum during periods of low ocean survival and 1,082 adults during periods of high ocean survival (Table 4.18-15).

<u>Bull Trout</u> – The Columbia River basin supports a total of 141 subpopulations of bull trout. Twenty of these are located in the lower Columbia River Distinct Population Segment (DPS). Of these 20 subpopulations, 2 are located in the Lewis River basin (Federal Register, Vol. 63, No. 111, June 10, 1998). Currently, bull trout are found in Lake Merwin, Yale Lake, and Swift Reservoir. Most spawning and juvenile rearing occurs in Cougar, Rush, and Pine creeks (tributaries to Yale Lake and Swift Reservoir) (Faler and Bair 1992, Lesko 2001). Lake Merwin does not appear to contain any appreciable bull trout spawning habitat. Additionally, sub-adults have been observed in the Swift canal, Lewis River bypass reach and in the Swift Creek arm of Swift Reservoir (PacifiCorp 1999b). Bull trout inhabiting Lake Merwin are believed to have moved downstream from Yale Lake.

Historical information describing the abundance and distribution of bull trout in the Lewis River basin is limited. However, the number of bull trout spawners using Cougar Creek has been documented annually since 1979. From 1979 through 2002, the number of adult spawners in Cougar Creek (based on annual peak counts) has ranged from 0 in 1981 and 1982 to 40 in 1979 (Figure 4.18-22). The low number of spawners observed in the early 1980s may be related to impacts associated with the May 1980 eruption of Mount St. Helens. Because these surveys are thought to have not covered the entire spawning period, WDFW believes that bull trout spawners in Cougar Creek may be undercounted (WDFW 2003).

In addition to the survey work conducted in Cougar Creek, the USFS, WDFW, and PacifiCorp (Cooperators) have been collecting distribution and abundance information on bull trout since the late 1980s. Bull trout collected at the head of Swift Reservoir have been marked with Floy anchor tags every spring since 1989 to facilitate "mark and recapture" counts in Rush and Pine creeks (the primary spawning tributaries for the Swift bull trout population) (Faler and Bair 1992; Lesko 2001). Based on the available data, the Cooperators used a Peterson estimator to calculate the annual spawning population of bull trout in Swift Reservoir. Between 1994 and 2002, the annual spawner population in Swift Reservoir has ranged from 101 to 792 fish (Figure 4.18-23) (Lesko 2001; pers. comm., D. Rawding and J. Weinheimer, WDFW, 2003).

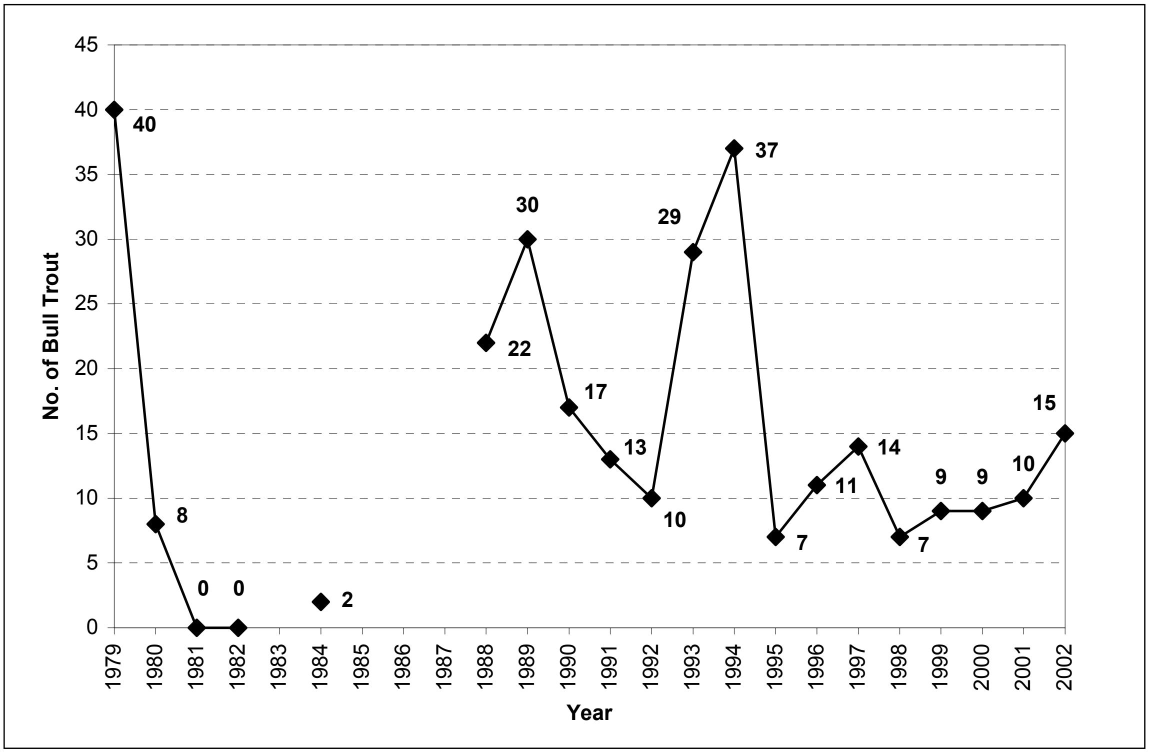

Figure 4.18-22. Annual peak counts of bull trout spawners observed in Cougar Creek 1979 through 2002.

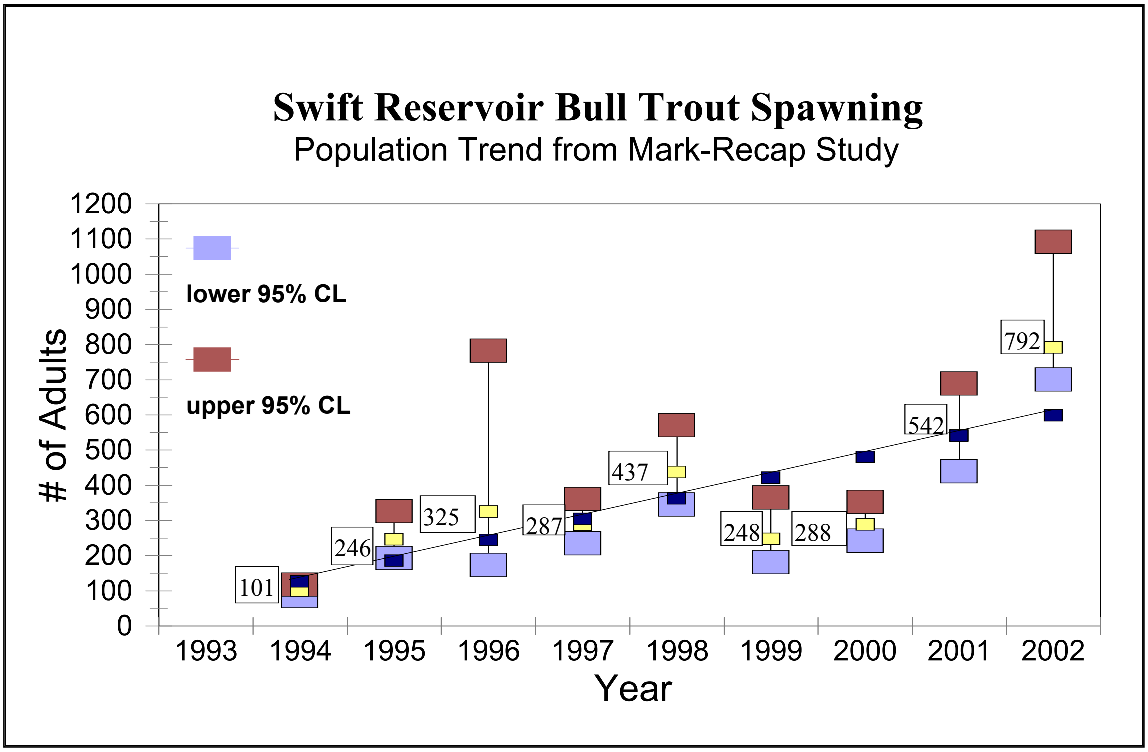

Figure 4.18-23. Spawning population estimate of bull trout in Swift Reservoir for the years 1994 through 2002.

PacifiCorp and WDFW staff have annually netted and transported bull trout from the Yale tailrace to the mouth of Cougar Creek (Yale Lake tributary). In total, 59 bull trout have been collected in the Yale tailrace since the program began in 1995 (Lesko 1999; Lesko 2000; Lesko 2001). Bull trout have also been observed in the Swift canal and Swift No. 2 tailrace.

Bull trout/Dolly Varden have also been captured in the ladder at the Lewis River Hatchery and the trap at Merwin Dam, most recently in 1992 (PacifiCorp and Cowlitz PUD 1999). Detailed records of these catches are not available.

According to WDFW (1998b), the bull trout populations in the Lewis River basin are considered as having a "moderate" risk of extinction. On November 1, 1999 the USFWS issued a final rule announcing the listing of bull trout throughout the coterminous United States as a threatened species under the ESA (Federal Register, November 1, 1999).

Kokanee – Kokanee are not native to the Lewis River basin. They were first introduced into Yale Lake and Lake Merwin in 1957, and into Swift Reservoir in 1961 (PacifiCorp and Cowlitz PUD 2000). Tributaries to all 3 reservoirs were stocked with kokanee from Kootenay Lake and Cultus Lake, both of which are located in British Columbia. The primary purpose of their introduction was to create a reservoir fishery. Self-sustaining kokanee populations currently exist in Yale Lake.

Yale Lake kokanee spawn primarily in Cougar Creek (Figure 4.18-2). Kokanee spawning surveys conducted annually by PacifiCorp in Cougar Creek since 1978 indicate large annual fluctuations in the spawning (and presumably the reservoir) population. Spawning estimates (excluding the years 1982 to 1984, when the fishery was affected by severe mud flows from the Mount St. Helens eruption) range from a high of about 180,000 (1991) to a low of 5,357 (1998) (Figure 4.18-24). Limited kokanee spawning has also been documented in the Lewis River bypass reach and Ole Creek (PacifiCorp 1999b). As is the case for bull trout, WDFW believes that kokanee spawners in Cougar Creek may be undercounted (WDFW 2003).

Kokanee in Lake Merwin spawn primarily in the lower 300 feet of Canyon Creek, as a natural barrier prohibits upstream passage beyond this point. Limited spawning also occurs in Speelyai Creek (downstream from the hatchery diversion), in lower Rock Creek and in the Yale tailrace (Table 4.18-17) (Graves 1982). It is thought that recruitment to Lake Merwin is largely a result of kokanee from Yale Lake passing over the dam during periods of spill or through the turbines during power generation. The relatively large number of kokanee observed in Canyon Creek and the Yale tailrace in 1980-1982 may be a result of a high spill that occurred during the Mount St. Helens eruption in 1980 (pers. comm., F. Shrier, PacifiCorp, 2001).

Kokanee are the primary target species for anglers in Yale Lake, and are the second most popular target species in Lake Merwin (WDFW 1998a). A 1995 creel survey in Lake Merwin (May through August) estimated that 19,337 hours were expended to catch 3,068 kokanee, 511 coho, 20 rainbow trout, and 20,764 northern pikeminnow (Hillson and Tipping 1999). Annual harvest is 12,000 to 20,000 kokanee from Yale Lake and 3,000 to 8,000 from Lake Merwin (WDFW 1998a).

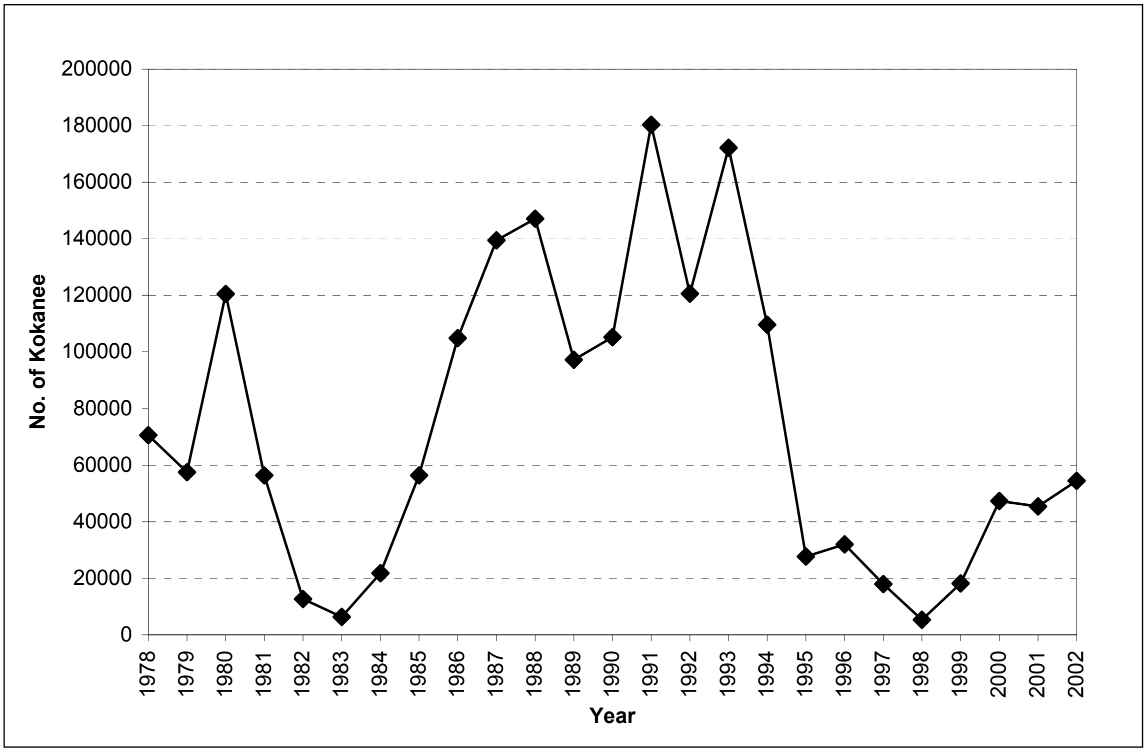

Figure 4.18-24. Peak counts of kokanee spawning in Cougar Creek (1978 to 2002).

Table 4.18-17. Peak kokanee spawner counts in tributaries to Lake Merwin, 1978 to 1982.

Date	Canyon Cr.	Speelyai Cr.	Rock Cr.	Yale Tailrace	Total
1978	500	150	125	NA	775
1979	100	30	60	NA	190
1980	1,100	110	20	1,600	2,830
1981	5,000	650	175	8,600	14,425
1982	300	40	5	2,500	2,845
Mean	**1,400**	**196**	**77**	**4,233**	**5,906**

From: Graves 1982

In 1996, WDFW decided to supplement the kokanee population in Lake Merwin using kokanee spawned and reared at Speelyai Hatchery. In 1999, Yale Lake received its first planting of kokanee since 1957 (PacifiCorp and Cowlitz PUD 2000). Plants in Yale Lake were temporary and discontinued in late 2001. The current kokanee production goal at Speelyai Hatchery is 45,000 fingerlings and 48,000 yearlings. All of these fish are planted in Lake Merwin.

Rainbow Trout – Non-native stocks of rainbow trout have been planted in Swift Reservoir since 1978 (PacifiCorp and Cowlitz PUD 2000; PacifiCorp 1999b). The goal of this program is to support a popular a sport fishery. Since 1978, approximately

800,000 to 1,000,000 rainbow trout fry at 25 per pound have been stocked annually (as required by Article 51 of the Merwin license). Juvenile rainbow trout used for this program are incubated and reared at the Merwin Trout Hatchery. The egg source is typically from the Goldendale Hatchery in Washington; however, rainbow trout stocks from the Spokane Hatchery (Washington) and Mount Whitney Hatchery (California) have also been planted (PacifiCorp and Cowlitz PUD 2000). Goldendale rainbow trout spawn from October through February, Spokane rainbow trout spawn from November through December, and Mount Whitney rainbow trout spawn from February through March (Crawford 1979).

As part of Merwin Project studies in 1990, PacifiCorp biologists completed a creel survey on Swift Reservoir (PacifiCorp 1996). From May through October 1990, Swift Reservoir had a catch rate 0.97 fish per hour. Rainbow trout comprised approximately 99 percent of the fish harvested (PacifiCorp 1996). Thus the high catch rate was most likely a result of the rainbow trout plants. From April 24 through October 1999, WDFW conducted an additional creel survey in Swift Reservoir and Swift canal (PacifiCorp and Cowlitz PUD 2001). During this survey, 496 anglers were interviewed. These bank and boat anglers fished a total of 1,800 hours to harvest 1,504 fish. Rainbow trout comprised 84.7 percent of the fish harvested (PacifiCorp and Cowlitz PUD 2001).

<u>Northern Pikeminnow</u> – Because of their preference for stillwater habitat, it is likely that very few northern pikeminnow occurred in the Lewis River basin prior to the construction of the Lewis River projects. Following the creation of substantial reservoir habitat, northern pikeminnow populations increased dramatically. In the last 40 years, large numbers of northern pikeminnow have been observed in Lake Merwin. Smaller numbers have been observed in Yale and Swift reservoirs. In 1961, the population of northern pikeminnow > 20 cm in length (7.9 in) in Lake Merwin was estimated to be about 350,000 fish (Hamilton et al. 1970). In 1980 and 1981, 8 northern pikeminnow 14 to 20 cm long (5.5 to 7.9 in) were caught in gillnets at the mouths of Cougar and Siouxon creeks and at the mouth of the Lewis River bypass reach (tributaries to Yale Lake). In 1982, 10 northern pikeminnow were caught by anglers in these same areas (Graves 1982). Northern pikeminnow were also observed during creel surveys in Yale Lake in 1995; however, detailed northern pikeminnow catch estimates were not developed as part of the survey (PacifiCorp 1999b). A 1995 creel survey in Lake Merwin (May through August) estimated that 19,337 hours were expended to catch 3,068 kokanee (*O. nerka*), 511 coho, 20 rainbow trout, and 20,764 northern pikeminnow (Tipping 1995 as cited in Hillson and Tipping 1999). More recent WDFW surveys on Swift Reservoir (1999-2000) indicated a substantial catch of the species (PacifiCorp and Cowlitz PUD 2000).

<u>Tiger Muskellunge</u> – Tiger muskellunge, a non-native sterile hybrid (northern pike and muskellunge cross) known to prey heavily on soft-rayed fishes, were introduced into Lake Merwin by WDFW in 1995. Like the tiger muskellunge program implemented in Mayfield Lake on the Cowlitz River, the goal of the Lake Merwin program is to reduce the abundance of salmonid-eating northern pikeminnow and to provide a sport fishery for anglers. Currently, juvenile tiger muskellunge are reared at the Merwin Trout Hatchery. The current production goal is approximately 3,000 fish at 7 per pound. Since the inception of the program, annual tiger muskellunge plants into Lake Merwin have ranged from 375 to just over 1,700 (Table 4.18-18). According to Hillson and Tipping (1999),

the first couple of tiger muskellunge releases did not survive; however, the survival of subsequent releases "appeared to be good." Little is known about tiger muskellunge habitat use in Lake Merwin and few anglers appear to be fishing for them. It is also unclear whether tiger muskellunge are reducing the northern pikeminnow population in Lake Merwin, although the percent of 20 to 29 cm northern pikeminnow in the lake appears to be in decline (Hillson and Tipping 1999; Hillson and Tipping 2000).

Table 4.18-18. Tiger muskellunge plants into Lake Merwin.

Date	Number Planted	Size (#/lb.)
September 1995	1,208	5.8
May 1996	375	2.0
May 1997	1,331	4.0
May 1998	1,945	3.5
October 1998	1,717	10.0
May 1999	1,273	2.9

In May 2000, 4 tiger muskies were implanted with sonic tags in an effort to characterize movement and seasonal habitat preferences in Lake Merwin. Only one of the 4 tagged fish was successfully tracked for a period exceeding one year (14 months). For the 3 fish tracked longer than 2 months, residence in Speelyai Bay was preferred over the main reservoir in all seasons except fall (Hillson 2001). Tagged fish showed a preference for shallower water (5 to 10 feet) during summer months, and deeper water (15 to 30 feet) during the fall and early winter.

To date, no efforts have been made to study the diet of tiger muskies released in Lake Merwin, and it is not known if they are preying upon salmonids. Recently, tiger muskies have been observed in the mainstem Lewis River below Merwin Dam; however, no studies have been conducted to determine how these fish moved into to the lower river (i.e. over the spillway or through the turbines), nor have there been efforts to determine the number of tiger muskellunge that have migrated out of the lake.

4.18.5.5 Historical and Current Genetic Structure and Life History Diversity

Early in the 20th century, managers adopted a simple approach to maintain the supply of Pacific salmon: hatcheries produced fish in direct support of harvest and the fisheries were regulated to return enough adults to the hatchery to replenish the supply. Natural production systems were largely considered inefficient and ineffective compared to artificial production systems (Lichatowich et al. 1999). The simple management approach, with artificial propagation as its centerpiece, dominated management for most of this century. Recently, however, the large number of endangered species listings has begun to shift management emphasis to natural production and the integration of natural and artificial production systems where they coexist in a watershed.

The simple management model for Pacific salmon focused on the number of fish: the number of adult salmon projected to recruit to the fishery, the number of salmon harvested, the number of adult salmon that escape the fishery and reach the spawning grounds and hatchery racks, and the number of smolts released from the hatchery. Often these numbers are aggregates, the product of lumping salmon from several populations. While rarely specifically acknowledged, the heavy reliance on these numbers as a basis for management implies 2 critical assumptions: 1) that the relative productivity of the component populations making up the aggregate is not important and, 2) that abundance alone can adequately describe the population and its relationship to the attributes of the watershed.

These assumptions led to the overharvest of many stocks (Thompson 1965) and to a delay of several decades of basic research into natural salmonid production systems. Attributes of the salmon production system were not easily quantified and were ignored. Ecological and biological attributes were irrelevant as long as artificial propagation could maintain the supply of fish. Some of the physical habitat attributes were discussed earlier. Two additional attributes are discussed here: genetic and life history diversity. Both of these have gained in importance in the last 2 or 3 decades.

The shift in emphasis from species to populations in fisheries was an important precursor to the recognition of the importance of genetic and life history diversity in fisheries management. Three European biologists, Heincke, Schmidt and Hjort, are credited with shifting the focus of fisheries science from species to populations in the late 19th and early 20th centuries (Sinclair and Solemdal 1988). In the Pacific Northwest, early hatchery operators such as R. D. Hume observed biological differences in Pacific salmon from different rivers and recognized these differences as adaptations to local environments (Hume 1893). Stanford University professor, Charles Gilbert, analyzed the scale patterns of sockeye salmon in the Fraser and other rivers and concluded that salmon from different rivers showed consistent differences in their growth and maturity. He used this information as evidence for homing in Pacific salmon and for their stock structure. In 1914 Gilbert wrote:

> *This fact disposes quite effectively of the general question concerning the return of our salmon to the river basins in which they are hatched. It can now be affirmed with entire confidence that they do so return, that they are effectively isolated and that they interbreed thus within the limits of their colony (cited in Dunn 1996).*

Gilbert and others clearly recognized the importance of populations several decades before such knowledge began filtering into management programs.

Genetic Diversity

The early work of Gilbert and others notwithstanding, biologists generally believed that Pacific salmon were genetically uniform (Ricker 1972)[12]. Prior to the rise of biochemical genetics in the late 1960s and 1970s, most recognition of genetic differences among stocks and populations focused on aspects of local adaptation or on quantitative genetic differences (e.g., differences in morphological traits or life history parameters) (e.g., Rich

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[12] Some of the information in the next several paragraphs comes from Lichatowich et al. 1998 and Lichatowich and Mobrand 1995 and is presented here in revised form.

1939). Throughout the first half of this century, both resident and anadromous salmonids were widely transplanted with little attempt to match the source of eggs and fry to the stocking locations. The widespread stocking of hatchery rainbow trout (derived from coastal rainbow trout) (Needham and Behnke 1962) is an example of this management practice, which contributed to the loss of native interior rainbow trout (i.e., redband trout) (Wishard et al. 1984; Currens et al. 1990; ISG 1996; Williams et al. 1997). In addition, the same practices contributed to the loss of many populations of various interior cutthroat trout populations (Leary et al. 1987; Allendorf and Leary 1988; Behnke 1992, 1995).

The stock structure of Pacific salmon was generally ignored in management until the 1960s and 1970s (e.g., Calaprice 1969; Berst and Simon 1981), a period that coincided with the development of biochemical molecular techniques (protein gel electrophoresis, also called allozyme analysis). The use of these tools confirmed that stocks differed from one another in genetic characteristics and population genetic structure (Utter et al. 1973a; Utter et al. 1973b; Allendorf and Utter 1974; Allendorf et al. 1975; Allendorf and Utter 1979). However, until recently, genetic information has had little direct effect on the management of salmonids (Allendorf et al. 1987; Allendorf and Leary 1988). Currently, the role of genetics in informed fisheries management has increased as fisheries managers are faced with decisions regarding recovery options for declining stocks. Genetic analysis can help identify appropriate management units for recovery (e.g., the ESUs) and it will also help identify appropriate stocks for use in recovery programs.

Genetic studies today focus on either the nuclear genome (DNA found in the chromosomes in the nucleus of the cell) using such techniques as allozyme analysis, DNA fingerprinting, DNA sequencing, DNA single locus probes, RAPDs (random amplified polymorphic DNAs), microsatellite DNA analysis, or on the mitochondrial genome (DNA found in the mitochondria in the cytoplasm of the cell) using DNA sequencing or RFLP (restriction fragment length polymorphism) analysis. The importance of these approaches lies not with the techniques used, but with the kind of information obtained from the nuclear versus mitochondrial analyses. Both analyses allow comparisons to be made among populations, but on very different time scales.

Analysis of the nuclear genome can provide fisheries managers with information, on the temporal stability of the population or on the effects of interbreeding with non-native fish (Allendorf et al. 1980; Allendorf and Phelps 1981; Campton and Johnston 1985; Campton 1995; ISG 1996). Analysis of the mitochondrial genome provides the fisheries manager with a longer, more historical view of fish stocks within a region. Such analysis is particularly useful for identifying evolutionary relationships, native genotypes, remnant populations, and possible metapopulation structure. When both nuclear and mitochondrial data are available, even more inferences can be made about a stock's present and historical genetic status (ISG 1996; Williams et al. 1997).

<u>Chinook Salmon</u> – The most complete genetic analysis of chinook salmon populations in the Columbia River basin was completed by the NMFS (Myers et al. 1998) using allelic frequency data from 55 samples (N=1,329) collected in Washington, Oregon and Idaho (Marshall et al. 1995, Waples 1991a, Waples 1991b, and Schreck et al. 1986). Using this information, the NMFS Biological Review Team separated chinook populations in the

Columbia and Snake rivers into 2 distinct groups or "clusters": those producing "ocean-type" juvenile outmigrants and those producing "stream-type" juvenile outmigrants (except for a sample of spring-run chinook salmon from the Klickitat River, which was genetically intermediate between the 2 groups) (Figure 4.18-25, Table 4.18-19). These stream type and ocean type groups were also described in (Marshall et al. 1995); however, Marshall et al. (1995) referred to these groups as major ancestral lineages (MALs)[13].

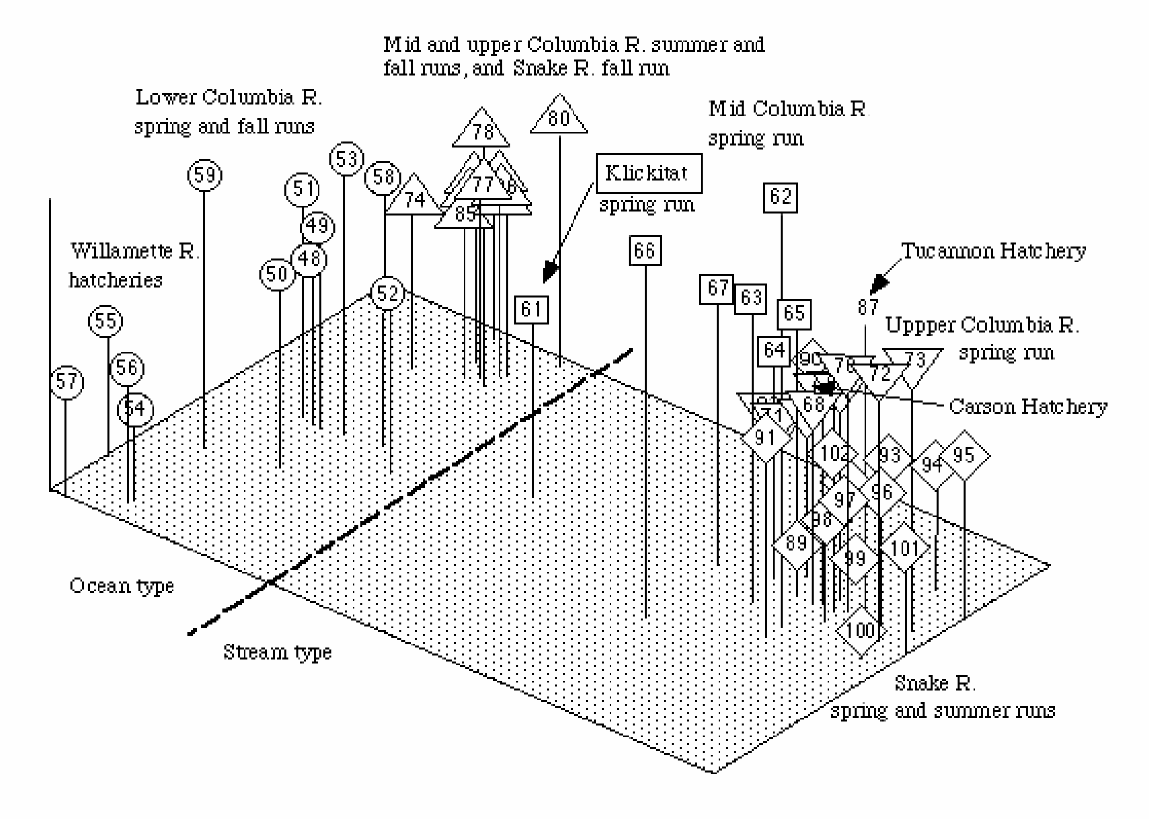

Figure 4.18-25. Multidimensional scaling (MDS) of Cavalli-Sforza and Edwards (1967) chord distances based on 31 allozyme loci between 55 composite samples of chinook salmon from populations in the Columbia River basin.[14]

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[13] A group of one or more genetic diversity units whose shared genetic characters suggest a distant common ancestry, and substantial reproductive isolation from other MALs.

[14] From Myers et al. (1998).

Table 4.18-19. Samples of lower Columbia River spring and fall chinook salmon used in the NMFS status review.

Sample Number	Source	Run
48	Cowlitz Hatchery	spring
49	Cowlitz Hatchery	fall
50	Kalama Hatchery	spring
51	Kalama Hatchery	fall
52	**Lewis Hatchery**	**spring**
53	**Lewis River**	**fall**
54	McKenzie and Dexter Hatcheries	spring
55	Clackamas Hatchery	spring
56	North Fork Clackamas River	spring
57	Marion Forks Hatchery	spring
58	Sandy River	fall
59	Spring Cr. and Big Cr. Hatcheries	fall

The ocean-type group includes chinook salmon in lower Columbia River tributaries, with both spring-run and fall-run "tule" life histories (lower Columbia River spring and fall runs)[15], as well as ocean-type populations found east of the Cascade Crest (mid and upper Columbia River summer and fall runs, and Snake River fall run).

Myers et al. (1998) also observed genetic population structure within these 2 groups. Within ocean-type chinook salmon, samples of spring- and fall-run chinook from the lower Columbia River were distinct from all inland samples (Figure 4.18-25). The Willamette River hatchery populations also form a distinct subgroup within the lower Columbia River group. The fall-run populations in the Snake River, Deschutes River, and Marion Drain (Yakima River) form another distinct subgroup (Figure 4.18-25) (Myers et al. 1998). Marshall et al. (1995) called these subgroups “genetic diversity units” (GDUs), defining a GDU as “a group of genetically similar stocks that is genetically distinct from other groups.”

The second major group (or MAL) of chinook salmon in the Columbia and Snake river drainage (the stream-type group) consists of spring- or summer-run fish. Three relatively distinct subgroups appeared within these stream-type populations (Figure 4.18-25):

- Populations in the Klickitat, John Day, Deschutes, and Yakima rivers of the mid-Columbia River;
- Upper Columbia River spring-run chinook salmon in the Wenatchee and Methow rivers, but also spring-run fish in the Grande Ronde River and Carson Hatchery; and
- Snake River spring- and summer-run populations in the Imnaha and Salmon rivers, and in the Rapid River and Lookingglass Hatcheries.

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[15] These ocean-type populations exhibit a range of juvenile life-history patterns that appear to depend on local environmental conditions.

Using this and other biological and ecological information, the NMFS Biological Review Team developed a series of 7 evolutionarily significant units (ESUs) of chinook salmon in the Columbia River basin:

- Lower Columbia River ESU
- Upper Willamette River ESU
- Mid Columbia River Spring-Run ESU
- Upper-Columbia River Summer- and Fall-Run ESU
- Upper Columbia River Spring-Run ESU
- Snake River Fall-Run ESU
- Snake River Spring- and Summer-Run ESU

All 7 of these chinook salmon ESUs are considered "distinct" and hence "species" as defined by the ESA.

The lower Columbia River ESU includes all native populations of chinook salmon from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. Lewis River fall chinook, a native stock with negligible hatchery influences (Section 4.18.5.2) is included in the Lower Columbia River ESU. Lewis River spring chinook, a mixed hatchery stock, is a component of the lower Columbia River ESU, but is not considered a listed species (USFWS and NMFS 2002).

As part of a comprehensive effort to inventory wild stocks of anadromous salmonids, the WDFW included native Lewis River fall chinook in the Lower Columbia River “Bright” Fall genetic diversity unit (GDU) (Marshall et al. 1995). It is the only Washington chinook stock in this GDU. According to Marshall et al. (1995), Sandy River (Oregon) fall chinook may also belong to this GDU. No other chinook stocks belong to the Lower Columbia River “Bright” Fall GDU.

Marshall et al. (1995) included Lewis River spring chinook in the Mid-and Lower Columbia River Spring Chinook GDU along with Cowlitz, Kalama, and Klickitat spring chinook. However, like Myers et al. (1998), Marshall et al. (1995) suspected that Klickitat spring chinook were a transitional population relative to the upper and lower Columbia River spring chinook ancestry. It should be noted that Cowlitz, Kalama, Carson (Wind River), Willamette and Klickitat spring chinook stocks were used to reintroduce spring chinook to the Lewis River basin following the extinction of the native stock (Section 4.18.5.4) (Hymer et al. 1993, Myers et al. 1998). All Washington populations of spring-run chinook salmon in the lower Columbia River are currently managed as populations of mixed origin (WDF and WDW 1993).

Coho Salmon – As a component of their *Status Review of Coho Salmon*, NMFS geneticists collected and summarized allozyme data from over 100 coho salmon samples, including 22 samples (N=1,586) from the Columbia River basin (Table 4.18-20) (Weitkamp et al. 1995, Milner 1993, Johnson et al. 1991). Using measures of genetic distance (Cavalli-Sforza and Edwards 1967 and Nei 1978) and regional patterns of allele frequency, NMFS separated coho populations into 7 major clusters. Two of these clusters (Clusters I and II) are from Alaska and British Columbia (Figure 4.18-26).

Clusters III, IV, and V consist of Oregon coastal populations, Cluster VI includes all of the Puget Sound and British Columbia samples, and Cluster VII includes all of the samples from the lower Columbia River and southwestern Washington coast (Figure 4.18-26). Cluster VII also includes a sample from the Rogue River Basin and one from Trask Hatchery (Weitkamp et al. 1995).

Table 4.18-20. Samples of Columbia River coho salmon used for genetic analysis in the NMFS status review.

Map Code	Name	Source	Brood Year	N
31	Lewis and Clark	Lewis and Clark River	1992	30
32	Grays	Grays River Hatchery	1989	40
33	Grays	Grays River Hatchery	1989	40
34	Grays	Grays River Hatchery	1982	100
35	Big Creek	Big Creek Hatchery	1989	80
36	Clatskanie	Carcus Creek	1989	50
37	Cowlitz	Cowlitz Late	1990	100
38	Cowlitz	Cowlitz Early	1989	80
39	Cowlitz	Cowlitz Late	1989	80
40	Scappoose	Siercks, Raymond, and Milton creeks	1989	44
41	**Lewis**	**Lewis River Hatchery Late**	**1989**	**80**
42	**Lewis**	**Lewis River Hatchery Early**	**1989**	**80**
43	Clackamas	North Fork Clackamas River	1990	90
44	Clackamas	Clackamas and N. F. Clackamas rivers	1989	60
45	Eagle	Eagle Creek Hatchery	1990	100
46	Eagle	Eagle Creek Hatchery	1989	80
47	Sandy	Sandy River Hatchery	1989	80
48	Sandy	Still Creek	1989	62
49	Sandy	Sandy River Hatchery	1990	100
50	Hardy	Hardy Creek	1989	50
51	Bonneville	Bonneville Hatchery	1989	80
52	Willard	Willard Hatchery	1989	80

Source: Weitkamp et al. (1995).

Within Cluster VII (lower Columbia River and southwestern Washington coast), NMFS identified several subclusters and 3 branches with only one or 2 members (Figure 4.18-26). Two of these subclusters comprise most of the lower Columbia River samples: one consisting primarily of samples from Washington and the other consisting primarily of samples from Oregon. Other subclusters contain samples from Willapa Bay, the Clackamas and Clatskanie rivers, and the Humptulips and Simpson hatcheries from southwestern Washington (Weitkamp et al. 1995).

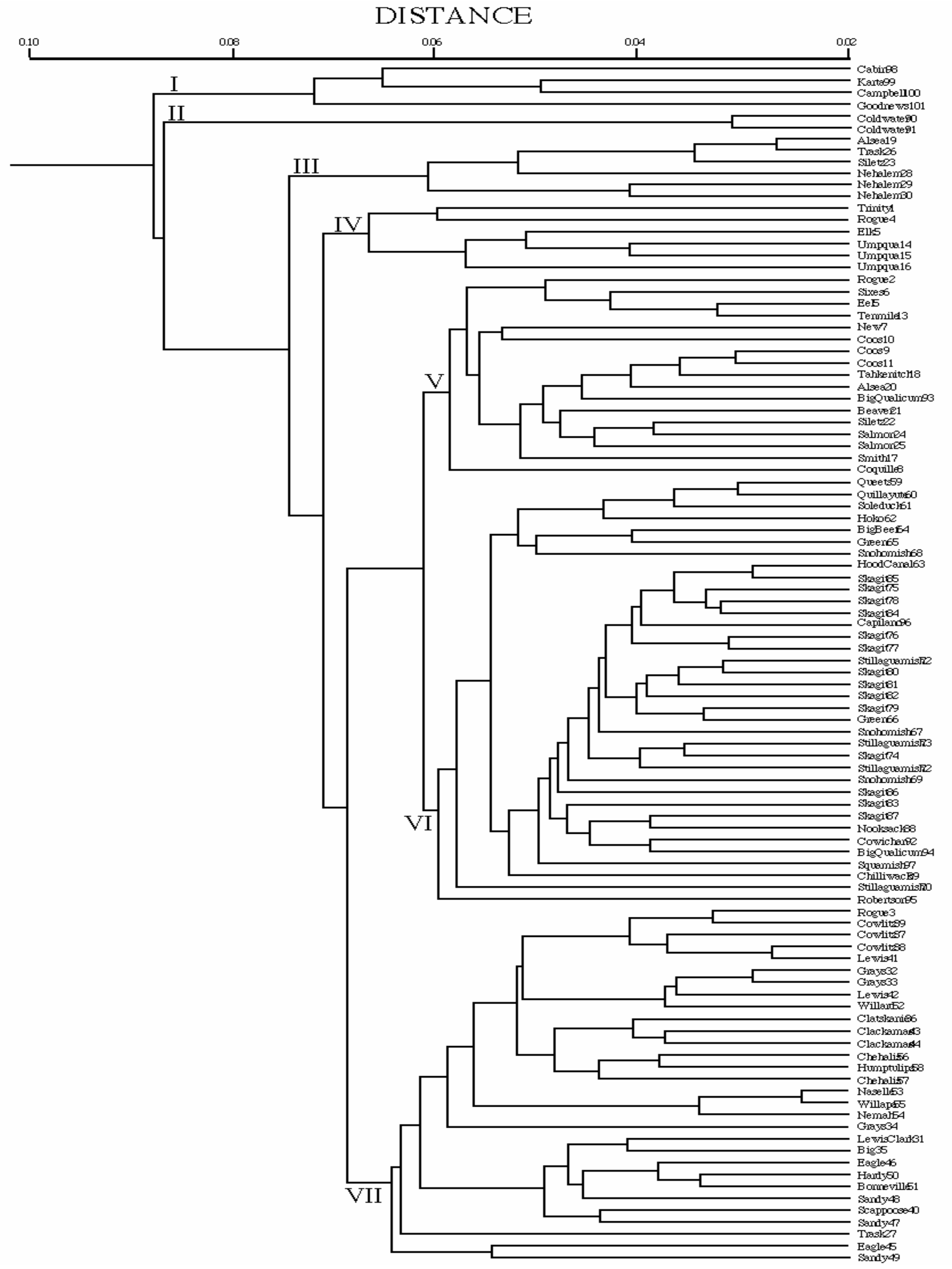

Figure 4.18-26. Dendrograms based on pairwise genetic values between 101 samples of coho salmon from the Pacific Northwest.[16]

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[16] From Weitkamp et al. (1995). Sample numbers correspond to map codes in Table 4.18-14.

Using this genetic data and other biological and ecological information, the NMFS Biological Review Team identified 6 ESUs for west coast coho salmon populations:

- Central California coast
- Southern Oregon/northern California coasts
- Oregon coast
- Lower Columbia River/southwest Washington coast
- Olympic Peninsula
- Puget Sound/Strait of Georgia

Lewis River coho (both early and late runs) are included in the Lower Columbia River/southwest Washington coast ESU; however, NMFS concluded that, as a result of massive and prolonged effects of artificial propagation, harvest, and habitat degradation, the agency could not identify any natural populations of coho salmon in the lower Columbia River that qualified for ESA consideration (Johnson et al. 1991, Shrier 2000). Essentially, years of intense hatchery augmentation, habitat degradation and excessive harvest have changed the native coho salmon runs in the lower Columbia River to a genetic mixture of native and hatchery stocks (Flagg et al. 1995).

Like other lower Columbia River coho, WDFW considers Lewis River coho to be a mixed stock sustained by both wild and artificial production (WDF and WDW 1993). Based on data presented in Weitkamp et al. (1995), the existing Lewis River coho population appears to be most closely related to Cowlitz River and Grays River stocks (Figure 4.18-26). This finding is not unexpected as the vast majority of out-of–basin coho planted in the Lewis River basin have originated from Cowlitz and Toutle stocks (Section 4.18.5.4). It is also likely that a substantial number of strays from both the Cowlitz River and Grays River enter the Lewis River system.

Steelhead – Allendorf (1975) described 2 major groups of *O. mykiss* in Washington, Oregon and Idaho, roughly separated by the Cascade Mountain range. He referred to these 2 groups as “coastal” and ‘inland” forms. Since that time, a number of studies have confirmed large genetic differences between these 2 groups, as well as significant stock structuring within the coastal and inland groups, but not between winter and summer races within drainages (Schreck et al. 1986, Busby et al. 1993, Waples et al. 1993, Phelps et al. 1994, and Busby et al. 1996). Leider et al. (1995) also found evidence that wild resident rainbow trout were genetically indistinguishable from anadromous steelhead and that the 2 forms were not reproductively isolated from each other. In other words, rainbow trout east of the Cascades are genetically more similar to steelhead from east of the Cascades than they are to rainbow trout west of the Cascades.

Using genetic data collected by NMFS and WDFW (from protein electrophoresis, DNA markers, and chromosomal analysis), Busby et al. (1996) found evidence that the inland group of *O. mykiss* is limited to populations occurring in the upper Columbia and Fraser river basins. Within the coastal group, Busby et al. (1996) and Phelps et al. (1994) found relatively modest genetic differences between populations from Puget Sound, coastal Washington, and the lower Columbia River. However, samples from coastal Oregon, the Klamath Mountains Province, the Sacramento River, and other populations in California are quite distinct from all other coastal and inland populations (Busby et al. 1996).

Consistent genetic differences were also are found between samples collected from the Snake and Columbia rivers.

Using these data and other ecological information, the Biological Review Team identified 15 steelhead ESUs, 12 of which include coastal forms and 3 of which include inland forms:

Coastal ESUs

- Puget Sound
- Olympic Peninsula
- Southwest Washington
- Lower Columbia River
- Upper Willamette River
- Oregon Coast
- Klamath Mountains Province
- Northern California
- Central California Coast
- South-Central California Coast
- Southern California
- Central Valley

Inland ESUs

- Middle Columbia River
- Upper Columbia River
- Snake River Basin

Naturally spawned (wild) summer and winter steelhead in the Lewis River basin (listed as threatened) are included in the lower Columbia River ESU. This ESU includes all naturally spawned populations of steelhead in the Columbia River and its tributaries from its estuary up to, and including, the Hood River in Oregon.

Although no genetic data are available describing naturally spawning Lewis River winter and summer steelhead, WDFW considers these stocks to be native, but acknowledges that some interbreeding has probably occurred with introduced hatchery stocks from the Beaver Creek, Chambers Creek, Skamania, and Cowlitz hatcheries (Section 4.18.5.4) (PacifiCorp and Cowlitz PUD 2002). In Washington, these hatchery strains have been broadly planted over decades, especially in lower Columbia River basin (Phelps et al. 1994). Beaver Creek winter steelhead are from Elochoman River and Chambers Creek (Puget Sound) origin. Skamania summer steelhead were developed from Washougal and Klickitat summer steelhead in the late 1950s at the Skamania Hatchery in Washington (Crawford 1979). The initial source for the Cowlitz Hatchery stock was a 1:1 mix of Chambers Creek and native Cowlitz River fish (Crawford 1979).

In 1992, the Clark/Skamania Fly Fisheries Club funded a genetic analysis (from protein electrophoresis) of rainbow trout collected in Canyon and Siouxon creeks to help determine the effects of past stocking on the native rainbow trout population (Phelps 1992). The results of this study indicated that Siouxon Creek contains at least 2 distinct populations of rainbow trout. It was also determined that these fish exhibit genetic diversity that is atypical of other coastal rainbow trout populations. No evidence of hatchery rainbow trout gene flow was found in the population collected in upper Siouxon Creek (i.e. these fish are pure native) and only minor gene flow was found in the lower Siouxon Creek collection (i.e. there appears to be a low level of hatchery introgression into this population). The Canyon Creek population does not appear to be hybridized with hatchery-origin rainbow trout (Phelps 1992).

Phelps et al. (1994) also found large genetic distances between 4 widely used rainbow trout hatchery stocks from Washington (Spokane, Goldendale, South Tacoma, and Tokul Creek) and all steelhead populations examined. They concluded that there has been little, if any, permanent genetic effect on the sampled steelhead populations from the widespread stocking of rainbow trout over the past century. Goldendale, Spokane and Mount Whitney Hatchery (California) rainbow trout stocks have been planted in the Lewis River reservoirs for decades (Section 4.18.5.4) (PacifiCorp and Cowlitz PUD 2002).

More recently, PacifiCorp, Cowlitz PUD, WDFW and the USFS have been conducting a study to determine the genetic characteristics of existing rainbow trout, cutthroat trout, and/or steelhead in the upper Lewis River basin (PacifiCorp and Cowlitz PUD 2002). For comparative purposes, genetic samples collected from the Lewis River, Rush Creek, Pine Creek, Muddy River and some of its tributaries will be analyzed against the hatchery strains of rainbow and steelhead that have been planted in the Swift Reservoir or the upper Lewis River. As described above, these stocks include Mount Whitney, Goldendale, South Tacoma, and Spokane rainbow trout and Lewis River winter steelhead. The results of this study are expected to be available in 2003.

<u>Chum Salmon</u> – Much of our present understanding of genetic diversity and structure in chum salmon also comes from the NMFS and WDFW (Johnson et al. 1997, Phelps et al. 1995). As part of its recent status review, the NMFS used genetic data to identify 2 major genetic groups of chum salmon in Washington, Oregon, and central and southern British Columbia (Johnson et al. 1997). One group consists of summer-run chum salmon in Hood Canal and the Strait of Juan de Fuca, and a second large group consists of fall-, winter-, and summer-run chum salmon in other areas. The second large group is weakly divided into 2 additional subgroups: 1) coastal populations along the outer coast of Washington and Oregon, including those in the Columbia River; and 2) the remaining populations in British Columbia and Washington (including the Strait of Juan de Fuca populations).

Using this genetic data and additional ecological data, NMFS identified 4 chum salmon ESUs in the Pacific Northwest:

- Puget Sound/Strait of Georgia
- Hood Canal Summer-Run
- Pacific Coast
- Columbia River

Three of these ESUs (Puget Sound/Strait of Georgia, Hood Canal Summer-Run, and Pacific Coastal) are similar to the major ancestral lineages identified by WDFW in Phelps et al. (1995); however, Phelps et al. (1995) considered Columbia River chum to be part of a larger MAL that included coastal and Strait of Juan de Fuca populations. NMFS determined that chum salmon in the Columbia River were different enough from other populations in nearby coastal river systems to warrant its own ESU designation (Johnson et al. 1997). The Columbia River ESU includes chum salmon found in the lower Lewis River below Merwin Dam (Federal Register, Vol. 65, No. 32, February 16, 2000).

<u>Bull Trout</u> – Significant genetic differences between the Klamath River and Columbia River populations of bull trout were first discovered in 1993 (Leary et al. 1993), and were instrumental in the development of the Klamath and Columbia rivers, Jarbidge River, St. Mary-Belly rivers and Coastal-Puget Sound Distinct Population Segments (DPS) (USFWS 2002). Since their 1998 listing, additional genetic analyses have suggested that bull trout populations may be organized on a finer scale than previously thought (Taylor et al. 1999, and Williams et al. 1997).

Using mitochondrial DNA samples from 47 populations located in British Columbia, Washington, Oregon, Idaho, and Nevada, Taylor et al. (1999) subdivided bull trout haplotypes into 2 geographic groupings roughly separated by the Cascade Crest. Like steelhead and chum salmon, these groups were termed “coastal” and “interior”. Taylor et al. (1999) also documented substantial variation among populations and among geographic regions, especially relative to other salmonid species. These data suggest that bull trout conservation, as measured by molecular assays, must focus on the conservation of as many populations within as many different geographic regions as possible, because it is at these levels that the majority of molecular variation exists (Taylor et al. 1999).

Using this genetic information and other biological attributes common to bull trout within a specific geographic area (as well as other factors), the USFWS identified 22 bull trout recovery units in the Columbia River basin, all within the Columbia River Distinct Population Segment (Table 4.18-21) (USFWS 2002). Bull trout occurring in the Lewis, Klickitat, and White Salmon rivers are included in the Lower Columbia Recovery Unit.

Within the Lower Columbia Recovery Unit, the USFWS further identified 2 core areas, the Lewis and Klickitat rivers. In the Lewis River core area, local populations of bull trout occur in Cougar, Pine, and Rush creeks (Section 4.18.5.4). Cougar Creek is tributary to Yale Lake, and Pine and Rush creeks are tributaries to the Lewis River above Swift Dam.

In 1995 and 1996, genetic samples were taken from bull trout collected in Lake Merwin, Yale Lake and Swift Reservoir and analyzed at the University of Montana’s Wild Trout and Salmon Genetics Lab (Spruell et al. 1998). Analysis showed that Lewis River bull trout were genetically similar to the Columbia River population. However, bull trout collected from Swift Reservoir were found to be significantly different. This implies that there may have been biological separation of the upper basin and lower basin stocks prior to completion of Swift Dam in 1958. Although the researchers could not exclude the possibility that the differentiation of bull trout in Swift Reservoir is the result of recent (post-project) genetic drift, they concluded that the most conservative approach to management of bull trout in the Lewis River is to consider the Swift Reservoir population to be a distinct population. They also suggest that if population sizes are approaching extinction, transfer of individuals between reservoirs may be appropriate. In the final rule for bull trout listing, the USFWS refers to 2 sub-populations of bull trout (Swift and Yale), although both are part of the Columbia River DPS listing. At this point in time, the USFWS does not believe that the 2 Lewis River sub-populations are at risk of extinction in the near term (USFWS and NMFS 2002).

Table 4.18-21. Bull trout recovery units in the Columbia River basin by state(s).

Recovery unit	State(s)
Clark Fork River	Idaho, Montana, Washington
Kootenai River	Idaho, Montana
Willamette River	Oregon
Hood River	Oregon
Deschutes River	Oregon
Odell Lake	Oregon
John Day River	Oregon
Umatilla-Walla Walla River	Oregon, Washington
Grande Ronde River	Oregon
Imnaha-Snake River[1]	Idaho, Oregon
Hells Canyon Complex[2]	Idaho, Oregon
Malheur River	Oregon
Coeur d’Alene Lake Basin	Idaho
Clearwater River	Idaho
Salmon River	Idaho
Southwest Idaho[3]	Idaho
Little Lost River	Idaho
Lower Columbia River[4]	Washington
Middle Columbia River[5]	Washington
Upper Columbia River[6]	Washington
Northeast Washington[7]	Washington
Snake River Washington[8]	Oregon, Washington

1. Includes Imnaha River and Snake River and tributaries in Idaho.
2. Includes Pine Creek, Powder River, and Snake River and tributaries in Idaho.
3. Includes Boise River, Payette River, and Weiser River basins.
4. Includes Klickitat River, Lewis River, and White Salmon River basins.
5. Includes Yakima River basin.
6. Includes Entiat River, Methow River, and Wenatchee River basins.
7. Includes mainstem Columbia River and tributaries upstream of Chief Joseph Dam (Washington), Pend Oreille River basin (Washington), and Spokane River basin upstream to Post Falls (Idaho).
8. Includes Asotin Creek basin and Tucannon River basin.

Life History Diversity

The life histories of Pacific salmon are composed of chains of favorable places that salmon must be able to get to at the appropriate season to carry out important life functions such as spawning, rearing and migration (Thompson 1959). Thompson's description of life history links it intimately to habitat. A discussion of habitat has little meaning unless it includes the specific life history stages that use it. A discussion of life history has little value unless it includes a description of the "chain" of habitats where the life history is carried out.

In the Pacific Northwest, habitats and environments are highly variable. Rivers flow through a complex matrix of diverse geologic, vegetation and climatic zones: coastal rain forests, stepp-shrub deserts, mountains, and interior valleys. Superimposed on this patchwork of habitats are the annual and decadal climatic variations that influence salmon habitat in freshwater and ocean. Environmental fluctuations may mean that some life histories are favored while others are subjected to high mortality, but the situation may change under different conditions. Life history diversity is the salmon's solution to the problems of survival and reproduction in diverse habitats and environmental fluctuations (Thorpe 1994). It spreads the risk of mortality and dissipates the probability of a catastrophic extinction (den Boer 1968).

Life histories are pathways through the salmon's complex mix of habitats in freshwater estuary and ocean. When viewed this way, one of the more important effects of habitat degradation is the termination of life history pathways -- breaking one or more links in the chain. For restoration to be effective, whole life history-habitat chains must be restored. Michael Healey (1994) described it this way:

> *Conservation efforts must nurture the whole life history, not focus inordinate attention on elusive 'bottlenecks" to production. I believe conservation efforts will fail if primary attention is not directed to providing the habitat opportunities that historically supported the stock in its natural state.*

Life Histories of Lewis River Stocks

> *The life histories of the salmon native to the Lewis River are so varied that it is impossible to generalize the conservation problems of the different salmon encountered in the investigation (Smith circa 1943, page 8).*

Chinook Salmon – Chinook salmon are anadromous and have a broad range of life history traits, including variation in age at seaward migration; variation in freshwater, estuarine, and ocean residence; variation in ocean distribution; and in age and season of spawning migration (Healey 1991, Myers et al. 1998). Most of this variation is exhibited in 2 distinct behavioral forms commonly referred to as stream-type (spring chinook) and ocean-type (fall chinook). Stream-type chinook reside in freshwater for a year or more before migrating to sea, and return to their natal river in spring or summer, several months prior to spawning. Ocean-type chinook migrate to sea in their first year of life, usually only a few months after emergence, and return to their natal river in the fall, a few days or weeks before spawning (Healey 1991). However, in some northern stocks, juvenile stream-type chinook may remain in fresh water for 2 or more years. Chinook stocks in Asia, Alaska, and Canada (north of the 55th parallel) and in the headwaters of the Fraser and Columbia rivers typically exhibit the stream-type life history. Ocean-type chinook are predominant in regions south of the 55th parallel, in Puget Sound, and in the lower reaches of the Fraser and Columbia rivers (Myers et al. 1998).

The amount of time spring and fall chinook spend at sea is highly variable, ranging from 1 to 6 years (more commonly 2 to 4 years), with the exception of a small proportion of yearling males (jacks), which mature in freshwater or return to freshwater after only a few months at sea (Myers et al. 1998).

Prior to the completion of Merwin Dam and the advent of large-scale hatchery supplementation, the mainstem Lewis River and its tributaries supported native spring and fall chinook salmon (Section 4.18.5.4). Both were relatively abundant and their life histories were well adapted to the basin's local environmental conditions.

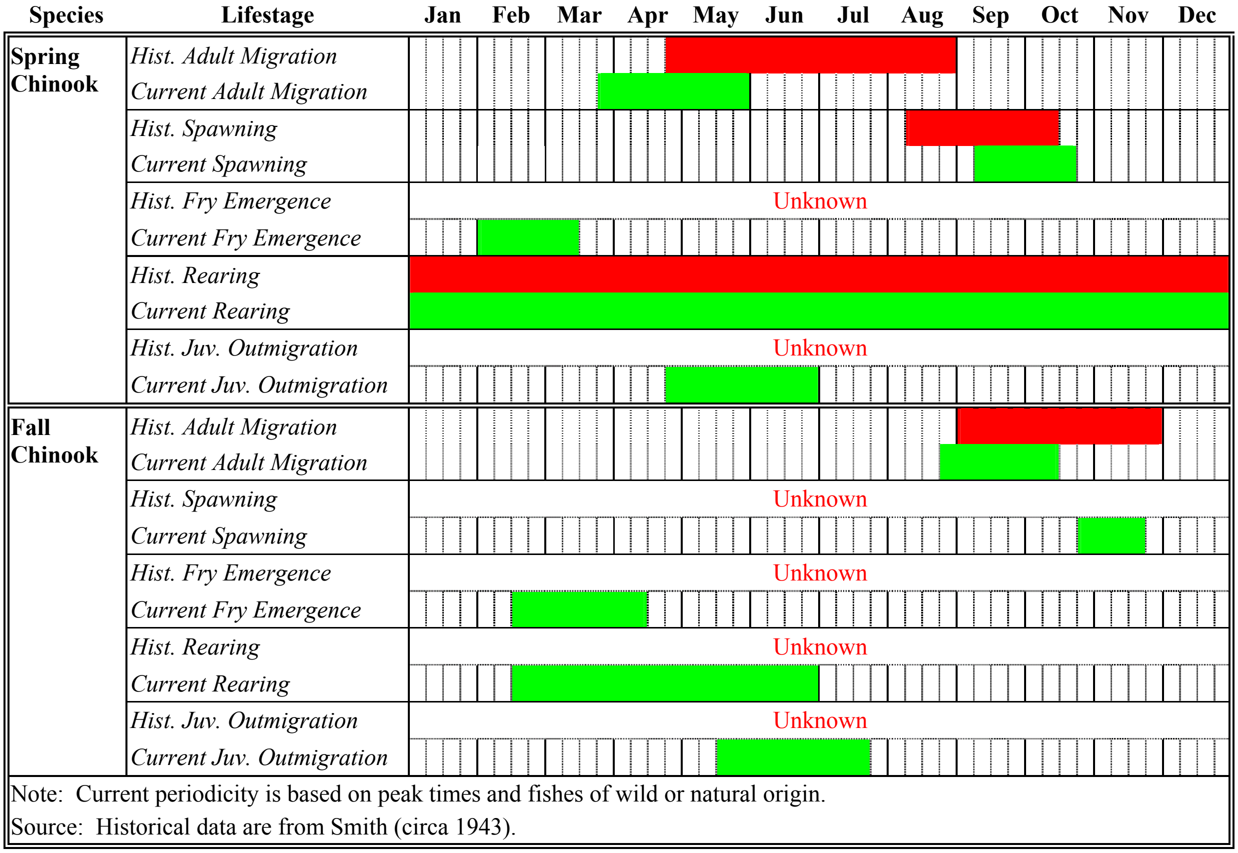
Unfortunately, no information on the life histories of Lewis River chinook salmon (or other species) prior to the early 1930s was found. The earliest available data were collected immediately following the completion of Merwin Dam, at the Merwin Dam Anadromous Fish Collection Facility. Life histories were also described as a component of early Lewis River hatchery investigations completed by Smith (circa 1943).

In the 1930s and early 1940s, adult spring chinook first appeared at the Merwin Dam collection facility in late April and early May, with the migration extending through late August (Smith circa 1943) (Figure 4.18-27). Spawning in the river below the dam peaked in late August and early September, although the spawning period was reported to extend from early August through mid-October. Fish that were trapped and hauled to the holding ponds at Cougar Creek (1939 through 1942) spawned slightly later than those in the lower river, likely due to the significantly cooler water temperatures. Since Merwin Dam was completed in 1932, spawning below the dam might have been influenced by altered water temperatures and therefore, may not reflect the "natural" timing.

The historical upstream migration of fall chinook was well separated from that of spring chinook, extending from early September through the month of November (Smith circa 1943). The heaviest migration occurred between September 10 and October 10 (Figure 4.18-27). Fall chinook spawning was reported to occur shortly after they entered the Merwin collection facility. Unfortunately, data describing other historical spring and fall chinook life history attributes (i.e. incubation periods, juvenile rearing periods, and juvenile outmigration timing) are not available.

Today, the majority of wild spring chinook (comprised of a mix of different hatchery stocks) enter the Lewis River basin from late March through May. The peak spawning period extends from early September through late October (pers. comm., E. Lesko, PacifiCorp, October 2000; WDF and WDW 1993), and peak emergence extends from early February through mid-March (Figure 4.18-27).

Although the current life history information presented in Figure 4.18-27 represents what are considered to be "peak periods" and does not capture the full range of variation, it is apparent the spring chinook migration in the Lewis River has shifted from its historical late April through August period to late March through May (Figure 4.18-27). Effects on the spring chinook spawning period are not as pronounced, although the majority of the spawning activity now occurs slightly later in the fall. The shift in spring chinook migration timing may be associated with the introduction of non-native stocks, changes in habitat associated with the creation of the project reservoirs, modifications of the flow regime, hatchery operations, or other factors.



Note: Current periodicity is based on peak times and fishes of wild or natural origin.
Source: Historical data are from Smith (circa 1943).

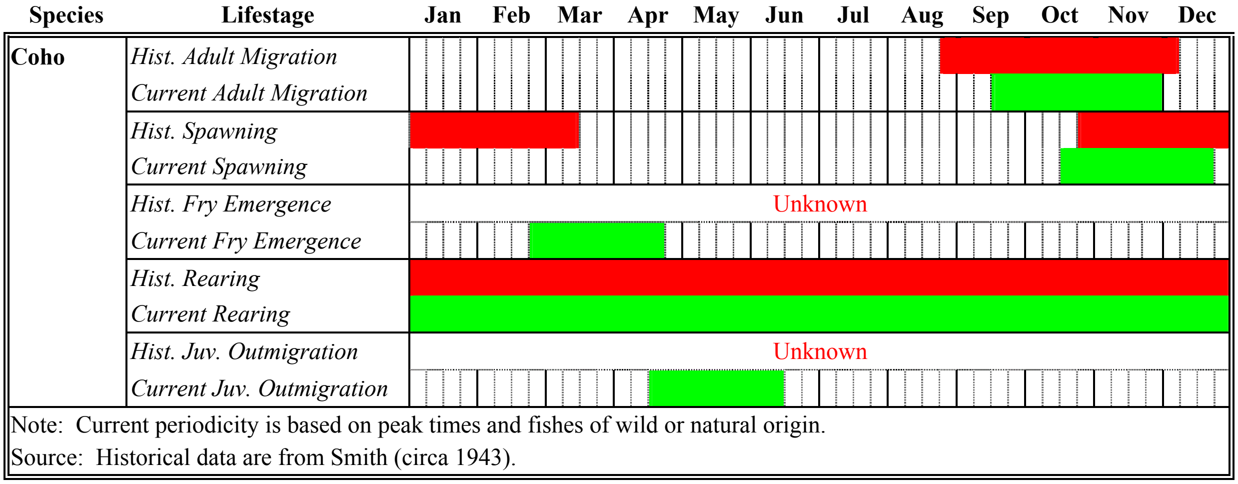
Figure 4.18-27. Historical and current life history periodicity chart for spring and fall chinook in the Lewis River basin.

Currently, Lewis River fall chinook (a native stock of natural origin) enter the basin from late August through mid-October (Figure 4.18-27). Peak spawning occurs from late October through late November. Emergence generally occurs from mid-February through mid-April and peak freshwater rearing is reported to extend from late February through the end of June (Figure 4.18-27) (pers. comm., E. Lesko, PacifiCorp, October 2000). McIsaac (1990) documented fall chinook rearing as late as September, with peak Columbia River estuary passage in early August. This is as much as 2 months later than most Columbia River hatchery stocks and may be an important factor contributing to the existing high survival rates in the Lewis River. McIsaac (1990) also documented that a minor fraction of the population (4 percent) overwintered to outmigrate in the second spring.

<u>Coho Salmon</u> – Like chinook salmon, coho salmon are anadromous and semelparous. Smolts rear in freshwater, typically migrate to sea in the spring of their second year, spend 16-20 months rearing in the ocean, and then return to freshwater in the autumn as 3-year-old adults. A variable proportion of males (jacks) return to freshwater to spawn after only 5 to 7 months in the ocean (Weitkamp et al. 1995, Sandercock 1991). However, within this basic pattern there are many variations that have evolved in response to opportunity and selective pressures. Stocks from British Columbia,

Washington, and the Columbia River often have very early (entering rivers in July or August) or late (spawning into March) runs in addition to normally timed runs (Weitkamp et al. 1995). In general, earlier migrating fish spawn farther upstream within a basin than later migrating fish, which enter rivers in a more advanced state of sexual maturity (Sandercock 1991).

As discussed in Section 4.18.5.4, the Lewis River basin historically had large runs of both early-run and a late-run coho salmon (Smith circa 1943, WDF and USFWS 1951). According to Smith (circa 1943), the early-run component, bound for the upper Lewis River basin, entered the Merwin Dam collection facility from late August through mid-November (Figure 4.18-28). The late-run component entered Cedar Creek from late September through the first week in December. In 1951, the WDF and USFWS also described the presence of an early-run in Cedar Creek and a late-run in the East Fork Lewis River. According to this report, early-coho spawned from late October through late November, late-coho spawned from late November well into March (Figure 4.18-28) (WDF and USFWS 1951). Data describing other historical coho life history attributes are not available.



Note: Current periodicity is based on peak times and fishes of wild or natural origin.
Source: Historical data are from Smith (circa 1943).

Figure 4.18-28. Historical and current life history periodicity chart for coho salmon in the Lewis River basin.

Today, coho salmon returning to the Lewis River basin are managed for 2 major hatchery stocks, a late run (Type-N) stock and an early run (Type-S) stock (Section 4.18.5.4). Type-S coho begin migrating to the Columbia River and their natal streams in late August and early September, peaking in September and October. Type-N coho follow approximately 6 weeks later. Coho enter the Lewis River from mid-September through November. In the Lewis River below Merwin Dam, peak spawning occurs from mid-October through late December (Figure 4.18-28) (pers. comm., E. Lesko, PacifiCorp, October 2000). Smolt outmigration in the lower Lewis River occurs from mid-April through the beginning of June (Figure 4.18-28) (pers. comm., E. Lesko, PacifiCorp, October 2000).

As is the case for chinook, the current coho life history data illustrated in Figure 4.18-28 represents peak periods and likely does not capture the full range of existing life history variation. Regardless of this fact, a narrowing of the historical coho spawning period from mid-October through mid-March to mid-October through late-December is fairly evident (Figure 4.18-28). Effects on migration timing are not as pronounced.

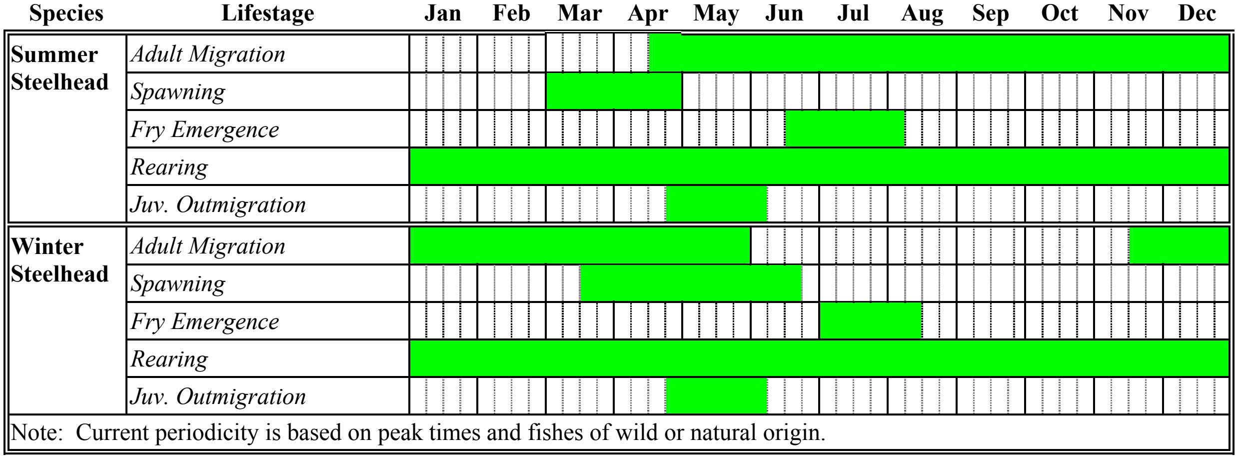
Steelhead – *O. mykiss* is considered by many to have the greatest diversity of life history patterns of any Pacific salmonid species, including varying degrees of anadromy, differences in reproductive biology, and plasticity of life history between generations. The species can be anadromous (steelhead) or freshwater resident (rainbow trout). It is believed that the progeny from resident rainbow trout have the potential to become anadromous (steelhead) and that the progeny of steelhead have the potential to become resident rainbows (Peven 1990). Biologically, the anadromous steelhead can be divided into 2 reproductive ecotypes based on their state of sexual maturity at the time of river entry and duration of their spawning migration. These 2 ecotypes are termed “stream maturing” (summer steelhead) and “ocean maturing” (winter steelhead). Summer steelhead enter freshwater during the summer months in a sexually immature state and require several months of maturation before they spawn. Winter steelhead enter freshwater ready to spawn in late winter or early spring (Busby et al. 1996). Unlike other species of *Oncorhynchus*, except *O. clarki* (cutthroat trout), steelhead are capable of spawning more than once before they die (Busby et al. 1996). However, the majority of steelhead spawn only once in their life.

The amount of time steelhead spend at sea is highly variable. North American steelhead most commonly spend 2 years in the ocean (2-ocean) before entering freshwater to spawn. Populations in Oregon and California have higher frequencies of age 1-ocean steelhead than populations to the north, but age 2-ocean steelhead generally remain dominant.

Both summer and winter steelhead are indigenous to the Lewis River; however, hatchery winter and summer steelhead (non-native stocks) have been planted in the system since the late 1940s (Section 4.18.5.4).

Prior to extensive hatchery supplementation, very few steelhead entered the Merwin Dam collection facility and as a result, there are limited data describing historical run timing. However, Smith (1939a) noted the steelhead first entered the Lewis River “running with spring chinook in April.” Unpublished Lewis River Hatchery records from the late 1930s also show that steelhead were first collected in early April, entering the collection facility throughout the month of July. No other historical Lewis River steelhead life history information is available.

Currently, adult winter steelhead enter the Lewis River from late November through May, with peak migration occurring in March (Figure 4.18-29) (pers. comm., E. Lesko, PacifiCorp, October 2000). Spawning occurs from mid-March through late June, and peaks from mid-March through April. Summer steelhead enter the Lewis River from mid April through December (Figure 4.18-29) (pers. comm., E. Lesko, PacifiCorp, October 2000, WDFW 2003). Summer steelhead spawning occurs from early-March through the end of April. Within the North Fork Lewis River, the majority of steelhead are captured at the Merwin Hatchery, although an estimated 5 to 10 percent of returning steelhead do spawn naturally.



Species	Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Summer Steelhead	*Adult Migration*				🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	Spawning			🟩	🟩								
	Fry Emergence						🟩	🟩	🟩				
	Rearing	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	Juv. Outmigration				🟩	🟩	🟩						
Winter Steelhead	*Adult Migration*	🟩	🟩	🟩	🟩	🟩						🟩	🟩
	Spawning			🟩	🟩	🟩	🟩						
	Fry Emergence							🟩	🟩				
	Rearing	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	Juv. Outmigration				🟩	🟩	🟩						

Note: Current periodicity is based on peak times and fishes of wild or natural origin.

Figure 4.18-29. Current life history periodicity chart for summer and winter steelhead in the Lewis River basin.

Chum Salmon – Chum salmon are semelparous and exhibit obligatory anadromy[17]. They also spend more of their life history in marine waters than other Pacific salmonids (Johnson et al. 1997). Mature adults enter freshwater at an advanced stage of sexual development and spawn in the lower reaches of coastal streams (typically, just above tidal influence). Rarely do chum salmon penetrate rivers more than 161 km (100 miles) (Scott and Crossman 1973). Although very capable swimmers, they are not leapers and are usually reluctant to enter long-span fish ladders (Salo 1991, Powers and Orsborn 1985). It should be noted, however, that chum salmon once migrated up the Columbia River as far as the Walla Walla River. To do this, they had to ascend Celilo Falls.

Juvenile chum salmon outmigrate to saltwater almost immediately following emergence (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions (Johnson et al. 1997). Freshwater residence (in rivers and streams) can range from a few hours to a few months. In Washington, chum salmon may reside in freshwater for as long as a month, migrating from late January through May (Johnson et al. 1997).

Throughout its range, most chum salmon (95 percent) mature between 3 and 5 years of age, with 60 to 90 percent of the fish maturing at 4 years of age. However, there is a higher proportion of 5-year-old fish in the north, and a higher proportion of 3-year-old fish in the south (southern British Columbia, Washington, Oregon) (Johnson et al. 1997). Age at maturity tends to follow a latitudinal trend in which a greater number of older fish occur in the northern populations of the species' range (Johnson et al. 1997).

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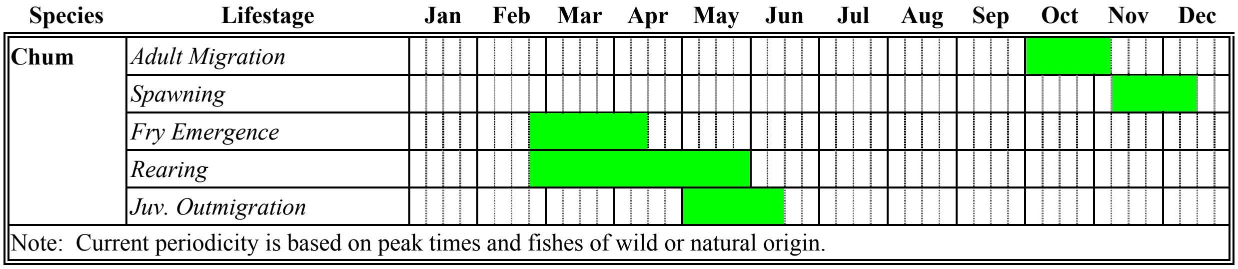
[17] They die after spawning and only reach sexual maturity in salt water.

Chum salmon may enter their natal river from June to March (Johnson et al. 1997). In Washington, a variety of seasonal runs are recognized, including summer, fall, and winter populations; most enter freshwater from October to December (Wydoski and Whitney 1979).

Prior to the completion of Merwin Dam and the advent of large-scale hatchery supplementation, the Lewis River basin supported a self-sustaining population of native chum salmon (Section 4.18.5.4). The species formerly ascended the mainstem Lewis River to the mouth of Speelyai Creek. Most spawning occurred in the mainstem Lewis River, East Fork Lewis River, and Cedar Creek. Unfortunately, there are limited data describing historical chum salmon life history in the Lewis River basin. WDF and USFWS (1951) noted that chum salmon passed through the lower Columbia River fishery in October and November. Peak spawning occurred during early November.

Currently, adult chum salmon enter the lower Columbia River and its tributaries in October and early November (Figure 4.18-30) (WDF and WDW 1993; pers. comm., E. Lesko, PacifiCorp, October 2000). Spawning occurs immediately after freshwater entry and typically extends into mid-December. Emergence occurs from late February through mid-April (pers. comm., E. Lesko, PacifiCorp, October 2000). Most chum salmon fry emerge during the nighttime hours and promptly migrate downstream to estuarine water where they remain until they make the transition to areas of higher salinity (Wydoski and Whitney 1973, Johnson et al. 1997).



Note: Current periodicity is based on peak times and fishes of wild or natural origin.

Figure 4.18-30. Current life history periodicity chart for chum salmon in the Lewis River basin.

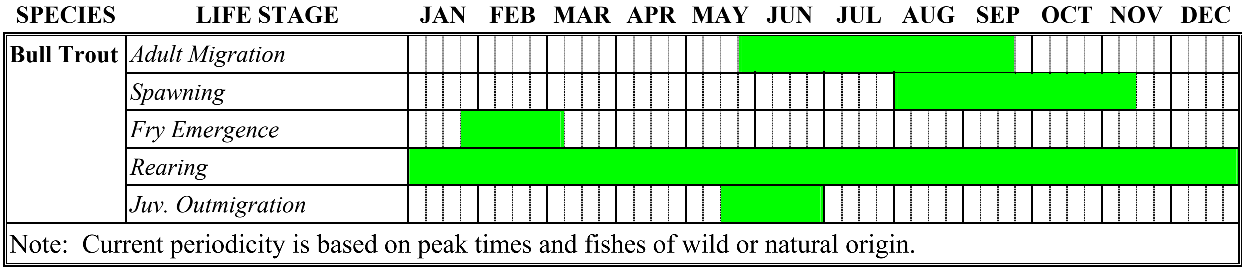
Bull Trout – Throughout its range, bull trout exhibit 2 distinct life-history strategies: resident and migratory. Resident bull trout complete their entire life cycle in the tributary streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear for up to 6 years before migrating to either a lake (adfluvial), river (fluvial), or in certain coastal areas, to saltwater (anadromous), where maturity is reached in one of the 3 habitats (Fraley and Shepard 1989; Goetz 1989). Resident and migratory forms may be found together and it is suspected that bull trout give rise to offspring exhibiting both resident and migratory behavior (Federal Register: June 10, 1998, Rieman and McIntyre 1993). The migratory forms of bull trout are generally of the most concern throughout its inland range (Brown 1994).

Typically, adfluvial bull trout mature for 2 or 3 years in lakes and reservoirs before undergoing spawning migrations (usually at 4 to 7 years of age). Spawning generally occurs in late summer to early fall as water temperatures begin to drop (Goetz 1989).

In the Lewis River basin, migratory (adfluvial) populations of bull trout are found in all 3 project reservoirs (PacifiCorp and Cowlitz PUD 2002). A very small number of unidentified adult char (bull trout or Dolly Varden) have also been captured in the ladder at the Lewis River hatchery downstream of Merwin Dam.

Due to a lack of historical life history information, it is not known how the present hydroelectric reservoirs have affected the Lewis River bull trout population. However, the USFWS and NMFS (2002) speculate that 2 life history theories are possible: 1) the original population of bull trout in the North Fork Lewis River were fluvial, with adults residing in the Columbia River and migrating into the North Fork Lewis River to spawn; or 2) the original population was fluvial and completed its life cycle entirely in the North Fork Lewis River and its tributaries. Prior to dam construction, the Lewis River also may have supported anadromous and fluvial bull trout/Dolly Varden (WDFW 1998).

Currently, bull trout residing in Swift Reservoir migrate into tributary streams from late May through early-August, and spawn from early August through the end of October (Figure 4.18-31) (Faler and Bair 1992; Graves 1982; pers. comm., E. Lesko, PacifiCorp, October 2000). The adfluvial population of bull trout in Yale Lake migrates into tributary streams from the middle of August through late September. Spawning in Cougar Creek, a spring fed tributary to Yale Lake, occurs from late September through mid November (Figure 4.18-31) (Graves 1982; pers. comm., E. Lesko, PacifiCorp, October 2000, WDFW 2003). Most adult bull trout migration occurs at night (Brown 1994). Unfortunately, the exact timing of bull trout redd construction in the Lewis River tributaries has not been documented. Emigration of juveniles from the tributaries to Swift and Yale reservoirs is believed to occur from mid-May through June (Figure 4.18-31) (pers. comm., E. Lesko, PacifiCorp, October 2000).



SPECIES	LIFE STAGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bull Trout	*Adult Migration*					🟩	🟩	🟩	🟩	🟩			
	Spawning								🟩	🟩	🟩	🟩	
	Fry Emergence	🟩	🟩	🟩									
	Rearing	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	Juv. Outmigration					🟩	🟩						

Note: Current periodicity is based on peak times and fishes of wild or natural origin.

Figure 4.18-31. Current life history periodicity chart for bull trout in the Lewis River basin.

Kokanee – *Oncorhynchus nerka* occur in 2 forms: the anadromous sockeye salmon, and the non-anadromous kokanee. Anadromous sockeye salmon typically spend their first year of life in a lake before migrating to the ocean to rear and mature, while kokanee complete their entire life cycle in freshwater (Meehan and Bjornn 1991). Kokanee usually mature at a smaller size than sockeye salmon because there is usually less food in lake environments than in the ocean (Meehan and Bjornn 1991). Throughout its range, the average life span of kokanee is 4 years (3 years in southern populations), although some as old as 8 years have been reported (Scott and Crossman 1973).

As discussed in Section 4.18.5.4, kokanee were first introduced into the North Fork Lewis River basin above Merwin Dam in the in the late 1950s and early 1960s. Self-sustaining kokanee populations currently reside in Yale Lake and Lake Merwin.

Migration into Cougar Creek, the primary kokanee spawning stream in the project area, typically starts in mid-September and continues to mid-October, peaking in early October (Figure 4.18-32) (pers. comm., E. Lesko, PacifiCorp, October 2000). Peak spawning also occurs in October, although pre-spawning condition fish have been reported in Cougar Creek as late as November 22 (Figure 4.18-32). Emergence occurs in February and early March and outmigration extends from mid-March through April (Figure 4.18-32). Kokanee outmigration is highly synchronized and occurs during the night, so that thousands of fry swim or drift en masse to the lake in an attempt to minimize predation (Burgner 1991). In the Lewis River basin, juvenile kokanee rear for an average 2 to 3 years before spawning.

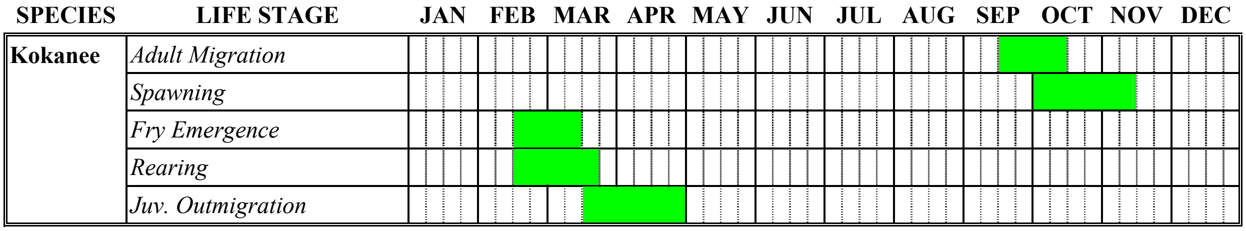


Figure 4.18-32. Current life history periodicity chart for kokanee in the Lewis River basin.

4.18.5.6 Decadal Climate and Ocean Productivity Fluctuations

Pacific salmon and steelhead integrate several different habitats including headwater streams and main stems of rivers, estuaries, and the ocean. However, biologists have had a tendency to conceive of salmon management actions in those different habitats not as and integrated whole, but as though river, estuary and ocean were 3 independent cubby holes where salmon are found at various times in their life history. The ocean was believed to be a stable and virtually limitless feeding ground for artificially and naturally produced salmon and steelhead.

Even after the effects of variable oceanic conditions on salmon survival was well established in the 1980s, integration between freshwater and ocean was ignored. For example, it is now believed that the general collapse of the salmon and steelhead over the past few decades and especially the 1990s was due to ocean conditions that resulted in low salmon survival. This has led to the widely held assumption that humans have no power to change the ocean, so freshwater restoration will not solve a problem that is in the sea beyond our control. But the salmon's marine and freshwater habitats are connected. Habitat degradation in freshwater, poor hatchery practices and excessive harvest have, over the last century, contributed to the loss of life history diversity in anadromous salmonids. This loss of life history diversity in freshwater may decrease the ability of salmon to survive oceanic environmental fluctuations (ISG 2000). Degradation of river and estuarine habitats may determine the magnitude of the salmon's response to changing oceanic conditions.

Ocean conditions vary over 40 to 60 year cycles (Ware and Thomson 1991). Thompson (1927), Lawson (1993) and Beamish and Bouillon (1993) describe the management problems associated with the long term productivity cycles. Of particular importance are the transition years when ocean conditions are shifting from poor to high survival or from high to poor survival. Those transitions present particularly challenging management problems (Lichatowich 1997). The following are a few examples:

- A shift to conditions that result in higher marine survival can falsely be interpreted as the outcome of restoration programs. This could lead to investment in restoration technology that is not effective.
- Higher marine survival could also cause a relaxation of habitat protection and restoration measures under the false assumption that the problem has been solved.
- A failure to recognize the transition in oceanic conditions could easily lead to over harvest of naturally reproducing salmon and steelhead populations.
- Monitoring programs that are not designed to identify and separate the effects of ocean conditions from the outcomes of management programs can lead to poor decisions.

In the Lewis River, dams, harvest, hatchery practices, logging, agriculture, urban development and natural disturbance events have all contributed to the decline of salmon and steelhead. However, to develop sound management and restoration programs, managers must incorporate into their planning cyclic changes in productivity. For example, during periods of low ocean survival and shrinking capacity of the ecosystem, the continued release or the increase in releases of artificially propagated salmon may not be the best strategy (Beamish and Bouillon 1993). Productivity cycles also mean that the evaluation of management programs may require long term monitoring. The outcomes of management and restoration programs receive their most important evaluation during the periods of low ocean survival.

4.18.5.7 Lewis River Regulatory / Policy Context

A number of policies and regulatory mandates influence decisions regarding fish management in the Lewis River basin. The following section summarizes the major policies and documents, and characterizes the relative importance of each in the decision-making process.

<u>Laws and Treaties</u>

<u>Federal Power Act</u> – The Federal Power Act (the Act) requires FERC to award a license to the project that is the best adapted comprehensive plan for waterway commerce, power development, fish and wildlife, and other public uses (section 10(a)); and the applicant whose proposal is “best adapted to serve the public interest” (section 15(a)(2)).

The Act creates various avenues for mandatory fish, wildlife and habitat protection measures to be incorporated into license articles.

- Section 4(e) (protection of federal "reservations," including National Forests). In cases where the project to be licensed by FERC is located on a federal reservation, the federal agency responsible for managing that land can file terms and conditions to protect the reservation that become, upon filing, mandatory upon FERC to include in any license issued. Both the Forest Service and the Bureau of Land Management have 4(e) authority in the Lewis River license proceedings.

- Section 18 (fishways); The Act authorizes the Secretaries of Commerce (NOAA Fisheries) and the Interior (U.S. Fish and Wildlife Service) to prescribe fishways at projects to be licensed by FERC. Such fishway prescriptions are mandatory.

- Section 10(j) fish and wildlife agency and 10(a)(2)(B) tribal recommendations. In issuing licenses, FERC must include conditions to adequately protect, mitigate damage to, and enhance fish and wildlife (and their habitats), based on recommendations of state and federal fish and wildlife agencies made in accordance with Section 10(j) of the Act. In addition, FERC must consider the resource recommendations made by tribal interests in accordance with Section 10(a)(2)(B). FERC is not required to incorporate Section 10(j) or 10(a)(2)(B) recommendations into the license, but they must provide justification for omission of these recommendations.

- Section 10(a)(2)(A) – This provision requires that FERC consider the extent to which a project would be consistent with comprehensive plans for improving, developing, or conserving waterways affected by the project. A total of 12 plans pertaining to the project area are included on FERC's list, including USFS land and resource management plans, various state plans, the *U.S. v. Oregon* settlement and other harvest agreements, local land use plans, and the Northwest Power Planning Council plan. These are described in Section 8.1.5.4 of the 2001 Technical Study Status Reports (PacifiCorp and Cowlitz PUD 2002).

<u>Clean Water Act</u> – Section 401 of the Clean Water Act (CWA) requires an applicant for a federal license or permit to conduct any activity that may result in a discharge into navigable waters to provide the licensing or permitting agency with a certification from the state that the discharge will comply with the applicable provisions of CWA sections 301, 302, 303, 306, and 307, including applicable state water quality standards. The authority to review the Lewis River Projects for consistency with Section 401 is the responsibility of the Washington Department of Ecology (WDOE). An application for 401 Certification will be submitted to WDOE prior to filing the license application with the FERC.

Endangered Species Act – Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat for such species. Federally listed and species proposed for listing that may occur in the Lewis River Project area include:

- Bald eagle; threatened: no critical habitat designation
- Bull trout; threatened: critical habitat proposed
- Lower Columbia River steelhead trout: threatened, no critical habitat designation
- Lower Columbia River chinook salmon: threatened, no critical habitat designation
- Columbia River chum salmon: threatened, no critical habitat designation

The federal listings of Columbia River fish species have led to a number of developments:

Habitat – The Federal Columbia River Power System (FCRPS) biological opinion (BiOp) was drafted by NMFS. The BiOp puts a high priority on protecting and restoring habitat, and in the short-term requires the Bureau of Reclamation to initiate programs in priority subbasins to address all flow, passage and screening problems over a 10-year period. The Lewis River Subbasin is a priority subbasin, having received the highest priority ranking in the Lower Columbia (FCRPS Biological Opinion at 9-133, 9-134, December 21, 2000).

Tributary Passage – Under NMFS's "take" rules, developed under Section 4(d) of the ESA, projects that comply with NMFS juvenile passage guidelines and criteria avoid ESA liability for juvenile passage (65 FR 42478-42479).

Hatcheries – NMFS insulates hatchery programs from ESA take liability if a state or federal Hatchery and Genetics Management Plan has been approved by NMFS under criteria set out in the agency's 4(d) rule (65 FR 42477). Draft Hatchery and Genetics Management Plans are attached to the Draft Lewis River Subbasin Summary.

Harvest – NMFS's 4(d) rules insulate harvest management programs from ESA take liability if fisheries are managed in accordance with a NMFS-approved Fishery Management and Evaluation Plan (65 FR 42476). A draft Fishery Management and Evaluation Plan for the Lewis River subbasin is attached to the subbasin summary mentioned in the Draft Lewis River Subbasin Summary.

FERC will prepare a biological assessment (BA) in accordance with Section 7 of ESA to be submitted to NMFS and USFWS based upon the license application. The BA will discuss how the proposed action may impact listed fish and wildlife species and their habitats.

Magnuson Stevens Fishery Management and Conservation Act – Section 305(b) of the Magnuson Stevens Fishery Management and Conservation Act ("Magnuson Stevens Act") requires Federal action agencies to consult with NMFS if their action may adversely affect essential fish habitat (EFH). NMFS must provide recommended measures to the action agency to conserve EFH. The action agency must respond to NMFS describing measures it will take to conserve EFH and explaining the reasoning if recommendations are not followed. The Pacific Coast Salmon Fishery Management Plan includes designation of EFH in the Lewis River for chinook and coho salmon downstream of Merwin Dam. FERC makes the determination as to whether the proposed action may adversely affect EFH and therefore about the need to consult with NMFS. NMFS would likely recommend that the EFH assessment be combined with ESA Section 7 consultation.

<u>National Environmental Policy Act</u> – The National Environmental Policy Act of 1969 (NEPA) aims to encourage harmony between people and the environment, to promote efforts to prevent or eliminate damage to the environment and the biosphere, and to enrich the understanding of ecological systems and natural resources important to the country. All federal actions, including issuance of a FERC license, are subject to NEPA and must demonstrate compliance with the law and its implementing regulations. As such, FERC must prepare either an environmental assessment (EA) or an environmental impact statement (EIS) to document the potential project impacts on the natural and built environment. In the Lewis River relicensing process, the Applicants are preparing a preliminary draft environmental assessment (PDEA) that will be submitted to FERC with the license applications. FERC will then issue either a final EA or EIS.

<u>National Forest Management Act</u> – The National Forest Management Act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. It is the primary statute governing the administration of national forests.

In accordance with this law, the Forest Service manages federal lands in the Lewis River project vicinity under the Gifford Pinchot National Forest Land and Resource Management Plan, which was drafted in accordance with the National Forest Management Act and the Northwest Forest Plan.

<u>State of Washington, 1998 Salmon Recovery Planning Act, 1998 Watershed Planning Act and 1999 Salmon Recovery Funding Act</u> – Washington has salmon recovery initiatives that were developed under the 1998 Salmon Recovery Planning Act (general authorization for recovery efforts), a 1998 Watershed Planning Act (encourages voluntary watershed planning by local jurisdictions), and a 1999 Salmon Recovery Funding Act (creates a Salmon Recovery Funding Board to integrate state funding for salmon recovery). The umbrella policy for the State's efforts is Extinction Is Not an Option, described below. The State also has area-specific conservation initiatives, including the Lower Columbia Steelhead Conservation Initiative, which has conservation strategies and actions for Lewis River watersheds, among others. A Lower Columbia Fish Recovery Board develops and implements habitat aspects of recovery plans and intends to use the Lewis River basin as a "case study" in the prioritization of restoration sub-watersheds in the lower Columbia River basin.

<u>U.S. v. Oregon, Pacific Salmon Treaty and Other Harvest Agreements</u> – *United States v. Oregon*, originally a combination two cases, *Sohappy v. Smith and U.S. v. Oregon*,

legally upheld the Columbia River treaty tribes reserved fishing rights. Although the Sohappy case was closed in 1978, *U.S. v. Oregon* remains under the federal court's continuing jurisdiction serving to protect the tribe's treaty reserved fishing rights.

In 1969 the court ruled in the *Sohappy v. Smith* case that the state regulatory power over Indian fishing is limited and tribes have the right to fish at "all usual and accustomed" places whether on or off reservation. Under this ruling state regulation must comply with specific standards including:

- States may regulate only when reasonable and necessary for conservation.
- States must offer proof that particular regulations are necessary to accomplish conservation.
- Regulations must not discriminate against the Indians.
- Regulations must be the least restrictive.
- Fisheries can not be managed so that little or no harvestable fish reach upstream areas where most of the Indian fishery takes place.
- Treaty fishing rights may not be subordinated to some other state objective or policy.
- The protection of treaty fishing rights must be a state regulatory objective coequal with its fish conservation objectives.
- Indians may be permitted to fish at places and by means prohibited to non-Indians.
- The tribes are entitled to "a fair and equitable share" of the resource.

The Sohappy decision did not define what was meant by a "fair and equitable share." In the 1974 *United States v. Washington* case, Judge Boldt ruled that a "fair and equitable share" is 50 percent of all the harvestable fish destined for the tribes' traditional fishing areas. Judge Belloni applied the 50 percent standard in 1975 in the *U.S. v. Oregon* case, which remains under federal court jurisdiction.

Policies and Plans

Columbia River Inter-Tribal Fish Commission Wy-kan-Ush-me-Wah-Kish-Wit, the Spirit of the Salmon – The Columbia River Inter-Tribal Fish Commission (CRITFC) is the technical support and coordinating agency for fishery management policies of the 4 Columbia River treaty tribes. These tribes include: the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Membership is composed of the fish and wildlife committees of these Tribes.

Wy-kan-Ush-me-Wah-Kish-Wit is the long term fishery management plan of the CRITFC and is geared toward the recovery of chinook, coho, sockeye, steelhead, chum, eels (Pacific lamprey) and sturgeon, above Bonneville Dam. Underlying *Wy-Kan-Ush-Mi Wa-Kish-Wit* is tribal recognition of the "connection of all life," respect for nature and the natural structure and function of the salmon's ecosystems, and the wise use of technical expertise. This plan and other supporting documents guide the resource recommendations of the CRITFC membership Tribes.

Federal Conceptual Recovery Plan for Conservation of Columbia Basin Fish – In December 1999 the Federal Caucus released the Draft Conservation of Columbia Basin Fish, Building a Conceptual Recovery Plan. The Federal Caucus consists of the Army Corps of Engineers, Bonneville Power Administration, Bureau of Indian Affairs, Bureau of Land Management, Bureau of Reclamation, Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Forest Service, and the National Marine Fisheries Service. The purpose of this document is to provide a conceptual foundation for a recovery plan for anadromous salmonids. The plan presents basic options and alternatives for recovery and analysis of potential biological effects of the alternatives. A final document has not been issued and the planning process for a lower Columbia River salmonid recovery plan is ongoing. The current schedule asserts that a final recovery plan should be issued in 2004.

Federal Northwest Forest Plan Aquatic Conservation Strategy – An attachment to the 1994 Northwest Forest Plan outlines an aquatic conservation strategy for the management of U.S. Forest Service and Bureau of Land Management lands in the range of anadromous salmonids. The conservation strategy involves designating riparian reserves, conducting watershed analyses, defining key watersheds, and drafting watershed restoration strategies to restore aquatic ecosystem health in key areas. On November 25, 2002, the Department of Agriculture issued a notice of intent to prepare a supplement to the final EIS to clarify the intent of the aquatic conservation strategies. Judicial interpretation of the guidelines has resulted in permitting and project delays, which were not intended by the original guidelines. Revision of the conservation strategy is ongoing.

Lower Columbia Steelhead Conservation Initiative – The lower Columbia Steelhead Conservation Initiative drafted in 1998 by the State of Washington is a working document to deal with the recovery of lower Columbia River steelhead. The strategies in the document work in concert with the state's watershed-based salmonid recovery approach. It addresses steelhead habitat, hatchery propagation, hydropower, and harvest. The state is currently adapting this plan to address the other listed salmonid species in the lower Columbia River. A final version of this document has not been completed, although the draft is available at: http://www.governor.wa.gov/gsro/lcsci/lowdraft.htm.

Northwest Power Planning Council, Columbia River Basin Fish and Wildlife Program – In accordance with the Northwest Power Act of 1980, this program is designed to "protect, mitigate, and enhance fish and wildlife…affected by…[Columbia River Basin hydropower facilities] while assuring the Pacific Northwest has an adequate, efficient, economical and reliable power supply." The program has set goals for salmon and steelhead, resident fish, and wildlife. The program supports sub-basin planning efforts to meet fish and wildlife objectives. The Lewis River subbasin plan, completed in 1990, defines production plans for spring chinook, fall chinook, coho, chum, summer steelhead, and winter steelhead. The plan also includes strategies for implementation.

Draft Lewis River Subbasin Summary prepared by WDFW: prepared to guide Northwest Power Act investments in Fish and Wildlife Mitigation – This document prepared by WDFW in 2002 contains a detailed summary of existing aquatic resources in the Lewis River and describes current management strategies. It then makes management recommendations for Northwest Power Planning Council funding in the basin. This

document can be viewed at:
http://www.cbfwa.org/files/province/lwrcol/subsum/020517Lewis.pdf

State of Washington, Extinction Is Not an Option – In 1999 the State of Washington issued its overarching policy and strategy for the recovery of the state's salmonid stocks. The document uses the context of the four "Hs" (habitat, hatcheries, harvest, hydropower) oftentimes cited in discussions of northwest fisheries. The document does not outline specific actions to be taken, but instead provides a basic framework for state recovery efforts.

What Trumps What?

Mandatory Conditions That Bind FERC – When issuing a license, Section 4(e) conditions for federal lands, section 18 fishway prescriptions, and Clean Water Act section 401 conditions bind FERC. These conditions can be challenged, but FERC cannot second-guess or revise them in the relicensing process and their incorporation in license articles is mandatory.

Endangered Species Act Requirements – The ESA prohibits all parties from "taking" listed species without a permit or incidental take statement. As a practical matter, ESA biological opinions, which are accompanied by incidental take statements, bind FERC in relicensing. The ESA also influences other sources of fish and wildlife protection, such as Federal Power Act section 4(e) and 18 prescriptions, Clean Water Act certifications, state agency policies and recommendations, and Northwest Power Planning Council subbasin plans.

State Law and Policies – The state administers the Clean Water Act section 401 process, which ensures compliance with state water quality standards or any other "appropriate requirement of State law" including instream flow requirements and other water uses (fishing, boating, etc.). Section 401 certification binds FERC. Other state law and policy on fish and wildlife issues influence FERC primarily through comprehensive plans and section 10(j) recommendations.

Federal Obligations to Indian Tribes – FERC must consider the effect of its decisions on Indian treaty rights and the nation's trust obligations to the tribes. FERC tends to treat these obligations as considerations in public interest balancing, while tribes contend that they impose hard constraints. Section 10(a)(2)(B) of the Federal Power Act explicitly requires FERC to consider recommendations of Indian tribes affected by a project, and FERC must take care in responding to them.

Northwest Power Planning Council Subbasin Plans – If the Northwest Power Planning Council develops subbasin plans that satisfy NMFS expectations (outlined in the FCRPS biological opinion), subbasin plans will play a significant role in a range of federal decisions. Subbasin planning is likely to be an involved process and it remains to be seen whether it will deliver plans on schedule (2005 for the Lower Columbia) and in a form that satisfies NMFS. Apart from its Endangered Species Act significance, FERC must take the Council program into account "to the fullest extent practicable."

Recommendations from Fish and Wildlife Agencies – Section 10(j) recommendations from fish and wildlife agencies do not bind FERC, but FERC must pay close attention to them.

Comprehensive Plans – FERC must consider comprehensive plans, but is not bound by them in the issuance of a project license.

4.18.5.8 A Conceptual Foundation for the Management of the Lewis River Salmonid Populations.

The conceptual foundation consists of 6 statements followed by a summary of their implications to the management and recovery of salmonids in the Lewis River. The statements reflect our review of the available information and our conclusions regarding the functioning of the salmonid production system. The statements are necessarily broad and general. It is beyond the scope of this assignment to attempt to anticipate and incorporate into the report the hundreds of specific actions, decisions or proposals that could be part of the management and recovery programs in the basin. The purpose of the conceptual foundation is to provide a yardstick against which the appropriateness of any specific action or decision can be evaluated.

Statement 1

The Lewis River is a natural-cultural ecosystem that has undergone considerable change since the arrival of Euro-Americans. Three major dams (Merwin, Yale and Swift) and the Lewis River bypass reach located in the North Fork Lewis River between RM 19 and RM 45 are the most important cultural modification of the river's salmonid habitat and the ecological processes that form and maintain salmonid habitat. The dams have:

- Limited access of anadromous salmonids to the lower 20 miles of the watershed, cutting off as much as 176 miles of potential historical habitat.
- Converted 39 miles of mainstem river into reservoirs inundating what was probably prime habitat for salmonids.
- Diverted all river flow (except during spill events) from a 2.7-mile-long reach of the Lewis River above Yale Lake.
- Reduced or eliminated habitat connectivity for resident and adfluvial fish.
- Altered temperature and flow regimes in the mainstem Lewis River below Merwin Dam.
- Severely limited the downstream transport of habitat building materials.
- Caused the loss of marine derived nutrients (from salmon carcasses) above Merwin Dam for 70+ years. The effect of this loss on aquatic productivity, riparian vegetation and terrestrial food webs was substantial.

- With the exception of fall chinook, shifted the natural salmonid production system to a heavy reliance on artificial propagation.

- Severely reduced connectivity between upper and lower river habitats makes it doubtful that the historical life histories of anadromous salmonids can be reestablished following reintroduction to the upper basin. However, alternative life histories compatible with the altered conditions are likely to emerge following reintroduction.

These changes resulted in the permanent loss of the inundated riverine habitat. This loss of habitat, and its associated production, cannot be fully restored as long as the dams are in place. Mitigation and alternative production strategies have not achieved historical (pre dam) levels of production. Continued hatchery supplementation will be necessary for the life of the dams.

Other cultural activities that alter salmonid habitat in the basin include extensive logging, agriculture and urban development. The eruption of Mount St. Helens was a significant natural disturbance that altered stream habitat. Although the quality of the existing habitat in the mainstem Lewis River and tributaries above the Lewis River dams is highly variable, a large percentage of this habitat would likely support anadromous salmonids. Whether or not the existing habitat in the upper basin is capable of supporting self-sustaining life histories without periodic hatchery supplementation is not known.

Native Lewis River fall chinook, coastal cutthroat trout, Columbia River smelt and a small but persistent run of chum salmon are the only self-sustaining runs of anadromous salmonids remaining in the North Fork Lewis River. While there is limited natural spawning of other anadromous species below Merwin Dam, it is not known if such spawning could be sustained without the continued release of artificially propagated fish.

Because of cultural development in the basin, the Lewis River will need both natural and artificial production systems for the foreseeable future. These 2 production systems should be integrated. That means the artificial production system should compensate fully for lost habitat and years of lost marine derived nutrients in a way that adds to the full natural potential of the watershed and does not diminish it. There is not enough information to determine if the natural and artificial production systems for anadromous salmonids that now exist in the Lewis River have been effectively integrated. What information is available suggests they are not integrated.

Implication

Given the magnitude of the changes in the Lewis River ecosystem, it is obvious that the natural-cultural status of the Lewis River must be taken into account in the design of any restoration or management program for the basin. Restoration must recognize the continuing need to compensate for lost (inundated) habitat through artificial propagation and to improve available habitat and habitat forming processes. However, the natural and artificial production systems should be effectively integrated and coherent with the current and future attributes of the ecosystem. The need for integration also applies to any use of artificial propagation to introduce anadromous salmonids above the dams.

Natural production of spring chinook, coho and steelhead should be given a higher priority. At the present time it appears to be an inconsequential adjunct to the hatchery program.

The reintroduction of anadromous salmonids above the mainstem dams is an opportunity to reassess the integration of natural and artificial production systems in the Lewis River. Successful reintroduction will create an opportunity to evaluate and adjust hatchery programs in the lower river to improve the balance between natural and artificial production.

Statement 2

Because of the fragmented condition of the watershed, the Lewis River no longer functions as a system of complex, interconnected anadromous salmonid habitats, which are created and maintained by natural processes. The new attributes of the ecosystem have eliminated or limited the natural reproduction of native and introduced anadromous salmonids. For example, the native Lewis River spring chinook are extinct[18] and a change in the thermal regime below Merwin Dam may be limiting the natural reproduction of the introduced stock of spring chinook and reducing life history diversity and survival of native fall chinook. For spring chinook, coho and steelhead, a system of 3 hatcheries is expected to compensate for the loss and degradation of habitat (see the discussion above on the need to integrate natural and artificial production systems in the basin). While the hatchery program generally meets its production targets, the anadromous runs into the Lewis River are probably well below historical levels of natural production. The actual historical abundance of salmonids in the Lewis River is not known.

It is not clear to what extent the attributes of salmonid habitat in the Lewis River above and below the dams can be improved, but an analysis of the possibility of shifting them toward their historical condition should be a high priority. An important objective should be the restoration of marine derived nutrients from salmon carcasses.

Implication

Shifting habitat conditions toward the historical is not an attempt to move the Lewis River ecosystem to the conditions that existed in the 1840s. However, the historical conditions should serve as a guide for any attempt to improve habitat in the basin. To the extent possible, restoration should focus on restoring physical and ecological processes as well as site-specific improvements. The EDT model will most likely assist in this endeavor.

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[18] We acknowledge a difference of opinion regarding this statement. Two reviewers question the use of the term extinct and the irreversible nature of the loss. We acknowledge that spring chinook from another population could and may have produced a small self-sustaining run of spring chinook in the Lewis River. However we prefer the more conservative approach, which assumes local adaptation in a native population and shifts the burden of proof to those who want to assume the opposite.

Statement 3

Given the level of change in habitat attributes and the history of management and mitigation programs in the basin, there is little doubt that the genetic structure and life history diversity of anadromous salmonids have been diminished from predevelopment levels. Unfortunately, the lack of empirical, historical information makes it impossible to fully describe the extent of those changes. It is impossible to restore the historical genetic structure and life history diversity. The native Lewis River spring chinook are extinct so they are lost forever, and the NMFS cannot at present identify any remaining coho salmon in the lower Columbia River (excluding the Clackamas River)[19]. In addition, the 39 miles of reservoirs and the resulting loss or impairment of connectivity between the upper and lower river, makes it doubtful that historical life history patterns can be restored after reintroduction. It is also impossible to develop an effective management and restoration program without a more thorough understanding of the current life history diversity of anadromous salmonids and its relationship to the ecosystem and its habitats. The lack of this information is perhaps the most important data gap in the basin.

The 39 miles of reservoir and its impact on connectivity makes it impossible to predict what life histories will emerge when anadromous salmonids are reintroduced to the upper basin. The salmon managers should be open to the appearance of unique life histories suited to the altered conditions and be prepared to nurture them through an adaptive program. Following reconnection and reintroduction, anadromous salmonids can express a diversity of life history strategies.

Implication

While the number of fish produced, harvested, allowed to spawn, etc. are important indicators of progress toward management goals, numbers alone are not the best indicator of the long-term sustainability of salmonid production systems. Any program to integrate natural and artificial production systems in the basin, to improve habitat or reintroduce anadromous salmonids to the upper basin should be based on an understanding of the genetic structure and life history diversity of the populations. The program to reestablish anadromous salmonids above the dams should consider the development of sustainable life history-habitat relationships to be as important as the abundance targets. This means effective integration of natural and artificial production systems, the reintroduction of anadromous salmonids to the upper basin, and modification of habitat towards its historical attributes will require a better understanding of the life history-habitat relationships than is evident today.

Statement 4

Current objectives for anadromous fish management in the Lewis River basin are too general to provide the context needed for adaptive management, to provide adequate consideration of the physical and ecological attributes of the populations and habitats, and to provide a clear picture of what success looks like. The following example of management goals for spring chinook illustrates the problem.

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[19] See footnote 1 in Section 4.18.5.1.

- Produce adult fish for harvest;
- Meet hatchery production goals;
- Manage for adequate escapement;
- Minimize interactions with listed fish through proper broodstock management;
- Minimize interactions with other fish populations through proper rearing and release strategies;
- Maintain stock integrity and genetic diversity;
- Maximize in-hatchery survival of broodstock and their progeny; and limit the impact of pathogens associated with hatchery stocks, on listed fish; and
- Ensure that hatchery operations comply with state and federal water quality standards through environmental monitoring.

The goals should provide enough specificity to identify impacts on wild salmonids from hatchery and harvest management and clear accountability for monitoring and mitigating those impacts.

Implication

The general and uninformative nature of the management goals has contributed to the lack of information on the Lewis River ecosystem. The goals as they stand do not mandate the need for information, because almost any condition can be construed to satisfy them.

Statement 5

Management of the recreation fishery in the Lewis River reservoirs has resulted in the introduction of several nonnative species including kokanee, tiger muskellunge, and a nonnative stock of rainbow trout. The creation of relatively slow moving reservoir habitat has also resulted in the proliferation of the northern pikeminnow. The presence of these species together with altered habitat has changed the "natural" ecological processes in the basin and created the potential for negative or positive interactions with introduced salmonids.

Implication

Any plan to reintroduce anadromous salmonids to the upper basin needs to carefully consider the potential interactions between the reintroduced species and the current assemblages of fishes. The priority should be given to the conservation and restoration of native species in the basin.

Statement 6

Although the resident fish populations in the upper Lewis River basin have been impacted by many of the same cultural activities that have affected anadromous fish (i.e., habitat fragmentation, loss of nutrients and habitat degradation), self-sustaining populations of bull trout, coastal cutthroat trout, rainbow trout, mountain whitefish, largescale sucker, and other native species are found throughout the watershed. Many of these species currently occupy habitat that was formerly shared by anadromous fish.

Implication

Given the limited habitat above the dams, reintroducing anadromous fish into the upper watershed will likely affect the distribution and abundance of native resident species. The most likely scenario is that reintroduced anadromous fish will benefit native resident fish.

The existing Lewis River hatchery program supports a very popular in-river recreational fishery. Although fishery management in the Lewis River basin is the responsibility of WDFW, any plans to reintroduce anadromous fish need to carefully address the potential effects on recreation fishing and the effects of fishing on reintroduced fishes. Monitoring should be implemented along with reintroduction to track changes in the distribution and abundance of native resident fishes and determine both the negative and positive effects of reintroduction.

4.18.5.9 Recommendations to Guide Future Fish Management

Management objectives based on the following recommendations will be included in the Draft Fish Planning Document (phase II of AQU 18).

Recommendation 1

Native species and natural production should be a high priority. Fishery management in the basin appears to treat the watershed as 3 isolated units: the upper basin above the dams, the 3 reservoirs, and the river below Merwin Dam. The introduction of tiger muskellunge, a nonnative predator, into Lake Merwin is an outcome of the fragmented management of the basin's fisheries. An ecosystem perspective would be particularly important if anadromous salmonids are reintroduced to the watershed upstream of Swift Reservoir. Species interactions should also be considered as part of this ecosystem perspective. Monitoring of this program and future distribution is necessary to determine potential impacts on native species. Non-native species programs that adversely affect native fish populations should be minimized or discontinued.

Recommendation 2

Monitoring and research should be initiated to provide current, empirical information on the life history-habitat relationships of naturally spawning salmonids in the lower river. The limited information available on life history relationships in the basin is an important data gap that needs to be addressed as part of any program to reintroduce anadromous salmonids. McIsaac's (1990) work on fall chinook in the Lewis River is the only thoroughly evaluated recent life history information we were able to locate. Studies of life history-habitat relationships are needed to test hypotheses generated in the EDT analysis, to design effective habitat protection and restoration programs and to effectively integrate the artificial and natural production systems in the basin. While we emphasize here the need to monitor life history, we recognize the need for a comprehensive monitoring program to reduce uncertainties associated with the management and restoration program. Monitoring should be long-term and extend beyond several fish generations.

Recommendation 3

Revise management objectives. The current management objectives lack the specificity needed to make them useful in the design and implementation of management and recovery programs. It is impossible to determine with any degree of certainty when the objectives have been met or even if they have not been met. There is little opportunity for accountability. The revised objectives should include specific measurable targets, a clear description of what success looks like, criteria that will specify failure, how monitoring will allow a determination of the above, and the accountable position within the appropriate organization. Hatchery targets should be returning adults not pounds produced or smolts released. However, in making this recommendation, we are drawing a distinction between hatchery performance and mitigation responsibility.

Recommendation 4

Prepare a management plan that integrates the natural and artificial production systems in the Lewis Basin. This recommendation should be accomplished in conjunction with other ongoing hatchery reform programs in the Columbia Basin. It should also incorporate the results of actions in Recommendations (2) and (3). The reintroduction of anadromous salmonids in the upper basin should be used as an opportunity to reevaluate the hatchery program and its the role in the Lewis Basin. As is currently occurring for fall chinook, emphasis should be placed on the natural reproductive processes of the other species in the basin; however, we recognize that a successful reintroduction program will likely require a long-term supplementation.

Recommendation 5

River management, habitat restoration, hatchery and harvest management should all have as a primary objective moving as close to historical conditions as possible. EDT will provide guidance on those attributes that have the potential to be modified. Priorities should be placed on recovery of natural processes. Any changes should take into consideration the existing cultural systems in the watershed. The USFS and other land managers should be encouraged to continue to protect aquatic and riparian habitat, moving toward desired future conditions over the long term[20].

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[20] One reviewer suggested adding this sentence: "Establish a Lewis River restoration Fund as mitigation that may be accessed by USFS and other groups that are conducting restoration activities in the basin. We support the restoration of habitat in the basin, but the mechanism used to fund it is a policy decision that is beyond the scope of the project.

Recommendation 6

When reintroducing anadromous salmonids to the upper basin, use those stocks whose life histories are best suited to the attributes of the ecosystems.

Recommendation 7

Monitoring in the upper basin should be capable of detecting the emergence of unique life histories following the reintroduction of anadromous salmonids.

Recommendation 8

Management of fisheries resources in the Lewis River basin must take into account natural decadal climatic oscillations and fluctuations in ocean productivity in the following ways:

- Hatchery production levels should be adjusted to reflect changing conditions so as not to overwhelm the capacity of the Lewis River, mainstem Columbia, estuary, and ocean.
- During the transition from poor ocean survival to good ocean survival conditions, harvest of hatchery returns should be carefully regulated to protect the recovery of naturally reproducing stocks[21]. Hatcheries, fish harvest and hydro-operations should have the capacity to implement short-term management options to protect fish populations during periods of low out-of-basin survival. Those actions may include supplementation, harvest restrictions, and hydro management changes to increase in-river survival.
- Monitoring programs should be designed to separate the effects of natural decadal fluctuations from program effects.
- Determine the real effectiveness of a recovery program over several generations and by the population's response during periods when ocean survival is the lowest.

4.18.5.10 Schedule

This study is complete.

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[21] One reviewer suggested this sentence as a replacement: "Hatchery, fish harvest and hydro operations should have the capacity to implement short-term management options to protect the population during periods of low out-of-basin survival such as when ocean capacity declines. Those actions may include supplementation, harvest restrictions and hydro management changes to increase in-river survival. We feel that this sentence does not reflect the point we were trying to make. We would be happy to discuss this issue further.

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