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4.0 AQUATIC RESOURCES

4.1 REPORT ON LIFE HISTORY, HABITAT REQUIREMENTS, AND DISTRIBUTION OF AQUATIC ANALYSIS SPECIES (AQU 1)

During the Lewis River watershed study scoping and planning process, the Aquatics Resource Group (ARG) identified 14 fish species plus macroinvertebrates that would be the focus species for the Lewis River aquatic resources studies (Table 4.1-1). Analysis species were selected to identify and describe the commonly occurring as well as rare and declining species that are representative of the species guilds whose habitat and habitat features may be affected by continued operation of the Lewis River Projects.

The ARG also asked for a description of the life history, habitat requirements, and distribution of aquatic analysis species. This report responds to that request.

Table 4.1-1. Aquatic analysis species to be assessed.

Analysis Species	Selection Criteria
Chinook Salmon	Potential sensitivity to changes in aquatic and riparian habitat quality and connectivity. Strong ecological interactor.
Coho Salmon	Potential sensitivity to changes in aquatic and riparian habitat quality and connectivity. Strong ecological interactor.
Chum Salmon	Potential sensitivity to changes in aquatic and riparian habitat quality and connectivity. Strong ecological interactor.
Steelhead Trout	Potential sensitivity to changes in aquatic and riparian habitat quality and connectivity. Strong ecological interactor.
Sea-run Cutthroat Trout	Potential sensitivity to changes in aquatic and riparian habitat quality and connectivity. Strong ecological interactor.
Pacific Lamprey	Special habitat requirements during spawning and rearing stages. Important ecological species.
White Sturgeon	Long-lived species which may have been affected by construction of dams. May be vulnerable to overharvest.
Northern Pikeminnow	Top level predator. May have increased in numbers due to construction of dams.
Mountain Whitefish	Native species with some habitat requirements that differ from other salmonids.
Bull Trout	Federally listed threatened species. Unique habitat requirements. Top level predator.
Kokanee	Important introduced sport fish. Planktivore. Interspecific interactions with native fishes may be important.
Sculpins	Require cool water temperatures. Many species associated with high stream gradients. Benthic species.
Threespine Stickleback	Present in Yale and Merwin. Interspecific interactions with kokanee fry may be important.
Largescale Sucker	Juveniles may constitute important prey item for bull trout.
Aquatic Macroinvertebrates and Zooplankton Guilds	Changes in these communities may indicate changes in ecological conditions.

4.1.1 Study Objectives

As described in the Study Plan Document (PacifiCorp and Cowlitz PUD 1999, as amended), the objective of this study is to research, compile, and summarize existing information on life history, habitat requirements, and distribution of aquatic analysis species currently or historically occurring in the study area. Specific topics to be addressed in this review (as described in the study plan) are as follows.

4.1.1.1 Life History

- A biological description including physical descriptions, geographic distributions, average and record sizes, age and growth characteristics, food habits, and predator and prey dynamics.
- A general description of life history phases, including a periodicity chart and description of migratory behavior for each phase.
- A description of potential life history interactions between hatchery and wild or native fishes. Interactions will include potential competition for habitat and predation.
- A statement on Endangered Species Act (ESA) status or other key management goals for the species.

4.1.1.2 Habitat Requirements

- A general description of macro and mesohabitat requirements for each life phase including reproductive, early life, and adult. Key macro habitat components will include differentiation between lentic and lotic habitats; pelagic or littoral habitats; and water quality and temperature requirements. Mesohabitat requirements will include differentiation between preference for pools, riffles, turbulent/fast water, etc.
- A general description of micro habitat requirements will include water depth and velocity, cover, and substrate preferences.

4.1.1.3 Distribution

- A general description of the temporal and spatial distribution in the Lewis River watershed of each species and life stage, based on existing information.
- Natural and constructed blockages affecting distribution.
- Information on abundance, based on existing information.
- A map showing known current and historical distributions for anadromous and resident fish species.

4.1.2 Study Area

This study examines species in the Lewis River basin.

4.1.3 Methods

Existing information on life histories, habitat requirements, and distribution of aquatic analysis species is quite extensive, particularly for the sport, commercial, and ESA listed species. Sources will include, but not be limited to the following:

- Yale Relicensing Aquatic Resources Final Technical Report (PacifiCorp 1999)
- Published and unpublished WDFW current and historical population survey reports
- Published and unpublished PacifiCorp current and historical population survey reports
- Unpublished WDFW spawner and redd survey records
- WDFW harvest management reports and records
- WDFW planting and hatchery records
- WDFW creel survey records
- USFWS and NMFS Status Reviews of Listed or Petitioned Species under the ESA
- Biological Assessment of Chinook, Coho, and Chum salmon, Steelhead Trout, Cutthroat Trout and Bull Trout as Related to the PacifiCorp and Cowlitz PUD Lewis River Hydroelectric Projects
- Published and unpublished habitat suitability indices
- Published ichthyology books and monographs on life histories of freshwater fishes
- Scientific journal articles
- Academic papers, dissertations, and theses
- Verbal interviews with knowledgeable biologists and anglers.

A literature search will begin with documents containing information most pertinent to the Lewis River watershed. As local information becomes less available on a particular species, research will extend to regional and then to general information. Information obtained through the search will be summarized and documented to address the key questions of the study. In most cases, information will be provided as it is documented in the various reports listed above. If interpretations are required, they will be clearly noted in the report. The ARG will also be able to review the report and comment on information and any interpretations made in the report before it is finalized.

4.1.4 Key Questions

Key questions for this study include:

- What are the current and historical distribution and abundance of anadromous and resident fish species in the watershed?

  The current and historical distribution and abundance of spring Chinook, fall Chinook, coho, summer steelhead, winter steelhead, chum salmon, sea-run cutthroat trout, kokanee, bull trout, and northern pikeminnow are summarized in this section. Data describing the distribution and abundance of the remaining resident and anadromous fish species found in the Lewis River basin are limited. Available information was included in the report, and in AQU 1 Appendix 1.

- What are the life history strategies currently and historically used by anadromous and resident fish species in the watershed?

  A detailed description of the life histories of 14 aquatic analysis species found in the Lewis River basin is presented. Lewis River basin specific life histories are presented for spring Chinook, fall Chinook, Type-N and Type-S coho, summer and winter steelhead, chum salmon, sea-run cutthroat trout, kokanee, and bull trout. Regional life histories are presented for the remaining fish species.

- What changes to life history patterns or timing (e.g., migration, emergence, spawning) have been observed in the watershed's anadromous and resident salmonid populations?

  There are little or no data available that describe the life history patterns or timing of anadromous and resident salmonid populations in the Lewis River basin prior to dam construction and the advent of large-scale hatchery production (which began in the early 1930s). As a result, the changes in life history patterns due to hatchery practices and the introduction of non-native stocks are difficult to describe due to a lack of baseline information on native stocks. However, the geographic distribution of anadromous fish in the watershed has been substantially reduced by the projects.

- What was the population (run) size of resident and anadromous fish populations in the North Fork Lewis River basin prior to the construction of Merwin Dam?

  The earliest reliable anadromous fish population data (escapement data) for the Lewis River basin were obtained immediately following the completion of the Merwin Dam fish collection facility in 1932. Population data have been collected at the facility to date and are presented in this report. These numbers represent escapement to the facility and do not include fish taken in the commercial or recreation fishery. There are no reliable population data available describing resident fish populations prior to the construction of Merwin Dam.

4.1.5 Results

4.1.5.1 Chinook Salmon

Life History

Chinook salmon (*Oncorhynchus tshawytscha*), also referred to as king or tyee salmon, is the largest of the Pacific salmon species. In Washington State, mature adults average about 91 cm (36 in) in length and weigh about 10 kg (22 lbs.) (Wydoski and Whitney 1979). The current Washington State saltwater angling record is 32 kg (70.5 lbs.)[1]. Larger adults in British Columbia and Alaska can weigh up to 45 kg (99 lbs.) (Healey 1991, Roni 1992). A 57 kg (126-pound) Chinook salmon taken in a fish trap near Petersburg, Alaska in 1949 is the largest on record[2].

In the marine environment, the Chinook salmon has a bluish-green back, silvery sides, and a white belly. It is distinguished from the other Pacific salmon species by the presence of irregular black spotting on the back and dorsal fins and on both lobes of the caudal or tail fin. Chinook salmon also have a black pigment along the gum line, which gives them the name "blackmouth" in some areas. Spawning Chinook exhibit an overall olive-brown to purple color. Males are more deeply colored than the females and also are distinguished by their "ridgeback" condition and by their hooked nose or upper jaw[2]. Juvenile Chinook have 6 to 12 parr marks, each longer and wider than other Pacific salmon. Unlike other juvenile Pacific salmon, the adipose fin is normally edged with a black color (Scott and Crossman 1973, Healey 1991).

Spawning stocks of Chinook salmon are distributed from the Ventura River in central California to Kotzebue Sound, Alaska on the North American coast, and from northern Hokkaido, Japan to the Anadyr River, Russia on the Asian coast (Healey 1991, Myers et al. 1998). Along the coast of North America, there are well in excess of 1,000 spawning Chinook salmon populations. Fewer populations are known to occur along the Asian coast (Healey 1991). The marine distribution of Chinook salmon extends throughout the Pacific Ocean, Arctic Ocean, Sea of Japan, and the Bering and Okhotsk seas (Scott and Crossman 1973). Most fall Chinook (ocean-type) do not disperse more than 1,000 km (621 miles) from their natal stream. The dispersal of spring Chinook (stream-type) is much broader, although information describing the distribution of individual stocks is limited at best (Healey 1991).

Chinook salmon are anadromous and semelparous (die after spawning once) 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 two distinct behavioral forms (races). These races are commonly referred to as spring and fall Chinook (stream-type and ocean-type). Spring Chinook

[1] http://www.wa.gov/wdfw/outreach/fishing/bigfish.htm
[2] http://www.state.ak.us/adfg/notebook/fish/Chinook.htm

(stream-type) 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. Fall Chinook (ocean-type) 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). The timing of river entry varies among individual stocks and is generally related to local temperature and water flow regimes (Healey 1991). Chinook stocks in Asia, Alaska, and Canada (north of the 55th parallel) and in the headwaters of the Fraser and Columbia rivers exhibit a stream-type life history. Fall 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 lower Columbia River and its tributaries, including the Lewis River, support populations of both spring and fall Chinook.

The amount of time Chinook salmon 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). In the Lewis River basin, most fall Chinook return as 4-year-old fish (48 percent). Three-year-old fish comprise about 19 percent of the total return, and 5-year-old fish comprise about 18 percent. Two-year-old "jacks" comprise about 19 percent of the population. Only a small number of 6-year-old fall Chinook return to the Lewis River (NPPC 1990). Three-year-old fall Chinook are predominantly males, while 4 and 5 year old fish are mostly females. The majority (65 percent) of Lewis River spring Chinook also return as 4-year olds. Five and 6-year-olds comprise about 27 percent of the returns. Three-year-old spring Chinook comprise about 6.7 percent, while 2-year-old jacks comprise about 2 percent (NPPC 1990).

Lewis River fall Chinook enter the Lewis River from late August through mid-October. Lewis River spring Chinook (a mix of different hatchery stocks) enter from late March through May (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). The peak spawning period for the naturally spawning spring Chinook occurs from early September through late October (pers. comm., E. Lesko, PacifiCorp, October 2000; PacifiCorp and Cowlitz PUD 1999; and WDF and WDW 1993). The peak spawning period for Lewis River fall Chinook occurs from late October through late November (Figure 4.1-1).

Egg production (fecundity) in Chinook salmon is highly variable. This variation occurs both between and within populations and appears to be related to body size, age, migration distance, latitude, and fluctuating environmental conditions (Myers et al. 1998). In Washington, the average Chinook egg production is about 5,000 (range 2,250 to 7,750) (Wydoski and Whitney 1979). In the Lewis River basin, the average fecundity of both hatchery spring Chinook and wild fall Chinook is about 4,000 eggs (WDF and WDW 1993).

The emergence of fall Chinook generally occurs from mid-February through mid-April in the Lewis River basin. The emergence of spring Chinook extends from early February through mid-March (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Most spring Chinook from the Lewis River hatchery are released as yearlings.

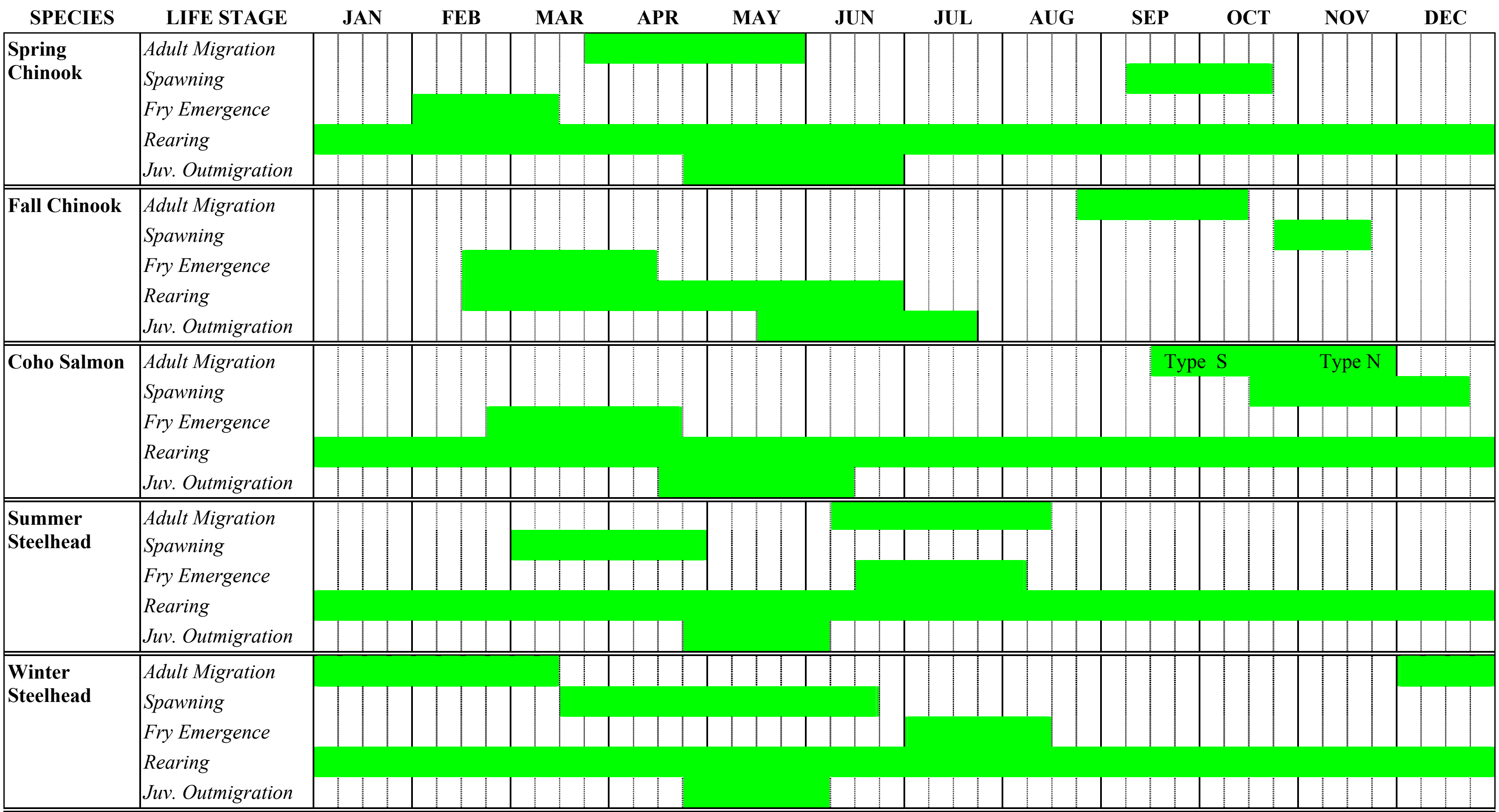

Figure 4.1-1. Periodicity chart for various life stages of fish species (with known life history information) in the Lewis River basin.

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

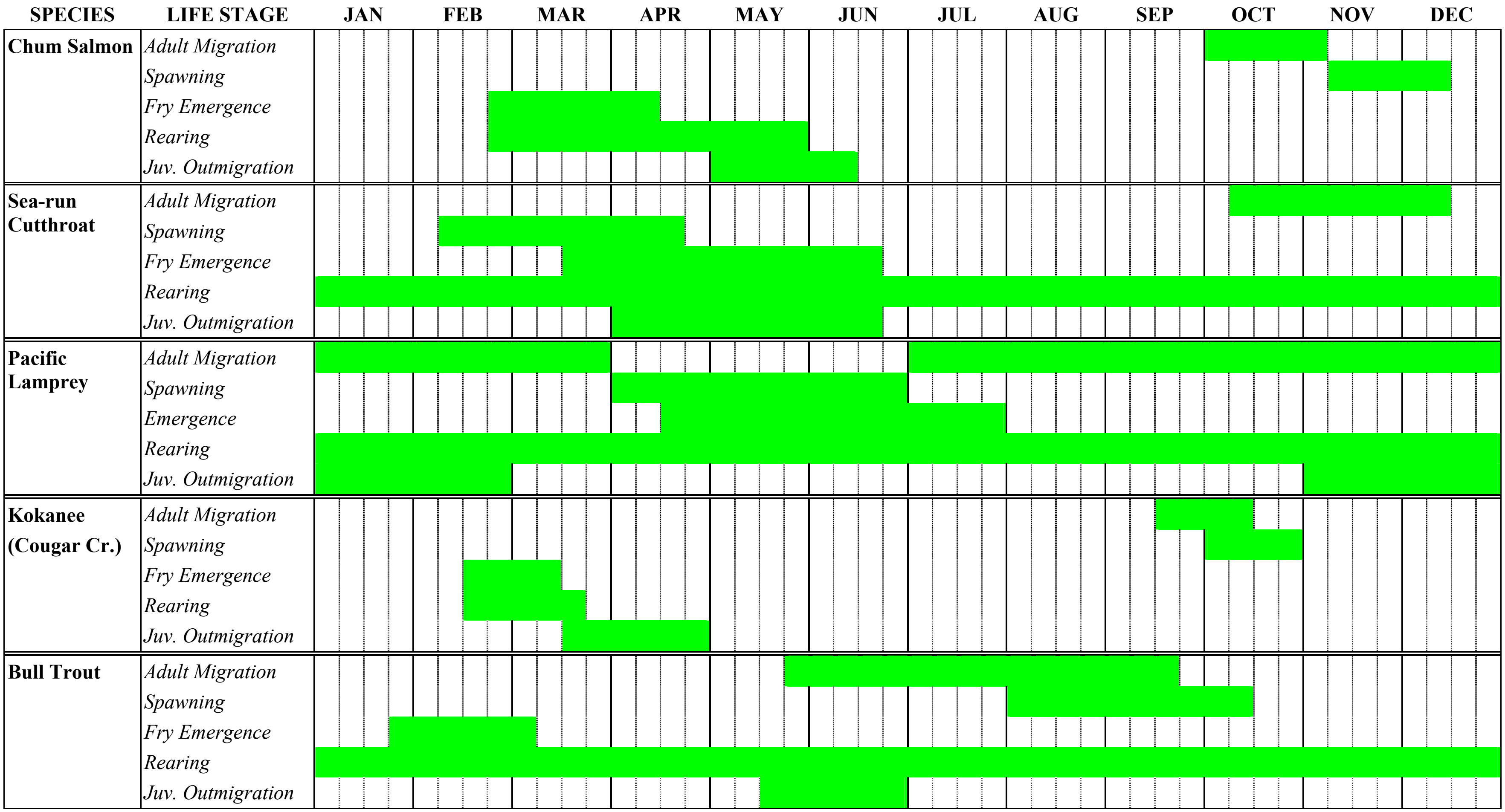

Figure 4.1-1. Periodicity chart for various life stages of fish species (with known life history information) in the Lewis River basin (cont.).

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

Following emergence, rearing for juveniles in freshwater can be minimal or extended. Wild fall Chinook enter saltwater during one of three distinct phases: (1) immediately after yolk reabsorption, (2) 60 to 150 days after yolk absorption, or (3) after one full year in freshwater (Myers et al. 1998). Throughout their range, the majority of fall Chinook emigrate at 60 to 150 days. Spring Chinook enter saltwater during their second or more rarely third spring (Myers et al. 1998). In the Lewis River basin, wild spring Chinook rear in freshwater year round, fall Chinook rear in freshwater from mid-March through the end of June (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000).

While rearing in freshwater, juvenile Chinook feed opportunistically on larval and adult insects and small crustaceans. In the tributaries to the Columbia River, dipterian larvae, beetle larvae (Coleoptera), stonefly nymphs (Plecoptera), and leaf hoppers (Homoptera) are the most abundant food items (Healey 1991). Unlike juvenile coho (*O. kisutch*), juvenile Chinook residing in fresh water do not seem to utilize fish as a food source in freshwater (Scott and Crossman 1973). In the marine environment, fish make up approximately 97 percent of the food base. Invertebrates, amphipods, shrimps, euphausiids, crab larva, and other crustaceans make up the remaining 3 percent.

Like other juvenile salmonids, young-of-the-year Chinook are preyed upon by piscivorous fish including rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), Dolly Varden (*Salvelinus malma*), bull trout (*S. confluentus*), coho salmon smolts, northern pikeminnow (*Ptychocheilus oregonensis*), sculpins (*Cottus* spp.), and by mergansers (*Mergus* spp.), kingfishers (*Chloroceryle* spp.), terns (*Sterna* spp.), gulls (*Larus* spp.), cormorants (*Phalacrocorax* spp.), herons (Ardeidea), and other diving birds. Adults in the marine environment fall prey to man, large mammals (California sea lions [*Zalophus calfornianus*], northern sea lions [*Eumetopias jubatus*], Pacific striped dolphins [*Lagenorhynchus obliquidens*]), and Pacific lamprey (*Lampetra tridentata*). Spawning adults are eaten by bears (*Ursus* spp.), river otters (*Lutra canadensis*), and mink (*Mustela vison*), and by bald eagles (*Haliaeetus leucocephalus*) (Tacoma Power 1999, Scott and Crossman 1973). A hatchery fish predation study conducted in the Lewis River from 1997 to 1998 found that relatively few hatchery smolts consumed wild Chinook fry; however, those that did often contained more than one. Mean stomach contents ranged from 0.05 to 0.11 fry per hatchery coho stomach, 0.01 to 1.13 fry per steelhead stomach, and 0.00 to 2.13 fry per cutthroat trout stomach (Hawkins and Tipping 1999). Captured wild unclipped smolts also contained fry.

After migrating downstream, fall Chinook take up residence in the river estuary and remain there until they are about 70 mm (2.8 in) in length (usually from 20 to 60 days) (Healy 1991). Juvenile spring Chinook enter the estuary as smolts and remain there for a relatively short period of time (Myers et al. 1998, Healy 1991). While in the estuary, juvenile Chinook are opportunistic feeders (Myers et al. 1998). Preferred food types include juvenile Pacific herring (*Clupea pallasii*), sticklebacks (*Gasterosteus* spp.), and other small fish, as well as zooplankton, chironomid larvae and pupae, and other aquatic and terrestrial insects (Scott and Crossman 1973, Healey 1991). Juvenile Chinook are also know to consume juvenile chum salmon (*O. keta*) (Healey 1991).

Habitat Requirements

Adult Chinook salmon will spawn in tributaries as small as 2 m (6.5 ft) wide and in the mainstem of larger rivers (e.g., the Columbia, Cowlitz, and Lewis rivers). Generally, spring Chinook prefer to spawn in middle and upper reaches of the mainstem areas, while fall Chinook prefer the middle and lower mainstem areas (WDFW 1994). Chinook will spawn in water depths ranging from 5 cm to 720 cm (0.2 to 23.6 ft) and in velocities ranging from 10 to 189 cm/s (0.3 to 6.2 ft/s) (Healey 1991, Bovee 1978). Preferred spawning depths are generally greater than 24 cm (9.4 in); preferred velocities range from 30 to 91 cm/s (1.0 to 3.0 ft/sec) (Bovee 1978, Bell 1986, Bjornn and Reiser 1991). Preferred gravel sizes range from 1.3 to 10.2 cm (0.5 to 4.0 in) in diameter. Spawning water temperatures are reported to range from 5.6 to 13.9°C (42 to 57°F) (Bell 1986).

Adequate spawning area and subgravel flow are also very important in the choice of redd sites. Spawning spring Chinook require about 16 m^2 (172 ft^2) of gravel per spawning pair. Ocean-type Chinook require about 24 m^2 (258 ft^2) of gravel (Burner 1951). Often, the preferred spawning areas of both spring and fall Chinook are located near deep pools and in areas with abundant instream cover. In the Lewis River basin, most spring and fall Chinook spawning occurs within the 6.4 km (4.0 mile) stretch of the Lewis River between the Lewis River Hatchery and Merwin Dam (NPPC 1990).

The successful incubation of Chinook eggs, like other salmonids, depends on a variety of extragravel and intragravel physical, chemical and hydraulic variables (Bjornn and Reiser 1991). Incubating salmon eggs require a relatively stable stream channel (with minimal bedload movement), adequate intragravel percolation rates (> 4.0 ft/h), relatively high dissolved oxygen (DO) concentrations [>5 parts per million (ppm)] and adequate water depth above the redd (Healey 1991). Because Chinook normally begin spawning in the fall, during a period of declining temperatures, water temperature has seldom been implicated in any significant loss of eggs (Healey 1991). However, it does affect the rate of egg development and the timing of emergence. Favorable water temperatures for incubating salmonid eggs range between 4 and 14°C (39 and 57°F) (Bjornn and Reiser 1991).

In unstable or disturbed watersheds, floods can displace the streambed containing the redd, or fine sediments can be deposited in the egg pocket, interfering with the supply of oxygen and the removal of metabolic waste products. Fine sediment can also interfere with emergence by blocking interstices in the gravel (Murphy 1995). Both the movement of bedload and the deposition of fine sediments can cause substantial mortality during incubation. In both regulated and unregulated rivers, periodic dewatering of redds can also reduce the survival of eggs and embryos (Healey 1991).

Immediately following emergence (usually at night), Chinook salmon fry swim or are displaced downstream. Once started downstream, they will either move into the estuary or take up residence in the lower velocity margins of the stream or river. These low velocity areas often contain instream cover in the form of wood, root wads, overhanging vegetation or undercut banks (Healey 1991, **NESC** 1984). As juvenile Chinook grow, they tend to move into the deeper, higher velocity portions of the channel (Myers et al.

1998). Unlike coho salmon, juvenile Chinook are seldom found in beaver ponds or off-channel sloughs (Murphy et al. 1989).

In the North Fork Lewis River, age 0+ Chinook fry from 2.5 to 5.0 cm (1.0 to 2.0 in) in length were found to utilize water depths ranging from 0.1 to 2.2 m (0.4 ft to 7.2 ft). The depth interval with the greatest utilization was 0.5 m (1.5 ft). These same fish were found in velocities ranging from 0.0 to 0.8 m/s (0.0 to 2.7 ft/s). Maximum utilization occurred at 0.0 cm/s (0.0 ft/s) (NESC 1984). Chinook fry use the entire range of substrates found in the Lewis River; most fry were found in a narrow band within 4.6 m (15 ft) from shore (NESC 1984). Larger age 0+ Chinook juveniles, from 5.5 to 11 cm (2.2 to 4.3 in) long, use a similar depth range as the fry, with a maximum utilization at 0.8 m (2.5 ft). Mean column velocities ranged from 0.0 to 0.5 m/s (0.0 to 1.5 ft/s) with a peak utilization at 0.1 m/s (0.4 ft/s). Larger juveniles used similar substrate and cover as Chinook fry and were found an average of 18.6 m (61 ft) offshore (NESC 1984). Overall, velocity appears to be the most important factor affecting the distribution of fry in the river.

As with other salmonids, water temperature influences the physiology, behavior, and mortality of juvenile Chinook salmon. The upper lethal temperature for Chinook fry is 25.1°C (77.2°F); the preferred temperature is 12 to 14°C (53.6 to 57.2°F) (Scott and Crossman 1973). The optimum temperature for growth depends on food availability, and salmonids will not grow until their metabolic requirements are met (Murphy 1995).

While rearing in the estuary, fall Chinook appear to prefer tidal channels with low banks and many subtidal refugia (Healey 1991). Spring Chinook tend to occupy deeper water habitats in the outer estuary.

While at sea, fall Chinook remain near shore and seldom disperse more than 1,000 km (621 miles) from their natal river. Spring Chinook appear to occupy a much broader range, extending well into the North Pacific Ocean and Bering Sea (Healey 1991).

Abundance and Distribution in the Lewis River Basin

Historically, the North Fork Lewis River upstream from Merwin Dam supported large numbers of both spring (stream-type) and fall (ocean-type) Chinook salmon. According to Smoker et al. (1951), "at least 3,000" spring Chinook were believed to enter the upper Lewis River on an annual basis. The pre-project fall Chinook run was believed to be "at least 1,300 adults." Because these spawning population estimates do not account for in-river and ocean harvest and were based on "early trap counts," "poor records," or in some cases "only one brood year," they are not thought to represent true pre-project populations. They are, however, the only available data describing pre-project Chinook abundance (escapement) in the basin.

Neither is the historical distribution of Chinook salmon in the Lewis River well documented. Prior to the completion of the 3 Lewis River dams, spring Chinook were thought to spawn throughout the "Lewis River headwater" upstream from the Merwin Dam site (Smoker et al. 1951). 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 Washington Department of Fisheries (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 (Chambers 1957). The lower portion of Muddy River was also though to provide an additional 46,500 m^2 (500,000 ft^2) of Chinook spawning area (Chambers 1957). No other Chinook spawning areas were described in the WDF report.

Following the construction of Merwin Dam in 1931, resident and anadromous fish passage into the upper Lewis River was blocked at the Merwin Dam site at River Mile [RM] 19.4. To mitigate for the loss of historical habitat located upstream from Merwin Dam, Pacific Power and Light (now PacifiCorp) and the WDF constructed the Lewis River Hatchery and the Merwin Dam anadromous fish collection facility (Hamilton et al. 1970). These facilities became fully operational in 1932, and for 28 years adult anadromous fish that were collected at the base of Merwin Dam were enumerated, transported upstream by truck, and either held at the Cougar Creek hatchery substation (Lewis River Hatchery holding facility) for use as broodstock in the hatchery, or released into the upper watershed. Fish that were released into the watershed above Merwin Dam (from 1931 to 1953) and then above Yale Dam (after 1953) and Swift Dam (after 1959) continued upstream to their natural spawning areas. The spillways and turbine outlets at each of these dams provided the only means of downstream passage for outmigrants; however, these routes were considered an inadequate means of downstream fish passage (Hamilton et al. 1970, Smoker et al. 1951, Chambers 1957). All hatchery fish produced during this period were released directly to the Lewis River below Merwin Dam.

During the early years of dam operation and hatchery production, spring and fall Chinook trap catches decreased dramatically (Table 4.1-2). Early attempts to save the 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 run sizes were greatly reduced. 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 runs, spring Chinook from the Cowlitz River, Wind River (Carson Hatchery), and Willamette River were introduced into the Lewis River basin in 1956 (PacifiCorp and Cowlitz PUD 2000c). Since then, the Lewis River hatcheries have supplemented spring Chinook with brood stock from a variety of sources including Cowlitz, Kalama, Carson, Klickitat, and Willamette stock. The stocks used now include Cowlitz and Kalama, along with instation returns to the Lewis River (WDF and WDW 1993).

Hatchery releases of juvenile spring Chinook have varied in number and size since the late 1950s (Hymer et al. 1993). In the last 10 years, an average of 1.3 million spring Chinook have been released annually. The majority of these releases have been yearlings. Prior to 1989, releases consisted mainly of a mixture of fry, fall releases, and yearlings (Pettit 1997). Under Article 50 of the existing Merwin Project license, the required mitigation goal is 250,000 juvenile spring Chinook (to produce 12,800 adult fish).

Table 4.1-2. The number of adult spring and fall Chinook collected at the Merwin Dam fish collection facility (1933 to 1953).

Year	Spring Chinook	Fall Chinook
1933	2,046	1,031
1934	4,007	1,506
1935	2,710	1,296
1936	97	394
1937	151	65
1938	26	29
1939	850	232
1940	7,397	592
1941	259	332
1942	114	164
1943	145	287
1944	259	205
1945	540	427
1946	152	634
1947	132	627
1948	100	685
1949	19	476
1950	199	839
1951	18	1,903
1952	53	1,146
1953	4	383

In the last 20 years (the period of best available data), adult spring Chinook returns to the Lewis River have been highly variable. From 1980 through 2000, the total adult spring Chinook return (including hatchery returns, natural escapement, and sport harvest) has ranged from 1,600 in 1996 to nearly 17,000 in 1987, with an average of approximately 5,600 fish (Table 4.1-3) (Pettit 1997, pers. comm., R. Pettit, WDFW, March 2001, WDF and WDW 1993). These numbers do not reflect the commercial harvest of Chinook.

Currently, there is very little natural production of spring Chinook in the Lewis River basin. From 1980 through 1997, the natural escapement of adult fish, 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 fish are considered a mixed stock of composite production (WDF and WDW 1993).

Table 4.1-3. Escapement estimates for adult spring Chinook and fall Chinook in the North Fork Lewis River (1980 to 2000).

Return Year	Number of Spring Chinook[1]	Number of Fall Chinook[2]
1980	2,265	16,394
1981	2,964	19,297
1982	3,889	8,370
1983	3,669	13,540
1984	6,381	7,132
1985	4,116	7,491
1986	8,259	11,983
1987	16,547	12,935
1988	10,618	12,059
1989	12,019	21,199
1990	9,299	17,506
1991	8,334	9,060
1992	6,025	6,307
1993	8,194	7,025
1994	3,066	9,936
1995	3,758	11,415
1996	1,596	13,950
1997	1,905	8,670
1998	1,602	6,392
1999	1,753	3,446
2000	2,221	NA
Average	5,642	11,205

1 Combined hatchery escapement, natural escapement, and sport catch below Merwin Dam (Pettit 1997).
2 Naturally spawning fall Chinook below Merwin Dam. No hatchery fall Chinook have been planted since 1985. From Hawkins (1998), based on a peak count expansion of 5.27.
NA = Data not currently available.

The current distribution of Lewis River spring Chinook is limited to the mainstem Lewis River and Cedar Creek (Table 4.1-4). Few if any spring Chinook return to the East Fork Lewis River (WDF and WDW 1993). In the mainstem Lewis River, most spring Chinook spawning and rearing occurs between Merwin Dam and the Lewis River Hatchery (RM 15.6 to RM 19.4). In Cedar Creek, spring Chinook are distributed from RM 0.0 to RM 18.2. Most spawning and rearing in Cedar Creek occurs between RM 11.0 and RM 18.2[1]. Information describing the physical barriers affecting access to "potential" spring and fall Chinook habitat and the amount of habitat that is currently blocked is presented in AQU 1 Appendix 2. These data are derived from Wade (2000).

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1 http://query.streamnet.org/Request?cmd=BuildPicklist&PicklistItem=ColumbiaSubbasin&Steps=Species,Run,DataCategory,Query,MainStates=Yes&Required=Run&State=5

Table 4.1-4. The current distribution and habitat use type for Chinook salmon in the Lewis River basin.

Species	Stream Name	Distribution (Mile Points)		Habitat Use Type
		From	To	
Spring Chinook	Cedar Creek	0.0	11.0	Primarily Migration
		11.0	18.2	Primarily Spawning and Rearing
	Lewis River	0.0	3.9	Primarily Migration
		3.9	15.6	Primarily Rearing and Migration
		15.6	19.4	Primarily Spawning and Rearing
Fall Chinook	Cedar Creek	0.0	8.2	Primarily Spawning and Rearing
	E. F. Lewis River	0.0	13.9	Primarily Migration
		13.9	20.6	Primarily Spawning and Rearing
	Lewis River	0.0	7.3	Primarily Migration
		7.3	15.4	Primarily Rearing and Migration
		15.4	15.6	Primarily Migration
		15.6	19.4	Primarily Spawning and Rearing

Source: http://query.streamnet.org/

Unlike spring Chinook, Lewis River fall Chinook are a native stock of wild production with negligible hatchery influences, although Kalama River and Little White Salmon River fall Chinook have been introduced into the basin in the past (PacifiCorp and Cowlitz PUD 2000c). Currently, Lewis River fall Chinook represent about 80 to 85 percent of the wild fall Chinook returning to the lower Columbia River (NPPC 1990). No hatchery releases of fall Chinook have occurred in the Lewis River since 1986. Like spring Chinook, the fall Chinook return to the Lewis River has been highly variable in the last 20 years. The total adult fall Chinook return to the Lewis River from 1980 through 1998 ranged from 6,200 in 1998 to 21,200 in 1989. The average over this period was 11,600 fish (Table 4.1-3) (Hawkins 1998). The escapement goal for Lewis River fall Chinook is 5,700 fish (PacifiCorp and Cowlitz PUD 2000c).

Lewis River fall Chinook are currently distributed throughout 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 (Table 4.1-4). In the East Fork Lewis River, most fall Chinook spawning and rearing occurs between RM 0.0 and RM 13.9, and in Cedar Creek most fall Chinook spawning and rearing occurs between RM 0.0 and RM 18.2 (Table 4.1-4). The distribution of fall Chinook in the mainstem Lewis River is similar to that of spring Chinook. Maps of the current distribution of spring and fall Chinook in the Lewis River basin is presented in Appendix 1, maps 1 and 2 (map source: WDFW 1995).

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 Evolutionarily Significant Unit (ESU), including Lewis River fall Chinook (both “bright” and “tule” stocks), were listed as threatened under the ESA on March 24, 1999 (Federal Register, Vol. 64, No. 56, March 24, 1999). The ESA ruling applies to all naturally spawned populations of spring (stream-type) and fall (ocean-type) Chinook in the Columbia River and its tributaries from the mouth up to, and including, the Hood River in Oregon. Lewis River spring Chinook, a hatchery stock, are a component of the lower Columbia ESU, but are not considered a listed species (USFWS and NMFS 2002). Critical habitat, as designated by the National Marine Fisheries Service (NMFS) on February 16, 2000, includes all river reaches accessible to listed Chinook salmon in Columbia River tributaries between the Grays and White Salmon rivers in Washington and the Willamette and Hood rivers in Oregon, inclusive. The Lewis River and its tributaries up to Merwin Dam are included in this designation. Also included are adjacent riparian zones, as well as river reaches and estuarine areas in the Columbia River. Excluded are tribal lands and areas above specific longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years)[2].

Under Section 4(d) of the ESA, the Secretary of the responsible agency for the listing (in this case the Department of Commerce through NMFS) is to issue regulations deemed necessary for conservation of the listed species. The 4(d) rule further defines actions that constitute a "take"[3] of the threatened species, which governs necessary compliance under Section 7 and Section 10 of the ESA. On January 3, 2000, NMFS issued a proposed 4(d) rule governing "take" in the lower Columbia River ESU. NMFS published the Final 4(d) rule on July 10, 2000. Section 7 consultation for federal actions is required upon the date that the listing becomes effective, and "take" permits for all threatened species under Section 10, except steelhead, are required 180 days following issuance of the 4(d) rule. "Take" permits for steelhead are required as of January 6, 2001.

WDFW's current population management objectives for Chinook salmon in the Lewis River are to: (1) achieve an annual harvest of 15,000 adult spring Chinook; and (2) maintain a minimum terminal run size of 12,000 fall Chinook from natural production. Instream habitat objectives are to maintain adequate pool habitat, large woody debris, spawning substrate, and flow stability (WDFW 1995).

4.1.5.2 Coho Salmon

Life History

Like Chinook salmon, coho salmon in the marine environment or shortly after entry into freshwater have silver sides, a steel-blue to slightly green dorsal surface, and a white ventral surface. They also have distinct black spots on both their back and tail. Unlike Chinook, these spots are slightly smaller and only appear on the upper lobe of the tail. The lower gums of adult coho are usually pale white (not black like Chinook). Spawning males take on a darker, dirty blue-green color along their dorsal surface, with bright red along the sides and a gray/black underbelly. The males also develop a prominent hooked snout with large teeth called a kype. Females and jacks are not nearly as brightly colored

[2] http://www.nwr.noaa.gov/1salmon/salmesa/chinlcr.html
[3] ESA, Section 3 (19): "Take" is defined to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

but appear more brassy green (Sandercock 1991). Juvenile coho are blue green on the back, with silvery sides and 8 to 12 narrow parr marks. The adipose fin is uniform, dusky, and the caudal fin and most of the anal fin is red-orange. The anal fin is large and the first rays are elongate with a black and white leading edge (Scott and Crossman 1973).

Adult coho are usually 43 to 58 cm (17 to 23 in) in length and weigh 3.6 to 5.4 kg (8 to 12 lbs.) (Scott and Crossman 1973), though they may reach a length of 91 cm (36 in) and weigh up to 14.1 kg (31 lbs.). The Washington State angling record for coho salmon is 9.3 kg (21 lbs.)[4]. Mature S-type coho returning to the Columbia River (described in the following sections) range in length from 55 to 70 cm (22 to 28 in) in length (fork length). N-type coho sampled in the lower Columbia River commercial fishery (also described in the following sections) range from 50 to 70 cm (20 to 28 in) in length (Howell et al. 1985).

Spawning stocks of coho salmon are distributed along the Pacific coast from Monterey Bay, California north to Point Hope in Alaska and from the Anadyr River in Russia to Hokkaido, Japan (Wydoski and Whitney 1979). Successful introductions have also occurred in most of the Great Lakes and in other cold temperate areas of North America (Scott and Crossman 1973, Sandercock 1991). The marine distribution of coho salmon extends throughout the North Pacific Ocean and Bering Sea (Sandercock 1991). In general, they are less abundant in the northern and southern fringes of their range and more abundant in the central portion (Sandercock 1991).

Like other Pacific salmon, coho are anadromous and semelparous. Adults migrate from the sea into their streams of origin to deposit eggs in the gravel. The eggs incubate during winter in the gravel; in the spring, free swimming fry emerge (Sandercock 1991). After emergence, the young spend from 1 to 2 years in freshwater before becoming smolts and migrating to the ocean. Maturing coho usually rear in the marine environment for approximately 18 months prior to returning to their stream of origin for spawning, although a variable proportion (6 to 43 percent) of males (jacks) return to freshwater to spawn after only 5 to 7 months in the ocean (Weitkamp et al. 1995).

Coho salmon in the Lewis River basin are managed for two major hatchery stocks, a late run Type-N stock and an early run Type-S stock. Type-N coho are north-turning and contribute more heavily to the northern ocean fisheries, while Type-S coho are south-turning and contribute more heavily to the southern ocean fisheries (NPPC 1990, Wydoski and Whitney 1979). Type-S coho mature at sea and begin migrating to the Columbia River and their natal streams in late August/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. Spawning occurs from mid-October through late December (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Coho return as 2-year-old jacks and 3-year-old adults.

The spawning behavior of adult coho is similar to that of other salmonids. On the spawning grounds, the female coho selects a nest site typically at the head of a riffle area, then defends the area against other females (Sandercock 1991). She begins digging the

[4] http://www.wa.gov/wdfw/outreach/fishing/bigfish.htm

nest by lying on her side and violently beating her tail up and down, creating a hollow approximately 18 to 38 cm (7.1 to 15.0 in) deep. This can take as many as 5 days to complete. During this period, males will be aggressive with each other, attempting to gain access to the female. Upon completion of the nest, the dominant male and female swim into the nest, depositing the eggs and sperm. The female then swims upstream and digs several times with her tail to cover the fertilized eggs with upstream gravels. Adults usually die a few days to a few weeks after spawning (Scott and Crossman 1973). Fecundity (the number of eggs produced by the female) in coho salmon is highly variable and dependent on the size of the female. In the Lewis River basin, the average number of eggs produced is about 2,500 (NPPC 1990).

In the Lewis River basin, the majority of returning coho are captured at the Merwin hatchery, though an estimated 5 to 10 percent spawn naturally within the mainstem Lewis River below Lake Merwin and in several tributaries including Ross, Cedar, Chelatchie, Johnson, and Colvin creeks (WDF and WDW 1993). Coho that are collected at the hatchery are spawned, reared, and released either directly from the Lewis Hatchery, or reared at Speelyai Hatchery and released downstream of the Merwin Dam.

The length of time required for coho salmon eggs to incubate in the gravel is largely a function of temperature. In the Lewis River, at 10°C (50°F), fertilization to eyed-egg stage takes about 3.5 weeks, eyed-egg to hatching takes about 2.5 weeks, and hatching to emergence about 8 weeks (Hymer et al. 1993). The emergence of wild coho occurs from late February through late April (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Following emergence, coho fry spend the remainder of the spring and summer within their natal streams, although larger, more dominant fish may displace smaller fish downstream, especially during freshets (Sandercock 1991). Juvenile coho are very territorial, especially as flows diminish during the summer, thus limiting available rearing habitat. This results in further migrations downstream and increased predation on those fish residing in marginal habitat.

Growth during the freshwater rearing stage is largely dependent on food availability and water temperature, but coho smolts are typically 10 cm (3.9 in) in length after one year (Scott and Crossman 1973). While rearing in freshwater, juvenile coho feed mainly on insects including dipterous larva, Tricoptera, Plecoptera, and Coleoptera. At the yearling stage, coho may become piscivorous, supplementing their insect diet with the fry of their own and other species (Sandercock 1991). In the Lewis River, hatchery coho yearlings have been documented to prey on juvenile Chinook and other fish species (Hawkins and Tipping 1999). In general, juvenile coho are considered a major predator of wild fall Chinook salmon.

Coho eggs and fry are subject to a variety of impacts while residing in the stream environment. Physical characteristics (flood flows, freezing temperatures, siltation) within the stream typically limit survival to emergence (Sandercock 1991), while predation by a variety of fish and birds can further impact survival. Cutthroat trout follow the spawning coho adults up into tributary streams, preying upon any stray eggs. In the lacustrine environment, coho fry become prey to northern pikeminnow, rainbow trout, cutthroat trout, and bull trout. Appreciable predation by birds further impacts coho survival. Common mergansers (*Mergus merganser*) in particular have been cited as a major predator (Sandercock 1991), especially when coho populations are in high density.

As stream water temperatures and flows increase during the spring months, the coho smolts typically begin their outmigration in early April or May. Migration to the sea can take as long as 3 months but are likely concentrated during those periods of highest spring run-off (Sandercock 1991). In the Lewis River, smolt outmigration occurs from mid-April through the beginning of June (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). As coho smolts enter saltwater, they remain nearshore in small schools of 20 to 40 fish for the first few months (Sandercock 1991). Columbia River coho migrate short distances both north and south of the Columbia River estuary, the majority of early (S-type) coho heading south and late (N-type) coho moving northward over the next 12 months (Hymer et al. 1993). On initial entry into saltwater, coho feed mostly on marine invertebrates (shrimp, copepods, other zooplankton). As the coho grow, they move further offshore, becoming more piscivorous. They can be important predators of juvenile pink (*O. gorbuscha*) and chum salmon fry, but are known to prey on surf smelt (*Hypomesus pretiosus*), anchovy (*Engraulis* sp.), and sand lance (*Ammodytes hexapterus*) (Sandercock 1991). Smolt-to-adult survival is calculated to be 3.7 percent for the Lewis River subbasin coho stocks (NPPC 1990).

Habitat Requirements

Throughout their range, coho salmon spawn in streams along the coast and in small tributaries of larger rivers. Optimum coho salmon habitat is considered to be streams with widths of 1 to 5 m (3.3 to 16.4 ft) in low flow periods, gradients less than 3 percent, pool to riffle ratios of 1:1, and vegetative canopy closures of 50 to 75 percent (WDFW 1994, McMahon 1983). In general, coho salmon migrate further upstream than pink and chum salmon but usually not as far as sockeye (*O. nerka*) and Chinook (Sandercock 1991). Rarely do they migrate more than 240 km (149 miles) up large rivers to spawn. Typically, coho spawn in gravelly transition areas between pool and riffle habitats. Preferred gravel sizes range from 1.3 to 10.2 cm (0.5 to 4.0 in) in diameter (pea to orange size). Preferred water depths range from 10 to 53 cm (4 to 21 in) (Bjornn and Reiser 1991) and preferred velocities range from 30 to 91 cm/s (1 to 3 ft/s). Preferred spawining gravel patches are at least 2 m^2 (21.5 ft^2) in area and located in relatively stable areas of the stream channel (Reeves et al. 1989). Suitable spawning gravel needs to contain fewer than 30 percent fine sediments to maintain sufficient intra-gravel flow of oxygenated water. Spawning areas are often located close to cover that provides protection from predation on the spawning female (Schuett-Hames and Pleus 1996).

As with other salmonids, successful incubation of coho eggs depends to a large extent on the stream and streambed conditions. Winter flooding with substantial bedload movement, low flows, freezing, heavy silt loads, infections, and predation can all substantially reduce egg survival. Under average conditions, probably 15 to 27 percent of the coho eggs in a redd will survive to emergence (Sandercock 1991). In disturbed watersheds, egg survival can be much lower.

Following emergence, coho fry form schools and move into shallow [<30 cm (12 in)], low velocity areas [<10 cm/s (0.33 ft/s)] typically found in backwater pools, dam pools, and beaver ponds (Reeves et al. 1989). Often coho fry are associated with cover such as overhanging or submerged logs, undercut banks, overhanging vegetation, or large substrate. These structures afford protection from predation and increase macroinvertebrate production offering increased food sources for the young fry. As the fry become older, they begin to occupy areas near the open shoreline and progressively move into areas of higher velocity (Sandercock 1991, Reeves et al. 1989). Preferred water temperatures range from 9 to 13°C (48 to 55ºF) (WDFW 1994).

Preferred habitat for coho during the winter months includes side channels and backwater channels, especially those areas with heavy groundwater influence. These areas provide protection from extreme flows, freezing temperatures, and predation (Sandercock 1991). In the early spring, the pre-smolts move back into the mainstem channels in preparation for their seaward migration.

After entering salt water, coho first occupy the quiet marine inshore areas and inlets, later foraging out over the continental shelf in depths of less than 90 m. Preferred depths are 0 to 50 m (0 to 165 feet). Most stay near the shoreline but some coho have been captured up to 150 km (93 miles) offshore during their ocean life stage (Sandercock 1991). Coho do not randomly drift but appear to actively migrate in a circular pattern with the currents. Distributions depend largely on availability of good feeding areas (Sandercock 1991).

Abundance and Distribution in the Lewis River Basin

The Lewis River basin historically had large runs of coho salmon. In 1951, the WDF estimated the pre-project coho escapement to the basin to be about 15,000 fish, with 10,000 entering the North Fork (early-run coho) and 5,000 entering the East Fork (late-run coho) (WDF and WDW 1993, WDF and USFWS 1951). Bryant (1949) described the Lewis River as one of the most important coho producers in the Columbia River basin. Between 1932 and 1969, the number of coho returning to the Merwin Dam fish collection facility ranged from to 614 to 29,264 fish and averaged 5,500 fish (Table 4.1-5). The data in Table 4.1-5 do not reflect coho taken by the commercial or recreation fishery.

Prior to the completion of the 3 Lewis River dams, coho were reported to spawn in the Muddy River and in Pine, Clearwater, Clear, Smith, Drift and Cougar creeks (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. According to WDF and USFWS (1951), both early-run and late-run coho spawned in Cedar Creek.

Table 4.1-5. The number of adult coho collected at the Merwin Dam fish collection facility (1932 to 1969).

Year	Number of Coho	Year	Number of Coho
1932	5,674	1951	7,917
1933	29,264	1952	4,187
1934	3,153	1953	6,079
1935	1,231	1954	4,233
1936	24,595	1955	1,110
1937	3,859	1956	2,894
1938	643	1957	2,834
1939	19,814	1958	1,405
1940	3,202	1959	1,951
1941	7,032	1960	816
1942	3,938	1961	2,221
1943	7,375	1962	930
1944	7,919	1963	614
1945	4,858	1964	1,881
1946	4,603	1965	1,696
1947	10,664	1966	2,433
1948	3,507	1967	3,588
1949	5,947	1968	2,130
1950	9,550	1969	3,251
Average = 5,500			

From: WDF and USFWS 1951 and Smoker et al. 1951.

Currently, coho salmon returning to the Lewis River basin are managed for two major hatchery stocks. The WDFW has supplemented the early run coho in the Lewis River with Toutle stock since the days of the Johnson Creek fish facility dating back to 1906. Late run Cowlitz stock coho were introduced in 1971 and 1972 (Shrier 2000). Over time, WDFW hatchery practices have attempted to stratify coho production into two groups, "early" (Type S) and "late" (Type N), to meet harvest management requirements. The current WDFW coho production goal for the Lewis River Hatchery complex is 880,000 early-coho smolts and 800,000 late-coho as mitigation for the hydroelectric projects in the basin (funded by the licensees). The current escapement goal for Lewis River coho salmon is 3,800 fish (PacifiCorp and Cowlitz PUD 2000c). Under Article 50 of the existing Merwin Project license, the licensee is required to pay all expenses associated with the annual hatchery production of approximately 2,100,000 juvenile coho (to produce 71,000 adult fish).

From 1980 to 2001, adult hatchery returns of both Type S and Type N coho have ranged from about 2,400 to over 98,000 fish, with an average of around 29,000 fish (Table 4.1-6). However, returns to the hatchery only account for a small portion of the adult coho produced in the basin since the bulk of the production (65 to 85 percent) is harvested in the mainstem Columbia River and Pacific Ocean (WDFW 1994). The number of Lewis River coho natural spawn escapement is unavailable, but likely 5 to 10 percent of total basin production (Hymer et al. 1993).

Table 4.1-6. Escapement estimates for adult coho in the North Fork Lewis River (1980 to 1998) (counts do not include jacks or fish harvested by recreational anglers).

Return Year	Early Coho (Type-S)	Late Coho (Type-N)	Total Number of Coho
1980	NA	NA	7,408
1981	NA	NA	4,669
1982	12,709	10,803	23,512
1983	4,365	13,410	17,775
1984	5,324	9,712	15,036
1985	1,016	9,236	10,252
1986	2,914	48,001	50,915
1987	13,388	9,036	22,424
1988	4,997	27,765	32,762
1989	13,357	34,998	48,355
1990	4,733	21,286	26,019
1991	27,752	46,220	73,972
1992	4,369	17,368	21,737
1993	1,713	8,719	10,432
1994	3,916	8,513	12,429
1995	1,141	1,299	2,440
1996	4,782	5,230	10,012
1997	5,943	12,571	18,514
1998	6,882	10,772	17,654
1999	15,057	17,717	32,774
2000	17,033	23,068	40,119
2001	38,132	60,285	98,417
Average	**9,476**	**19,800**	**29,278**

Source: Hymer et al. 1993, PacifiCorp 1999

Currently, the distribution of coho salmon in the Lewis River basin is limited to the Lewis River and its tributaries downstream from Merwin Dam. Most coho salmon spawning occurs in Cedar, Ross, Chelatchie, Johnson, and Colvin creeks (Table 4.1-7) (WDF and WDW 1993). The most extensively utilized stream is Cedar Creek. Coho travel upstream for 24 km (15 miles) into North and South Fork Chelatchie Creeks. On low water flow years, coho spawn intensively in the North Fork Lewis River upstream from the Lewis River Hatchery to Merwin Dam. On the East Fork Lewis River, coho spawning occurs below Lucia Falls (RM 21), particularly in side channel areas. Lockwood, Mason, and Rock creeks are extensively used by spawning coho. Some spawning does occur above Lucia Falls, but high river flow is needed for fish passage

Table 4.1-7. The current distribution and habitat use type for coho salmon in the Lewis River basin.

Stream Name	Distribution (Mile Points)		Habitat Use Type
	From	To	
[122324545769] Unnamed Stream, trib to Rock Creek	0.0	0.2	Primarily Migration
[1224497458399] Unnamed Stream, trib to East Fork Lewis River	0.0	0.4	Primarily Migration
[1224578459194] Unnamed Stream, trib to Cedar Creek	0.0	0.3	Primarily Migration
	0.3	1.8	Primarily Spawning and Rearing
[1225404459291] Unnamed Stream, trib to Cedar Creek	0.0	1.0	Primarily Migration
	1.0	2.0	Primarily Spawning and Rearing
[1225891458427] Unnamed Stream, trib to Mason Creek	0.0	1.4	Primarily Migration
[1226050458131] Unnamed Stream, trib to East Fork Lewis River	0.0	2.0	Primarily Migration
[1226295458279] Unnamed Stream, trib to East Fork Lewis River	0.0	1.5	Primarily Migration
[1226454459411] Unnamed Stream, trib to Houghton Creek	0.0	0.6	Primarily Migration
[1227088459308] Unnamed Stream, trib to Lewis River	0.0	2.7	Primarily Migration
Big Tree Creek, trib to East Fork Lewis River	0.0	2.3	Primarily Migration
Breeze Creek, trib to East Fork Lewis River	0.0	1.0	Primarily Migration
Cedar Creek, trib to Lewis River	0.0	3.7	Primarily Migration
	3.7	6.5	Primarily Spawning and Rearing
	6.5	9.4	Primarily Migration
	9.4	10.2	Primarily Spawning and Rearing
	10.2	14.9	Primarily Migration
	14.9	18.2	Primarily Spawning and Rearing
Chelatchie Creek, trib to Cedar Creek	0.0	0.5	Primarily Migration
	0.5	4.5	Primarily Spawning and Rearing
East Fork Lewis River, trib to Lewis River	0.0	28.7	Primarily Migration
Houghton Creek, trib to Staples Creek	0.0	2.1	Primarily Migration
John Creek, trib to Cedar Creek	0.0	1.2	Primarily Migration
Johnson Creek, trib to Lewis River	0.0	0.4	Primarily Migration
	0.4	1.4	Primarily Spawning and Rearing
Lewis River, trib to Columbia River	0.0	19.4	Primarily Migration
Lockwood Creek, trib to East Fork Lewis River	0.0	0.7	Primarily Migration
	0.7	2.4	Primarily Spawning and Rearing
	2.4	2.9	Primarily Spawning and Rearing

Table 4.1-7. The current distribution and habitat use type for coho salmon in the Lewis River basin. (cont.).

Stream Name	Distribution (Mile Points)		Habitat Use Type
	From	To	
Mason Creek, trib to East Fork	0.0	2.2	Primarily Migration
	2.2	5.1	Primarily Spawning and Rearing
McCormick Creek, trib to East Fork Lewis River	0.0	2.1	Primarily Migration
North Fork Chelatchie Creek, trib to Chelatchie Creek	0.0	1.2	Primarily Spawning and Rearing
Pup Creek, trib to Cedar Creek	0.0	0.9	Primarily Migration
	0.9	2.0	Primarily Spawning and Rearing
Robinson Creek, trib to Lewis River	0.0	1.1	Primarily Migration
Rock Creek, trib to East Fork Lewis River	0.0	5.6	Primarily Migration
Rock Creek, trib to East Fork Lewis River	0.0	1.5	Primarily Migration
	1.5	3.6	Primarily Spawning and Rearing
Ross Creek, trib to Lewis River	0.0	0.1	Primarily Migration
	0.1	1.7	Primarily Spawning and Rearing

Source: http://query.streamnet.org/

(Hymer et al. 1993). A map of the current distribution of coho salmon in the Lewis River basin is presented Appendix 1, map 3 (map source: WDFW 1995). Information describing the physical barriers affecting access to “potential” coho habitat and the amount of habitat that is currently blocked is presented in AQU 1 Appendix 2. The data in the appendix are from Wade (2000).

According to the WDFW, the Lewis River coho stock status is "depressed" based on long-term decline in escapement (NPPC 1990). In 1993, NMFS was petitioned to list west coast coho salmon, including Columbia River populations. After reviewing existing information, NMFS found that at least one ESU of coho salmon probably exists in the lower Columbia River Basin, although the agency was unable to identify any remaining natural populations to protect. NMFS concluded, however, that there is sufficient concern regarding the overall health of this ESU to add the lower Columbia River/ southwest Washington coho salmon ESU to the candidate species list (Federal Register, Vol. 60, No. 142, July 25, 1995). Designation as a candidate species does not implement protection measures but is a formal statement that existing information is not sufficient to comprehensively define the status of the species.

NMFS is currently conducting a thorough reevaluation of this ESU to assess the distribution and health of native coho populations. If upon further evaluation NMFS finds that a listing of threatened or endangered is warranted, a proposed rule of listing will be published.

WDFW's current escapement goal for coho salmon in the Lewis River basin is 3,800 fish (PacifiCorp and Cowlitz PUD 2000c). According to the WDFW (1995), WDFW's current population management objectives for coho salmon in the Lewis River are to increase adult escapement by 1,400 early stock and 15,000 late stock. There are no current instream habitat objectives because the majority of the production comes from hatcheries (WDFW 1995).

4.1.5.3 Chum Salmon

Life History

Chum salmon, also called dog salmon, is second only to Chinook in size. Mature adults average about 64 cm (25 in) in length and 4.5 kg (10 lbs.) in weight (Scott and Crossman 1973, Wydoski and Whitney 1979). The Washington State saltwater angling record is 9.0 kg (19.9 lbs.).

The species is best know for its large canine-like fangs and striking body color of spawning males (dark olive to almost black above, grey-red on both sides, with dirty green, vertical bars or blotching) (Scott and Crossman 1973, Johnson et al. 1997). Females are similarly but less flamboyantly marked. During their ocean phase, chum salmon are steel blue on the back and upper sides, the sides are silver, and the ventral surface is silvery to white. Unlike Chinook and coho, chum salmon have no distinct spots on the back, sides, or fins. Juvenile chum salmon are bright, mottled green on the back, silvery, iridescent green on the sides and ventral surface, and the sides are marked by 6 to 14 narrow, short parr marks, most of which do not cross the lateral line (Scott and Crossman 1973).

Chum salmon have the widest distribution of any Pacific salmon species. Spawning populations occur from Korea to the Arctic in Asia, and from Monterey, California to the Arctic coast and east to the Mackenzie River in North America (Beaufort Sea) (Salo 1991). In North America, most major spawning populations occur only as far south as Tillamook Bay on the northern Oregon coast. The oceanic distribution of chum salmon extends throughout the North Pacific Ocean and Bering Sea. Asian chum salmon populations apparently migrate farther across the Pacific Ocean than do North American fish. North American chum salmon are rarely found west of the mid-Pacific Ocean (beyond longitude 175°E), whereas Asian chum salmon were routinely encountered far east of this line (Johnson et al. 1997).

Chum salmon are semelparous and exhibit obligatory anadromy[5]. 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 of various sizes (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).

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

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).

Throughout their 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). In the Columbia River, 70.5 percent of the chum salmon mature at age 3, 28.7 percent mature at age 4, and 0.8 percent mature at age 5 (Salo 1991). 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).

Like other anadromous salmonids, there is a seasonal north to south gradation in the timing of chum salmon runs that is largely dependent on winter precipitation, water temperature, and streamflow. Throughout their range, 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). Adult chum enter the lower Lewis River mainly in October and early November (Figure 4.1-1) (WDF and WDW 1993; pers. comm., E. Lesko, PacifiCorp, October 2000). Spawning occurs immediately after freshwater entry and extends into mid-December.

Spawning behavior of chum salmon is similar to that of other Pacific salmon. The males are aggressive on the spawning grounds. The female prepares the redd by facing upstream, lying on one side and vigorously lashing the tail up and down to displace sand and silt. A single female is often attended by more than one male and may build and spawn in more than one redd. The male and female settle in the nest, their mouths gape, and eggs and milt are released during rapid vibration of the two fish. Immediately following egg deposition, the female fills the nest pocket with gravel and digs a new redd in front of the first one. The females usually build 4 to 6 redds in succession. When all the eggs are buried, they defend the redd until death (Scott and Crossman 1973, Salo 1991). Fecundity is variable with size, area and year, and may reach 4,000 eggs, but usually varies from 2,000 to 3,600 (Johnson et al. 1997). Spawning adults are preyed upon by bears, other mammals, and birds such as osprey (*Pandion haliaetus*) and eagles.

As with all salmonids, the rate of chum salmon egg incubation and emergence depends to a large degree on water temperatures. Typically, incubating eggs hatch in about 2 to 18 weeks (Wydoski and Whitney 1973, Johnson et al. 1997). In the Lewis River basin, 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). Other factors, such as dissolved oxygen, gravel size, salinity, nutritional condition, and even the behavior of alevins in the gravel, can also influence the time to hatching, emergence from the gravel, or both (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). Several cues influence the timing of fry migration. These include: time of spawning, water temperature during incubation, fry size and condition, population density, food availability, stream discharge volume and turbidity, tidal cycles, and day length (Johnson et al. 1997). Very often, chum and pink salmon fry migrate together from nearby spawning grounds. In the Lewis River basin, most chum salmon outmigrate from mid-April through May (pers. comm., E. Lesko, PacifiCorp, October 2000). While moving downstream, chum fry tend to form loose schools and apparently lack a pronounced hiding behavior whether schooled or not (Salo 1991). Some studies have shown that chum fry begin feeding early in their migration on the larvae of chironomids, Ephemeroptera, Trichoptera, and other insects.

Like other species of *Oncorhynchus*, young chum salmon on the spawning grounds and during downstream migration are preyed upon by cutthroat and rainbow trout, Dolly Varden, coho salmon smolts, northern pikeminnow, and sculpins. Kingfisher, merganser, and other piscivorous birds and mammals are also responsible for a small loss (Scott and Crossman 1973).

When chum salmon enter the estuary, some fry remain near the mouth of their natal river, but most disperse within a few hours into tidal creeks and sloughs up to several kilometers from the mouth of their natal river (Johnson et al. 1997). Chum salmon are second only to ocean-type Chinook in dependence upon estuaries. Observed residence times range from 4 to 32 days and extend from January to July (Johnson et al. 1997). While rearing in the estuary, juvenile chum salmon grow rapidly, feeding on such epibenthic crustaceans as harpacticoid copepods, gammarid amphipods, and isopods, whereas larger juveniles in neritic habitats feed on drift insects and on such plankton as calanoid copepods, larvaceans, and hyperiid amphipods (Johnson et al. 1997, Wydoski and Whitney 1973, Salo 1991). The movement of chum salmon out of the estuary and into the offshore waters is closely correlated to water temperature and to the distribution of zooplankton (prey availability). As warmer currents move inshore, the plankton populations, which consist of primarily cold water species, move farther offshore. This movement of plankton forces the rearing chum farther offshore and into deeper water.

In their first year at sea, North American chum, pink and sockeye salmon juveniles tend to group together and remain nearer to shore (within 36 km [22.4 miles]) than juvenile coho and Chinook salmon and steelhead. As these groups of chum reach Alaska, they move offshore in a generally southwestern direction into North Pacific Ocean and Bering Sea. Movement appears to be strongly influenced by currents (Johnson et al. 1997). While in the marine environment, chum salmon are preyed upon by man, marine mammals, lampreys and in the early sea life, possibly by other fishes (Scott and Crossman 1973).

Habitat Requirements

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. Some chum salmon even spawn in intertidal zones of streams at low tide, especially in Alaska, where tidal fluctuation is extensive and upwelling of groundwater in intertidal areas may provide preferred spawning sites (Johnson et al. 1997). Preferred water depths for spawning are usually greater than 18 cm (7 in), preferred water velocities range from 46 to 101 cm/s (1.5 to 3.3 ft/s) and preferred substrate sizes range from 1.3 to 10.2 cm (0.5 to 4.0 in) in diameter (Bovee 1978, Bell 1986, Bjornn and Reiser 1991). The average size of chum salmon redds in Washington is about 2.3 m^2 (24.3 ft^2) (Scott and Crossman 1973). In the Lewis River, chum prefer to spawn in side channel habitat that contains spring water inflow or upwelling (pers. comm., E. Lesko, PacifiCorp, March 2001).

The peak of chum salmon migration generally usually occurs when water temperatures range between 7° and 11°C (45 to 52°F). Preferred water temperatures for spawning range from 7.2 to 12.8°C (45 to 55°F) (Bell 1986). Subgravel flow (upwelled groundwater) may also be important in the choice of redd sites by chum salmon. Salo (1991) reported that "chum salmon prefer to spawn immediately above turbulent areas or where there was upwelling." However, WDFW reported that chum salmon in Washington do not preferentially choose areas of upwelling groundwater for redd construction; rather, they suggest that chum salmon in Washington "most commonly use areas at the head of riffles" (Johnson et al. 1997).

As with other salmonids, the rate of egg incubation and the timing of emergence depend on a variety of physical factors such as streamflow, water temperature, dissolved oxygen, and gravel composition, and by such biotic factors as genetics, spawning time, and spawning density, all of which can affect survival. The rate of embryonic development in chum salmon is influenced most by water temperature (Salo 1991). For example, fertilized eggs hatch in about 100 to 150 days at 4°C (39°F), but hatch in only 26 to 40 days at 15°C (59°F) (Johnson et al. 1997). Favorable water temperatures for incubation and emergence range between 4 and 14°C (39 and 57°F) (Bjornn and Reiser 1991). The survival of chum salmon eggs is also related to the intergravel dissolved oxygen. Salo (1991) reported that the survival of chum salmon eggs decreased rapidly when the concentration of oxygen dropped below 2 mg/l. The lethal level for chum salmon eggs is 1.67 mg/l.

Following their emergence, chum salmon fry form loose schools and concentrate in areas of current (facing upstream) during all times of the day. They appear to lack any type of pronounced hiding behavior; however, chum fry do appear to be attracted to the shade or darkness of waterweed communities (Salo 1991). Once in the estuary, juvenile chum salmon occupy shallow nearshore areas and disperse into tidal creeks and sloughs. Preferred microhabitats include shallow eel grass beds and other productive areas with relatively low velocities. Some populations in British Columbia also exhibit daily tidal migrations into and out of the mouths of major rivers (Johnson et al. 1997).

Abundance and Distribution in the Lewis River Basin

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. Today, only a remnant population of chum salmon (of uncertain stocking history) exists 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).

Prior to the completion of Merwin Dam, chum salmon were common in the lower Lewis River basin. During the 10-year period following the construction of Merwin Dam (1930 to 1940), the Lewis River Hatchery supplemented the wild run. In 1951, WDF estimated the Lewis River chum escapement to be about 3,000 fish. Chambers (1957) reported 96 chum salmon spawning just downstream from Merwin Dam in mid-November of 1955.

Historically, Lewis River chum salmon were reported to "ascend the main stem above the dam site and spawn in the present reservoir area" (Smoker et al. 1951). Following the completion of Merwin Dam, the run declined dramatically, and currently only a remnant population exists in the lower river. More recently, 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 healthy smolt study in 1998. Annually, about 3 or 4 adult chum salmon have also been captured at the Merwin fish trap (PacifiCorp and Cowlitz PUD 2000c). All of these fish were believed to be wild; hatchery supplementation has not occurred since 1940. Poor hatchery practices and habitat loss are believed to be responsible for the long-term decline of this stock (NPPC 1990). The current distribution of chum salmon in the Lewis River basin is limited to mainstem Lewis River, East Fork Lewis River, and Cedar Creek. The distribution in river miles is the same as that for fall Chinook (Table 4.1-4). Information describing the physical barriers affecting access to “potential” chum salmon habitat and the amount of habitat that is currently blocked is available in AQU 1 Appendix 2. The data used in AQU 1 Appendix 2 are from Wade (2000).

After receiving several petitions to list Pacific coast chum salmon under the ESA, NMFS conducted a status review of all available information on the status of chum. A NMFS biological review team (BRT) found that remnant chum salmon populations of low abundance and uncertain stocking history exist in the lower Columbia River and are a distinct ESU, separate from other Pacific coast populations. Naturally spawned fish within this distinct Columbia River chum salmon ESU were listed as threatened by NMFS on March 25, 1999 (Federal Register, Vol. 64, No. 57, March 25, 1999). On February 16, 2000, critical habitat was designated to include all river reaches accessible to listed chum salmon (including estuarine areas and tributaries) in the Columbia River downstream from Bonneville Dam, excluding Oregon tributaries upstream of Milton

Creek at river km 144 near the town of St. Helens[6]. Also included are adjacent riparian zones. Excluded are tribal lands and areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). This ESU includes chum salmon found in the lower Lewis River below Merwin Dam (Federal Register, Vol. 65, No. 32, February 16, 2000).

On January 3, 2000, NMFS issued a proposed 4(d) rule governing "take" in the Columbia River ESU. NMFS issued the Final 4(d) on June 20, 2000. Section 7 consultation for federal actions is currently required and incidental "take" permits are required 180 days following the June 20, 2000, issuance of the 4(d) rule.

4.1.5.4 Steelhead Trout

Life History

The spotting and color patterns of *O. mykiss* (steelhead and rainbow trout) vary with life stage, environment, and strain of fish. At sea, nearly mature steelhead have a steel-blue, blue-green, or yellow-green dorsal surface, silvery sides, a white belly, and black spots on the back and on the dorsal and caudal fins. After entering freshwater to spawn, steelhead usually take on the appearance of resident (stream) rainbow trout. The back becomes olive green and the sides and belly less silvery. As spawning time approaches, the adults, particularly the males, darken and develop pink cheeks and opercula, and a vague pink to red along the lateral line. Males also develop kypes (hooked jaws), as do other mature Pacific salmon (Barnhart 1991). Juvenile steelhead in streams look exactly like resident coastal rainbow trout. Both have an olive green to grey-blue back, slightly pink cheeks and opercula, and a pink to red band along their lateral line. Both juvenile steelhead and coastal rainbow trout (the resident form of *O. mykiss* found in the Lewis River basin) also have black spots on the back and dorsal and caudal fins and 5 to 10 wide parr marks extending above and below the lateral line. The dorsal and anal fins are tipped with white or orange, the dorsal having a dark leading edge (Barnhart 1991). Stream resident rainbow trout often retain their parr marks, whereas fish migrating to lakes or out to the ocean lose their parr marks (Scott and Crossman 1973).

The size of steelhead at maturity depends primarily upon how long they have lived. Most of the steelhead returning to Washington streams weigh 2 to 5 kg (5 to 10 lbs.), although fish as large as 16 kg (35 lbs.) have been caught in the state[7]. The world record, taken in Alaska on hook and line, is 19 kg (42 lbs.) (Barnhart 1991). Adult resident rainbow trout average about 20 to 45 cm (7.9 to 17.7 in) in length, though catches of much larger fish do occur, especially within lakes (Scott and Crossman 1973). The largest resident rainbow trout caught in Washington state by an angler weighed 11.6 kg (25.5 lbs.). Sport caught resident rainbows sampled during a 1998 creel survey on Lake Merwin ranged from 14 to 28 cm (5.5 to 11.0 in) in length and had a mean length of 24 cm (9.5 in) (Hillson and Tipping 1999). Creel surveys by Graves (1982) indicated lengths of rainbows in Lake Merwin to range from 21 to 30 cm (8.3 to 11.8 in), in Yale Lake from

[6] http://www.nwr.noaa.gov/1salmon/salmesa/chumcr.html
[7] http://www.wa.gov/wdfw/outreach/fishing/bigfish.htm#fresh

18 to 29 cm (7.1 to 11.4 in), and 27 to 32 cm (10.6 to 12.6 in) in the Swift Reservoir. In 1995, rainbow trout caught by anglers in Yale Lake ranged from 18 to 36 cm (7.1 to 14.2 in) in length (PacifiCorp 1999).

Steelhead and rainbow trout naturally occur throughout the eastern Pacific Ocean and in freshwater systems west of the Rocky Mountains, from northwest Mexico to the Kuskokwim River in Alaska (Scott and Crossman 1973). Successful introductions have occurred throughout the continental United States, New Zealand, Australia and Tasmania, South America, Africa, Japan, southern Asia, Europe, and Hawaii (Scott and Crossman 1973).

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. As discussed previously, 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 and that the progeny of steelhead have the potential to become resident rainbows (Peven 1990). Biologically, the anadromous steelhead can be divided into two reproductive ecotypes (races), based on their state of sexual maturity at the time of river entry and duration of their spawning migration. These two ecotypes are termed "stream maturing" or "summer" steelhead and "ocean maturing" or "winter" steelhead. Summer steelhead enter freshwater as sexual immatures during the summer months 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* (described in the following section), 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 most widespread run type of steelhead is the winter steelhead. Winter steelhead occur in essentially all coastal rivers of Washington, Oregon, and California, south to Malibu Creek. Summer steelhead (including spring and fall steelhead) are less common than winter steelhead and usually occur in more inland watersheds (Busby et al. 1996). Winter-run steelhead are not found above the Deschutes River in the Columbia River basin. Both summer and winter steelhead are indigenous to the Lewis River; hatchery winter and summer steelhead were first introduced to the Lewis River system in 1954 and 1964, respectively (WDFW 1994).

Winter steelhead mature at sea and begin migrating to the Columbia River and their natal streams in December and January. Summer steelhead begin their entry and migration into freshwater during June or July, over-wintering in freshwater until they spawn the following March and April. WDFW has intentionally developed early spawning (January/February) hatchery stocks of winter steelhead for planting into coastal and lower Columbia River drainages. The early run timing is meant to accomplish two main objectives: (1) to provide a harvest opportunity from the hatchery stocks while limiting impacts on native stocks, and (2) to minimize interbreeding between hatchery steelhead spawning in the river and native steelhead (Busby et al. 1996).

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. Ocean-age at spawning (and mean adult length) appears to increase with increasing latitude (Busby et al. 1996). In the Lewis River basin most (83 percent) winter steelhead return as 2-ocean fish. Three-ocean fish make up the next largest group. Unfortunately, there are limited data describing the age composition of summer steelhead in the basin (NPPC 1990).

Adult winter steelhead enter the Lewis River from early December through mid-March, with peak migration occurring in March (Figure 4.1-1) (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 early June through mid-August (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). 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, though an estimated 5 to 10 percent of returning steelhead do spawn naturally. Steelhead spawning has been reported in the mainstem Lewis River below Lake Merwin and in several tributaries including Ross, Cedar, Chelatchie, Johnson, and Colvin creeks (WDF and WDW 1993).

The spawning behavior of steelhead is similar to that of other Pacific salmon. On the spawning grounds, the female selects a nest site typically at the head of a riffle area, then defends the area against other females as she prepares the nest. She begins digging the nest by lying on her side and violently beating her tail up and down, creating a hollow approximately 18 to 38 cm (7.1 to 15.0 in) deep. Depth of egg deposition is loosely related to the size of the spawning female, but studies of resident rainbow trout cited by Chapman (1988) showed average egg depth to be 20 cm (7.9 in). Digging the redd can take as many as 5 days to complete. During this period, males are aggressive with each other, attempting to gain access to the female. Upon completion of the nest, the dominant male and female swim into the nest, depositing the eggs and sperm. The female then swims upstream and digs several times with her tail to cover the fertilized eggs with upstream gravels (Scott and Crossman 1973). In the Lewis River basin, summer steelhead spawn from early-March through April (Figure 4.1-1). Winter steelhead spawn from mid-March through June. Adult steelhead usually migrate back out to sea, though fewer than 10 percent typically return to spawn again. Estimates of repeat spawners for the Cowlitz and Toutle rivers is 4 to 5 percent (Busby et al. 1996).

After spawning, the surviving steelhead descend back to the sea. For steelhead populations north of Oregon, repeat spawning is relatively uncommon, and more than two spawning migrations is rare. In Oregon and California, the frequency of two spawning migrations is higher, but more than two spawning migrations is still unusual (Busby et al. 1996).

Fecundity of steelhead is variable and dependent on the size of the female. Fecundity ranges from 2,000 to over 9,000; most steelhead average about 3,500 eggs (Peven 1990).

Average fecundity for steelhead returning to the Lewis River is 3,000 eggs/female (Smoker et al. 1951). Incubating steelhead eggs hatch in about 4 to 7 weeks depending on the water temperature (Scott and Crossman 1973). The young alevins remain in the gravel until their yolk sac is depleted (usually from 2 to 5 weeks after hatching). Once they are "buttoned-up," the young fry (approximately 25 mm in length) struggle out of the gravels and begin their freshwater residence in the streams or lakes. In the Lewis River basin, emergence of summer steelhead starts in mid-June and continues through early August (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Emergence of winter steelhead occurs from early July through mid-August. As is the case for all salmonids, rainbow and steelhead eggs and fry are subject to a variety of impacts while residing in the stream environment. Physical characteristics (flood flows, freezing temperatures, siltation) within the stream typically limit survival to emergence, while predation by a variety of fish and birds can further impact survival.

After emergence, juvenile steelhead fry feed primarily on food sources associated with the stream bottom. Most food items are aquatic insects (e.g., Diptera, Ephemeroptera, Plecoptera and Coleoptera, amphipods, aquatic worms [Peven 1990]). Within the Lewis River reservoirs, Graves (1982) found zooplankton to be the main food source for yearlings, except during the early spring and late fall, times when plankton production is low and when insects or small fish provide food. Yearling steelhead are also known to prey on fall Chinook fry (Hawkins and Tipping 1999). In drainages open to anadromous salmonids, young steelhead often compete with young coho and Chinook salmon, cutthroat trout, Dolly Varden, and bull trout for both food and space (Meehan and Bjornn (1991).

Natural rearing of steelhead typically lasts 2 years prior to ocean migration, although some juveniles smolt after only 1 year or as much as 3 years (Figure 4.1-1) (Hymer et al. 1993). While rearing in freshwater, juvenile steelhead are preyed upon by other trout species, sculpins, great blue herons (*Ardea herodias*), belted kingfishers (*Ceryle alcyon*), mergansers, the American dipper (*Cinclus mexicanus*), the common garter snake (*Thamnophis sirtalis*), and various mammals such as the otter and the raccoon (Barnhart 1991).

The outmigration of steelhead smolts in the Lewis River basin extends from late April through early June, typically in sync with spring runoff (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Outmigrants typically measure between 12 to 18 cm (4.7 to 7.1 in) in length and can take as long as 2 to 3 months to move downstream to the estuary, although variation occurs among streams (Wydoski and Whitney 1979). Naturally produced smolts in the North Fork Lewis River outmigrate at an average size of 16 cm (6.3 in); the majority (83 percent) were 2-year-olds, while about 17 percent were 3-year-olds (NPPC 1990). Hatchery conditions usually allow steelhead to smolt in 1 year, due to increased food and water temperatures (Busby et al. 1996). In Lake Merwin, out-migrating smolts caught at the dam averaged 21 cm (8.3 in) in length during May and June (Allen 1963). Smolts trapped at the mouth of Speelyai Creek averaged 16.5 cm (6.5 in).

In the lacustrine environment, rainbow fry become prey to northern pikeminnow, juvenile coho salmon, cutthroat trout, and bull trout. Appreciable predation by birds further impacts rainbow survival. Common mergansers in particular have been cited as major predators to salmonids (Barnhart 1991), especially when fish populations are in high density.

Not much is known about the saltwater phase of steelhead development. Due to their extensive freshwater residence, steelhead smolts do not spend an appreciable amount of time in the estuarine areas, but rather move directly into deeper, open water. In the ocean, steelhead feed heavily on a variety of organisms, especially juvenile greenling, squids (Teuthoida), and amphipods. They are in turn preyed upon by other fish and marine mammals (Barnhart 1991). During surveys for salmon, Washington and Oregon steelhead have been identified in scattered locations westward as far north as 160° W to the Gulf of Alaska, and westward along the Aleutians to 175° W (Wydoski and Whitney 1979). LeBrasseur (1966) reported that stomach contents of adult steelhead caught in the northeastern Pacific Ocean contained predominantly fish and squid.

Habitat Requirements

Steelhead and rainbow trout prefer relatively small, fast flowing streams with a high proportion of riffles and pools (Barnhart 1991). As with most salmonids, spawning typically occurs in streams where the water is cool, clear, and well oxygenated. Preferred water depths for steelhead spawning usually range from 10 to 138 cm (4 to 54 in), preferred velocities range from 6 to 15 cm/s (2 to 5 ft/s), and preferred gravel sizes range from 0.6 to 13 cm (0.25 to 5 in) in diameter (Barnhart 1991). The most common steelhead redd site is at the tail of a pool close to the point where the smooth surface water breaks into the riffle below. Like other Pacific salmon, these areas are often associated with deep pools and abundant instream cover. The optimum spawning temperature for steelhead is about 7°C (45°F), but they have been reported spawning at temperatures of 3.8° to 12.6°C (39 to 55°F) (Bell 1986, Barnhart 1991).

The habitat requirements of steelhead and rainbow trout eggs during incubation are similar to those for other anadromous salmonids (i.e., they require a relatively stable stream channel, adequate intragravel flow and dissolved oxygen, and adequate water depth above the redd). Dissolved oxygen concentrations at or near saturation with no temporary reductions below 5 ppm are best for incubation. Sustained dissolved oxygen concentrations below 2 ppm usually result in the complete loss of eggs (Barnhart 1991).

After emergence, steelhead fry form small schools and inhabit the margins of the stream. As they grow larger and more active, they slowly begin to disperse downstream. The individual fish then establish territories (microhabitats that contain feeding lanes and resting area), which they defend (Barnhart 1991). In 1 or 2 months, steelhead fry grow to fingerling size and move into the riffle areas of the stream. Most steelhead in their first year of life live in riffles, but some larger fish also inhabit pools or deep fast runs (Barnhart 1991). Instream cover such as large rocks, logs, root wads, and aquatic vegetation are very important for juvenile steelhead. This cover provides resting areas, visual isolation from competing salmonids, food, and protection from predators. Often steelhead densities are highest in streams with abundant instream cover. The preferred water temperature for rearing steelhead ranges from 10 to 13°C (50 to 55°F) (Bjornn and Reiser 1991).

The time when steelhead smolts migrate to sea appears to be controlled primarily by photoperiod but is influenced by other environmental factors such as flow, temperature, and lunar phase. Once at sea, steelhead may stay close to their home stream, as do the "half pounders" of some Oregon and California stocks, or they may migrate far off shore, as do some stocks that have been caught in the high seas fishery in the Gulf of Alaska (Meehan and Bjornn 1991).

Abundance and Distribution in the Lewis River Basin

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 (WDFW 1994, NPPC 1990). Unfortunately, the full extent of their historical distribution in the upper basin (above Merwin Dam) is unknown, but it is likely it was similar to that of coho salmon (Section 4.1.3.2).

Based on our review of existing literature, the historical (pre-hatchery) abundance of steelhead in the Lewis River basin is extremely limited, although Smoker et al. (1951) estimated that the total spawning escapement exceeded 1,000 steelhead. Lavoy (1983) estimated that the total spawning escapement ranged from 8,000 to 11,000 fish (WDFW 1994). Between 1930 and 1950, an average 403 summer and winter steelhead were collected at the Merwin Dam fish collection facility (range 86 to 1,366) (Smoker et al. 1951).

Today, North Fork Lewis River winter steelhead are thought to be native, although some interbreeding has probably occurred with introduced stocks from Elochoman, Chambers Creek, Cowlitz, and Skamania hatcheries that have been planted in the basin since the late 1940s (NPPC 1990). The summer steelhead stock in the Lewis River is also considered native, although interbreeding with introduced Skamania hatchery stock has likely occurred (NPPC 1990). 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 (WDFW 1994).

From 1979-80 through 1997-98, annual angler catch of summer steelhead in the mainstem and North Fork Lewis River has averaged 2,569 fish. Catch of winter steelhead during this same period has averaged 1,466 fish (Table 4.1-8) (PacifiCorp 1999). Prior to 1994, all steelhead captured at the Lewis River Hatchery were returned to the river for angler harvest. Therefore, pre-1994 hatchery returns are not an accurate indicator of total run size. Today, all steelhead collected at hatcheries are marked before being released back to the river to avoid double counting.

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.

Table 4.1-8. Angler catch of summer run and winter run steelhead in the mainstem Lewis River and North Fork Lewis River (1979-80 through 1994-95).

Year[1]	Angler Catch				Total	
	Mainstem Lewis River		N. F. Lewis River			
	Summer Run	Winter Run	Summer Run	Winter Run	Summer Run	Winter Run
1979 – 1980	416	541	700	450	1,116	991
1980 – 1981	NA	NA	NA	NA	NA	NA
1981 – 1982	425	757	2,187	574	2,612	1,331
1982 – 1983	265	602	3,254	863	3,519	1,465
1983 – 1984	217	563	1,580	1,546	1,797	2,109
1984 – 1985	352	506	2,498	1,953	2,850	2,459
1985 – 1986	751	310	2,764	1,294	3,515	1,604
1986 – 1987	516	302	6,100	1,931	6,616	2,233
1987 – 1988	443	244	4,807	1,247	5,250	1,491
1988 – 1989	407	218	1,649	1,444	2,056	1,662
1989 – 1990	311	233	1,867	1,588	2,178	1,821
1990 – 1991	338	187	1,576	1,126	1,914	1,313
1991 – 1992	283	138	2,089	1,396	2,372	1,534
1992 – 1993	NA	NA	NA	NA	NA	NA
1993 – 1994	323	67	2,640	359	2,963	426
1994 – 1995	218	123	2,078	546	2,296	669
1995 – 1996	NA	NA	1,366	1,889	1,366	1,889
1996 – 1997	NA	NA	403	779	403	779
1997 – 1998	NA	NA	854	1,148	854	1,148
Average	**376**	**342**	**2,260**	**1,184**	**2,569**	**1,466**

[1.] May through April.
NA: Data not available.

Current steelhead population distribution on the mainstem North Fork Lewis River occurs from approximately RM 7 to RM 19.4 (Merwin Dam). 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 (Hymer et al. 1993). The East Fork Lewis River allows steelhead access and spawning throughout most of the river. Few steelhead were reported to have ascended Sunset Falls prior to 1982 when the falls were "notched." This lowered the falls from 13.5 feet to 8 feet and made the upper reaches more accessible. Now spawning takes place in the mainstem as well as Rock Creek and other tributaries. Summer run fish do not pass over the falls as readily as winter run fish, and numerous small falls provide barriers to migrating adults during periods of low flow (Hymer et al. 1993). The current distribution and habitat use type for winter and summer steelhead in the Lewis River basin is presented in Tables 4.1-9 and 4.1-10. A map of the current distribution is presented Appendix AQU 1, maps 4 and 5 (map source: WDFW 1995). Information describing the physical barriers affecting access to "potential" habitat and the amount of available habitat is presented in AQU 1 Appendix 2. The source of this data is Wade (2000).

Table 4.1-9. The current distribution and habitat use type for winter steelhead in the Lewis River basin.

Stream Name	Distribution (Mile Points)		Habitat Use Type
	From	To	
[1222945457593] Unnamed Stream, trib to Coyote Creek	0.0	0.4	Primarily Spawning and Rearing
[1223506457777] Unnamed Stream, trib to Cedar Creek	0.0	0.2	Primarily Migration
[1223519457924] Unnamed Stream, trib to Rock Creek	0.0	0.3	Primarily Migration
[1223657458011] Unnamed Stream, trib to Rock Creek	0.0	0.5	Primarily Spawning and Rearing
[1226056458133] Unnamed Stream, trib to East Fork Lewis River	0.0 0.2	0.2 1.7	Primarily Spawning and Rearing Primarily Spawning and Rearing
Big Tree Creek, trib to East Fork Lewis River	0.0	0.5	Primarily Migration
Cedar Creek, trib to Rock Creek	0.0	4.6	Primarily Spawning and Rearing
Cedar Creek, trib to Lewis River	0.0	18.2	Primarily Spawning and Rearing
Chelatchie Creek, trib to Cedar Creek	0.0	1.7	Primarily Spawning and Rearing
Cold Creek, trib to Cedar Creek	0.0	0.7	Primarily Migration
Copper Creek, trib to East Fork Lewis River	0.0	3.2	Primarily Spawning and Rearing
Coyote Creek, trib to Rock Creek	0.0	1.7	Primarily Spawning and Rearing
East Fork Lewis River, trib to Lewis River	0.0 5.5 5.7	5.5 5.7 31.9	Primarily Migration Primarily Spawning and Rearing Primarily Spawning and Rearing
Johnson Creek, trib to Lewis River	0.0	1.4	Primarily Spawning and Rearing
King Creek, trib to East Fork Lewis River	0.0	0.2	Primarily Migration
Lewis River, trib to Columbia River	0.0 12.2 12.4	12.2 12.4 19.4	Primarily Migration Primarily Spawning and Rearing Primarily Spawning and Rearing
Mason Creek, trib to East Fork Lewis River	0.0	3.2	Primarily Migration
North Fork Chelatchie Creek, trib to Chelatchie Creek	0.0	1.2	Primarily Spawning and Rearing
Pup Creek, trib to Cedar Creek	0.0	1.0	Primarily Spawning and Rearing
Rock Creek, trib to East Fork Lewis River	0.0	1.9	Primarily Spawning and Rearing

Source: http://query.streamnet.org/

Table 4.1-10. The current distribution and habitat use type for summer steelhead in the Lewis River basin.

Stream Name	Distribution (Mile Points)		Habitat Use Type
	From	To	
[1222945457593] Unnamed Stream, trib to Coyote Creek	0.0	0.4	Primarily Spawning and Rearing
[1223506457777] Unnamed Stream, trib to Cedar Creek	0.0	0.2	Primarily Migration
[1223657458011] Unnamed Stream, trib to Rock Creek	0.0	0.5	Primarily Spawning and Rearing
Big Tree Creek, trib to East Fork Lewis River	0.0	0.5	Primarily Spawning and Rearing
Cedar Creek, trib to Rock Creek	0.0	4.6	Primarily Spawning and Rearing`
Cedar Creek, trib to Lewis River	0.0	18.2	Primarily Migration
Copper Creek, trib to East Fork Lewis River	0.0	1.3	Primarily Spawning and Rearing
Coyote Creek, trib to Rock Creek	0.0	1.7	Primarily Spawning and Rearing
East Fork Lewis River, trib to Lewis River	0.0 3.3	3.3 40.1	Primarily Migration Primarily Spawning and Rearing
Green Fork, trib to East Fork Lewis River	0.0	1.1	Primarily Spawning and Rearing
Green Fork, trib to East Fork Lewis River	0.0	1.1	Primarily Spawning and Rearing
King Creek, trib to East Fork Lewis River	0.0	2.2	Primarily Migration
Lewis River, trib to Columbia River	0.0	19.4	Primarily Migration
Little Creek, trib to East Fork Lewis River	0.0	1.0	Primarily Spawning and Rearing
Mason Creek, trib to East Fork Lewis River	0.0	3.2	Primarily Migration
McKinley Creek, trib to East Fork Lewis River	0.0	1.1	Primarily Migration
Poison Creek, trib to East Fork Lewis River	0.0	0.8	Primarily Spawning and Rearing
Rock Creek, trib to East Fork Lewis River	0.0	8.0	Primarily Spawning and Rearing

Source: http://query.streamnet.org/

Lewis River steelhead are currently managed for both hatchery and wild production. The 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.). WDFW also plants an average of 800,000 rainbow trout into Swift Reservoir annually to provide a recreation fishery (PacifiCorp and Cowlitz PUD 2000c). Present Lewis River steelhead releases are from broodstock collected at the Merwin fish trap. According to Article 50 of the existing Merwin Project license, the licensee shall pay all operating and maintenance expenses to annually produce approximately 250,000 juvenile steelhead (about 41,600 pounds).

According to WDWF, 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). The lower Columbia River 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. Critical habitat is designated to include all river reaches accessible to listed steelhead in Columbia River tributaries between the Cowlitz and Wind rivers in Washington and the Willamette and Hood rivers in Oregon, inclusive. Also included are adjacent riparian zones, river reaches, and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the Hood River in Oregon. Excluded are tribal lands and areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). In addition, NMFS included the adjacent riparian area along the designated stream reaches as part of the critical habitat. NMFS defines this as the “area adjacent to a stream that provides the following functions: shade, sediment, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter.” Impacts on riparian critical habitat would be assessed site-specifically based on the potential effects of land use activities on the riparian functions listed above.

NMFS published Final 4(d) rules for the lower Columbia River steelhead ESU on July 10, 2000. Incidental "take" permits under Section 10 of the ESA became necessary on September 8, 2000.

4.1.5.5 Sea-run Cutthroat Trout

Life History

Anadromous (sea-run) coastal cutthroat trout belong to the same genus as Pacific salmon and steelhead, but are generally smaller, rarely over-winter at sea, and do not usually make extensive ocean migrations (Johnson et al. 1999). They are distinguished from other species of *Oncorhynchus* by the presence of numerous black spots on the back and sides, hyoid teeth at the base of the tongue, a maxillary that extends well beyond the posterior margin of the eye, and red-orange "slash marks" on the underside of the lower jaw (although variable in size and intensity). Like steelhead, coastal cutthroat trout are iteroparous rather than semelparous, and adults have been known to spawn each year for more than 6 years (Johnson et al. 1999). Although relatively small, growth and potential maximum size are highly variable. Most adult anadromous coastal cutthroat trout range from about 0.7 to 1.8 kg (1.5 to 4 lbs.) (Scott and Crossman 1973).

The distribution of coastal cutthroat trout extends along the Pacific coast of North America from the Eel River in northern California to Prince William Sound in Alaska, extending to Gore Point on the Kenai Peninsula (Scott and Crossman 1973). The eastern range is bounded by the Cascade Mountain Range in California, Oregon, and Washington and by the Coast Range in British Columbia and southeastern Alaska (Johnson et al. 1999).

The life history of coastal cutthroat trout is extremely complex (Johnson et al. 1999, Trotter 1991). Both migratory and non-migratory (anadromous, adfluvial, fluvial, and resident) forms may be present within the same population. These variations in life history may be related to environmental conditions, particularly those affecting growth rates. The Lewis River basin contains both migratory and non-migratory life history types.

All cutthroat trout, regardless of their life history type, are spring spawners. Actual spawning time depends on latitude, altitude, water temperature, and flow conditions (Trotter 1991). Depending on their time of freshwater entry, anadromous coastal cutthroat trout (sea-run cutthroat trout) in Washington, Oregon, and British Columbia are referred to as either "early entering" or "late entering." Early entering stocks migrate to freshwater from late June through October, reaching a peak in September and October. Late entering stocks return to freshwater from December through March (Trotter 1991). Early entering fish are typically found in larger streams with summer low flows greater than 45 cubic feet per second (cfs). Late entering stocks utilize smaller streams that often flow directly into salt water (i.e., Puget Sound). In both cases, run timing is fairly consistent from year to year for specific streams, but can be highly variable between streams in different geographic regions (Johnston 1982). In the Lewis River basin, sea-run cutthroat trout enter freshwater from early October through mid-December (WDFW 2000).

Sea-run cutthroat trout spawning in the Lewis River basin typically starts in early February and continues through late April, with a peak in February (Figure 4.1-1) (PacifiCorp and Cowlitz PUD 2000c). Spawning takes place in the upper reaches of small, low gradient streams and in the upper reaches of small tributaries of moderate-size streams. Often these relatively small systems contain low gradient sloughs or wetlands in their lower reaches. The volume of water in sea-run cutthroat trout spawning streams seldom exceeds 10 cfs during the low flow period, with most averaging less than 5 cfs (Johnston 1982, Trotter 1991). Population genetics studies have shown that homing in sexually mature sea-run cutthroat trout is relatively precise; however, immature fish do not always return to their home stream (Trotter 1991).

Anadromous coastal cutthroat trout spawning takes place both during the day and night, and can extend over a period of 2 to 3 days. As with other anadromous salmonids, males court the females and are aggressive toward other males. The female prepares the redd and eventually settles into the pocket. The male then moves into a position parallel to the female, both fish gape, become rigid, and release sperm and eggs within a few minutes. After spawning, the female covers the eggs with approximately 6 to 8 inches (15 to 20 cm) of gravel. Females may spawn with more than one male, and males may spawn with more than one female (Scott and Crossman 1973).

Fecundity in sea-run cutthroat trout is highly variable depending on the size and age of the female. In Washington, females ranging from 34 to 46 cm (13.4 to 18.1 in) in length reportedly produce between 226 and 4,420 eggs (Scott and Crossman 1973). In general, eggs of older, larger sea-run cutthroat trout returning to spawn the second or third time are larger than first-spawning fish. First-spawning fish generally produce 10 to 11 eggs per gram of eggs; second and third spawning fish produce closer to 7 eggs per gram (Trotter 1989).

In Oregon, sea-run cutthroat trout were reported to lose between 29 and 38 percent of their body weight during spawning. Despite this substantial weight loss, an average of 41 percent of the spawned out adults in Washington and Oregon survive and return to saltwater in late March or early April. Typically, this occurs about one month before the peak out-migration of sea-run cutthroat trout smolts (Trotter 1989).

Sea-run cutthroat trout eggs hatch in approximately 6 to 7 weeks, and alevins remain in the gravel for another 1 or 2 weeks prior to emergence. Peak emergence of fry typically occurs from March through June (Trotter 1991). In the Lewis River basin, emergence extends from mid-March through late June (Figure 4.1-1) (PacifiCorp and Cowlitz PUD 2000c).

While rearing in freshwater, young sea-run cutthroat trout are opportunistic feeders. Fry begin feeding on small invertebrates between 14 to 23 days after hatching (Scott and Crossman 1973). As they increase in size, they begin to feed on larger aquatic and terrestrial insects, salmon eggs, and small fish. Food availability is very important in determining microhabitat distribution, and often sea-run cutthroat trout are in direct competition with coho salmon and steelhead (Pauley et al. 1989). This competition can lead to the displacement of cutthroat fry from their preferred habitat.

After surviving their first winter in freshwater, non-smolting juvenile cutthroat trout range more widely than young-of-the-year fish. Many begin to move downstream into mainstem reaches; however, this net downstream movement lasts only until the onset of higher winter flows (November through January). Winter freshets trigger an upstream movement that often takes the fish back into the smaller tributaries. This movement may be in response to seasonal physiological changes, changing stream flows, food availability, or crowding due to recruitment (Trotter 1989).

Juvenile sea-run cutthroat trout migrate to sea between the ages of 1 and 6. However, the majority are reported to migrate at age 2, 3, or 4 depending on their geographic location (Trotter 1997). Data have shown that the age at which sea-run cutthroat trout smolting first occurs is somewhat size-dependent. Fish that spend more time in freshwater prior to outmigration (i.e., age 3 and 4 fish) tend to grow slower, and are only slightly larger than age 2 outmigrants. Throughout Washington, Oregon, and British Columbia the average age of sea-run cutthroat trout outmigrants is 3 or 4. Fish in these age groups have an average length of 20 to 25 cm (7.9 to 9.8 in) (Pauley et al. 1989).

In most of Washington and Oregon, the juvenile outmigration begins as early as March and peaks in mid-May. In the Lewis River basin, outmigration extends from early April through late June (Figure 4.1-1) (PacifiCorp and Cowlitz PUD 2000c).

Cutthroat trout smolts are believed to begin schooling just before they enter saltwater. These schools, which may serve to increase marine survival, remain intact until they re-enter the freshwater environment (Trotter 1989). While off the coast of Oregon and Washington, cutthroat feed opportunistically on fish, mysids, crab magalops, and euphausids. Fish are the largest component of their diet in terms of biomass (Pearcy 1992).

Throughout most of Washington State, sea-run cutthroat trout reach sexual maturity at age 4 and 5, following their first year in the marine environment (Johnston 1982). However, a small percentage of Columbia River and Puget Sound sea-run cutthroat will not reach sexual maturity until they spend a second year at sea. In the Cowlitz River, 85 percent of the male and 69 percent of the female fish (hatchery returns) were reported to be sexually mature on their initial return to the river (Tipping 1986). The remaining sexually immature 1-salt fish return to freshwater to simply feed and over-winter. These fish will not spawn until the following year.

Habitat Requirements

As with all anadromous salmonids, substrate composition, cover, water depth, water velocity, and water quality are important habitat elements before and during spawning (Bjornn and Reiser 1991). In general, adult coastal cutthroat trout spawn in low gradient riffles that are 15 to 45 cm (6 to 18 in) deep and in shallow pool tail-outs. Preferred water velocities range from 11 to 72 cm/s (0.4 to 2.4 ft/s). The preferred spawning substrate is clean pea-sized to walnut-sized gravel (0.5 cm to 5 cm [0.2 to 2.0 in] in diameter) (Trotter 1997). Often, the preferred spawning sites are located near deep pools, which are presumed used by adults for cover. Again, the volume of water in spawning streams seldom exceeds 10 cfs during the low flow period and most average less than 5 cfs (Johnston 1982, Trotter 1991). In streams that are used by other anadromous salmonids (i.e., coho and steelhead), sea-run cutthroat trout spawning and nursery areas are usually located farther upstream (although some overlap may occur). This life-history strategy is believed to minimize competition with these other larger, more aggressive salmonids. This spatial separation, along with slight differences in spawning time also reduces the incidence of hybridization between sea-run cutthroat trout and steelhead (Trotter 1989). Spawning takes place both during the day and night, and can extend over a period of two to three days. Spawning behavior is similar to that observed for other salmonids.

The habitat requirements of coastal cutthroat trout eggs during incubation are similar to those for other anadromous salmonids (i.e., they require a relatively stable stream channel, adequate intragravel flow and DO, and adequate water depth above the redd). Coastal cutthroat trout eggs require about 300 temperature units for incubation and another 150 to 200 temperature units before the newly hatched fry are mature enough to emerge from the gravel (Trotter 1991).

Newly emerged fry move quickly into low velocity stream margin, backwater, and side channel habitat with abundant instream cover. They will remain in these areas for a few weeks until they become large enough to hold in slightly higher velocity, more productive habitats (Trotter 1997). In the absence of competing juvenile salmonids, sub-yearlings will remain in these preferred habitat areas throughout their first year (Trotter 1989). However, if competing juvenile coho salmon and steelhead/rainbow trout are present in the same natal stream reach, the smaller, less dominant cutthroat are often displaced into higher velocity riffles.

Yearling coastal cutthroat trout range more widely in the stream than do young-of-the-year fish (Trotter 1991). As the water temperatures start to warm during spring and summer, yearling cutthroat trout begin to move downstream out the nursery tributaries and disperse throughout the mainstem. As flows begin to increase in the fall, they move back upstream into the smaller tributaries (Trotter 1991). The optimum water temperature for rearing cutthroat trout is considered to be about 10°C (50°F). The upper lethal temperature for rearing cutthroat trout is 22.8°C (73°F) (Bjornn and Reiser 1991).

While in the marine environment, sea-run cutthroat trout remain relatively close to shore and close to their home streams (Johnston 1982). Their migrations in saltwater seldom exceed 70 km (43.5 miles) (Trotter 1991). Smolts from the lower Columbia River basin enter the Columbia River estuary and, although some go out to sea, most remain in the estuary during the first migration (Tipping 1981). These fish remain in saltwater from 2 to 5 months, during which time they grow an average of 1 mm/day (0.04 in/day) (Johnston 1982).

While off the coast of Oregon and Washington, cutthroat trout feed opportunistically on fish, mysids, crab magalops, and euphausids. Fish are the largest component of their diet in terms of biomass (Pearcy et al. 1990). Fish found in the stomachs of cutthroat trout collected from the Columbia River plume included: juvenile cabezons (*Scorpaenichthys marmoratus*) and kelp greenlings (*Hexagrammos decagrammus*), adult Pacific sand lances, adult and juvenile northern anchovies (*Engraulis mordax*), brown Irish lords (*Hemilepidotus spinosus*), and rockfishes (*Sebastes* spp.) (Trotter 1989, Pearcy et al. 1990). A relatively small number of juvenile salmonids have also been observed in the stomachs of cutthroat captured off the coast of Washington and Oregon (Trotter 1989). Fall Chinook fry were also observed in the stomachs of cutthroat rearing in the Lewis River (Hawkins and Tipping 1999).

Predation represents a major source of marine mortality for sea-run cutthroat. However, marine survival of sea-run cutthroat trout is higher than that for other anadromous salmonids. Estimates from studies conducted in Oregon indicate a 20 to 40 percent survival of initial migrant sea-run cutthroat trout in the marine environment (Pauley et al. 1989). In the Cowlitz River, Tipping (1986) noted that survival was considerably higher for hatchery fish that were released as smolts when they are 21 cm and larger (13.7 percent returns) than for smaller smolts (2.4 percent returns). Pacific hakes (*Merluccius productus*), spiny dogfish (*Squalus acanthias*), harbor seals (*Phoca vitulina*), and adult salmon are believed to be the primary marine predators (Trotter 1989).

Abundance and Distribution in the Lewis River Basin

Anadromous, fluvial, adfluvial, and resident forms of coastal cutthroat trout are found throughout the Lewis River watershed (WDFW 2000, PacifiCorp 1999). The anadromous form (sea-run cutthroat trout) is currently found in the North Fork Lewis River and its tributaries up to Merwin Dam (RM 19.4) and in the East Fork Lewis River up to Lucia Falls. Fluvial and resident coastal cutthroat trout are found throughout the upper and lower watershed (upstream and downstream of Merwin Dam), and adfluvial fish have been observed in Merwin, Yale, and Swift reservoirs (WDFW 2000). Although hatchery-origin anadromous cutthroat trout have been released as smolts into the mainstem North Fork Lewis annually (Cowlitz River and Skamania River stocks), the existing Lewis River coastal cutthroat trout stock is considered native with wild production (WDFW 2000). WDFW staff believes that few genetic interactions have occurred between wild and hatchery populations, although recently, WDFW has elected to discontinue cutthroat trout production at the Merwin Hatchery (PacifiCorp and Cowlitz PUD 2000c). While the existing Merwin Project license requires the production of approximately 25,000 juvenile sea-run cutthroat trout (up to 6,250 pounds), WDFW recently discontinued the production of sea-run cutthroat trout at the Merwin Hatchery (PacifiCorp and Cowlitz PUD 2000c).

Information describing the abundance of coastal cutthroat trout in the Lewis River basin is extremely limited. According to WDFW (2000) there is no data available describing average run size distribution in the basin. In 1998, sea-run cutthroat trout creel survey results on the Lewis River showed a catch of only 20 fish (Hillson and Tipping 1999).

Resident cutthroat trout were the most abundant salmonid species captured during PacifiCorp's 1996-1997 fish population surveys in Yale Lake tributaries. In September 1996, the Swift No. 2 bypass reach contained an estimated 924 cutthroat trout greater than 65 mm (2.5 in) in length (254 cutthroat trout per mile) (PacifiCorp 1999). Cutthroat trout fry and adults were also captured in Ole Creek, Dog Creek, Speelyai Creek, and Panamaker Creek in 1996 and 1997. No other salmonids were observed during sampling in these smaller tributaries. In 1995, the USFS observed low numbers of cutthroat trout in Cougar Creek (USFS 1995a).

A NMFS status report on sea-run cutthroat trout in the lower Columbia River indicates that returns of both naturally spawned and hatchery produced fish have declined in almost all lower river tributaries over the past 10 to 15 years. One of the key concerns is the potential reduction in life-history diversity. In many streams, freshwater forms are well distributed with relatively high abundance in comparison to the anadromous forms in the same streams. NMFS concluded that habitat degradation and poor ocean and estuarine conditions are the likely causes of the severe depletion of anadromous forms of sea-run cutthroat trout. Therefore, on April 5, 1999, NMFS and the U.S. Fish and Wildlife Service (USFWS) jointly issued a proposed rule for the listing of the southwestern Washington/Columbia River sea-run cutthroat trout ESU as threatened under the ESA (Federal Register, Vol. 64, No. 64, April 5, 1999). The ESU includes populations of coastal cutthroat trout in the Columbia River and its tributaries downstream from the Klickitat River in Washington and Fifteenmile Creek in Oregon (inclusive) and the Willamette River and its tributaries downstream from Willamette Falls. Cutthroat trout found in the Lewis River are included in this ESU, although the status of Lewis River coastal cutthroat trout is currently unknown because of "insufficient quantitative information to identify a trend in abundance or survival" (WDFW 2000).

4.1.5.6 Pacific Lamprey

Life History

Pacific lamprey (*Lampetra tridentata*) belong to a very unique class of fish known as agnaths, or "jawless fishes." As the name implies, transformed individuals (non-larval lamprey) are jawless, with a nearly circular buccal funnel (suctorial disk) on the underside of the head. This funnel, the point of attachment for parasitic feeding, contains a raspy tongue and sharp teeth (Scott and Crossman 1973). Pacific lamprey have a round, elongate, almost cylindrical body to the dorsal fins where it becomes laterally compressed (Scott and Crossman 1973). The skin is smooth with no scales. Coloration can range from dark bluish gray to dark brown, although males can develop a reddish color during spawning (Hart 1973). The eyes of Pacific lamprey are small with no eyelids. Behind each eye there are a series of seven slits that open into gill pouches. The size of adult Pacific lamprey is variable. Adults can reach a length of 76 cm (30 in) and weigh over half a kilogram (1 lb.)[8]. Larval Pacific lamprey (ammocoetes) are pale brown in color and have no eyes or mouth, spending their larval years as sedentary, blind filter feeders (Moore and Mallat 1980).

The distribution of Pacific lamprey is similar to that of Pacific salmon. They are found in coastal streams along the Pacific coast, from Baja California to the Bering Sea in Alaska and Asia. The species is rare north of the Alaska Peninsula. In Washington, Pacific lamprey are found in most large coastal rivers including the Columbia, Snake, and Yakima river systems (Wydoski and Whitney 1979). Little is known about the marine distribution of the species.

Like Pacific salmon, Pacific lamprey are anadromous. They hatch and rear in freshwater streams, migrate out to the ocean, and return to freshwater as mature adults to spawn. As juveniles, they are filter feeders, using a hood-like flap to filter microscopic plants and animals from above and within the substrate (Moore and Mallatt 1980). As adults, Pacific lamprey are external parasites feeding on the body fluids of various species of fish, using their sucker-like mouths to attach to a fish. Once attached to its prey, lamprey use their tooth-lined tongue to rasp a hole through the skin. They are then able to feed upon blood and tissue, maintaining the flow by secreting an anti-coagulant to keep the prey's blood from clotting.

The spawning migration of adult Pacific lamprey usually extends from July to October (Figure 4.1-1) (Scott and Crossman 1973). They ascend rivers by swimming upstream briefly, then attaching to rocks and resting. Feeding appears to cease during the early stages of upstream migration. Upon entering freshwater, the sexually immature lampreys

[8] http://www.psmfc.org/habitat/edu_lamprey_fact.html

overwinter attached to stones or other structures. Starting in early spring the lamprey continue their voyage to the spawning grounds in the headwaters (Scott and Crossman 1973). Migrating lamprey may travel up to several hundred miles to their spawning grounds where both sexes will build a nest through sinuous body movement and suction. In the Columbia River system, the Pacific lamprey has been estimated to move 4.5 km (2.8 miles) per day (Kan 1975). A moderately strong swimming ability and the capacity to cling to rocks, dams, and fishways enable them to surmount most obstacles (Scott and Crossman 1973). During this freshwater migration the Pacific lamprey does not eat, and shrinkage in body size has been measured around 20 percent (Beamish 1980).

Pacific lamprey spawning takes place in spring (from April to July) when water temperatures are between (10 and 16°C) (50 and 60°F) (Figure 4.1-1). The males may arrive first, and both sexes dig the shallow nest 53 to 58 cm (21 to 23 in) in diameter with body movements and by moving stones with their suctorial disk. Once a shallow nest is built, the female attaches to a rock and floats over the nest. The male will gently move from tail to head, using slight suction and wrapping his body around the female. Once the male reaches the head, he wraps around the female, upon which eggs and sperm are emitted (Russell et al. 1987). Males will spawn with more that one female in different nests. Adults die within 4 days of spawning, after depositing about 10,000 to 100,000 extremely small eggs in their nest (Scott and Crossman 1973). Lower fecundity may be associated with those lampreys spawning further inland due to the higher bioenergetic cost of migration. Eggs are small and oval shaped, 1.06 to 1.09 mm (0.041 to 0.042 in) wide and 1.12 to 1.24 mm (0.044 to 0.048 in) long (Pletcher 1963). Upon initial spawning the eggs are adhesive and will stick to the substrate for 2 hours during which they are covered by substrate material stirred up by additional spawning activity.

Lamprey eggs hatch within 2 to 4 weeks, depending on water temperature. At 15°C (59°F), hatching time is 19 days (Pletcher 1963). After hatching, the larvae remain in the gravel for approximately 2 or 3 weeks before emerging and drifting to backwater or eddy areas with low water velocities and soft substrate (Figure 4.1-1). The juvenile lamprey then burrow into the substrate (typically silt/mud) and stay burrowed for 4 to 6 years, moving only rarely to new areas. During this period, the ammocoetes are blind, sedentary filter feeders (Richards 1980; Kan 1975; Pletcher 1963). Before emerging from the substrate, the ammocoetes undergo a metamorphosis lasting approximately 2 months where morphological and physiological changes prepare them for a parasitic life at sea. This metamorphosis is triggered by unknown factors but is generally complete by October or November (Beamish and Levings 1991). Larvae emerge from the substrate at this time as young adults and burrow themselves into cobble and gravel substrate while continuing to develop (Pletcher 1963). In the late fall or early spring, the juveniles emerge and take advantage of high flows to migrate to the ocean (Beamish and Levings 1991). During its ocean phase, Pacific lamprey are scavengers, parasites, or predators on larger prey such as salmon and marine mammals. After 2 to 3 years in the ocean they return to freshwater to spawn.[9]

[9] http://www.psmfc.org/habitat/edu_lamprey_fact.html

Like many of the other lamprey species, the adult Pacific lamprey does not have many predators. This may be in part to the distasteful secretions the lamprey produces through glands in its skin (Scott and Crossman 1973). During the larval stage Pacific lamprey fall victim to a wide variety of species including trout, crayfish (Astacidae), and birds.[10]

Habitat Requirements

Pacific lamprey spawn in the headwaters of both large and small streams in low gradient, sandy gravel areas located at the upstream end of riffles (Kan 1975, Scott and Crossman 1973). Preferred spawning velocities range from 0.5 to 1.0 m/s (1.6 to 3.3 ft/s) (Pletcher 1963; Kan 1975). Rearing habitat varies depending on life stage. Ammocoetes prefer slow current, soft substrate areas with temperatures ranging from 4 and 25°C (39 to 77°F) (Beamish 1980). Optimum growth seems to occur at 14°C (57°F) (Mallat 1983).

Upon emergence from the substrate, the almost fully developed lampreys burrow into cobble and boulder substrate. Migration takes place during high flow events because like most lamprey, the Pacific lamprey drifts (not swims) downstream with the current. Migration occurs during the night in the Columbia River system.

Upon entering saltwater, young lamprey move to water of depths over 70 m (230 ft) (Beamish 1980). During the ocean phase, Pacific lamprey are parasitic feeders, feeding mainly on other fish species. Feeding begins as soon as the lamprey enter saltwater (only occasionally in freshwater). Common food species are rockfish, salmon, lingcod (*Ophiodon elongatus*), sable fish (*Anoplopoma fimbria*), turbot (*Psetta spp.*), hake and pollock (*Theragra chalocogramma*). Attacks on halibut (*Hippoglossus stenolepis*) and whales have also been recorded. The high incidence of feeding marks on hake and pollock seem to show a preference for this mid-water layer associated with the plankton layer (Beamish 1980). While in saltwater, the pacific lamprey may roam great distances, having been collected at distances ranging from 10 km (6 miles) to greater than 100 km (62 miles) off of the Oregon coast (Kan 1975).

Abundance and Distribution in the Lewis River Basin

Based on our review of existing literature, no information currently exists describing the abundance and distribution of Pacific lamprey in the Lewis River basin. However, current stocks of the Pacific lamprey in the Columbia and Snake river systems are in a steep decline (Close et al. 1995). Due to their role in the food web of North Pacific ecosystems as predator and prey, and their status as a food and cultural resource for the Pacific Northwest Indian Tribes, plans for restoration of the stock are currently being developed.

[10] www.psmfc.org/habitat/edu_lamprey_fact.html

4.1.5.7 White Sturgeon

Life History

White sturgeon (*Acipenser transmontanus*), one of 8 species of sturgeon in North America, is a primitive, slow growing, bottom dwelling fish with a long cylindrical body, large head, and bluntly rounded snout. Body depth is approximately 14 percent of its total length (Scott and Crossman 1973). The species has four sensory barbels located near the anterior of its ventrally located, tube-like mouth[11]. Like all sturgeons, the white sturgeon has a cartilaginous skeleton and large modified scales (bony plates) called scutes that serve as a type of protective armor. The white sturgeon is distinguished from other species of *Acipenser* by the specific arrangement and number of scutes along its body. White sturgeon have 11 to 14 scutes in front of their single dorsal fin, no scutes behind the dorsal, 38 to 48 scutes on the side and 9 to 12 ventral scutes[12]. Dorsal coloration ranges from dark to light gray, pale olive and gray-brown being most common. Ventral surfaces are white and fins are dusky to opaque gray. Young white sturgeon are generally lighter in color than adults.

The white sturgeon is the largest fish found in the freshwaters of North America. It can reach a length of up to 6.1 meters (20 ft) and weigh of up to 816 kg (1,800 lbs.). In the Columbia River, white sturgeon reach a length of 36 inches when they are about 8 to 9 years old (Scott and Crossman 1973, Wydoski and Whitney 1979).

White sturgeon are distributed throughout the Pacific shores of North America from Ensenada, Mexico to Cook Inlet, Alaska. In Washington, they are found in the Columbia River (including the Lewis and Cowlitz rivers), Snake River, Grays Harbor, Willapa Bay, Puget Sound, and Lake Washington (Wydoski and Whitney 1979). Lower Columbia River white sturgeon have been captured in marine environments as far away as 528 km (328 miles) to the north and 298 km (185 miles) to the south of the Columbia River (Devore and Grimes 1993). Reports of lower Columbia River white sturgeon being captured as far away as Naknek, Alaska have not been substantiated, but it is within the northern reaches of the range.

The white sturgeon is a long-lived, slow growing, late maturing anadromous fish, although they do not require saltwater to complete their life-cycle. Typically, anadromous adults move into large rivers to spawn in the early spring, although some younger fish are reported to enter freshwater in the fall and winter (Scott and Crossman 1973). Spawning usually extends from May through June. Spawning activity is reported to occur over rocky substrate in the swift currents near rapids or waterfalls, when water temperatures are between 8.9 and 16.7°C (48 and 62°F) (Scott and Crossman 1973). Adults usually survive spawning and return to spawn more than once. However, only a portion of adult white sturgeon are reproductive each year, with the spawning frequency for females estimated at 2 to 11 years. Spawning was estimated to occur every 3 years for females in the lower Columbia River (DeVore et al. 1993). For white sturgeon in

[11] http://endangered.fws.gov/r/fr94549.html
[12] http://www.psmfc.org/habitat/edu_wsturg_fact.html

general, the size or age of first maturity in the wild is quite variable (PSMFC 1992). Females normally require a longer period to mature than males, with females for most sturgeon species spawning between 15 to 25 years of age. Males mature at about 12 years of age.

White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Female sturgeon are surrounded by males that fertilize the eggs as soon as they are extruded. Female white sturgeon may carry from 0.1 million to 7 million eggs depending on fish size and age (Scott and Crossman 1973). Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature. Recently hatched yolk-sac larvae swim or drift in the current for a period of several hours and settle into interstitial spaces in the substrate. Larval white sturgeon require 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes[13].

Early growth is highly variable. White sturgeon in the lower Columbia River are reported to reach a length of 36 inches in 8 to 9 years (Wydoski and Whitney 1979). Growth rates are slower after 35 years of age (Scott and Crossman 1973). Growth patterns do not indicate a decrease in rate that would lead to predictions of maximum size. A more recent study of lower Columbia River white sturgeon (DeVore et al. 1995) showed mean fork lengths of approximately 60 cm (24 in) at 10 years, 125 cm (49 in) at 20 years, 175 cm (69 in) at 30 years, 200 cm (79 in) at 40 years, 220 cm (87 in) at 50 years, and 240 cm (95 in) at 60 years. Life-span of the species is unknown although it is highly possible that the largest specimens are over 100 years of age (Scott and Crossman 1973).

The white sturgeon is a bottom feeder. The food of smaller sturgeon is mainly chironomids, mysids, *Daphnia*, molluscs, immature mayfly, caddisfly (Trichoptera), and stonefly. Older sturgeon feed primarily on fish, shellfish, crayfish, and various invertebrates and amphipods[14]. In May, migrating eulachon (*Thaleichthys pacificus*) and lamprey are the primary food sources (Scott and Crossman 1973). Swimming prey is gathered through a quick protrusion of the mouth that creates a vacuum which sucks the prey in. This feeding motion requires that the sturgeon avoid detection by the prey (BPA 1985). Availability of food is thought to account for seasonal changes in population distribution (DeVore and Grimes 1993).

The adult (non-landlocked) white sturgeon spends most of its time in the marine environment. While at sea, it is thought to stay close to shore in shallow water (depths up to 30 m [9,100 ft]). In fresh water, juvenile sturgeon are reported to move upstream in the fall and early winter with a corresponding move downstream in the late winter and early spring (Scott and Crossman 1973).

There are no published accounts of predation on either young or old sturgeon except for Pacific lamprey attacks (Scott and Crossman 1973). A PSMFC report describes finding

[13] http://endangered.fws.gov/r/fr94549.html
[14] http://www.psmfc.org/habitat/edu_wsturg_fact.html

walleye (*Stizostedion vitreum*) with small sturgeon in their stomachs. Suckers (*Catastomus* spp.), northern pikeminnow, and carp (Cyprinidae) have been found with sturgeon eggs in their stomachs. Man is believed to be the greatest predator on white sturgeon populations through exploitation of the resource and creation of physical and ecological barriers created by dams within historical population centers. A specific change resulting from this development is the reduction of water velocity and the turbulence created by it. As turbulence decreases, the ability of light to penetrate the water column increases, thus reducing the sturgeon's ability to capture swimming prey. This increased light also has the effect of increasing the vulnerability of sturgeon larvae to those predators using visual hunting techniques (BPA 1986).

Habitat Requirements

Most white sturgeon spawning in the lower Columbia River takes place during May and June. Preferred water temperatures range from 10 to 18°C (50 to 64°F), although most spawning takes place at 14°C (57°F). Preferred spawning water velocities range from 1.0 to 2.8 m/s (3.3 to 9.2 ft/s). The preferred spawning substrate appears to be cobble and boulders (Parsley et al. 1993). In the lower Columbia River, the available habitat that meets these parameters is almost always located within the 4 km (2.5 mile) reach directly downstream of Bonneville Dam, except during high flow years when adequate spawning conditions appear to exist farther downstream. During the high flow years of 1990 and 1991, fresh sturgeon eggs were collected at a site 41 km (25.5 miles) downstream from the dam (Tracy 1993).

Unlike salmon and trout, white sturgeon appear to require muddy, turbulent water for spawning. It is thought that this mud or silt is critical in preventing the clumping (reducing adhesiveness) and subsequent suffocation of eggs (Conte et al. 1988). As discussed in the previous section, white sturgeon appear to be mass spawners without any elaborate rituals associated with spawning. Female sturgeon are surrounded by males that fertilize the eggs as soon as they are extruded. Conditions for incubation are similar to those for spawning. The optimal temperature for incubation is reported to be 14°C (57°F) (Wang et al. 1985), which is equivalent to the preferred spawning temperature.

Upon hatching, sturgeon larvae immediately disperse into the water column. This stage lasts for about 6 days, less in fast water and more in slow water to control dispersal (Brannon et al. 1984). When not influenced by the current, hiding seems to begin when the larvae become negatively phototaxic.

The habitat requirements for juvenile white sturgeon are quite broad. In the lower Columbia River, larvae are typically found in relatively deep water with sand substrate. Rearing water velocities average about 1.6 m/s (5.2 ft/s) (Parsley et al. 1993). Sand substrate also appears to be important in that it allows the larvae to bury themselves and avoid predation. Larvae within the Columbia River impoundments typically are found in slightly shallower, lower velocity waters when compared to the lower river.

Young-of-the-year and juvenile sturgeon spend at least their early years in freshwater. It is not known at what age a tolerance for salinity is developed although fish as small as 46 cm (18 in) have been found in brackish water and as small as 107 cm (42 in) in ocean water. Travel to the ocean is not a requirement for the white sturgeon, with some sturgeon spending their entire life in fresh to brackish water. Large concentrations of sub-adult white sturgeon have been reported in the Columbia River estuary during the summer months.

Not much is known about the ocean life of white sturgeon. They have been found to roam great distances through incidental reports of tagged sturgeon being caught, but no formal studies of ocean life have been undertaken.

White sturgeon have become the principal sport fish on the lower Columbia River, with well over 100,000 angler trips annually[15]. With this popularity has come increased pressure on a population already stressed by changes to natural spawning grounds by the creation of dams. Populations in the lower Columbia River are considered relatively healthy and are monitored closely to maintain this status. Between 1983 and 1994, there were 15 regulatory changes implemented on the mainstem Columbia River as a result of increased fishing[16]. There are currently experimental programs and studies to research the potential for hatchery enhancement of this fishery to reduce fishing pressures and keep populations strong in multiple states.

Abundance and Distribution in the Lewis River Basin

Like Pacific lamprey, there is currently no published information available describing the abundance and distribution of white sturgeon in the Lewis River basin (Hanson et al. 1992). However, an approximately 80 to 100 lb. white sturgeon was captured with a gill net in the Yale Dam tailrace (Lake Merwin) in 1995 (pers comm., E. Lesko, PacifiCorp, November 2000).

The following management objectives have been adopted by Washington and Oregon for the lower Columbia River white sturgeon:

- Provide adequate recruitment to the broodstock population;
- Manage fisheries for optimal sustainable yield (OSY);
- Maintain an OSY harvest rate determined for the legal-sized population in sport and commercial fisheries;
- Maintain concurrent Washington and Oregon regulations in the Columbia River;
- Provide for year-round sport fishing opportunity;
- Maintain sport and commercial shares in the fishery; and

[15] www.worldstar.com/~dlarson/sturgeon/SturgeonoftheColumbia2.htm
[16] http://biology.usgs.gov/s%2Bt/noframe/e065.htm

- Consider emergency regulatory action if harvest is projected to compromise management objectives.

4.1.5.8 Northern Pikeminnow

Life History

The northern pikeminnow (*Ptychocheilus oregonenis*), previously known as the northern squawfish, is one of the largest native minnows (family Cyprinidae) in North America (Olney 1975). It can reach a weight of up to 13 kg (29 lbs.) and a length of up to 64 cm (25 in) (McPhail and Lindsey 1970). Individuals from the Columbia River basin are reported to grow as large as 61 cm (24 in) and weigh as much as 3.6 kg (8 lbs.)[17]. The species has an elongated, shallow body with a large terminal mouth extending back to below the anterior margin of the eye. Greatest body depth is approximately 15 to 19 percent of its total body length (Scott and Crossman 1973). Body coloration is dark green or green-brown above and silvery white or creamy ventrally. During spawning, the pectoral and pelvic fins of male northern pikeminnow become reddish, and both sexes usually develop a dark lateral band extending from head to tail.

Northern pikeminnow are distributed throughout the Pacific drainages of North America from the Nass River in British Columbia, Canada to the Harney River basin in Oregon, and eastward over to the Columbia River to Nevada (Page and Burr 1991). In Washington, northern pikeminnow are found throughout the Columbia River system and coastal Puget Sound drainages (Wydoski and Whitney 1979).

The northern pikeminnow is typically a lake and reservoir species, preferring still waters to swift flowing streams and rivers (Scott and Crossman 1973). Spawning occurs from April to July depending of geographic location. In Lake Merwin, most spawning is reported to occur between late May and mid-July (Graves 1982). Spawning northern pikeminnow tend to gather in large numbers, but no nest is built. Typically, the males greatly outnumber the females. During spawning, the female swims along the edges of large groups of males until a male or multiple males break off and follow the female. Eggs and sperm are released in the water column; fertilized eggs, which are adhesive and demersal, settle and adhere to the gravel-cobble substrate (Scott and Crossman 1973). This mating action is repeated several times. In the lower Columbia and Snake rivers, each female produces an average of 30,000 eggs (range 6,037 to 95,089), with the larger fish generally producing more eggs (Olney 1975). Fertilized eggs hatch in about 1 week and the young fish swim freely about 2 weeks after hatching[18].

Northern pikeminnow are slow growing and long-lived. Life expectancy for the species is 15 to 20 years (McPhail and Lindsey 1970). Growth is both sex and temperature dependant. Females generally grow faster than males (Wydoski and Whitney 1979). Most female northern pikeminnow reach sexual maturity at age 6. Males usually reach sexual maturity at age 3 (Wydoski and Whitney 1979).

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[17] http://www.streamnet.org/ff/Lifehistory/squawfish_facts.html
[18] http://www.streamnet.org/ff/Lifehistory/squawfish_facts.html

Northern pikeminnow are opportunistic feeders, consuming a wide variety of prey depending upon availability. Young individuals (10 to 25 cm [4 to 10 in]) have been known to consume fish eggs and larvae, aquatic plants, grain, terrestrial insects, and aquatic invertebrates (primarily insects and crustaceans). Fish become an increasingly important dietary component when pikeminnow reach and exceed 31 cm (12 in) in length. Sculpins are probably the most commonly utilized prey fish, but northern pikeminnow also prey on juvenile salmonids when available. Losses of juvenile anadromous salmonids can be significant in severely altered habitats such as near hydroelectric dams in the lower Columbia River basin. Dams concentrate, disorient, and injure outmigrating juvenile salmonids, making them more vulnerable to northern pikeminnow and other predators. In John Day Reservoir, the diet of northern pikeminnow under 20 cm (7.9 in) in length consisted of mainly insects (41.2 to 90.5 percent). The diet of 30 cm (11.8 in) fish was comprised of approximately 21 percent salmonids. The diet of even larger fish was comprised of up to 83 percent salmonids (Poe et al. 1991). In Lake Merwin, zooplankton was the major food item of northern pikeminnow less than 30 cm (11.8 in) long (Hamilton et al. 1970). The consumption of zooplankton decreased as fish size increased and was replaced by fish and crayfish. No fish were observed in the stomachs of squawfish less than 20 cm (7.9 in) in length.

The predatory habits of the northern pikeminnow are widely studied due to their impacts on game species. In John Day Reservoir, an estimated 14 percent of the juvenile salmonid population is lost to predation. Of these, 78 percent were consumed by the northern pikeminnow (Rieman et al. 1991).

Habitat Requirements

Northern pikeminnow spawn in the gravelly shallows along lake shores, in lakes near tributary streams, and in the lower reaches of tributary streams (Scott and Crossman 1973). Lake dwelling populations appear to spawn in streams only when gravelly shallows are not available (Jeppson and Platts 1959, Patten and Rodman 1969). Preferred spawning temperatures range from 10 to 15°C (50 to 59°F) (Beamesderfer 1992). However, spawning has been observed in water temperatures ranging from 6 to 20°C (43 to 68°F) by Reid (1971). Preferred spawning grounds typically have low velocities [0.06 to 0.43 m/s (0.2 to 1.4 ft/s)] (Rulifson 1984). Following spawning, most adults move back into the lake or reservoir. In the Lewis River basin, northern pikeminnow have been observed spawning in Speelyai, Canyon, Buncombe Hollow, and Rock creeks (Graves 1982). Lake spawning has also been observed at several sites near the southern end of Lake Merwin (WDF 1970).

Juvenile northern pikeminnow spend their first year in the shallow shoreline margins. The young pikeminnow form aggregations of around 50 and up to thousands. As the fish reach 1 year of age they begin to move slightly offshore, continuing in groups but expanding habitats to include deeper waters, pools, and sloughs (Beamesderfer 1992). In summer, northern pikeminnow occupy the shallows or move to the surface in the pelagic zone of the lake or reservoir where water temperatures are similar to those in nearshore areas. During the summer months, high concentrations of northern pikeminnow have been observed at the mouth of the Tilton River in Mayfield Lake, Washington (on the

Cowlitz River) (Tacoma Power 1999). In winter, northern pikeminnow are typically found in deeper water (Wydoski and Whitney 1979).

Abundance and Distribution in the Lewis River Basin

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 construction of the projects and the creation of substantial reservoir habitat, northern pikeminnow populations appeared to have 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 (WDF 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 Swift No. 2 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 1999). A 1995 creel survey in Yale Lake (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 (1999-2000) indicated a substantial catch of the species (PacifiCorp and Cowlitz PUD 2000c). More detailed information on this 1999-2000 catch will be available from WDFW in the spring of 2001.

Throughout their range, populations of the northern pikeminnow are managed mainly as game fish predators, and as such, management is focused on reduction of the species. Many studies have been done relating to this goal, covering chemical eradication, ecosystem manipulation, and dynamite control of pikeminnow populations (Scott and Crossman 1973). The Columbia River Basin has developed a program for system-wide predator control that includes bounty programs, long-line fisheries and dam fishing for northern pikeminnow in order to control the predation on salmonids. Over 1.1 million northern pikeminnow were removed by these programs between 1990 and 1996 (Ward and Zimmerman 1999).

4.1.5.9 Mountain Whitefish

Life History

The mountain whitefish (*Prosopium williamsoni*), one of six species in the genus *Prosopium*, has a slender, elongate, almost cylindrical body with silver sides, soft-rayed, dusky colored fins, and an adipose fin that clearly distinguishes it from suckers and chubs. The species also has a small terminal mouth and a single flap of skin between its nostrils. Although a member of the Salmonidae, the scales of the mountain whitefish are larger than those of both trout and salmon (fewer than 100 along the lateral line). The head is short, comprising about 20 percent of its total length (Wydoski and Whitney

1979). Juvenile mountain whitefish have 8 to 10 parr marks and one or more rows of black spots on sides (Scott and Crossman 1973).

The largest mountain whitefish on record is a 56 cm (22 in) 2.7 kg (6 lb.) specimen taken from Lake Tahoe, California. A fish about 30 cm (1 ft) long and weighing 0.34 kg (0.8 lbs.) would be considered a good-sized fish for Washington. The maximum recorded age for a mountain whitefish is 23 years, although few individuals live longer than 12 years (McPhail and Troffe 1998).

The mountain whitefish is distributed throughout western North America from central California to about the northwestern boundary of British Columbia, further north in upper Liard and Mackenzie rivers tributaries, and east to the Alberta-Saskatchewan border. In the southern reaches of its distribution (California, Nevada, Utah), it is limited to elevations of about 1,400 m (4,600 ft) due to high water temperatures (Northcote and Ennis 1994).

Mountain whitefish spawning usually occurs in the fall from October to December over coarse substrate (gravel and cobble), but also may occur on gravel shoals along the shores of lakes. Like salmon and steelhead, mountain whitefish exhibit strong homing instincts. Occasionally, they spawn in the same region as their summer foraging area, but most populations migrate to different spawning sites (McPhail and Troffe 1998). Usually these spawning migrations are downstream into the lower reaches of large tributaries or to the mainstem of large rivers. As with most salmonids, the exact time of spawning varies depending on location (latitude and elevation) (Wydoski and Whitney 1979). Peak spawning activity usually occurs at temperatures below 6°C (43°F); however, spawning has been observed at water temperatures ranging from 0 to 10°C (32 to 50°F) (McPhail and Troffe 1998). Mountain whitefish are nocturnal spawners (Brown 1952, McPhail and Lindsey 1970), spawning in small groups of two to four fish swimming closely together (Brown 1952). No nest or redd is prepared (Scott and Crossman 1973); rather, the eggs (which are adhesive) are simply scattered over the substrate. Fecundity averages about 5,000 eggs per female (Scott and Crossman 1973). The number of eggs per female generally increases with an increase in size (Northcote and Ennis 1994). Mountain whitefish eggs are relatively large and when water hardened average about 3.7 mm (0.15 in) in diameter (Brown 1952). Following spawning, there are usually well-marked post-spawning migrations to overwintering sites (McPhail and Troffe 1998).

At 8.9°C (48°F), mountain whitefish eggs hatch in about one month; lower water temperatures require a longer incubation period (Wydoski and Whitney 1979). Emergence from the substrate (interstitial spaces) usually occurs between late March and early June, depending on latitude and altitude (McPhail and Troffe 1998). Newly emerged fry are small and may drift downstream before moving into shallow, low velocity areas along the river margins (McPhail and Troffe 1998). The fry are positively phototactic (Liebelt 1970), which may account for their tendency not to hide under rocks as do other stream salmonids (Nelson and Paetz 1992).

The diet of juvenile mountain whitefish consists mainly of chironomid larvae and mayfly nymphs (Stalkner et al. 1974). As they age, the diet may grow to include caddis larvae, small mollusks, leeches, eggs of its own and other species (including eggs of other salmonids), and on occasion, fishes (Scott and Crossman 1973, Davies and Thompson 1976). When bottom fauna is scarce, mountain whitefish will eat midwater plankton and surface insects (Scott and Crossman 1973). Juveniles may be in competition with rainbow trout and salmon species since they eat many of the same foods (Scott and Crossman 1973). The young-of-the-year grow rapidly and reach about 6 to 10 cm (2.4 to 3.9 in) by October (the end of the first growing season). By the end of their second growing season, populations in southern British Columbia often exceed 20 cm (7.9 in) in length. Rapid growth continues into their third growing season and then slows as individuals reach maturity (McPhail and Troffe 1998). The growth rate for male and female mountain whitefish is similar. Sexual maturity is usually reached when the fish are 3 to 4 years old (Brown 1952, Wydoski and Whitney 1979). In Swift Reservoir, captured mountain whitefish ranged from 26 to 46 cm (10 to 18 in) in length (Graves 1982).

Mountain whitefish appear to have few natural predators besides man. It has been established that lake trout (*Salvelinus namaycush*) and possibly burbot (*Lota lota*) will eat them in some areas (Scott and Crossman 1973). The mountain whitefish has not been shown to be a serious predator on salmon or trout in Canadian waters, although it may be a minor competitor for food in some areas (Scott and Crossman 1973).

<u>Habitat Requirements</u>

River resident and lake resident populations of mountain whitefish commonly move into smaller tributaries to spawn (Brown 1952, Bruce and Starr 1985), although there is evidence of some mainstem and lake spawning populations (Hildebrand and English 1991, Simon 1946, McPhail and Lindsey 1970). In streams, spawning usually occurs in shallow water ranging from 13 to 122 cm (5 to 48 in) deep, over rubble and gravel substrate. Typically, preferred spawning areas are located in or just upstream from riffles or rapids (McPhail and Troffe 1998, Brown 1952). In lakes, spawning usually occurs along gravel shoals near the lake edge at depths of 13 cm (5 in) to 120 cm (4 ft) (Scott and Crossman 1973, McPhail and Lindsey 1970).

The upper optimal temperature for mountain whitefish egg development is 6 °C (42.8°F) (Rajagopal 1975 and 1979). High mortality and abnormality rates begin to develop as water temperatures exceed 9°C (48.2°F). All eggs die at temperatures between 12 and 15°C (53.6 to 59.0°F). Dissolved oxygen saturation levels were found to affect egg survival once it decreased to 35 percent at 4°C (39.2°F), with a marked reduction upon reaching 25 percent (Siefert et al. 1974).

Following emergence from the substrate, mountain whitefish fry usually spend a few weeks in the stream shallows before moving into deeper, higher velocity areas (Scott and Crossman 1973). Preferred habitat consists mainly of protected backwaters created by rubble and boulders or side channel habitat (Brown 1952). Upon reaching approximately 5.5 cm (2.2 in) in length, mountain whitefish fry move away from this lateral habitat and are found in fringes or tail of pools over rock or rubble substrates (Davies and Thompson 1976).

Relatively little specific information is available regarding habitat use by yearling mountain whitefish in streams and rivers. Overwintering typically takes place in backwater shallows 18 to 30 cm (7.1 to 11.8 in) deep (Davies and Thompson 1976), or in pools. In the summer, yearling mountain whitefish typically occupy mainstem riffles and runs. Yearlings undergo seasonal migrations between feeding and overwintering habitats, but these typically do not exceed a few kilometers.

Adult mountain whitefish exhibit a much wider range to reach seasonably preferred habitats. They may inhabit small, turbid pools as well as cold, deep lakes, but are most frequently found in the uppermost 5 to 6 m (15 to 20 ft) (Scott and Crossman 1973). Stream velocities are usually on the fast side, but they have been found in water with velocities of 80 cm/s (2.6 ft/sec) during low streamflow periods (Wydoski and Whitney 1979). Preferred temperatures range from 8.9 to 11.1°C (48 to 52°F), although that changes seasonally with that in spring being higher than winter, and that in the pre-spawning period being higher than in the postspawning period (Ihnat and Bulkley 1984).

<u>Abundance and Distribution in the Lewis River Basin</u>

Very little information is available describing the abundance and distribution of mountain whitefish in the Lewis River basin. In 1971, WDF (1971) reported capturing large numbers of mountain whitefish in the mainstem Lewis River "just upstream from Colvin Creek" (below Merwin Dam). In 1980, Graves (1982) reported capturing mountain whitefish in the Swift No. 2 bypass reach, the inlet to Siouxon Creek, and near Cougar Creek. Size range was 20 to 30 cm (7.9 to 11.8 in) in length. No mountain whitefish were caught in or near Yale Lake in 1981 or 1982. Graves (1982) also reported capturing immature mountain whitefish in gillnets in Swift Reservoir "in every inlet connected to a stream" as well as adult mountain whitefish in the Swift No. 2 canal. Adult mountain whitefish were also caught in the "Eagle Cliff area at confluence of river and reservoir and Swift Creek inlet in April and September". Anglers in Swift Reservoir also caught 24 mountain whitefish, most of which were released. No mountain whitefish were observed or captured in Lake Merwin during the 3 years of study (Graves 1982). Mountain whitefish have also been observed in the lower 6.6 km (4.1 miles) of Pine Creek, the lower 0.4 km (0.25 miles) of Cougar Creek, the lower 10.0 km (6.2 miles) of Muddy River, and in Rush Creek downstream from the falls (USFS 1994, USFS 1995a, USFS 1995b).

4.1.5.10 Bull Trout

<u>Life History</u>

Bull trout are classified in the same genus as Dolly Varden, brook trout (*S. fontinalis*), lake trout, and Arctic char (*S. alpinus*). The species closely resembles Dolly Varden; for almost 100 years, it was considered an inland form of that species. In 1978, taxonomists formally recognized bull trout as a distinct species (Cavender 1978). This distinction was based on morphometric (measurement), meristic (geometrical relation), and osteological (bone structure) differences in the two species.

The bull trout is shaped like a trout but has light colored (cream to crimson) spots on an olive green background (trout and salmon have dark spots on a lighter background), a white margin on the leading edge of the ventral fins, and teeth only at the head of the vomer (Bjornn 1991). Juvenile bull trout have 8 to 12 irregular parr marks with a dark speckling on the ventral surface (Scott and Crossman 1973, Goetz 1989). During spawning, the male bull trout becomes very dark green on the flank and back, the dorsal spots fade, the ventral surface turns a coral/orange color; and the gill covers and head turn black. Female bull trout retain a lighter green body color with a grey-white underside (Goetz 1989). Bull trout are distinguished from other chars by the shape and size of the head and lower jaw; the number and arrangement of basibranchial teeth (on the roof of the mouth); the morphology of the gill rakers; the number of pores on the mandibles; and the configuration of bones in the cranium (Bjornn 1991, Goetz 1989).

As with most salmonids, the size of adult bull trout depends on the life history type and region. Adult bull trout, which are generally larger than adult Dolly Varden, can reach more than 102.5 cm (40.5 in) in length and weigh more than 14.5 kg (32 lbs.) (Goetz 1989, USFWS 1998b). Adfluvial bull trout (described in the following section) are known to reach the largest size while headwater resident populations have the smallest adult fish. Bull trout as large as 82 cm (32.4 in) have been captured in the Lewis River basin (WDFW 1995). The Washington State rod and reel bull trout record is 10.2 kg (22.5 lbs.), taken from the Tieton River in 1961 (Brown 1994).

Bull trout are native to most of the interior and some coastal drainages of the Northwest, from the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in Northwest Territories, Canada. To the west, bull trout range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska (Bond 1992). Bull trout are widespread throughout tributaries of the Columbia River basin, including its headwaters in Montana and Canada. They also occur in the Klamath River basin of south central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and the MacKenzie River system in Alberta and British Columbia (Federal Register, June 10, 1998 [Volume 63, Number 111], Cavender 1978; Bond 1992).

Bull trout exhibit two 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 three 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 or migratory behavior (Federal Register: June 10, 1998 [Volume 63, Number 111], Rieman and McIntyre 1993). The migratory forms of bull trout are generally of the most concern throughout their inland range (Brown 1994). In the Lewis River basin, migratory (adfluvial) populations of bull trout are found in all three project reservoirs (PacifiCorp and Cowlitz PUD 2000c). 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 (PacifiCorp and Cowlitz PUD 2000c).

Throughout their range, 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, bull trout residing in Swift Reservoir migrate into tributary streams from late May through early-August, and spawn from early August through the middle of September (Figure 4.1-1) (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 (primarily in Cougar Creek) occurs from late-September through early-October (Figure 4.1-1) (Graves 1982; pers. comm., E. Lesko, PacifiCorp, October 2000). 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.

All life forms of bull trout generally spawn in low gradient stream reaches with water temperatures between 5 and 9°C (41 and 48°F). Spawning areas contain gravel substrates and are often associated with cold-water springs and groundwater infiltration. Proximity to instream cover is also an important component of redd site selection (Fraley and Shepard 1989). Redds are commonly found in glides and the tail-outs of pools (Shepard, Pratt and Graham 1984 in Polacek 1998). Homing is relatively precise and some adults return to the same spawning area each year (Goetz 1989, Scott and Crossman 1973).

Spawning behavior is similar to that of other salmonids. Redd construction is usually completed by one male and one female (Goetz 1989). The female digs the redd with an up and down tail action, moving in an upstream direction. Pre-spawning behavior includes body pressing and quivering. Eggs and milt are released after the males and female press together, arch their backs, gape and quiver. A female may be accompanied by as many as five males (Goetz 1989). Adult bull trout are capable of spawning year after year, although most adults spawn every second year. Fecundity is variable and dependent on the size of the female (Brown 1994). Thirty-two bull trout sampled in the Flathead River basin contained an average of about 5,500 eggs (Fraley and Shepard 1989). Bull trout captured in Arrow Lakes, British Columbia, were smaller and contained fewer than 2,000 eggs (McPhail and Murray 1979). In 3 southeastern Washington streams, the fecundity of 7 bull trout ranged from 490 for a 270 mm fish to 3,350 for a 620 mm fish (Martin et al. 1992). Bull trout eggs are orange-yellow in color, demersal and non-adhesive, ranging in size from 5.0 to 6.2 mm (.20 to .24 in) (Goetz 1989).

Following spawning, bull trout embryos incubate in the gravel for 50 to 250 days depending upon water temperatures (Fraley and Shepard 1989). Optimum water temperatures for incubation are between about 2° and 4°C (36 to 39°F) (McPhail and Murray 1979; Brown 1985; and Carl 1985 in Brown 1992). Throughout their range, bull trout fry usually emerge from early April through May. In the Lewis River basin, emergence is believed to occur from late-January through early-March (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000).

Juvenile adfluvial bull trout remain in the tributary (nursery) streams for up to 6 years before migrating downstream to lakes or rivers (Goetz 1989). In most rivers, bull trout juveniles migrate downstream at 2 to 3 years of age (Fraley and Shepard 1989; McPhail and Murray 1979). Rearing fry and juveniles are very territorial, inhabiting stream bottoms in covered areas (riparian vegetation, pools, boulders, etc.) with low water velocities and cool water temperatures.

While rearing in the tributary streams, juvenile bull trout are opportunistic feeders. Preferred food items of juvenile bull trout under 11 cm (4.3 in) in length include immature insects, leeches, snails, and salmonid eggs. Between 11 and 14 cm (4.3 and 5.5 in), bull trout become more piscivorous (Goetz 1989).

The timing of juvenile emigration varies by age, size, and habitat availability (Goetz 1989). Throughout their range, juvenile bull trout emigration has been reported to occur during the spring, summer and fall (Shepard et al. 1984; and Oliver 1979 in Pratt 1992). Emigration of juveniles from the tributaries to Swift and Yale reservoirs is believed to occur from mid-May through June (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000).

While rearing in the lake/reservoir environment, larger adfluvial bull trout are highly piscivorous. They are known to prey heavily on kokanee, rainbow trout, mountain whitefish, sculpins and yellow perch (*Perca flavescens*). Cannibalism of fry and juveniles by larger individuals has also been reported. The bull trout is also known to consume a number of exotic items including squirrels, ducklings, snakes, mice and frogs (Goetz 1989).

Bull trout eggs are preyed upon by whitefish and suckers. Juvenile bull trout fall victim to larger adult bull trout and adult bull trout are preyed upon by bear, mink, otter, and osprey (Brown 1994). During the mid- to late-summer period of staging, bull trout pre-spawning aggregations are extremely susceptible to angling mortality (Brown 1994).

Interspecific competition between bull trout and other fish species occurs to some extent. Studies of food habits and interspecific competition between char and other salmonids such as coho salmon, rainbow trout, and cutthroat trout have generally concluded that in competitive situations, the char tend to be excluded from the upper water column and make greater used of benthic areas and benthic food. Competition for prey between bull trout and northern pikeminnow has also been documented (Brown 1994).

The large scale stocking of brook trout throughout the Pacific Northwest is a major threat to bull trout populations, including those bull trout in the Lewis River basin. Hybridization can occur between bull trout and brook trout (Goetz 1989). Researchers have postulated that this hybridization is frequent and may lead to the extirpation of bull trout by displacement. Bull trout and brook trout are also known to have the same feeding habits and occupy the same habitat (Brown 1994).

Habitat Requirements

Bull trout distribution is strongly influenced by water temperature. Researchers recognize temperature as the most consistent factor influencing bull trout distribution (USFWS 1998a). Optimum water temperatures for bull trout have been estimated at 2 to 10°C (36 to 50°F), while temperatures above 15°C (59°F) are thought to provide a thermal barrier for most bull trout (Federal Register, Vol. 63, No. 111, June 10, 1998). A narrow range from 10 to 12°C (50 to 54°F) represents the preferred water temperatures for spawning migrations.

Preferred spawning habitat generally consists of low gradient stream reaches often found in high gradient streams that have loose, clean gravel and late summer to early fall water temperatures of approximately 5 to 6°C (41 to 43°F) (USFWS 1998a). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater inflow (Federal Register, Vol. 64, No. 210, November 1, 1999). In general, an increased proportion of fines in the substrate (gravel) is inversely related to salmonid egg survival and emergence. Mortality increases sharply with mixtures of 30 percent or more fines (less than 6.35 mm). Zero survival was reported for mixtures of 50 percent or more fines (Watson and Hillman 1997). However, recent research on kokanee incubation and survival in Idaho has shown an increase in the survival of preemergent fry from redds located in up-welling sites compared to redds in other areas, even if the upwelling sites contained significantly more fine sediments (Garrett et al. 1998). As for all salmonids, extreme streamflows may result in embryo and fry mortality; high flows scour redds and smaller substrates while low flows expose redds (Goetz 1989).

Small bull trout (less than 10 cm [3.9 in]) are primarily bottom-dwellers, occupying positions above, on, or below the stream bottom (Federal Register, Vol. 64, 1 November 1, 1999). High juvenile densities have been observed in locations characterized by diverse cobble substrate and a low percent of fine sediments (Federal Register, Vol. 64, November 1, 1999). Bull trout juveniles are strongly associated with cover, including the interstitial spaces in the substrate, which makes them especially vulnerable to effects of sediment deposition, bedload movement, and changes in channel morphology (Pratt 1985, USFWS 1998a).

In lakes and reservoirs, adult bull trout are found throughout the water column during the fall, winter and spring, often near the mouths of migration routes (USFWS 1998a). In the summer, as water temperatures begin to warm, they are reported to move into deeper water, often below the thermocline (Goetz 1989). Adult adfluvial bull trout have been reported to go as deep as 110 m (360 feet). Thermal preference (between 8 and 14°C [46 and 57 °F]) influences vertical distribution (Goetz 1989). Diel migrations have been noted for the adfluvial bull trout (Goetz 1989, Baxter and McPhail 1997). Adult bull trout also maintain close association with substrate and show preference for deep, cold water. Summer habitat has been characterized by water temperatures from 9 to 15°C (48 to 59°F), gradients of 10 to 20 percent, moderate to fast currents, and stream widths of 2 to 5 meters (6.5 to 16.4 ft) (Goetz 1989). Resident adults often overwinter in deep pools or migrate downstream to deeper water near tributary mouths. Fluvial adults winter in deep pools, or in lower reaches of mainstream rivers, to make use of woody debris and overhanging banks for cover (Goetz 1989). Watson and Hillman (1997) found direct relationship between bull trout density, maximum pool depth, and percentage of undercut banks.

Abundance and Distribution in the Lewis River Basin

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 (Federal Register, Vol. 63, No. 111, June 10, 1998). In the Lewis River, 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 No. 2 bypass reach and in the Swift Creek arm of Swift Reservoir (PacifiCorp 1999). 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 utilizing Cougar Creek has been documented annually since 1979. During this period, 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 4.1-2). 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.

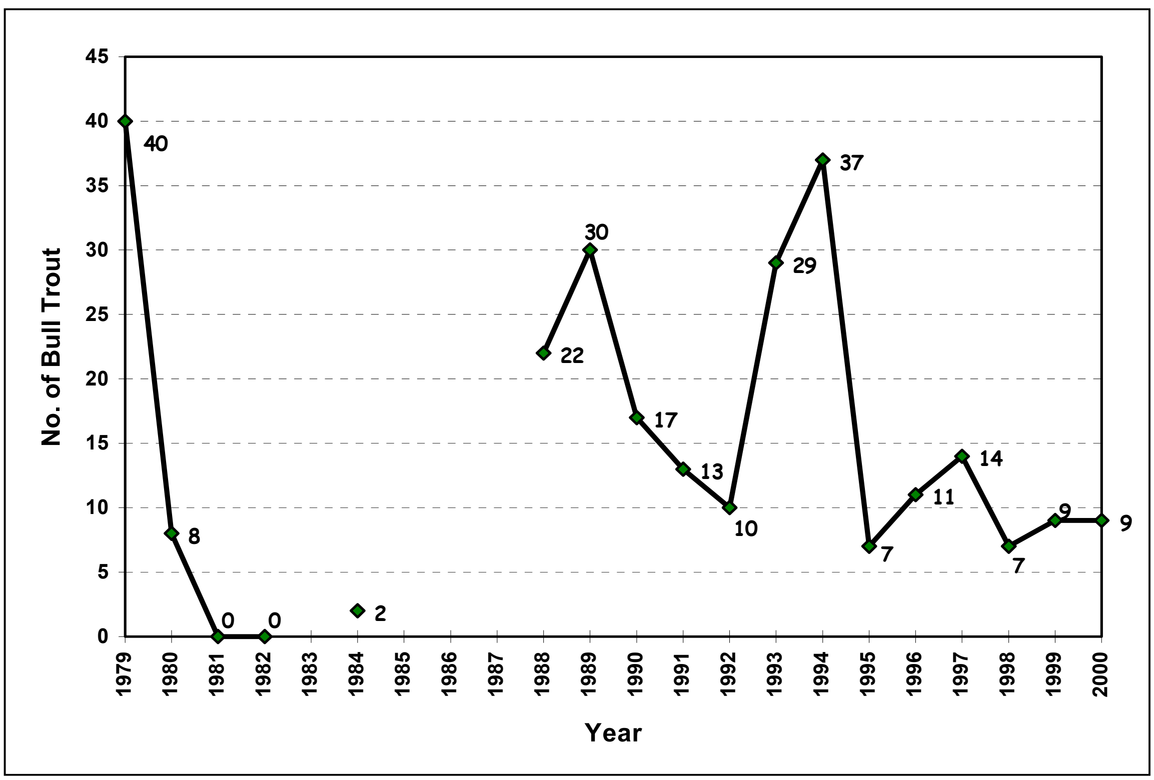

Figure 4.1-2. Annual peak counts of bull trout spawners observed in Cougar Creek 1979-2000.

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; Lesko 2001). Based on the available data, the Cooperators estimated, using a Peterson estimator, the annual spawning population of bull trout in Swift Reservoir. Between 1994 and 2000, the annual spawner population in Swift Reservoir has ranged from 101 to 437 fish (Figure 4.1-3) (Lesko 2001; pers. comm., Dan Rawding and J. Weinheimer, WDFW, 2000).

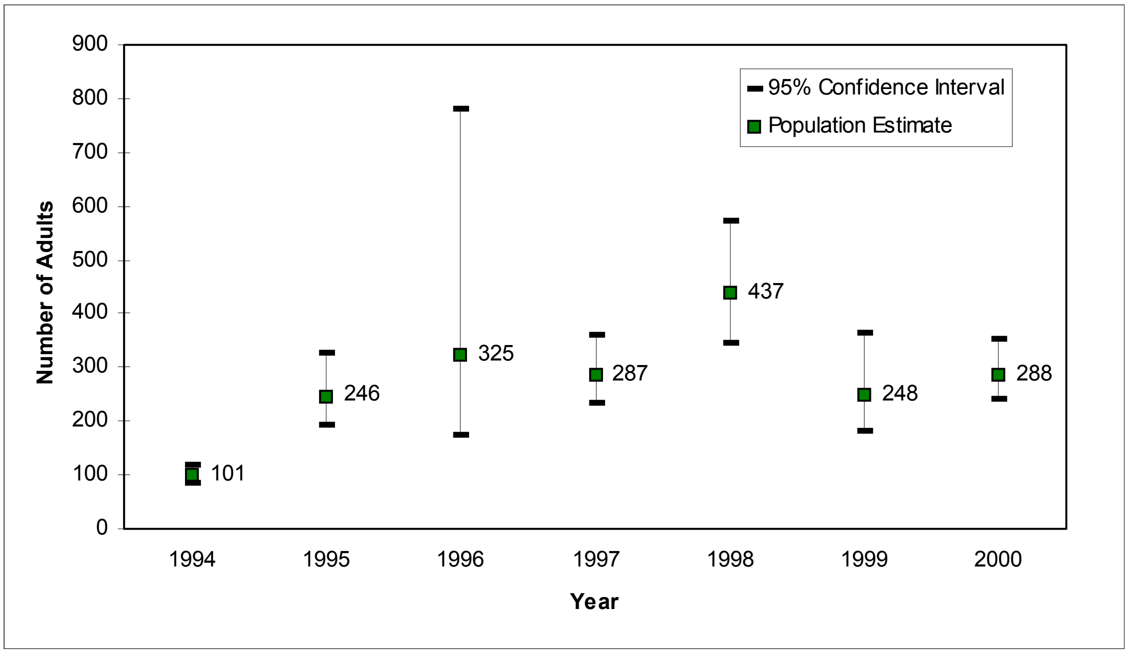

Figure 4.1-3. Spawning population estimate of bull trout in Swift Reservoir for the years 1994 through 2000. (Source: Dan Rawding and John Weinheimer, WDFW)

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 (including fish collected in 2000) (Table 4.1-11) (Lesko 1999, Lesko 2000, Lesko 2001). Of these, 45 were transferred to the mouth of Cougar Creek and 14 were released back into Lake Merwin (Table 4.1-11).

The lengths of bull trout captured in the Yale tailrace during this period ranged from 33 to 82 cm (fork length) (PacifiCorp 1999). Based on recapture data from the Cooperators, growth can range from 30 to 60 mm (1.2 to 2.4 inches) in one year.

In 1999, PacifiCorp and the WDFW began netting bull trout in the Swift No. 1 tailrace and Swift No. 2 tailrace and canal, an enhancement measure included in the Yale license application. This effort was initiated in response to creel reports in 1999 and 2000 that documented angler catch of bull trout in the canal. The purpose of this sampling was to better understand the number of bull trout residing in the Swift canal through direct sampling of the tailrace and canal. To date, only 1 bull trout has been captured in the Swift No. 1 tailrace (canal) and 2 in the Swift No. 2 tailrace (Lesko 2001). In July 2000, an adult bull tout was observed in the Swift No. 1 surge tank along with approximately 80 rainbow trout (Lesko 2001).

Table 4.1-11. Number of bull trout collected from the Yale tailrace (Lake Merwin) and transferred to the mouth of Cougar Creek (Yale Lake) or released back into Lake Merwin (1995 through 2000).

Year	Number Collected in Yale Tailrace (not including recaptures)	Number Transferred to the Mouth of Cougar Creek (not including recaptures)	Number Released Back into Lake Merwin
1995	15	9	6
1996	15	13	2
1997	10	10	0
1998	6	6	0
1999	6	0	6
2000	7	7	0
Total	**59**	**45**	**14**

Bull trout/Dolly Varden have also been captured in the ladder at the Lewis River hatchery or the trap at Merwin Dam. The last known bull trout/Dolly Varden was captured at the Lewis River ladder in 1992 (PacifiCorp and Cowlitz PUD 1999). Detailed records of these catches are not available.

Genetic samples were taken from bull trout captured in Lake Merwin, Yale Lake, and Swift Reservoir in 1995 and 1996. Analysis showed that Lewis River basin bull trout were genetically similar to the Columbia River population (Spruell et al. 1998). However, the Swift population was found to be significantly different from that in Yale Lake and Lake Merwin (Spruell et al. 1998). This implies that there may have been biological separation of the upper and lower basin stocks prior to completion of Swift Dam in 1958.

According to WDFW (1998), the bull trout populations in the Lewis River basin are considered as having a “moderate” risk of extinction. On November 1, 1999 the U.S. Fish and Wildlife Service (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, Vol. 64, No. 210, November 1, 1999). This rule was based upon the previous listing of Klamath River, Columbia River, and Jarbidge River population segments and the need to list Coastal-Puget Sound and St. Mary-Belly River population segments. Together, these population segments encompass the entire range of bull trout within the mainland United States (Federal Register, Vol. 64, November 1, 1999).

4.1.5.11 Kokanee

Life History

Kokanee salmon (*Oncorhynchus nerka*) occur in two 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. Kokanee complete their entire life cycle in freshwater (Meehan and Bjornn 1991). Like other Pacific salmon, the body of the kokanee is fusiform and laterally compressed. Coloration is steel-blue to green-blue on the back with no distinct spotting. Sides are silvery and the underside is white. Fins are generally clear, though the dorsal fin, adipose fin, and tail are dark colored. Coloration during spawning can change greatly, with males developing a red back and sides, and a green head. Females are similar but the body is a darker grey-red (Scott and Crossman 1973).

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 their range, the average length of kokanee adults ranges from about 20 to 38 cm (8 to 15 in), although kokanee as large as 53 cm (21 in) are not uncommon, especially in more southern locations. Female kokanee sampled in Cougar Creek (Yale Lake) had a mean length of 29.1 cm (11.5 in) (range 24.2 to 37.5 cm [9.5 to 14.8 in]) (1978-1998 data, PacifiCorp 1999). The length of kokanee sampled during creel surveys on Lake Merwin ranged from 26 to 42 cm (10.2 to 16.5 in), with most fish measuring 33 to 36 cm (13 to 14.02 in).

Kokanee are present over much of the range of the sockeye salmon, extending from the Klamath River, California, to Point Hope in Alaska, and in Asia from northern Hokkaido, Japan, to the Anadyr River, Russia. It occurs naturally in many lakes to which anadromous salmon no longer have access but must have had at one time. Populations occur most widely and abundantly in British Columbia. Kokanee introductions have occurred throughout North America including the Great Lakes and Canada (Scott and Crossman 1973). Kokanee were introduced into the North Fork Lewis River above Merwin Dam in the late 1950s from Kootenay Lake and Cultus Lake, British Columbia (PacifiCorp 1999).

Kokanee mature and migrate into their natal streams from late August through October. Peak spawning usually occurs from September through late October (Scott and Crossman 1973). In the Lewis River basin, migration typically starts in mid-September and continues to mid-October, peaking in October (Figure 4.1-1) (pers. comm., E. Lesko, PacifiCorp, October 2000). Peak spawning also occurs in October (Figure 4.1-1). In this system, the majority of kokanee spawning occurs in the lower reaches of Cougar Creek, a tributary to Yale Lake. Some limited spawning has also been observed in the Swift No. 2 bypass reach and Ole Creek (PacifiCorp 1999). In Lake Merwin, spawning is reported to occur in the lower portion of Canyon Creek and in Speelyai Creek below the hatchery diversion. It is likely that there is minimal natural production in the tributaries to Lake Merwin and that the primary recruitment of kokanee into this reservoir is largely from Yale Lake (as a result of fish passing the dam).

While on the spawning grounds, the male kokanee is quite aggressive toward other males, guarding access to the female while she prepares the redd. The female prepares the redd by lying on her side and beating her tail up and down, creating a shallow hollow streambed. The male and female swim into the nest and deposit the eggs and sperm into the depression. The female covers the nest by digging upstream of the nest and allowing the gravels to settle upon the egg pocket. The female may dig and spawn in more than one redd with different males, and a single male may spawn with more than one female (Scott and Crossman 1973). Adults of both sexes usually die a few days to a few weeks after spawning.

Fecundity is extremely variable and dependent on the size of the female. In Cougar Creek, kokanee were found to contain an average of 490 eggs per female (range 360 to 716 eggs per female) (PacifiCorp 1999).

Assuming constant winter temperatures just above freezing, kokanee hatch in late December or early January (80 to 140 days) (Meehan and Bjornn 1991). The young kokanee alevins remain in the gravel, feeding off their yolk sac until the spring. Once they are "buttoned-up," the young fry struggle out of the gravel and begin their migration down to the lake for summer rearing. In Cougar Creek, kokanee emerge from the gravel in February and early March and outmigrate from mid-March through April (Figure 4.1-1). Kokanee outmigration is highly synchronized and occurs during the night, so that thousands of fry swim/drift en masse to the lake in an attempt to minimize predation (Burgner 1991).

While rearing in the lake environment, kokanee are mainly pelagic, plankton feeders, targeting small freshwater shrimp, *Daphnia, Cyclops, Diaptomus, Epischura,* mayflies, black fly larvae (Simulidae), and other assorted zooplankton (Scott and Crossman 1973). Kokanee diets in Lake Merwin and Yale Lake were reported to consist of mainly *Bosmina* sp. and naupli in May and June. From July through October, cladocerans and copepods were the main prey items (Graves 1982). A serious competitor with young kokanee for food in many lakes is the threespine stickleback (*Gasterosteus aculeatus)*, which has been observed in Yale Lake (PacifiCorp 1999). A large crop of actively feeding sticklebacks can potentially have a serious effect on the growth and well-being of a population of kokanee (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). In the Lewis River basin, juvenile kokanee rear for an average 2 to 3 years before spawning. Reaching maturity at age 3 is quite typical in the southern portion of the species range. Kokanee populations found in Yale Lake and Lake Merwin exhibit highly density-dependent growth rates. Measurements of body size and spawning escapement indicate a strong inverse relationship (i.e., the larger the spawning population, the smaller the mean length of spawning fish (PacifiCorp 1999).

Kokanee eggs and fry are subject to predation by a variety of fish and birds while still in the stream environment. Cutthroat trout (*O. clarki*) in particular follow the spawning kokanee adults up into tributary streams. In Lake Merwin, adult cutthroat trout were found congregated near spawning kokanee in Speelyai and Canyon creeks. Gut analyses of these fish showed stomachs full of single kokanee eggs. Similar observations were made in Cougar Creek, the main tributary spawning area for kokanee within Yale Lake (Graves 1982). In the lacustrine environment, zooplankton and insects are the preferred prey item of juvenile northern pikeminnow, rainbow and cutthroat trout, bull trout, coho and Chinook salmon. During the early spring and late fall, zooplankton is less plentiful and kokanee fry become the targeted prey item for these predaceous fish species.

Habitat Requirements

Adult kokanee spawn in small streams flowing into lakes, in the gravel areas along lake shores, or in the upper reaches of lake outlet streams (Meehan and Bjornn 1991). Stream spawning kokanee often select the slower moving riffle areas near the stream margins. Preferred spawning gravel sizes in streams range from 1.3 to 1.9 cm (0.5 to 0.7 in) in diameter (Meehan and Bjornn 1991). Lake spawning populations prefer areas of groundwater upwelling along lake shores. Preferred gravel sizes in lakes range from 0.3 to 2.5 cm (0.1 to 1.0 in) in diameter. Preferred water depths range from 0.3 to 9.1 m (1 to 30 ft).

The habitat requirements during incubation are similar to those of other salmonids. Adequate water flow is needed to maintain oxygen levels within the egg pocket and to flush metabolic wastes. Developing eggs require protection from freezing, dewatering, or physical damage caused by shifting substrates. Because there must be an optimum time of emergence that coincides with favorable feeding and survival conditions, spawn timing in relation to environmental temperature is extremely important to optimize emergence timing (Burgner 1991). If emergence is too early in the season, no food resources will be available to the young fry. If emergence is too late, aquatic insects and zooplankton may be too large for the fry to consume.

Kokanee fingerlings enter the lake environment in late spring and early summer and remain in the nearshore environment, preferring depths less than 9.1 m (30 ft). By midsummer (July), kokanee begin to school together, inhabiting deeper water, and exhibiting a diel behavior. The fry appear near the surface at dusk and leave at dawn, descending to the deeper, cooler waters to spend the daylight hours (Burgner 1991).

Since both kokanee and bull trout spawn in Cougar Creek in September and October, there is concern that bull trout redds are disturbed by spawning kokanee. Several factors occur that may reduce interspecific impacts between spawning bull trout and kokanee:

- There is some degree of spatial separation as bull trout tend to spawn in the upper reaches of Cougar Creek and kokanee spawn in the lower portion of the creek.

- Kokanee deposit eggs in shallow redds, while bull trout deposit eggs in redds up to 12 inches deep (Faler and Bair 1992).

- Following hatching, kokanee fry move directly to the reservoir, whereas bull trout remain in the stream for 2 to 3 years (Faler and Bair 1992).

Abundance and Distribution in the Lewis River Basin

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 2000c). Tributaries to all three reservoirs were stocked with kokanee from Kootenay Lake and Cultus Lake, British Columbia. The primary purpose of their introduction was to create a reservoir fishery. Self-sustaining kokanee populations currently exist in Yale Lake and Lake Merwin. In 1996, WDFW decided to supplement the kokanee population in Lake Merwin using hatchery kokanee spawned and reared at Speelyai Hatchery. In 1999, Yale Lake received its first planting of kokanee since 1957. Plants in Yale Lake were temporary and discontinued in late 2001.

Yale Lake kokanee spawn primarily in Cougar Creek. 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) (Table 4.1-12). The data also show a strong inverse relationship between spawning escapement and mean kokanee length; that is, the larger the spawning population, the smaller the mean length of spawning fish (letter from E.

Table 4.1-12. The spawning year, peak count, estimated escapement, number of females and the mean fecundity of spawning kokanee in Cougar Creek (1978 to 2000).

Spawning Year	Peak Count	Estimated Escapement	Mean Length (mm) Females	Mean Fecundity
1978	32,064	70,541	325	582
1979	26,136	57,499	300	515
1980	54,782	120,520	275	448
1981	25,614	56,351	300	515
1982	5,750	12,650	375	716
1983	2,875	6,325	359	673
1984	9,915	21,813	329	593
1985	25,623	56,371	294	499
1986	47,680	104,896	264	419
1987	63,406	139,493	242	360
1988	66,865	147,103	254	392
1989	44,199	97,238	284	472
1990	47,859	105,290	270	435
1991	81,993	180,385	256	397
1992	54,801	120,562	260	408
1993	78,260	172,172	259	405
1994	49,830	109,626	269	432
1995	12,590	27,698	287	480
1996	14,508	31,918	284	472
1997	8,169	17,972	308	537
1998	2,435	5,357	308	537
1999	8,260	18,172	281	464
2000	21,495	47,289	308	537
Mean	**34,135**	**75,097**	**291**	**491**

Lesko, PacifiCorp, to J. Weinheimer, WDFW, Vancouver, Washington, November 1997). Limited kokanee spawning has also been documented in the Swift No. 2 bypass reach and Ole Creek (PacifiCorp 1999).

Kokanee in Lake Merwin spawn primarily in the lower 95 m (311 ft) of Canyon Creek, as a natural barrier prohibits upstream passage beyond this point. Limited spawning also occurs in Speelyai Creek, in lower Rock Creek and in Yale tailrace (Table 4.1-13) (Graves 1982). It is thought that recruitment to Lake Merwin is largely a result of kokanee from Yale Lake that pass 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).

Table 4.1-13. 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 the early 1990s, Yale Lake anglers expressed concern about the small size of kokanee harvested from the lake. In 1992, WDFW responded to this concern by increasing kokanee harvest in the lake to 16 fish per angler per day, and extended the season to year-round. Since age 2+ and older kokanee exhibit strong density-dependent growth (Rieman and Myers 1992), it has been shown that by harvesting more kokanee, the size of harvestable fish would increase as intraspecific competition decreased. To date, this limit and extended season are still in effect. This may be more a result of high winter flows and turbidity in the reservoirs which has reduced the escapement.

Data from Cougar Creek during the past several years have shown a moderate increase in female kokanee mean length, from 260 mm (1992) to 308 mm (1998) (Table 4.1-12). Spawning escapement during this period has declined substantially. Coincident with the decline in overall escapement, mean length of spawning female kokanee increased to levels that have not been exceeded since 1985. The 1998 and previous years' spawning escapement data further support the inverse relationship between spawning escapement and mean length of female kokanee mentioned above.

Kokanee are the primary target species for sportfishers in Yale Lake, and are the second most popular target species in Lake Merwin (WDFW 1998a). A 1995 creel survey (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 (Tipping 1995 as cited in Hillson and Tipping 1999). Annual harvest is 12,000 to 20,000 kokanee from Yale and

3,000 to 8,000 from Merwin (WDFW 1998a). The WDFW management objective for kokanee is for naturally-reproducing populations to sustain the fishery (WDFW 1998a).

4.1.5.12 Sculpin

Life History

The sculpin family, Cottidae, consists of a large number of species that are difficult to identify because of their slight morphological variation and small size (Wydoski and Whitney 1979). In general, the sculpin is a large-headed, heavy-bodied fish that tapers from head to tail. The head shape is usually wider than deep and has a well-developed jaw. Pectoral fins are large and fanlike. There are usually two dorsal fins that are slightly separated from each other, with the first fin having spines and the second being soft-rayed.

The genus *Cottus* inhabits freshwater environments of the Northern Hemisphere. Eleven species inhabit the inland waters of Washington, of which at least six occur in the lower Columbia River and its tributaries. These species, their habitat, age and growth, reproductive biology, and food are summarized in Table 4.1-14 (Scott and Crossman 1973, Wydoski and Whitney 1979).

In freshwater, Cottids are typically small (less than 17.8 cm [7 in]). For those species in the lower Columbia River, the maximum size range is from 7.6 cm to 15.2 cm (3 to 6 in) (Wydoski and Whitney 1979). Sculpin live from 4 to 7 years, with the most rapid growth occurring in the first few years.

All freshwater sculpins exhibit similar feeding habits. During the larval and young-of-the-year lifestages, cottids remain in the water column, feeding primarily on plankton and aquatic insect larvae (Ikusemiju 1967). As they mature, they move to a more benthic existence and the diet expands to include benthic organisms, mollusks, fish eggs and fry. The torrent sculpin in particular can target larger prey items due its large mouth (Scott and Crossman 1973).

Sculpin are predators of the eggs and fry of some game fish species, particularly trout and salmon (reviewed in Ikusemiju 1967). However, sculpin provide an important prey item for more mature salmonids within the stream and lake environment (Hendricks 1997, Heard 1965). Sculpin may also be a food source for fish-eating birds such as the American merganser.

Of those cottids in the lower Columbia Basin, only three of the six species have notable migration patterns. The coastrange sculpin (*Cottus aleuticus*) is thought to have a migration pattern that follows the movement of prey items such as salmon eggs and fry (Scott and Crossman 1973). The torrent sculpin (*C. rhotheus*) has a pre-spawning migration during January-March, then returns downstream (April-June) after spawning. Similarly, the prickly sculpin (*C. asper*) has a migration associated with spawning, moving downstream to spawning grounds, with the males going first as a group and the females following one at a time (Scott and Crossman 1973). Sexual maturity usually occurs at 2 or 3 years of age. Specifics for each of the seven lower Columbia River species are listed in Table 4.1-14.

Table 4.1-14. Summary of sculpin species within the lower Columbia River and tributaries.

Species	Habitat	Age and Growth	Reproduction	Food
Coastrange Sculpin *Cottus aleuticus*	Medium to large streams with moderate to rapid current. Also found in lakes. Gravel bottoms.	In Oregon, 4 year max, 7.6 cm (3.0 in).	At 3 years, early spring. 257-834 eggs/female. Spawns under surface of rocks.	Plankton, insect larvae, insects, eggs, fry, worms.
Shorthead Sculpin *C. confusus*	Cold, fast riffles at higher altitudes. Rubble and gravel bottoms.	4 year max, 10.2 cm (4 in).	At 2-3 years in spring. 47-219 eggs/female.	Similar to above.
Piute Sculpin *C. beldingi*	Usually wide streams with slight to moderate gradient. Lower elevations. Rubble/gravel bottom.	5 year max, 12.7 cm (5 in).	At 3 years in May-June. 11-517 eggs/female. Spawns on rocks in stream riffles or wave-swept beaches, 12.2°C (54°F).	Ostracods, algae, insect larvae, mollusks.
Torrent Sculpin *C. rhotheus*	Swift streams or lake beach areas. Fast current or wave swept. Rubble/gravel/large rock bottom.	6 year max, 15.2 cm (6 in).	At 2 years in late spring. 100-412 eggs/female. Spawns under stones in swift water.	Copepods, ostracods, insect nymphs and larvae, mollusks, fishes.
Mottled Sculpin *C. bairdi*	Cool water streams and lakes with sandy substrates.	5 years max, 12.7 cm (5 in).	At 2-3 years in late spring. 46-275 eggs/female. Spawns under stones or in a crevice. 12.8° - 18.3°C (55°-65°F).	Insect nymphs and larvae, shrimp, snails, fish eggs.
Prickly Sculpin *C. asper*	Pools/quiet waters of large streams, some lake/estuaries. Open areas with sand/gravel/rubble bottoms.	7 year max, 15.2 cm (6 in) in WA and OR.	At 2 years + in April-May. 280-7000 eggs/female. Spawns under rocks and logs in areas of slow water, 10º- 17.8° C (50º-64°F).	Plankton and larvae, benthic organisms, fish eggs and young when larger.

Sculpin are nest spawners. The male sculpin both builds and guards the nest. Nests have been found with multiple batches of eggs at varying stages of development, indicating that males spawn with numerous females (as many as 10 different females), with the fertilized eggs placed in the nest (Scott and Crossman 1973). It is also reported that some sculpin females are able to spawn more than once per season. Numbers of eggs per female vary greatly across the various species, though fecundity has been correlated to body size in most sculpin species (Table 4.1-14).

Incubation periods for sculpin have not been studied in detail. Mason and Machidori (1976) studied two species, the coast range and prickly sculpin, in coastal Vancouver Island streams. Incubation periods were determined to be 19 to 20 days at 10 to 12°C (50 to 54°F). Similarly, emergence has only been described in detail for the coast range and prickly sculpins. Upon hatching, these sculpin enter a 30 to 35-day larval stage during which they are pelagic (Scott and Crossman 1973). Other sculpin species likely exhibit this initial pelagic larval stage. Information on survival rates during incubation is scarce. The prickly sculpin is described as having a 50 percent survival rate at 15.0°C (59°F) and 0 percent survival at 17.8°C (64°F) under laboratory conditions (Wydoski and Whitney 1979).

Larval sculpin distribute themselves by drifting downstream with the current. Some of the species exhibit strong migrations within the water column to avoid being caught in bright day or moonlight during this dispersal, drifting only at night (Wydoski and Whitney 1979). Upon reaching the end of their larval stage, sculpin begin their benthic existence along stream, river, and lake bottoms.

Habitat Requirements

Spawning and incubation habitat for most sculpin species is within faster-moving water, among larger gravel and cobble substrate. Of the six species in the lower Columbia River, two notable exceptions are the mottled sculpin and the torrent sculpin. These fish prefer to build nests in slower moving water, though they still require large rubble/cobble substrate or rock crevices. Preferred water temperatures are between 7.8 and 18.3°C (46° to 65° F).

Abundance and Distribution within the Lewis River Basin

No quantitative estimates of sculpin populations have been made for the Lewis River basin and associated reservoirs. An extensive survey of fish resources within Lake Merwin, Yale Lake, and Swift Reservoir was conducted between 1978 and 1982 by the WDG (Graves 1982). Based on stomach analysis, cottids were reported to be a major food source for Dolly Varden (bull trout) and brook trout within Cougar and Siouxon Creeks, and within Yale Lake itself. Cottids were the most abundant fish sampled using baited gillnets set in the Swift Reservoir and tributary inlets in the summer 1980. A subsequent gillnet sample captured only suckers and a few sculpin. Similar to the findings in Yale Lake, stomach analysis indicated that cottids were important prey items for Dolly Varden (bull trout) in Swift Reservoir (Graves 1982). Plankton tows conducted within Swift Reservoir found extensive sculpin alevins within the water column during June (1979 and 1980).

As part of the relicensing process for the Yale Hydroelectric Project, resident fish within Yale Lake tributaries were studied in the summer of 1996. Approximately 170 m (555 ft) of stream channel in the lower half mile of Panamaker Creek contained "less than 100 sculpin." "Hundreds" of sculpins were observed in the lower mile of Ole Creek, the area containing a mix of pool and riffle habitat, with cobble-dominated substrate and numerous log jams. The lower half mile of Dog Creek contained "between 100 and 200 sculpin."

Similar to Ole Creek, this area contained cobble-dominated pool and riffle habitat units. Areas both upstream and downstream of the diversion canal on Speelyai Creek contained over 100 sculpin during fish sampling. This is a higher gradient stream, characterized by riffle and glide habitat in the lower reach, and riffle-dominated habitat above the diversion (PacifiCorp 1999).

4.1.5.13 Threespine Stickleback

Life History

The threespine stickleback (*Gasterosteus aculateus*) is so named for its three large dorsal fin spines. The body of the threespine stickleback is elongated and laterally compressed, tapering greatly before the tail. Bony plates are often present on both sides of the stickleback, with the saltwater species having upwards of 30 such plates and the freshwater varieties having few to none. Coloration is green-brown, olive, or gray to blue-black on the back, and silvery-white on the belly. Fins are generally clear. Coloration of males during spawning can change greatly with males developing a red belly and throat.

The threespine stickleback is one of the most widespread fishes in the world, having an almost circumpolar range in the northern hemisphere. North American populations range across most of the temperate areas of both the Pacific and Atlantic coasts.

The maximum size attained by threespine stickleback is about 7.6 cm (3 in). The largest three spine stickleback ever recorded at was about 10.2 cm (4 in) in length. The life-span of threespine sticklebacks is short, probably not more than 3.5 years. In Washington, about 90 percent live for only one year, the rest surviving an additional season (Scott and Crossman 1973). Growth is rapid in the first year, slowing considerably thereafter.

The threespine stickleback is an opportunistic feeder. Zooplankton and aquatic insect larvae make up a large part of the diet, but crustaceans, worms, and eggs and fry of fish (including their own) are consumed as well (Scott and Crossman 1973, Wootton 1976).

The relatively small threespine stickleback is prone to being consumed by other animals. Coastal (sea-run) cutthroat trout are known to consume stickleback in marine and freshwater environments. In Wapato Lake, Washington threespine stickleback was the main prey of rainbow trout during the winter months (Scott and Crossman 1973). Other predators include birds, snakes, seals, and other small mammals (Coad et al. 1995).

Sexual maturity in threespine stickleback is reached by the end of the first year. Spawning for freshwater varieties takes place from May through July, sometimes stretching into August. For the marine subspecies, migration to freshwater takes place in early June (Wydoski and Whitney 1979). However, for exclusively freshwater varieties, spawning migrations consist only of movement from deeper water to shallow water, or movement from the main river into tributaries and backwaters (Wootton 1976).

The spawning behavior of threespine stickleback is quite elaborate. Stickleback are nest spawners. The male builds the nest out of small twigs and other plant matter held together by a sticky secretion produced in the kidney. Nests are hollow with smooth, circular openings on each end of a barrel-shaped structure. Once the nest is built, the male stickleback entices a female into the nest by performing a zigzag courtship dance until getting a sign of acceptance, and then pointing out the nest opening with his snout. The female enters the nest, and is stimulated to lay her eggs by the male touching her near the base of her tail (Wootton 1976).

Threespine stickleback females typically produce from 100 to 150 eggs, though marine forms produce double that amount (Wydoski and Whitney 1979). The female departs the nest and the male follows up by entering and fertilizing the eggs. This process is repeated with a number of different females until the nest is full of eggs. The male continues to guard the nest, fanning it with his tail for aeration and protecting the eggs from predators. The rate of egg development depends on water temperature. The lower the water temperature, the longer the development of the embryo takes. At 8°C (46.4°F), threespine stickleback eggs take 40 days to hatch, at 12°C (53.6°F) they take 20 days to hatch; and at 25°C (77°F) they take only 6 days to hatch (Heuts 1956 as cited in Wootton 1976). The male continues to guard the nest for a few days after the eggs hatch, at which time the fry have developed sufficiently to survive on their own (Breder and Rosen 1966, Wydoski and Whitney 1979). Once the young threespine stickleback are active and free-swimming, they disperse from the nest and form schools (Wootton 1976).

Although there are forms of the threespine stickleback that use both marine and freshwater, the variety within the Lewis River basin is thought to spend its entire life cycle within the freshwater environment. The anadromous subspecies spends most of its life in salt water, traveling inland up to 1.6 km (1 mile) in order to spawn. The threespine stickleback is a widespread species that plays an important role in the food chain when abundant.

Habitat Requirements

Threespine sticklebacks are found in fresh, brackish and salt-water habitats, though they are most commonly found in slow-flowing backwaters and tributaries of rivers and in ditches, dykes, sheltered bays, and harbors. They are found in lakes and ponds, in areas of emergent or submerged, rooted vegetation (Wootton 1976). They are not found in steep, fast-flowing streams and so are rare or absent in mountainous areas. Preferred habitat for spawning is sandy bottoms in the shallows (Fish 1932), near and/or within vegetation (Wydoski and Whitney 1979).

Sticklebacks are highly tolerant of water temperature fluctuations and salinity conditions. Depending on salinity levels, lethal water temperatures can be as warm as 28°C (82.4°F) (Wootton 1976). The minimum oxygen concentration at which sticklebacks can exist is about 0.25 to 0.50 mg/l, though respiratory distress becomes evident at levels of 2.0 mg/l with an increase of opercular movement and short agitated swimming movements (Jones 1952 as cited in Wootton 1976).

Abundance and Distribution

No quantitative estimates of stickleback populations have been made for the Lewis River basin and associated reservoirs. Threespine stickleback were observed, but not abundant, in a backwater area of Beaver Bay wetlands (Yale Lake) in 1995. In addition, 5 sticklebacks were captured in the Eagle Cliff screw trap between June 16 and August 22, 2002, and 378 were collected in the Swift No. 2 canal between April 21 and June 13, 2002.

4.1.5.14 Largescale Sucker

Life History

The largescale sucker (*Catostomus macrocheilus)* is a relatively long fish with a moderate body depth. As its common name suggests, it has much larger scales than most other sucker species. Its mouth is subterminal, with a complete cleft that is not overhung by its snout like the mouth of the longnose sucker (*Catostomus catostomus*) (Scott and Crossman 1973). The largescale sucker has no teeth in its mouth but does have a single row of flat pharyngeal teeth. Coloration is markedly different above and below the lateral line with black, olive or blue-gray upper coloration changing to a white or yellow-white belly. Young fish may have 3 or 4 dark spots on their sides.

The largescale sucker is capable of reaching a length of 61 cm (24 in) and 3.2 kg (7.0 lbs.) (Wydoski and Whitney 1979, Coad et al. 1995). Maximum life-span is estimated to be 15 years (Coad et al. et al. 1995). In Montana, growth is relatively slow with total length measurements of 4.6 cm (1.8 in) at 1 year, 8.4 cm (3.3 in) at 2 years, 13.2 cm (5.2 in) at 3 years, 18.5 cm (7.3 in) at 4 years, 32.5 cm (12.8 in) at 5 years, 39.6 cm (15.6 in) at 6 years, and 42.2 cm (16.6 in) at seven years (Wydoski and Whitney 1979).

The distribution of the largescale sucker is limited to the Pacific Northwest, occurring from British Columbia and Alberta, Canada to the north, extending south to the Sixes River of Oregon, and eastward to western Idaho and Montana. In some areas in the northern reaches of its range, it may hybridize with the white sucker (*C. commersoni*), the largescaled sucker of the plains and eastern Canada.

The diet of the largescale sucker changes as it matures. As fry, prey items include small zooplankton in the surface and midwater areas. As they mature, the mouth migrates downward and they become bottom dwellers, subsisting on aquatic insect larvae and diatoms. As the fish get larger, prey such as crustaceans, earthworms, snails, and other bottom organisms are included in their diet. A high percentage of fish eggs were found in the stomachs of suckers during spawning periods of kokanee and Pacific salmon (Scott and Crossman 1973). Despite the presence of salmon eggs in their diet, the largescale sucker is not thought to be a serious predator on salmon eggs (Coad et al. 1995).

While the adult largescale sucker has a distribution that keeps it safe from predation by other fish species, the young may be preyed upon by game fish. Both adults and juveniles are eaten by birds such as osprey, eagles, and mergansers, and are part of the diet for some bears and other mammals.

It is unclear what effect the largescale sucker has on salmonid populations. Because much of the diet (chironomid larvae) of both species overlaps, there may be some competition for food. However, suckers feed mainly along the bottom substrates and salmonids are typically surface and drift feeders. Furthermore, suckers tend to remain in nearshore areas of depths less than 5 m (16.4 ft) (Dauble 1986). Coad et al. (1995) reports that the sucker is not thought to be a serious predator on salmon eggs, and Scott and Crossman (1973) suggest that eggs eaten by suckers may be those exposed due to multiple spawning at nest sites.

Males of this species tend to mature earlier than females. In Montana, males may mature as early as 3 years of age with most female fish maturing between 4 or 5 years (Wydoski and Whitney 1979). Populations in British Columbia, Canada usually don't mature until about 5 years for males and 6 years for females (Coad et al. 1995).

Spawning generally occurs from April to May, sometimes stretching into late June in parts of British Columbia. Fish ladder counts of suckers (*Catostomus* spp.) moving upstream of Priest Rapids Dam peaked in June. It is not known if this was a spawning migration or if their movements were feeding migrations, though the white sucker (*C. commersoni*) has been shown to home to spawning streams (Dauble 1986). The spawning process starts when water temperatures in the streams reach 8 to 9°C (46.4° to 48.2°F) (Coad et al. 1995). Largescale suckers are broadcast spawners; multiple males fertilize the eggs immediately after they are deposited along the bottom. Females deposit as many as 20,000 eggs (Coad et al. 1995; Wydoski and Whitney 1979; Scott and Crossman 1973). Eggs hatch in about 2 weeks (Wydoski and Whitney 1979), and fry remain in the gravel or near the bottom surface until the yolk is absorbed, a period of a couple weeks (Coad et al. 1995; Scott and Crossman 1973).

Juvenile largescale suckers are pelagic until their mouths migrate into a more ventral position. As pelagic fish, juveniles have a terminal mouth to assist the capture of plankton. Fry exhibit diel movements, inhabiting shallow areas during the day and moving into deeper areas at night.

Habitat Requirements

The largescale sucker inhabits lakes, pools, and runs of medium to large rivers (Page and Burr 1991, Dauble 1986). It is frequently found in areas where streams enter lakes, but in spring, it can also be found in the backwaters and shallows of lakes. Water depths are generally shallow, but suckers have been captured in waters as deep as 24.6 m (80 ft). Water temperature tolerance studies have established a maximum (lethal) temperature of 29.4° C (85°F) (Black 1953).

Largescale suckers will spawn in deeper, sandy areas of streams, lake outlets, or gravel and sand lake shoals (Scott and Crossman 1973). Dauble (1986) observed spawning males holding in riffle areas of the mainstem Columbia River where the river bottom consisted of packed cobble, with coarse sand along the river margins. Females remained in the lower velocity areas segregated from the males except when actively spawning.

Abundance and Distribution in the Lewis River Basin

Largescale sucker populations in the Lewis River have not been quantified. Largescale suckers (lengths of 25 to 510 mm [0.9 to 20 in]) in Lake Merwin were observed around shoreline areas and creek inlets (Graves 1982). From early June to mid-August, adults were seen spawning in Speelyai, Canyon, Buncombe Hollow, and Rock creeks (Graves 1982).

No direct observations of suckers in Yale Lake were mentioned in the Graves report (1982), although stomach contents of bull trout sampled during the spring included juvenile suckers. In 1980, gillnets were set at 31 stations in and around Swift Reservoir and stream inlets. Sculpins and largescale suckers were the most abundant species caught during the late June to early September sampling effort. In August 1981, a gillnet set in the Swift Creek inlet caught 10 trout, 3 bull trout, 2 cutthroat, 42 largescale suckers, and 10 crayfish (Graves 1982). After an acoustic survey (April 1981) estimated a total population of 10,000 fish in the Swift Reservoir, subsequent net sampling found only suckers and a few sculpin.

4.1.5.15 Aquatic Macroinvertebrates and Zooplankton Guilds

Information describing the macroinvertebrate communities within the Lewis River Basin is limited, although some macroinvertebrate data have been collected within Lake Merwin, Yale Lake, and Swift Reservoir (Graves 1982, PacifiCorp 1999). Macro-invertebrate data have also been collected in several tributaries to Yale Lake (PacifiCorp 1999). The emphasis of Graves' (1982) work was to identify the types of plankton present in the reservoirs and assess its availability to the existing salmon and trout populations. In Lake Merwin, plankton abundance and diversity increased throughout the summer months, peaking in mid-August through October. Phytoplankton was dominated by diatoms, *Fragilaria* sp., *Asterionella* sp., and *Ceratium* sp. and rotifers, *Polyarthra* sp., *Daphnia* sp., and other cladocerans, and copepods dominated zooplankton communities. Copepods were the major prey item for juvenile salmonids rearing in the lake (Graves 1982).

In Yale Lake, Graves (1982) found the algae flora and zooplankton species were representative of alkaline, semi-soft drainage systems (i.e. dominated by diatoms, green flagellates, and blue-green algae). Rotifers, *Asplanchna* sp. and *Polyarthra* sp., *Daphnia* sp., and copepods were the dominant zooplankton, peaking in abundance during July and September.

Similarly, Swift Reservoir was dominated by diatoms, although it also supported a high diversity of other phytoplankton species. Eight species of rotifers and seven species of crustacean zooplankton were identified during sampling from 1978 to 1982. Peak densities occurred in most years during August and September.

In 1996 and 1997, PacifiCorp (1999) conducted vertical plankton tows to characterize the phytoplankton and zooplankton of Yale Lake. The number of phytoplankton species identified ranged from 6 (near the Yale Dam) in March 1996, to 27 in May and November 1996 (at the upstream end of the reservoir). Consistent with Graves (1982), diatoms dominated the plankton community in the springtime. There was a pronounced shift toward blue-green algae species in June. Overall, *Daphnia* sp. were the dominate zooplankton in Yale Lake, though other cladoceran species, copepods, and rotifers were also present in high numbers, especially during the June through August sampling periods.

The zooplankton community in these reservoirs, dominated by cladocerans, exhibits low population densities during winter. As water temperatures and the abundance of photosynthesizing algae and bacteria increase, the populations of zooplankton increase. Population cycles in the summer are more variable, being influenced by reduced food supply, shifts in the quality of food to less palatable species, and predation by other zooplankton, fishes, and other organisms (Wetzel 1975). Marzolf (1990) summarizes some key differences between natural lakes and reservoirs and how they effect the composition of the zooplankton community. These differences are:

1. Reservoirs are geologically new bodies of water. Physical characteristics may change over time, resulting in shifts in the macroinvertebrate community structure.

2. The catchment areas of reservoirs are much larger relative to their surface areas than are the relative catchment areas of natural lakes. Littoral zones are much reduced.

3. The inflow of water from the catchment basin of reservoirs is dominated by the flow from the impounded river. Inflow to natural lakes more often enters from several low-order streams. Typically, these drain through marshes or extensive littoral deltas before the water becomes the limnetic habitat of the zooplankton. The “filtering” and/or exchange phenomena that influence water quality as it moves through littoral zones may be significant.

4. The volume of many reservoirs is small relative to the discharge of the river into them, and they are shallow relative to the fetch of the wind. Reservoirs behind high dams in mountainous regions are obvious exceptions.

It was noted in PacifiCorp (1999) that increased densities of blue-green algae may signify increasing eutrophication within the lake environment. Eutrophication is the enrichment of a water system by inorganic nutrients, primarily nitrogen and phosphorus (Hutchinson 1969). Eutrophication affects aquatic insects by increasing the production of algae, bacteria, and other vegetation that provides them with substrate, shelter, and food. However, as this increased production undergoes bacterial decomposition coupled with increased respiration of the additional plant biomass (during the night and early morning hours), low oxygen conditions may result, causing serious impacts to many species of aquatic insects (Wiederholm 1984).

The habitat available to macroinvertebrates in Lake Merwin, Yale Lake, and Swift Reservoir is largely confined to open-water areas due to the steep shorelines, limited number of creek deltas, and the lack of any appreciable littoral zones (due to drawdowns). In its Yale relicensing studies, PacifiCorp assessed benthic macroinvertebrate communities in the Yale Lake vicinity. The health and diversity (biotic integrity) of macroinvertebrate populations was evaluated as an indirect measure of water quality and aquatic habitat condition. Samples were collected at three sites: the Swift No. 2 bypass reach, Cougar Creek and Siouxon Creek (PacifiCorp 1999). The bioassessment methodology (ABA 1996) that was used was designed to evaluate benthic invertebrate communities based on what is considered to be "ideal". A high taxa richness, or a predominance of taxa adapted to high water quality and diverse aquatic habitat is considered a positive sign. "Ideal" conditions are based on a mid-order mountain stream with:

- a dense riparian overstory,
- moderate to high gradient,
- a cobble/gravel dominated substrate,
- a perennial flow of cool water,
- a relatively narrow channel with high habitat complexity,
- a moderate to high amount of bole wood present to increase habitat complexity and aid retention of course particulate organic matter (CPOM),
- high diatom production,
- high inputs of leaf and needle material,
- low inputs of fine sediment
- limited scouring and resorting of substrates, but with some moderate level of disturbance,
- a hyporheic zone open to invertebrate colonization, and
- a high amount of "crevice space" around and under surface rocks.

Samples collected at the Swift No. 2 bypass reach and within Siouxon Creek had low habitat complexity scores, reflecting significant habitat and/or water quality limitations. Cougar Creek scored within the high habitat complexity category. Specifically, total species and the Ephemeroptera/Trichopetera/Plecoptera (ETP index) taxa richness were high within Cougar Creek, but overall densities were low and the majority of species found were cold-water dependent. Samples contained Hydrobiidae snails, which are potentially threatened or endangered species, though further analysis is underway to determine whether any listed species were collected.

Invertebrate densities within the Swift No. 2 bypass reach were moderate, but total and EPT taxa richness were low. Black fly larvae dominated the benthic community, percent contribution of cold-water biota was low and there were few long-lived taxa present.

Results from the Siouxon Creek samples show the influence of periodic inundation and dewatering from Yale Lake fluctuations. Total scores were low to severely low, total and EPT taxa richness were very low, and cold-water biota and taxa indicative of high habitat complexity were absent. Note also that samples were taken entirely within the influence of Yale Lake and that conditions further upstream in Siouxon Creek would likely score higher.

No additional information has been identified to describe the macroinvertebrate resource in other areas of the Lewis River basin, specifically the mainstem North Fork Lewis River below and above the hydroelectric projects and other tributary streams draining into the North Fork Lewis River (Speelyai, Cougar, Muddy, etc.). However, Table 4.1-15 summarizes typical insect communities found within various types of streams. Additionally, a rich community of filter-feeding insect larvae that use the organic material produced in the lentic environment is often found in lake outlets and below reservoirs. Such communities may have a more eutrophic character than those downstream, but the enrichment effects usually do not persist very far below these outlets (Wiederholm 1984).

Table 4.1-15. Resource utilization by insects in several aquatic habitats [1] (adapted from Merritt et al. 1984).

Habitats	Nutrient Resources				
	Algae	**Vascular Plants**	**FPOM[2]**	**Leaf Litter (CPOM)[3]**	**Wood**
Headwater Streams (orders 1-3) (100-250 species)	S; some scraper species: Ephemeroptera Plecoptera Trichoptera Coleoptera Diptera	A (except mosses and liverworts); possibly a few species using mosses: Ephemeroptera Trichoptera	C; many collector species: Ephemeroptera Trichoptera Diptera	C; many shredder species: Trichoptera Coleoptera Diptera	C; few shredder species: Trichoptera Coleoptera Diptera
Oligotrophic lakes (25-100 species)	C (primarily littoral); moderate numbers of species, many are stream riffle analogs: Ephemeroptera Trichoptera Diptera	A (or S); few if any species	S (primarily in profundal zone); few species: Ephemeroptera Coleoptera Diptera	S (or A) (seasonally); few shredder species: Trichoptera Diptera	S (or A); no known species
Midreach rivers (orders 3-6) (200-500 species)	C; many species: Ephemeroptera Trichoptera Diptera	C (eutrophic lake littoral zone analogs); few species: Trichoptera Lepidoptera Coleoptera Diptera	C (especially in transport); many collector species: Ephemeroptera Trichoptera Coleoptera Diptera	S; a few shredder species in protected areas seasonally or localized at entrance of low order streams: Trichoptera Diptera	S (or C), distributions very clumped; few species: Diptera

Table 4.1-15. Resource utilization by insects in several aquatic habitats [1] (adapted from Merritt et al. 1984) (cont.).

Habitats	Nutrient Resources				
	Algae	Vascular Plants	FPOM[2]	Leaf Litter (CPOM)[3]	Wood
Eutrophic lakes (10-50 species)	S (epiphytes on plants in littoral zone); few species: Ephemeroptera Diptera	C (littoral zone); some live plant tissue shredders: Trichoptera Lepidoptera Coleoptera Diptera	C; few gathering collector species, some at high density: Ephemeroptera Diptera	S (littoral zone); few shredder species: Trichoptera Diptera	S (or A); no known species
Large rivers (orders > 6) (10-50 species)	S; very few species: Ephemeroptera Diptera	S (A); few if any species: Diptera	C (especially in transport) (mostly Annelida, Mollusca); few species of insects at high densities: Ephemeroptera Trichoptera Coleoptera Diptera	A (or S in protected areas); shredders rare or absent as in midreach rivers: Trichoptera Diptera	S (or A), very clumped distribution; few if any species: Ephemeroptera (*Povilla* burrows in wood) Diptera
Temporary Ponds (and streams) (50-75 species)	S (attached to plants, etc.); few species: Ephemeroptera Diptera	S (or C seasonally); few species (eutrophic lake analogs): Coleoptera Diptera	C; few species (may be limited by anaerobic conditions or moisture at times): Ephemeroptera Diptera	S (or C, depending on presence of riparian vegetation); some shredder species: Plecoptera Trichoptera Diptera	S (C in some headwater intermittent streams); few species: Diptera

[1] The relative dominance of each resource type for a given habitat is shown at the beginning of each entry (C = Common, S = Sparse, A = Absent). Below each habitat category, a hypothetical range of insect species richness is given parenthetically.

[2] FPOM: Fine Particulate Organic Matter (0.5 µm < FPOM < 1 mm)

[3] CPOM: Coarse Particulate Organic Matter (> 1 mm)

4.1.6 Discussion

Historically, the Lewis River basin supported large numbers of native spring Chinook, fall Chinook, coho, chum, and steelhead. Thousands of each species were reported to spawn in the mainstem Lewis River, side channels, and tributaries both upstream and downstream of the Merwin Dam site (RM 19.4) (PacifiCorp and Cowlitz PUD 2001). Above the Merwin Dam site, spring Chinook were reported to spawn in the upper reaches of the Lewis River and in the lower Muddy River. Fall Chinook and chum salmon were reported to spawn in the Lake Merwin reach of the mainstem Lewis River, and coho were reported to spawn in the mainstem Lewis River, Muddy River, Pine Creek, Clearwater Creek, Clear Creek, Smith Creek, Drift Creek, and Cougar Creek (WDF and WDW 1993, Chambers 1957). Although their historical distribution above the Merwin Dam site is unknown, steelhead prefer relatively small, fast flowing streams with a high proportion of riffles and pools. These characteristics are still common in numerous streams located above Merwin, Yale, and Swift dams (PacifiCorp and Cowlitz PUD 2001).

The completion of Merwin, Yale, and Swift dams between 1932 and 1958 blocked access to over 96 miles (155 km) of historical anadromous fish habitat, inundated historical spawning grounds, and modified the natural flow regime in the lower Lewis River. This loss of habitat, combined with poor hatchery practices, habitat modification, and over-harvest, severely impacted native Lewis River stocks. Dramatic declines in native salmon and steelhead abundance followed; by the mid-1950s, native Lewis River spring Chinook were extinct. Fall Chinook, coho, and steelhead returns also declined but then rebounded as dam operations, hatchery practices, and commercial harvest regulations improved. Chum salmon have not recovered, and currently only a remnant population exists in the lower Lewis River.

Today, the vast majority of the anadromous fish entering the Lewis River basin are produced at the Lewis River Hatchery Complex (Lewis River, Merwin, and Speelyai hatcheries) (Table 4.1-16). With the exception of fall Chinook, few wild (naturally produced) anadromous fish return to the Lewis River. Fortunately, the native Lewis River fall Chinook population has remained healthy with negligible hatchery influences, and represents about 80 to 85 percent of the wild fall Chinook returning to the lower Columbia River (NPPC 1990).

Table 4.1-16. Current WDFW fish production goals for the Lewis River Hatchery Complex.

Species	Hatchery	Release Site	Production Goal
Spring Chinook	Lewis River/Speelyai	Lewis River	1,050,000
Early Coho (Type-S)	Lewis River/Speelyai	Lewis River	880,000
Late Coho (Type-N)	Lewis River	Lewis River	800,000
Summer Steelhead	Merwin	Lewis River	175,000
Winter Steelhead	Merwin	Lewis River	100,000
Kokanee	Speelyai	Lake Merwin	45,000 fingerlings, 48,000 yearlings
Tiger Musky	Merwin	Lake Merwin	Approx. 3,000
Rainbow Trout	Merwin	Swift Reservoir	800,000

Unlike fall Chinook, spring Chinook, coho, and steelhead populations have been maintained by hatchery production using a mixture of hatchery returns and non-native broodstock. In the late 1950s, spring Chinook were reintroduced to the Lewis River using Cowlitz, Kalama, Carson, Klickitat, and Willamette stocks. Coho have been supplemented using Cowlitz River and Toutle River stock, and steelhead have been supplemented using Skamania and Beaver Creek stocks. Non-native resident rainbow trout, sea-run cutthroat trout, kokanee, and tiger musky have also been introduced to enhance recreation fishing (Table 4.1-16). Currently, spring Chinook and coho (Type-N and Type-S) are managed as hatchery stocks. Steelhead are managed for both hatchery and wild production. Fall Chinook are managed strictly for natural production.

In the past 20 years, an average of approximately 6,300 spring Chinook, 22,400 coho, and 4,400 steelhead have returned to the Lewis River basin annually (PacifiCorp and Cowlitz PUD 2001). Wild fish (the progeny of natural spawners) represent only a small percentage of these total returns. Wild spring Chinook comprise approximately 15 to 20 percent of the total spring Chinook run (Pettit 1997), and wild steelhead account for only 7 percent of the total return (WDFW 1994). The natural escapement of wild coho is likely 5 to 10 percent of total basin production (Hymer et al. 1993).

4.1.7 Schedule

This study is complete.

4.1.8 References

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4.1.9 Comments and Responses on Draft Report

This section presents stakeholder comments provided on the draft report, followed by the Licensees' responses. The final column presents any follow-up comment offered by the stakeholder and in some cases, in italics, a response from the Licensees.

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
WDFW – JIM BYRNE	1	AQU 01	Table 4.1-1.	Why are there no smelt on the list? They come into the Lewis River irregularly – commercial catch - $$ fish.	The list of aquatic analysis species and the AQU-1 study plan were developed by the ARG, including representatives from the WDFW. The Licensees are uncertain of the grounds for this decision.	If they are a important commercially viable species, they belong. They may not require a new section but should at least appear in the table. **Licensees' Response**: *Even though this community is important, it was not identified as part of the original study plan. Adding it to the table of species studied would be misleading.*
WDFW – KAREN KLOEMPKEN	1	AQU 01	Missing distribution maps.	There are no distribution maps "showing known historical distributions for anadromous and resident fish species" for Chinook, coho, and steelhead. There were no maps at all for chum, sea-run cutthroat, lamprey, white sturgeon, northern pikeminnow, mountain white fish, bull trout, kokanee, sculpin, stickleback and largescale suckers.	Distribution maps for each of these species are included in the Appendices to the 2000 Technical Study Status Reports (on a CD) and will also be included in the Final 2001 Report. Maps illustrating the distribution of chum, sea-run cutthroat, lamprey, white sturgeon, northern pikeminnow, mountain white fish, bull trout, kokanee, sculpin, stickleback and	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
					largescale suckers were not included in the report due to a lack of information describing their distribution in the basin. When information was available, it was presented in the text. See the "*Abundance and Distribution in the Lewis River Basin*" section for each of these species. To speculate on the full extent of their distribution in the basin would be inappropriate and misleading.	
J. Sampson, Technical Advisor to the Conservation Groups	1	AQU 01-3 answer to key question in third bullet	"…it is difficult to determine if there have been substantial changes in life history patterns of salmonid populations due to hatchery practices and the introduction of non-native stocks."	This statement is not accurate and does not completely address the key question. It should be revised to say: "…the changes that have resulted in life history patterns of salmonid populations due to hatchery practices and the introduction of non-native stocks are difficult to describe due to a lack of baseline information on native stocks. However, the geographic distribution of anadromous fish in the watershed is substantially curtailed by the projects."	Agreed, the statement will be revised as suggested in the final report.	
WDFW – KAREN KLOEMPKEN	1	AQU 01-11 para 3, 2nd sentence	Mitigation.	The Merwin Hatchery was built as required mitigation for the upstream habitat that was being inundated by the building of the Merwin Dam.	Agreed, this sentence will be included in the final report.	
WDFW –	1	AQU 01-	Outmigrants.	The spillway and turbine outlets at	Agreed. This sentence will	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
KAREN KLOEMPKEN		11 para 3, 2nd to the last sentence		each of these dams were not adequate means for downstream fish passage for outmigrants.	be modified to include "…were not adequate means for…." In the final report.	
WDFW – JIM BYRNE	1	AQU 01-18 para 1	Life Histories.	Coho are a major predator of wild fall Chinook.	Agreed, information describing coho predation on fall Chinook will be included in the final report.	
WDFW – JIM BYRNE	1	AQU 01-20	Late run coho never existed in the Lewis River.	This is not true. Old 1951 records talk about early and late runs with the appropriate time frames.	The information on late run coho was provided by Robin Nicolay (WDFW) to Frank Shrier for inclusion in the Biological Assessment	The Lower Columbia River Fisheries Development Program Lewis River Area (WDF,1951) indicates 10 K earlies (spawn late Oct.- late Nov.) and 5 K late coho (spawn late Nov – March) in the Lewis. **Licensees' Response**: *Thank you for identifying this data. It has been added to the final report*.
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	AQU 01-22	Table 4.1-7	Please provide accessible length of stream along with the length utilized by a species. The reader should not have to go to a different study report to tease out such a fundamental piece of information. This is easily accommodated by one more column, and perhaps a notation for whether accessibility is limited by a natural or human-made obstruction.	If these length and obstruction data are available from WDFW, they will be included in the final report.	There is no question that the data are available. Please include them in the report. **Licensees'Response:** *The data have been obtained from Wade (2000) and included in the final report.*
WDFW – KAREN KLOEMPKEN	1	AQU 01-34 para 4, last two sentences	Fish.	The hatcheries mark the adult fish that are retuned to the stream so they won't be double counted.	Information describing hatchery marking of adult steelhead will be included in the final report.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
WDFW – JIM BYRNE	1	AQU 01-51	Scientific name.	There is no scientific name listed with the common name northern pikeminnow.	This will be added to the final report.	
WDFW – JIM BYRNE	1	AQU 01-54	Whitefish world record 22”.	There were some that big found during the Swift Power Canal rescue mission.	WDFW and USFWS did not record the lengths of whitefish collected during the fish rescue in the canal. Regardless of fish observed in the canal, the referenced statement was reporting the official sport catch record for whitefish.	No argument. Is it worthwhile to report near record size fish are present in this system?
WDFW – JIM BYRNE	1	AQU 01-56	Scientific name.	There is no scientific name listed with the common name bull trout (*S. confluentus*).	This will be added to the final report. It is, however, included on page AQU 1-8 in the discussion of predation on fall Chinook.	
WDFW – JIM BYRNE	1	AQU 01-58	Bull trout spawning time.	We really don’t know the Lewis River bull trout spawn timing. Can’t document redds to specific days.	A sentence describing uncertainties regarding the specific spawn timing of bull trout in the Lewis River basin will be included in the final report.	
WDFW – KAREN KLOEMPKEN	1	AQU 01-59 para 4, 2nd sentence	Word tense.	“They are know to…” Should be “They are known to…”	This correction will be made.	
WDFW – JIM BYRNE	1	AQU 01-62 para 2	Fish netting in Yale and Swift 1 & 2 tailraces.	PacifiCorp conducted halfhearted attempts to net fish at Yale and Swift 1 & 2. Only one or two attempts each year. There is a need to do better.	PacifiCorp (and Cowlitz PUD from Swift No. 2) will continue to work with the WDFW and other resource agencies to net fish (specifically bull trout) at Yale and Swift No. 2	Yale was netted twice last year and twice this year. The netting operation is timed to cessation of generation (usually 2 hours), not bull trout availability. Four bull trout were captured this year, yet overall netting

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
					tailraces. This program is a required component of the recent FWS and NMFS Biological Opinion and will continue until more permanent passage facilities are implemented (if deemed necessary by the agencies). Currently Yale is fished 3 times/year. There are not enough fish to sustain a constant effort. For example, in 2001, no fish were captured and an underwater camera revealed no bull trout.	occurred for less than 5 hours. Swift 2 was netted only once, and Swift 1 not netted at all this year. The 3 effort criteria has not been met for the past two years. **Licensees' Response**: *The criteria to conduct netting is based on the number of fish present, not a set number of times per year. Netting at Swift No. 1 is not part of the criteria, therefore it is not done. Swift No. 2 could not be netted as planned this year and it is currently in unnettable condition.*
WDFW – KAREN KLOEMPKEN	1	AQU 01-62 para 3, last sent	Conversion of mm to cm.	Check the conversion of 30 mm & 60 mm to 1.2 cm & 2.4 cm. The math doesn't seem right.	The will be revised to 1.2 inches and 2.4 inches.	
WDFW – JIM BYRNE	1	AQU 01-67	Kokanee spawning.	Need more rigorous survey effort. One or two stream walks are not sufficient.	Currently surveys are conducted 4 or more times/year depending on when the peak count is reached. This method is consistent with records and techniques that date back to 1978.	I believe 3 surveys occurred last year. I participated in one survey. Substantial discrepancy occurred between PacifiCorp count 17K and WDFW count 9K on that occasion. **Licensees' Response:** *The number of surveys depends on reaching a peak count, so there are always at least 3 surveys. This methodology does take some "calibration," which is why we have 2*

Commenter	Volume	Page/ Paragraph	Statement	Comment	Response	Response to Responses
						observers check each other's estimates. The idea is to arrive at agreed upon numbers rather than opposing counts. Over the years, PacifiCorp has conducted a number of different counting methods, including snorkel verification of the count. A life table is maintained for the record that is dependent on the current methodology.
WDFW – KAREN KLOEMPKEN	1	AQU 01-67 para 1, last sentence	The statement that the kokanee population in Merwin are self sustaining.	This statement isn't consistent with the statement on page AQU 1-64, last sentence. Also the population is subsidized with hatchery plants each year.	The referenced statement will be clarified in the final report. It will include a discussion of the more recent hatchery kokanee plants in Lake Merwin. Our information indicates that the population of kokanee in Merwin was self-sustaining prior to kokanee plants by the WDFW.	
WDFW – JIM BYRNE	1	AQU 01-73 para (last)	Sighting of sticklebacks.	Three-spine sticklebacks were seen in the Lewis River Eagle Cliff trap and in the Swift Canal. These need to be added.	The new information on three spine sticklebacks will be added to the final report. We appreciate the additional data. Five sticklebacks were captured in the Eagle Cliff Screw trap between June 16 and August 22, 2002, and 378 were collected in the Swift No. 2 canal between April 21 and June 13, 2002.	