3. Biological Data on and Factors Affecting Covered Species

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The Forest Practices Habitat Conservation Plan (FPHCP) covers fish and aquatic or riparian-dependent amphibians. Chapter 1 provides information on which species are covered by the plan and why those species were chosen. This chapter provides a closer look at these species, including how they live (life history, habitat requirements), where they are found (distribution), how well they are doing (status) and factors that affect them.

3-1 Fish

Washington's new forest practices rules were developed to protect aquatic and riparian-dependent species, including all fish species. Salmonid species have historically been given the most attention due to their recreational and economic value, and to the fact that many populations have declined over recent years. However, non-salmonid fish species are also receiving recognition and protection from forest practices rules. Ten of the 41 FPHCP-covered non-salmonid fish species are federally listed and/or state listed species of concern (See Tables 3.1 and 3.2). Within this chapter, salmonid fish species are described first, due to their listing status and because of the greater abundance of fisheries management data and scientific literature.

3-1.1 Life History of Covered Fish Species

The life histories of various fish species covered by the FPHCP can differ greatly. Preferred habitat types and length of time within those habitats will vary by species. Some die after spawning, others return to spawn again the following year. Fish species—especially salmonids—can usually be described by one or more of the following life history strategies:

- Anadromous—Spawning and juvenile rearing (varying length of time) in freshwater; migration to saltwater for adult rearing
- Adfluvial—Spawning and juvenile rearing (varying length of time) in freshwater tributaries; migration to lakes or reservoirs for adult rearing
- Fluvial—Spawning and juvenile rearing (varying length of time) in small freshwater streams; migration to larger rivers for adult rearing
- Resident—Entire life history occurs in smaller streams

3-1.1.1 SALMONID SPECIES

Washington State salmonids (members of the family Salmonidae) covered under the FPHCP include several species of Pacific salmon, trout and char. Salmonid populations have evolved within their specific habitats throughout the last 10,000 years (Miller 1965). Water chemistry, water flow and physical habitat components unique to each watershed have contributed to the development of a wide variety of distinct populations for each salmonid species throughout the state. Each salmonid species has a unique set of physical traits and habitat preferences, which leads to different spatial and temporal habitat use patterns and diverse life histories. Although some overlap occurs, habitat use can be staggered in time and/or separated by distance. In addition to the diversity of life history patterns between species, there is also a rich diversity of life histories within a species or population, a strategy that contributes to sustainability during changing environmental conditions (Lichatowich 1993a).

The life cycle of salmonids can be divided into as many as seven distinct phases, depending on life history strategy: upstream migration, spawning, egg incubation, fry emergence, juvenile rearing, smolt outmigration and marine rearing. Migrating adult salmon (i.e., anadromous, adfluvial, fluvial) return to their natal streams to spawn and reproduce. The female excavates a pocket within the gravel substrate (redd) where she deposits her eggs. One or more males simultaneously fertilize the eggs prior to the female covering them with loose gravel. The eggs incubate within the interstitial spaces in the gravel substrate, developing from eggs to alevin and feeding on their yolk sack until emergence. Fry emerge from the gravels in search of food and protective cover. Anadromous juveniles rear in fresh water for anywhere from a few days (e.g. pink salmon) to a few years (e.g. steelhead) depending on the species and environmental conditions. Following the freshwater rearing period, juvenile salmon migrate from their natal streams and begin acclimating to saltwater through a process called smoltification. Smolts forage, rest and grow in estuaries and nearshore habitats as they migrate toward the ocean environment. Growth and development continues in the open ocean for a few months to several years, depending on the species. When mature, adult salmon begin migration back to their natal streams where they spawn and die, becoming part of the nutrient cycle that feeds future generations of fish and wildlife (Spence et. al. 1996; Salo and Cundy 1987).

The following text describes the life history of the various salmonid species.

Chinook *(Oncorhynchus tshawytscha*)

Chinook salmon—also known as king salmon—are distinguished as adults by black spots on both lobes of the caudal fin and black gums along the lower jaw. At maturity, they can be the largest of salmon species (4-5 years average and 2-1/2 to 125 pounds, or 22 pounds average) (Wydoski and Whitney 2003). Chinook return to their spawning grounds, which can vary by population from just above tidal influence to as far as 1,200 miles upstream. Because of their size, preferred spawning habitat includes deeper water and larger gravels than for most other salmon species.

The timing at which adults return to fresh water to spawn (often termed as a “run”), can occur during spring, summer or fall, depending upon the particular population and river system. Spring chinook adults begin to enter fresh water in May or early June and spawn from July through September—typically in small headwater streams. Eggs incubate through autumn and winter, generally requiring additional development time due to the colder headwater stream temperatures. Adult summer chinook enter freshwater streams as early as June and spawn from September through October. Fall chinook populations spawn from late September through December. Fall chinook eggs incubate in the gravel until January through early March.

After emerging from the gravel, juveniles rear in fresh water for two months to two years. Two life history types—ocean and stream—are recognized in chinook salmon, based upon the length of time the juvenile fish spend rearing in streams and rivers. Ocean-type chinook move relatively quickly into saltwater following emergence. Some fry enter marine environments almost immediately, but most inhabit the shallow side margins and side sloughs for up to two months. Most fall chinook are ocean-type. Stream-type chinook overwinter in fresh water, typically migrating to the ocean the following spring. However, in very cold, unproductive systems, young stream-type chinook may rear for two years before smolting. Spring and summer chinook populations are more likely than fall chinook populations to be stream-type (Marshall et al. 1995).

Outmigration of smolts to the marine environment occurs over a broad period—typically January through August (Smith 1999)—and varies between spring, summer and fall chinook. Smolts spend time within estuarine and nearshore environments before they enter the ocean.

Chum *(Oncorhynchus keta)*

Chum salmon—also known as dog salmon and/or calico salmon—are distinguished by the reddish purple vertical markings along the sides of spawning adults. In the Pacific Northwest, freshwater migration is typically short in distance (<50 miles). Chum salmon utilize the low-gradient (–between one and two percent), sometimes tidally-influenced reaches of streams for spawning. Chum fry typically spend less than 30 days in the fresh water after emergence, but remain in the estuary and nearshore environments as juveniles. In these environments, juveniles feed primarily on copepods, tunicates and euphausiids prior to migrating out to the ocean (Lichatowich 1993b). Chum return to fresh water in three to five years to spawn, with each female accompanied by one or more males. The average weight of spawning adults is nine pounds (range 3 to 45 pounds; Wydoski and Whitney 2003). Post-spawned chum carcasses provide high nutrient values for juvenile salmonids and numerous wildlife species. In Washington, the abundance of chum salmon tends to fluctuate during even and odd years, suggesting a possible competitive interaction with pink salmon in estuary or nearshore habitats (Salo 1991).

Chum salmon have three distinct run times: summer, fall and winter. Summer chum begin their upstream migration and spawning during low summer flows in mid-August through mid-October, with fry emergence ranging from the beginning of February through mid-April, depending on water temperatures (WDFW and Point-No-Point Treaty Tribes 2000). Fall chum adults enter the rivers in late October through November and spawn in November and December. Winter chum adults migrate upstream from December through January and spawn from January through February. Fall and winter chum fry emerge from the gravels in March and April, and quickly outmigrate to the estuary for rearing (Smith 1999).

Pink *(Oncorhynchus gorbuscha*)

Pink salmon—also known as humpback salmon—are distinguished by oblong spots on the dorsal and caudal fins, as well as white ventral and green dorsal surfaces in spawning adults. The males develop a distinctive dorsal hump when returning to the spawning grounds. Pinks typically begin their upstream migration in mid-July during low summer flows and spawn in September and October. They typically spawn in large groups, usually near tidewater (Spence et al. 1996). Fry emerge from their redds in late February to early May, depending on water temperature, and migrate downstream to the estuary within a month. Juveniles remain in estuarine/nearshore waters for several months and then move offshore as they migrate to the Pacific Ocean, where they remain a little over a year until the next spawning cycle. The average weight of spawning adults is four pounds (range two to nine pounds; Wydoski and Whitney 2003). Preferred foods include euphausiids, amphipods, fish, squid, copepods and pteropods (Lichatowich 1993b). Most pink salmon populations in Washington return to their natal streams only in odd years. The exception is the Snohomish Basin, which supports both even and odd year pink salmon populations (Smith 1999).

Coho *(Oncorhynchus kisutch)*

Coho—also known as silver salmon—are distinguished by black spots on the upper part of the caudal fin and a white mouth. Coho adults begin their upstream migration between September and December, penetrate deep into the upper watersheds, spawn from October through February and fry emerge in early March to late July. Most juvenile coho remain at least one year in fresh water, although recent studies have shown that some populations spend time in estuaries prior to smoltification. Those that remain in fresh water rear in shallow gravel areas near the stream bank, keeping to pools and side channels and away from severe winter flows. They school at first, but later disperse and become aggressive and territorial (Smith 1999). Coho smolt and migrate to sea in the spring (Lichatowich 1993b). They typically spend two years at sea and return as three-year-old adults. Most adult coho salmon weigh between 8 and 12 pounds; however, they have been known to reach 31 pounds (Wydoski and Whitney 2003).

In the autumn, as water temperatures decrease, juvenile coho move into available side channels, spring-fed ponds and other off-channel sites to avoid winter floods. Streams with more structure (logs/rootwads, boulders, undercut banks) support more coho, not only because they provide more territories/usable habitat, but they also provide more food and cover (Scrivener and Andersen 1982). There is a positive correlation between their primary diet of insect material and the extent to which the stream is overgrown with vegetation (Chapman 1965). During the winter, coho often feed on the adult salmonid carcasses (Bilby et al. 1996). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho use estuaries primarily for interim feeding while they adjust physiologically to saltwater and then move offshore to deeper waters (Smith 1999).

Sockeye and Kokanee *(Oncorhynchus nerka)*

Sockeye—also known as red salmon—are distinguished by their lack of spots on the back or caudal fin and, as spawning adults, by their red bodies and green heads. Sockeye enter fresh water for upstream migration during the summer months, spend time resting in deep pools or lakes and enter the spawning grounds when ready to spawn (usually from late summer to fall; Spence et al. 1996). Sockeye are unique in that they exhibit three types of the anadromous life history strategy. One type spawns in rivers but rears in lakes for one to three years to complete their freshwater life cycle prior to migrating out to sea. Another type spawns along lakeshores and rears in lakes for one to three years prior to migrating out to sea. Three-year migrants are uncommon in Washington State (J. Sneva, pers. comm., 2004). The third type spawns and rears in rivers and streams for one year (J. Sneva, pers. comm., 2004) prior to migrating to the sea.

Incubation time varies from 50 days to 5 months, depending on water temperature, after which emerging fry either remain in the river or find their way to a nursery lake for rearing, where they feed on larval and adult insects and zooplankton. Juvenile sockeye spend up to three years in fresh water prior to smoltification in spring, although some strains outmigrate immediately upon emergence and others become residual (Kokanee). Migrating sockeye juveniles remain within the estuarine/nearshore environment throughout the summer, feeding on insects, crustaceans and small fish and their larvae. Sockeye grow and develop two to four years in the ocean prior to returning to their natal stream or lake to spawn (Wydoski and Whitney 2003). Although adult sockeye salmon may reach a weight of 15.5 pounds, most adult fish weigh between 3.5 and 8 pounds.

Kokanee are either landlocked or residualized sockeye salmon. Populations occur in many lakes in northern Washington on both sides of the Cascade mountains. Typically, kokanee populations are maintained by stocking hatchery fish; however, self-sustaining populations also occur. Kokanee spawn where groundwater upwelling occurs along the shoreline of lakes or in tributaries. Juveniles rear in lakes, feeding on zooplankton and aquatic insect larvae (Wydoski and Whitney 2003).

Steelhead, Rainbow and Interior Redband Trout *(Oncorhynchus mykiss)*

Steelhead trout are distinguished by their uniform silvery color up until spawning time, when they darken in color. They are the anadromous form of this species, with a unique and complex life history. Unlike Pacific salmon, steelhead may return to sea after spawning and migrate again to fresh water to spawn again another year. There are two runs of steelhead: summer and winter. While there is some overlap, winter run steelhead typically enter streams for spawning between November and April, and summer steelhead enter streams between May and October (Wydoski and Whitney 2003). Summer steelhead usually spawn farther upstream than winter populations and dominate inland areas such as the Columbia Basin. The coastal westside streams typically support more winter steelhead populations (Smith 1999).

Steelhead fry emerge April through June and spend one to two years—and rarely three years—in fresh water (T. Johnson, pers. comm., 2002), preferring riffle areas in the summer and occupying pools during the rest of the year (Wydoski and Whitney 2003). Most steelhead returning to Washington streams after spending two years in saltwater weigh five to ten pounds (Wydoski and Whitney 2003). During the winter, they often feed on the carcasses of adult salmon (Bilby et al. 1996). Steelhead migrate to sea in the spring, spending two to four years in the open ocean (Wydoski and Whitney 2003) feeding on crustaceans, squid, herring and other fish (Lichatowich 1993b).

Rainbow trout, the non-anadromous form of the species, are distinguished by a reddish stripe that is usually present along the sides of adults. Two subspecies of rainbow trout occur in Washington: coastal rainbow (*Oncorhynchus mykiss irideus*) and Columbia redband trout (*Oncorhynchus mykiss gairdneri*). Native coastal rainbow inhabit streams and lakes in western Washington and inland into the Columbia River basin. They can exhibit the fluvial, adfluvial or resident life history strategies. Growth tends to be faster in eastside waters, where temperatures are higher and streams and lakes are typically richer in nutrients (Wydoski and Whitney 2003). Rainbow trout usually spawn between February and June, but there is also a fall spawning population. All spawning takes place in streams. Like steelhead, not all rainbow die after spawning. Fish mature between one and five years, depending on growth rate, and feed primarily on bottom-dwelling aquatic insects, amphipods, aquatic worms and fish eggs (Wydoski and Whitney 2003).

Native redband trout are the non-anadromous inland (east of the Cascade Range) subspecies of rainbow trout. Although redband trout appear to be widely distributed within the Columbia River Basin, their status is clouded by the uncertainty over taxonomic classification within the species, and by more than a century of stocking hatchery rainbow trout and steelhead. Interior redband trout are a Federal species of concern. Little published information exists for redband trout in Washington State, but Oregon status reports have described some life history traits. In some basins, fluvial and adfluvial redband trout migrate upstream in the spring and spawn in their respective basins from April to July depending upon elevation. Most stream-resident fish spawn in the spring and summer (ODFW 1999).

Coastal *(Oncorhynchus clarki clarki)* and Westslope *(Oncorhynchus clarki lewisi)* Cutthroat Trout

Cutthroat trout, in general, are distinguished by having a large mouth, which extends beyond the posterior eye margin, and a red/orange slit under the jaw. The two subspecies—coastal and westslope—are mainly distinguished by their spotting patterns. Coastal cutthroat have numerous dark spots present over their entire body, while the westslope cutthroat spotting occurs primarily above the lateral line and are most numerous on the caudal peduncle (directly anterior to the tail) (Wydoski and Whitney 2003).

The coastal cutthroat trout is the only subspecies of cutthroat exhibiting the anadromous life history strategy in addition to the other three life history strategies (i.e., adfluvial, fluvial, and resident). Cutthroat with different life history strategies often occupy the same areas without interbreeding. In Washington, the anadromous cutthroat trout (typically known as “searun” cutthroat) is widely distributed in the lower Columbia River and the Coastal and Puget Sound drainages. The searun cutthroat generally spawns between December and February in small headwater streams accessible to the ocean. They may outmigrate as young juveniles and take up residence in estuaries, feeding on smaller fish, amphibians and crustaceans. Growth is variable, but more rapid in marine waters with maturity typically reached at three or four years of age. Mature searun cutthroat may reach an average of two pounds (Wydoski and Whitney 2003).

Native freshwater (non-anadromous) cutthroat trout occur in many of Washington’s lakes and streams as one of two subspecies (i.e., Coastal and Westslope). Freshwater coastal cutthroat are primarily found in headwater streams of western Washington and tributaries of the Columbia River. Westslope cutthroat are found in the mid- and upper-Columbia tributaries, as well as throughout northeastern Washington. Spawning generally takes place from March through July in smaller headwater tributaries. The headwater tributaries used by resident cutthroat are typically cold, nutrient-poor waters that result in slow growth. Fluvial and adfluvial forms can exhibit more growth due to warmer water temperatures and nutrient availability. (Wydoski and Whitney 2003).

Bull Trout *(Salvelinus confluentus)* and Dolly Varden *(Salvelinus malma)*

Bull trout and Dolly Varden, both native char, were long considered to be the same species. The two native char have strong biological similarities (i.e., morphology, habits, habitat and life history; Wydoski and Whitney 2003). However, in 1978 bull trout and Dolly Varden became two species based on anatomical measurements and characteristics, as well as embryological development (Cavender 1978). Bull trout inhabit both eastern and western Washington, while Dolly Varden are only present in the Puget Sound and coastal rivers west of the Cascade Range. Bull trout exhibit four life history strategies: anadromous, adfluvial, fluvial and resident. Dolly Varden are often anadromous, but also exhibit the other life history strategies.

Bull trout and Dolly Varden move upstream (i.e., migratory forms such as anadromous, adfluvial and fluvial) in late summer and early fall to spawn in September and October—or in November at higher elevations (Wydoski and Whitney 2003). Both species prefer clean, cold water (50 °F) for spawning (Oregon Department of Environmental Quality 1995) and even colder water (36-39 °F) for incubation (Rieman and McIntyre 1993). Preferred spawning areas often include groundwater infiltration (Spence et al. 1996). Extended incubation periods (up to 220 days) make eggs and fry particularly susceptible to increases in fine sediments (USFWS 1998). Fry are typically found in shallow, backwater side channels and eddies in proximity to instream cover (Pratt 1984). Juveniles are typically found in interstitial spaces in the substrate, and subadults in deeper pools of streams or in the deep water of lakes with temperatures less than 59 °F (Pratt 1992). Both species mature at approximately 5 years and live for 12 or more years. Bull trout (and presumably Dolly Varden) typically reproduce in alternate years (Armstrong and Morrow 1980; USFWS 1998). While in marine waters (i.e., estuarine and nearshore habitats), bull trout have been observed to forage on surf smelt and other small schooling fish (e.g., sandlance, herring) (Kraemer 1994; Brenkman and Corbett 2003). They have also been observed to move through marine areas to independent tributaries, looking for foraging opportunities (Olympic Peninsula Management Unit Bull Trout Technical Guidance, *draft*, 2004). Bull trout often extend their time in estuaries into the fall, when they can follow adult migrating salmon upstream in order to feed upon their eggs.

Non-anadromous bull trout and Dolly Varden exhibit three life history strategies, each with unique habitat requirements: adfluvial, fluvial and resident. Adfluvial forms rear as juveniles in tributaries, migrate to lakes where most of their growth occurs, then return to the tributaries as adults to spawn. Spawning for fluvial forms occurs in smaller tributaries with major growth and maturation occurring in river mainstems. Resident forms complete all life stages (spawning, rearing, overwintering) in small headwater streams, often upstream of barriers to other salmonids (Brown 1994; Goetz 1989).

Pygmy Whitefish *(Prosopium coulteri)*

Pygmy whitefish are members of the trout and salmon family (Salmonidae) and are typically between five and six inches in length when mature, reaching a maximum length of about 11 inches. The pygmy whitefish is a remnant species from the last ice age, with a spotty distribution across northern North America and in the Columbia River drainage in Washington. The pygmy whitefish has been eliminated from a minimum of 40 percent of its range in the state. Historically, pygmy whitefish were known to have occupied 15 lakes; however, today they are currently found in only 9 (Hallock and Mongillo 1998). The future of pygmy whitefish populations is dependent upon maintaining water quality and spawning habitat, and preventing introduction of new predator species. Additionally, pygmy whitefish populations are especially vulnerable to local extinction because recruitment of new fish is usually impossible among isolated lake systems. The pygmy whitefish has no Federal status; however, WDFW considers the pygmy whitefish as State Sensitive (M. Hallock, pers. comm., 2003).

The pygmy whitefish inhabits lakes and cold streams. In lakes, the pygmy whitefish most often occurs in water deeper than 20 feet or in the shallows during spawning. Streams they inhabit may be of moderate to swift current, and may be silty or clear (Hallock and Mongillo 1998). McPhail and Carveth (1992) classify the pygmy whitefish as a coldwater stenotherm. Through temperature profiles, WDFW determined that they were almost always captured in water temperatures below 50 °F. Pygmy whitefish spawn in streams or lakes from late summer to early winter, depending upon geographic location and elevation. Within spawning streams, they preferred pools, shallow riffles and over pool tailouts. Lake spawning by pygmy whitefish occurs during the night-time, with fish moving into the shallows in late afternoon and back out into deep water towards the next morning's daylight (Wallace and Simpson 1978). It is believed that they scatter their eggs over coarse gravel, as do other species in their genus (Scott and Crossman 1973). Although variable across its range, pygmy whitefish are generally short-lived and grow slowly. Little water temperature data have been collected during the spawning period.

Mountain Whitefish *(Prosopium williamsoni)*

Whitefish are members of the trout and salmon family (Salmonidae). Mountain whitefish are typically about 10 to 16 inches in length when mature. They represent an important food fish for humans, providing a variety of angling opportunities. The mountain whitefish are the most common of the three whitefish in Washington (including the pygmy whitefish and the non-native lake whitefish) and are found throughout the state. The mountain whitefish is a long-lived species, known to live to about 11 years of age (Wydoski and Whitney 2003). They currently have no Federal or state listing status in Washington.

Mountain whitefish are found in streams and in cold, deep lakes. In streams they are found primarily in the riffle areas in summer, but prefer large pools during winter (Wydoski and Whitney 2003). They have been found in water with a velocity of about 2.6 feet per second. The mountain whitefish generally inhabits larger streams, with an average temperature of 48-52 °F. They may occur in the deep water of lakes, but in northern lakes they are usually found no deeper than 30 feet (Wydoski and Whitney 2003).

Mountain whitefish typically reach sexual maturity between three and four years of age. Spawning generally occurs in late October and early November. They prefer to spawn over gravel in stream riffles and on gravel shoals along lakeshores. Spawning typically occurs when water temperatures reach 40-45 °F. Eggs hatch in the early spring, and juveniles can be found along stream and lake shallows for a few weeks before migrating offshore into deeper water (Scott and Crossman 1973).

3-1.1.2 OTHER FISH SPECIES

Many native fish species besides salmonids inhabit Washington's freshwater streams and lakes, as well as estuaries and nearshore habitats. The following text describes the life histories and other relevant biological information for these species. Species are arranged in common groups where possible (e.g., lamprey, suckers, dace, sculpin, etc.); other species are described independently.

River Lamprey *(Lampetra ayresi)*

Lampreys are members of the family Petromyzontidae, an ancient fish group without true bones. River lamprey are one of the few parasitic fish found in coastal streams and estuaries from San Francisco Bay to southeastern Alaska, and inland in the Columbia River to the Columbia Gorge (Kostow 2002; Wydoski and Whitney 2003). Adult river lampreys are thought to occur in deep-water habitats of mainstem rivers (Kostow 2002). The river lamprey is a Federal Species of Concern in Washington, and has recently (1998) been listed as a State Candidate species. Population declines of the related Pacific lamprey have prompted concern for the river lamprey. Results of trawl surveys and sockeye smolt surveys at the Ballard Locks indicate that the river lamprey is a relatively common species in Lake Washington (City of Seattle 2000). Whether they are equally common elsewhere is unknown.

Little is known regarding the habitat requirements of the river lamprey. Adults are anadromous and parasitic on a wide variety of fish, including coho salmon, kokanee, smelt and herring (Kostow 2002; Scott and Crossman 1973). Parasitism of sockeye smolts has been observed in Lake Washington (City of Seattle 2000). Based on comparisons with other lamprey species, Hart (1973) surmised that river lamprey larvae remain in their natal streams for several years, usually in silt-sand backwaters and eddies near the bank. The larvae, indistinguishable from those of the western brook lamprey, are toothless and feed on microscopic plants and animals (Hart 1973; Scott and Crossman 1973). Metamorphosis occurs over a very long period, from July to April (Kostow 2002). In the final stages, lampreys congregate just upstream from saltwater, entering the ocean in late spring (Moyle et al. 1995). In their saltwater phase, river lampreys keep very close to shore and remain in the ocean for a short time—between 10 and 16 weeks (Kostow 2002; Moyle et al. 1995). Adults migrate back into fresh water in the fall, spawn in the winter and spring in clean gravel areas of small tributaries, and die after spawning (Moyle et al. 1995).

Western Brook Lamprey *(Lampetra richardsoni)*

The western brook lamprey (family Petromyzontidae) can reach seven inches in length and, unlike their regional relatives, are not parasitic. They also differ from the other species by spending their entire life in fresh water. Historically, their abundance and small size made them a commercial bait source for other fisheries in Washington (Wydoski and Whitney 2003).

Western brook lamprey are found in coastal streams of western North America, from California to British Columbia (Scott and Crossman 1973; Wydoski and Whitney 2003). In Washington, these lamprey are found in coastal and Puget Sound streams and as far inland as the upper reaches of the Yakima River (Wydoski and Whitney 2003). The western brook lamprey currently has no listing status in Washington.

Western brook lampreys spawn in the spring, creating nests in coarse gravel at the head of riffles in small streams. Eggs hatch after about ten days in water between 50-60 °F, taking longer in colder temperatures. Within 30 days after hatching, larvae emerge from the nests and move to the stream margin, where they burrow into silty areas. Similar to other lamprey larvae, they are filter feeders, consuming primarily diatoms. Larvae remain in the stream bottom—apparently moving very little—for approximately four to six years (Pletcher 1963).

In Canada, western brook lamprey larvae undergo metamorphosis between August and November. Metamorphosed lampreys move to deep burrows, where they remain from December to March or until they are ready to spawn (Pletcher 1963). Newly metamorphosed brook lamprey have been collected in the Lake Washington drainage in early February (Wydoski and Whitney 2003). Spawning, which occurs when water temperatures exceed 50 °F (April to July in Canada), is followed within one month by the death of the adults.

Pacific Lamprey *(Lampetra tridentatus)*

Pacific lamprey (family Petromyzontidae) are parasitic and the largest of Washington lamprey species—up to 30 inches in length. This species was a food source for indigenous peoples who smoked and sun dried them. Past commercial harvest has occurred for this species, particularly in the Columbia River system where it is still harvested in small numbers by Native Americans.

In Washington this species is found in most large coastal and Puget Sound rivers, and occurs long distances inland in the Columbia, Snake and Yakima River systems (Lee et al. 1980; Wydoski and Whitney 2003). Scott and Crossman (1973) describe the Pacific lamprey as “penetrating all major rivers, often to headwaters.” The Pacific lamprey is a Federal Species of Concern in Washington. Lamprey populations in the upper Columbia and Snake River basins have declined dramatically, likely as a result of elevated water temperatures, sedimentation of spawning gravels and barriers to migration (Close et al. 1995). The species has no state-level listing status.

The Pacific lamprey exhibits an anadromous life history, although some evidence exists that populations may occur in basins with no access to the ocean (Kostow 2002; Wydoski and Whitney 2003). Adults are parasitic on a wide variety of fish, including sockeye and pink salmon (Scott and Crossman 1973); the species is also known to attach itself to marine mammals (Wydoski and Whitney 2003). Between July and October, maturing Pacific lamprey enter fresh water and gradually move upstream to spawn the following spring (Hart 1973). The nest usually consists of a shallow depression built in gravel and rock substrates, or in sandy gravel at the upstream edge of a riffle (Hart 1973; Scott and Crossman 1973). Eggs hatch in two to four weeks (19 days at 59 °F); newly hatched larvae remain in their nests for two to three weeks before drifting downstream and burying themselves in mud at the bottom of pools or other areas of soft mud and sand (Hart 1973; Moyle 1976). Larvae live as filter-feeders, subsisting on algae and organic matter for at least five years; if a particular area’s food supply is exhausted, larvae may migrate to another area of the stream (Moyle 1976). Increased water flows during runoff can also encourage outmigration by washing away the sand and silt that the larvae require for anchoring themselves to the bottom (Hardisty and Potter 1971). After transformation from larvae to juveniles (or young adults), Pacific lampreys migrate downstream in spring and start parasitic life soon thereafter. The length of time spent in the ocean is not known, with estimates ranging from 6 to 40 months (Kostow 2002). Adults die after spawning (Moyle 1976).

Olympic Mudminnow *(Novumbra hubbsi)*

Olympic mudminnows are members of the Umbridae family—which includes only five species worldwide—and are the only known fish species endemic to Washington. They are small fish, generally about two inches long, and are found only in slow-moving streams, wetlands and ponds with soft mud-bottom substrate, little or no water flow and abundant aquatic vegetation (Harris 1974; Mongillo and Hallock 1999; Wydoski and Whitney 2003). Species distribution is limited to low gradients, low elevations (95 percent are below 328 feet elevation) in the coastal lowlands of the Olympic Peninsula, the rivers of the Chehalis and lower Deschutes drainages, and the south Puget Sound lowlands west of the Nisqually River (Mongillo and Hallock 1999; Wydoski and Whitney 2003). It is possible that observations of Olympic mudminnows in King and Snohomish counties are the result of illegal introductions from aquariums (Mongillo and Hallock 1999). The Olympic mudminnow is listed as a Washington State Sensitive species. The species is considered vulnerable due to its limited distribution and its dependence on healthy wetland habitat (Mongillo and Hallock 1999).

Wydoski and Whitney (2003) observe that mudminnows are usually found under overhanging banks or shore vegetation, preferring areas with low light and the brownish water of bogs and swamps. Meldrim (1968) found a wide tolerance for temperature extremes and low oxygen levels, but a restricted tolerance range for salinity and water current. Most of the sites where mudminnows occur are classified as wetlands, a habitat type that has been significantly diminished in quantity and quality over the last century and a half (Mongillo and Hallock 1999). Adults spawn between November and June (peaking in April and May) and females deposit eggs amidst clumps of vegetation to which fry remain firmly attached for approximately one week after hatching (Meldrim 1968 and Hagen et al. 1972; *in* Mongillo and Hallock 1999).

Columbia Tui Chub *(Siphateles columbianus gila bicolor)*

Tui chub, a member of the Cyprindae or “minnow” family, are typically long-lived small individuals, with some populations composed almost entirely of fish less than 5 inches long; however, they may attain lengths up to 16 inches over a lifespan of 20 years or more (Moyle et al. 1995; Wydoski and Whitney 2003). In Washington, tui chub are found in the central part of the state, east of the Columbia River (Wydoski and Whitney 2003). Lee et al. (1997) show records of tui chub only from the Lower Crab Creek and Lower Snake/Tucannon River drainages of eastern Washington. The tui chub currently has no listing status in Washington.

Tui chub inhabit lakes—alkaline lakes in particular—and the deep, quiet waters of large streams (Wydoski and Whitney 2003). For most of the year, adults gather in schools in deep water, moving to shallow, nearshore areas to spawn between May and June or July, when water temperatures are between 55 and 60 °F (Moyle et al. 1995; Wydoski and Whitney 2003). Algal beds in shallow, inshore areas appear to be necessary for successful spawning, egg hatching and larval survival (Moyle et al. 1995). Adults, in spawning aggregations, mill around dense algal beds in about three-foot-deep water and deposit adhesive eggs that stick to aquatic plants. Eggs hatch after about two weeks, and young remain in the nearshore environment until winter, when they migrate into deeper water offshore (Moyle et al. 1995, Wydoski and Whitney 2003). Generally, tui chub first spawn in their third year of life (Wydoski and Whitney 2003). Wydoski and Whitney (2003) noted that tui chub populations can become very dense, sometimes competing with trout. In some of the alkaline lakes of central Washington, tui chub populations are periodically controlled for the benefit of rainbow trout.

Chiselmouth *(Acrocheilus alutaceus)*

Chiselmouth, a moderately sized (up to 12 inches) member of the minnow family (Cyprinidae), is most commonly present in larger rivers and lakes. Its name comes from the unique mouth characteristics that enhance its ability to feed by scraping algae and vegetable matter from rocky surfaces. In Washington, this minnow species is found in streams and lakes in the Columbia, Snake and Yakima systems (Wydoski and Whitney 2003). The chiselmouth currently has no listing status in Washington.

Chiselmouth are generally found in the warmer areas of streams with slow currents, and occasionally in lakes (Wydoski and Whitney 2003). Adults spawn in tributary streams, apparently in June or July when water temperatures exceed 63 °F. The only detailed account of spawning comes from British Columbia, where eggs were found on the open bottom and among boulders (Scott and Crossman 1973). Juveniles require three to four years to attain sexual maturity and may live up to six years (Wydoski and Whitney 2003). Adults feed primarily on diatoms and filamentous green algae by scraping their distinctive chisel-like lower jaw along rocks or other bottom substrate, while juveniles consume surface insects (Scott and Crossman 1973; Wydoski and Whitney 2003).

Lake Chub *(Couesius plumbeus)*

Lake chub—a member of the minnow family, Cyprinidae—rarely exceed four inches in length (Scott and Crossman 1973). In Washington, they are known only from the northeastern part of the state (Wydoski and Whitney 2003). Lake chub have recently (1998) been listed as Washington State Candidate species because its distribution appears sparse and its status is unknown in Washington (Mongillo and Hallock 1999).

Lake chub exhibit a variety of habitat preferences across their range, living in large rivers at northern latitudes, but using lake habitat when it is available (Isaak et al. 2003; Scott and Crossman 1973). In the southern portion of their range, the lake chub is uncommon in lakes, but whether this represents a habitat preference or is simply because fewer lakes are available is unknown (Isaak et al. 2003). The only known Washington populations were observed in Cedar Lake in Stevens county in 1998 and in North Fork Beaver Creek in Okanogan county in 1999 (M. Hallock, pers. comm., 2003). Throughout their range, lake chub are found in clear, cool water with clean cobble or gravel substrates (Isaak et al. 2003).

Lake chub move into shallow areas along the margins of streams or lakeshores during the spring to spawn in water between 55-65 °F. The non-adhesive eggs are broadcast over large rocks and then settle into the substrate, hatching after approximately ten days (Isaak et al. 2003; Wydoski and Whitney 2003). Most lake chub attain sexual maturity at age three (some as young as two, others as old as four), and may have a high rate of post-spawning mortality (Isaak et al. 2003; Wydoski and Whitney 2003). Most fish probably do not live beyond five years (Scott and Crossman 1973).

Peamouth *(Mylocheilus caurinus)*

The peamouth, one of the most abundant Cyprinidae (“minnow”) species in the Columbia Basin, are found throughout Washington State (Troffe 1999; Wydoski and Whitney 2003). They can reach up to 14 inches in length and live up to 13 years. Peamouth are unusual among minnows for their ability to tolerate brackish water for limited periods, which may explain why they are the only native cyprinid to inhabit Vancouver Island and other coastal islands (Scott and Crossman 1973; Wydoski and Whitney 2003). The peamouth currently has no listing status in the state of Washington.

Peamouth are commonly found in the weedy shallows of rivers and lakes (Troffe 1999). Young fish remain in very shallow water during spring, summer and fall. They then move into deeper water during winter. Adults show some seasonal variation in their feeding habitats, tending to feed on the bottom near shore during spring and summer, and moving offshore to feed in the pelagic zone during fall and winter (Wydoski and Whitney 2003). Fish in Lake Washington tend to remain in the warmest water (Wydoski and Whitney 2003).

Spawning takes place in the inlets, outlets and gravel shallows of lakes during May and June, once waters reach about 54 °F (Wydoski and Whitney 2003). Spawning can take place in very shallow water—as little as one or two inches deep (Scott and Crossman 1973). During spawning, peamouth gather in schools, then females broadcast large numbers of sticky eggs, which hatch in seven to eight days depending on water temperatures (Scott and Crossman 1973; Wydoski and Whitney 2003). Juveniles reach sexual maturity three to four years after hatching (Wydoski and Whitney 2003).

Northern Pikeminnow *(Ptychocheilus oregonensis)*

Washington's largest native member of the minnow family (Cyprinidæ), northern pikeminnow (formerly known as northern squawfish) may live 15 to 20 years, reaching a length of 25 inches and weighing up to 29 pounds (Wydoski and Whitney 2003). The Columbia River basin includes the majority of the northern pikeminnow's distribution (Scott and Crossman 1973), but they are also found in lakes and streams with slow to moderate currents throughout Washington (Wydoski and Whitney 2003). Northern pikeminnow are the dominant predator of juvenile salmonids in the Columbia River system, especially in the lower Columbia River between the confluence of the Snake River and the estuary (Northwest Fisheries Science Center 2002). The northern pikeminnow currently has no listing status in Washington.

Pikeminnow spawn from late May through July; peaking in Washington in early July (Wydoski and Whitney 2003). Spawning habitat may include clean rocky substrates in slow-moving water at a wide range of depths in rivers, lake tributaries, lake outlet streams and shallow and deep littoral areas (Beamesderfer 1992). Eggs settle into the gravel and hatch after about seven days at 65 °F (Wydoski and Whitney 2003). Juveniles inhabit the shallow back channels and lake edges, while larger fish dwell along drop-off zones in the summer months (Scott and Crossman 1973). Sexual maturity occurs at three to eight years of age, with males typically maturing sooner than females (Beamesderfer 1992).

Longnose Dace *(Rhinichthys cataractae)*
Leopard Dace *(Rhinichthys falcatus)*
Speckled Dace *(Rhinichthys osculus)*
Umatilla Dace *(Rhinichthys umatilla)*

Dace are small fish in the minnow family (Cyprinidæ), with adults averaging two to three inches in length. The genus name *Rhinichthys* (“snout-fish”) refers to the prominent snout that characterizes these species. The four species of dace that occur in Washington share many key life history characteristics, such as breeding habitat, spawning period and habitat associations of juveniles. However, some differences among the life history traits of individual species are known; these are highlighted below. Currently, relatively little information is available about the Umatilla dace; at one time, this species was considered to be a stable hybrid between leopard dace and speckled dace. To date, it is not a “recognized” species in the United States by the American Fishery Society. The taxonomic status is still open to debate (M. Hallock, pers. comm., 2003).

The longnose dace is the most widespread of the four species, occurring from coast to coast in north-central North America. They are found throughout Washington (Wydoski and Whitney 2003). The leopard dace is a Columbia River system fish, found west of the Cascade mountains in the lower Columbia and the Cowlitz River system (M. Hallock, pers. comm., 2003) as well as in the Columbia River system east of the Cascade mountains (Scott and Crossman 1973; Wydoski and Whitney 2003). The speckled dace occurs throughout the western United States, with Washington and southern British Columbia at the northern extreme of its range (NFRG 2002; Wydoski and Whitney 2003). This species has been documented in the Chehalis and Deschutes rivers in western Washington (Scott and Crossman 1973), and throughout the Columbia River basin in eastern Washington (Lee et al. 1997). The Umatilla dace is endemic to the Columbia River basin (Troffe 1999). In Washington, the Umatilla dace has been reported from the Columbia, Yakima, Okanogan, Similkameen, Kettle, Colville and Snake Rivers (Wydoski and Whitney 2003).

The leopard dace and the Umatilla dace are Washington State Candidates species, but have no listing status at the Federal level. Concern for these species is prompted by their spotty distribution as well as their sensitivity to habitat alterations from reservoirs, pollution, water fluctuations and sedimentation (Wydoski and Whitney 2003). Neither the longnose nor the speckled dace currently has a listing status in the state of Washington.

All four dace species typically occur in shallow waters with cobble or gravel substrate (Scott and Crossman 1973; Troffe 1999; Wydoski and Whitney 2003). Longnose dace prefer faster current than the leopard dace or speckled dace, with the leopard dace preferring moderate current and the speckled dace preferring slow current (M. Hallock, pers. comm., 2003). Longnose, leopard and speckled dace occasionally are found at the margins of lakes (Wydoski and Whitney 2003). Breeding habitat for all four species consists of the gravel or cobble bottoms of shallow riffles (NFRG 2002; Troffe 1999, Wydoski and Whitney 2003). Speckled dace may select gravel that is cleaned by the current, or may clean individual stones by “mouthing” them (Troffe 1999; Wydoski and Whitney 2003). Leopard dace breed in slower, deeper waters than the other dace species, spawning in water greater than three feet deep (Troffe 1999; Wydoski and Whitney 2003). Speckled dace, in contrast, have been documented breeding in waters between one and four inches deep (NFRG 2002). The eggs of all four species are adhesive, clinging to the rocky substrate (Scott and Crossman 1973; Troffe 1999; Wydoski and Whitney 2003). Eggs that are not adequately hidden within the substrate are often cannibalized by adults (Wydoski and Whitney 2003).

The spawning period for all four species generally encompasses late spring through summer (Wydoski and Whitney 2003). Longnose dace generally breed when water temperatures exceed 53 °F (Wydoski and Whitney 2003). Fry hatch approximately six to ten days after eggs are fertilized, and juveniles spend the first few months of life in shallow, slow water (NFRG 2002; Troffe 1999; Wydoski and Whitney 2003). Longnose dace may overwinter in pools (Wydoski and Whitney 2003). Speckled dace are found in deeper runs (greater than three feet) during March (NFRG 2002). Most dace typically reach sexual maturity by the end of their second summer and have a life span of approximately five years, although speckled dace have a high rate of post-spawning mortality, with few fish living beyond three years (Wydoski and Whitney 2003).

Redside Shiner *(Richardsonius balteatus)*

The redside shiner is a small minnow (family Cyprinidae), typically four to five inches long. The fish often occurs in large schools, and has been widely introduced into lakes in some areas. The redside shiner occurs throughout the Pacific slope of North America, from the Peace River in Alberta to the Bonneville basin in Utah and Nevada (Scott and Crossman 1973; Troffe 1999). This species is found in streams and lakes throughout Washington (Wydoski and Whitney 2003). The redside shiner currently has no listing status in the state of Washington.

Redside shiners occur often in large schools in ponds, lakes, streams and irrigation ditches, with summer water temperatures typically between 55 and 68°F (Scott and Crossman 1973; Wydoski and Whitney 2003). Adults spawn in groups of 30 to 40, usually during April through July (Wydoski and Whitney 2003). Juveniles attain sexual maturity approximately three years after hatching, and females deposit small, adhesive eggs in multiple lots throughout the breeding season over an unprepared substrate (Scott and Crossman 1973). In streams, spawning may occur in riffles with a gravel substrate; in lakes, spawning takes place in vegetation along the shoreline (Scott and Crossman 1973; Wydoski and Whitney 2003). Fertilized eggs adhere to gravel and vegetation, and hatchlings are often swept downstream by the current to rear in lakes (Scott and Crossman 1973).

Lake-dwelling redside shiners have seasonal migratory and daily movement patterns, inhabiting shallow nearshore water by day and deeper waters during the night and winter months (Troffe 1999; Wydoski and Whitney 2003). As winter approaches, tributary stream inhabitants migrate into the lower reaches as water temperatures and day length decrease (Troffe 1999).

Burbot *(Lota lota)*

Known also as eelpout, ling, cusk and lawyer, burbot are the only member of the cod family (Gadidæ) that dwells in fresh water (Wydoski and Whitney 2003). Adults can be quite large, reaching lengths of 4 feet and weighing up to 75 pounds (Scott and Crossman 1973; Troffe 1999). In Washington, burbot are native to the Columbia River and scattered in deep lakes of eastern Washington, representing the southern extent of their distribution in the Pacific Northwest (Quigley and Arbelbide 1997).

Burbot prefer cold water, and will move to the lower zone of a thermally stratified lake or deep-water pools of large rivers during summer (Simpson and Wallace 1982). Although fairly sedentary most of the year, some populations will move great distances to spawn during winter (Simpson and Wallace 1982). As winter spawners and weak swimmers, burbot have a low tolerance for river flow regime changes. Increased winter flows may prevent burbot from reaching their spawning areas (American Wildlands and Idaho Conservation League 2000). Burbot spawn during winter in 35 °F water—usually in lakes, but also in rivers. Spawning typically occurs in shallow bays over a sand or gravel bottom (Scott and Crossman 1973; Wydoski and Whitney 2003). In rivers, burbot spawn in low-velocity areas in main channels or in side channels behind deposition bars. Preferred substrates range in size from fine silt to gravel (McPhail and Paragamian 2000). Eggs settle into cracks in the substrate and hatch after four to five weeks (McPhail and Paragamian 2000; Troffe 1999). Juveniles are sometimes abundant in streams and shallows of lakes, where they tend to select shoreline areas among rocks and debris for feeding and security (McPhail and Paragamian 2000; Wydoski and Whitney 2003). Burbot reach sexual maturity at 3 to 5 years of age, and may live up to 20 years (McPhail and Paragamian 2000; Scott and Crossman 1973).

Threespine Stickleback *(Gasterosteus aculeatus)*

The stickleback family (Gasterosteidæ) is represented in Washington by a single species, the threespine stickleback. These fish are approximately three inches in length and have a defense mechanism consisting of three prominent dorsal and pelvic spines. Despite these defenses, they are a prominent prey source for many trout, salmon and birds in both fresh and marine waters (Scott and Crossman 1973; Wydoski and Whitney 2003). In Washington, they are found in the brackish water of coastal streams, inland lakes and streams statewide, and in Puget Sound (Wydoski and Whitney 2003). The threespine stickleback currently has no listing status in the state of Washington.

The threespine stickleback is a remarkably adaptable species, occurring in environments ranging from the open ocean to landlocked lakes and ephemeral streams (Hart 1973; Moyle et al. 1995). In freshwater-breeding populations, sticklebacks prefer quiet water habitat such as pools with abundant aquatic vegetation, backwater areas and stream margins where water velocity is low (Moyle et al. 1995). They are usually found close to the bottom, and are often associated with aquatic vegetation (Wydoski and Whitney 2003). Sticklebacks are voracious eaters, consuming any available animal foods.

Threespine sticklebacks are short-lived fish, achieving sexual maturity and spawning within a single year. In Washington, about 90 percent die in their first year, shortly after spawning (Scott and Crossman 1973; Wydoski and Whitney 2003). The breeding period may extend from April through September, but the bulk of spawning occurs from May through July (Scott and Crossman 1973; Wydoski and Whitney 2003). Their nests are tube-shaped structures of twigs, algae and assorted debris, usually on the bottom in shallow, sandy areas. Males build the nests, guard and aerate the eggs until they hatch in approximately seven days at 64-66 °F, and remain with the hatchlings for about another seven days until they disperse (Scott and Crossman 1973; Wydoski and Whitney 2003).

Sandroller *(Percopsis transmontana)*

The sandroller is a small fish, generally less than five inches long, and is one of only two species in the trout-perch family (Percopsidæ) in North America. These fish appear to be very secretive in behavior, remaining well spaced from other individuals, and are rarely collected in abundance. In Washington, the sandroller is found only in the Columbia River system and some of its tributaries, including the Yakima and Cowlitz Rivers, and up the Snake River into Idaho (Wydoski and Whitney 2003). Katula (1992) speculates that sandrollers may be present in many rivers of southern Washington. The sandroller is a Washington State Monitor species, presumably due to its restricted range and the paucity of information about its life history needs. The species has no listing status at the Federal level.

The sandroller has been found in quiet backwaters with cover such as undercut banks, submerged tree roots and debris in small streams, but it is also found as deep as 71 feet in the Columbia River (Wydoski and Whitney 2003). Katula (1992) found sandrollers in small- to medium-sized rivers that do not remain consistently cool through summer. Habitat associations appear to vary with age: young-of-the-year occur primarily in weed bays or waterways adjacent to the main river, while adults may be associated with eddies behind large boulders, logs and bridge supports (Katula 1992). Page and Burr (1991) describe the sandroller as usually found near vegetation, over sand. Spawning may occur on rocky substrates in shallow streams or along the shallow shores of rivers (Katula 1992). In Idaho, spawning occurs in late May or early June (Simpson and Wallace 1982). Katula (1992), however, found that eggs were laid in an aquarium from mid-April to mid-July, when temperatures exceeded 60 °F. The eggs, which were strongly adhesive, were laid on top of gravel in territories defended by males (Katula 1992).

Longnose Sucker *(Catostomus catostomus)*
Salish Sucker *(Catostomus carli)*
Bridgelip Sucker *(Catostomus columbianus)*
Largescale Sucker *(Catostomus macrocheilus)*
Mountain Sucker *(Catostomus platyrhynchus)*

Suckers comprise a family of bottom-dwelling fish in the order Cypriniformes (minnows, carp and related fish). The genus name *Catostomus* ("inferior mouth") alludes to the ventral position of the mouth, which is a toothless structure with small projections (*papillae*) for sensing food—an adaptation for sucking up food from the bottoms of lakes and streams. The larger members of this group (longnose and largescale suckers) can grow up to two feet long and weigh seven pounds. Bridgelip and mountain suckers are slightly smaller, reaching maximum lengths of about 15 inches and 9 inches, respectively.

In Washington, longnose suckers occur primarily in the Columbia River system (Wydoski and Whitney 2003). The Salish sucker in Washington has been documented at Lake Cushman on the Olympic Peninsula, and in the river systems along east/northeast Puget Sound (M. Hallock, pers. comm., 2003). Bridgelip suckers are found in the upper and middle Columbia River drainage, but are absent from Box Canyon Reservoir and tributaries, as well as Boundary Reservoir. They are also found in the Spokane and Snake Rivers (Wydoski and Whitney 2003). The largescale sucker is found throughout Washington (Wydoski and Whitney 2003). The mountain sucker occurs in the Columbia River and its tributaries east of the Cascade Range (Wydoski and Whitney 2003) as well as in the Toutle and Cowlitz River systems west of it (M. Hallock, pers. comm., 2003).

The Salish sucker is a Washington State Monitor species. In British Columbia, the Salish sucker's restricted distribution—along with the effects of habitat degradation and loss—have led to considerable concern that the species may face extirpation in that part of its range. Populations in Washington appear to be more stable and face fewer threats BCMELP 1993). The mountain sucker is a Washington State Candidate species due to its sensitivity to high stream temperatures, sedimentation of spawning habitat and/or lack of preferred food items (WDF 1991). None of the sucker species have any listing status at the Federal level.

Most suckers spend the majority of their time at the bottom of lakes or other quiet waters, feeding on algae (bridgelip sucker) or invertebrates (all other sucker species)

(Scott and Crossman 1973; Wydoski and Whitney 2003). Longnose and largescale suckers are more commonly found in lakes, while bridgelip and mountain suckers are generally associated with cold, clear streams. The only known Salish sucker populations in Washington occur in lake and slough habitats (BCMELP 1993).

All five species spawn over gravel substrates in riffles. Largescale and mountain suckers appear to prefer riffles at the downstream ends of pools, while longnose and largescale suckers have occasionally been observed spawning in shallows of lakes (BCMELP 1993; Isaak et al. 2003; Scott and Crossman 1973; Troffe 1999; Wydoski and Whitney 2003). Compared to the other species, largescale suckers may use sand and finer gravels more frequently as spawning substrate (Wydoski and Whitney 2003). The eggs of all five species are adhesive. Scott and Crossman (1973) reported that eggs of the large scale sucker hatch after approximately two weeks; the incubation period of the other species is probably similar (Wydoski and Whitney 2003).

Spawning for all five species occurs during spring and early summer. Salish suckers have been observed spawning in April, when water temperatures were 44-46°F, although specimens in spawning condition have been seen as late as August (BCMELP 1993). Longnose suckers spawn in April and May—shortly after the ice has melted in some areas—when water temperatures are approximately 40 °F (Scott and Crossman 1973; Wydoski and Whitney 2003). Largescale suckers typically spawn between mid-May and late June, in 46-48 °F water (Scott and Crossman 1973). The breeding chronology of bridgelip suckers is largely unknown, but Scott and Crossman (1973) speculate that it takes place in late spring, based on an observation of ripe females in northern British Columbia in early June. Mountain suckers appear to spawn later and in warmer water than the other species—mostly June or early July, in water between 52-66 °F (Isaak et al. 2003; Wydoski and Whitney 2003).

Most suckers reach sexual maturity between three and five years of age; the larger species may live for many years, spawning for five successive years or more. Longnose suckers in Great Slave Lake have been aged at 19 years, but these ages may have been underestimated by up to five years (Scott and Crossman 1973). In contrast, the oldest recorded age for mountain suckers is seven to nine years (Wydoski and Whitney 2003).

Juvenile suckers are found in a variety of habitats. Hatchling longnose suckers typically remain in gravel or shallow weedy areas for approximately one to two weeks before moving to lake habitats (Scott and Crossman 1973; Wydoski and Whitney 2003). Fingerling mountain suckers have been found in small, intermittent streams with little discharge and abundant vegetation, and larger juveniles have been associated with weedy side channels or deep pools (Scott and Crossman 1973; Wydoski and Whitney 2003). Largescale sucker fry move to bottom habitats by the end of their first summer (Scott and Crossman 1973; Wydoski and Whitney 2003).

White Sturgeon *(Acipenser transmontanus)*
Green Sturgeon *(Acipenser medirostris)*

Sturgeon are members of the family Acipenseridae. The white sturgeon is the largest fish found in the fresh waters of North America, purported to reach a length of 20 feet and a weight of 1,800 pounds (Scott and Crossman 1973). Green sturgeon are somewhat smaller but still formidable: the largest reported specimen was seven feet long and weighed 350 pounds (Wydoski and Whitney 2003). Both species are notable also for their lack of scales, being covered instead with large, bony plates (Scott and Crossman 1973). With the exception of a few landlocked populations, sturgeon spend most of their time in marine waters, moving into fresh water only to spawn (Scott and Crossman 1973; Setter and Brannon 1992).

In Washington, white sturgeon are found in the Columbia River, Snake River, Grays Harbor, Willapa Bay, Puget Sound and Lake Washington (Wydoski and Whitney 2003). Although this species is considered to be anadromous, Setter and Brannon (1992) note that some populations in the Columbia River have adapted to the environmental alterations caused by dam construction, and may be reproducing successfully in some impoundments. Washington waters with green sturgeon fisheries include the Columbia River, Willapa Bay and Grays Harbor. Individuals are also occasionally caught incidentally in small coastal bays and the Puget Sound (Adams et al. 2002). Green sturgeon have been reported as far as 140 miles inland in the Columbia River, but are presently restricted to areas below the Bonneville Dam and are found almost exclusively in the lower 40 miles of the river (Wydoski and Whitney 2003).

Currently, neither sturgeon species has any listing status in the state of Washington. Both species currently sustain commercial, sport and tribal fisheries, but are susceptible to overexploitation due to their longevity, slow growth and delayed maturation (DeVore et al. 1999). Overexploitation led to a collapse of white sturgeon fisheries in the lower Columbia River above Bonneville Dam during the 1980s (Beamesderfer and Nigro 1993). The National Oceanic and Atmospheric Administration (NOAA) Fisheries has classified green sturgeon as a candidate for listing, however, noting that the species is known to spawn in only three river basins (Klamath, Rogue and Sacramento), leaving it vulnerable to a catastrophic event.

Freshwater habitats used by sturgeon are generally large and deep. Spawning for both species takes place in deep, fast-flowing sections of rivers (Beamesderfer and Nigro 1993; Wydoski and Whitney 2003). Spawning habitat for white sturgeon is also characterized by cobble or boulder substrates. Rapids and falls throughout the lower Columbia River once provided suitable spawning habitat conditions, but impoundments have restricted suitable habitat to the tailrace areas of dams during high-discharge periods (Beamesderfer and Nigro 1993). White sturgeon spawn primarily at water temperatures between 50 and 66 °F, and freshly fertilized eggs have been collected at turbidities ranging from 2.2 to 11.5 Nephelometric Turbidity Units (NTU) (McCabe and Tracy 1993). Physical characteristics of green sturgeon eggs suggest that the species probably requires colder, cleaner water for spawning and probably does not spawn in Washington waters (S. Doroshov, University of California Davis, pers. comm., as cited in USFWS 1995). White sturgeon in the Columbia River below Bonneville Dam spawn between late April and early July (McCabe and Tracy 1993). Eggs of white (and presumably green) sturgeon are broadcast-spawned, then settle to the bottom and hatch after approximately one week (Wydoski and Whitney 2003). McCabe and Tracy (1993) found white sturgeon young-of-the-year as early as late June, less than two months after spawning was estimated to have begun. Young-of-the-year were most abundant in depths greater than 40 feet. Juvenile white sturgeon avoided vegetated areas, favoring even, sandy bottoms or those with stones or depressions (McCabe and Tracy 1993). Where marine access is available, juveniles are presumed to migrate out to sea before two years of age (Moyle et al. 1995). Fish in three lower

Columbia River reservoirs traveled widely within each reservoir, but rarely passed a dam (North et al. 1993).

Studies in the Columbia River suggest that white sturgeon migrate upstream during fall and downstream during late winter and spring (DeVore and Grimes 1993), although Scott and Crossman (1973) describe adults as moving into rivers in early spring and back out to sea in late summer and fall. Green sturgeon appear to follow a migration pattern similar to the latter, moving upstream during spring and downstream during fall and winter (Adams et al. 2002). White sturgeon first spawn at 11 to 34 years of age (earlier for males, later for females), while first spawning for green sturgeon occurs at 15 (males) to 17 (females) years (Adams et al. 2002; Scott and Crossman 1973). Females of both species spawn once every five years or so, and can spawn many times over a lifetime that may extend up to 50 (green sturgeon) or 100 years (white sturgeon) (Adams et al. 2002, Scott and Crossman 1973).

The Columbia River estuary and other coastal Washington estuaries appear to attract concentrations of green sturgeon during late summer and early fall. Neither feeding nor spawning occurs in association with these concentrations, and there is no information about how much of the population is in these concentrations each year, or whether this varies (Adams et al. 2002).

Coastrange Sculpin *(Cottus aleuticus)*

The tan/gray, blotchy-colored coastrange sculpin is distinguished by eyes located on the top of its head and a light colored “notch” on its back between the dorsal and tail fin. It is common in the brackish water of estuaries and in freshwater systems of the Olympic Peninsula, tributaries to Puget Sound and the lower Columbia River, downstream of Bonneville dam. Coastrange sculpin generally prefer the gravel substrate of medium or large streams kept clean by a moderate to fast current, but they have also been found on sand/mud bottoms of lakes (Wydoski and Whitney 2003). They blend in well with the substrate. The average age is four to eight years, and the average size varies between three and four inches, with the largest fish recorded at about 4.2 inches. A “dwarf” form inhabits Lake Washington (M. Hallock, pers. comm., 2003). Females can spawn more than once and deposit their adhesive eggs in grouped nests that are located under rocks and guarded by the male. The coastrange larvae feed initially on plankton in lakes, then drop to the lake/stream bottom where they feed on the larvae of stoneflies, caddisflies, true flies and mayflies. Adults feed on stray salmon eggs, fry and worms dislodged from gravels during salmon spawning. Coastrange larvae provide food for juvenile sockeye salmon, and juveniles/adults provide forage for trout and char (Wydoski and Whitney 2003).

Prickly Sculpin *(Cottus asper)*

The prickly sculpin is covered with many prickles, has a large head with well-developed palatine teeth and is found along the coastal areas of Washington, as well as 400 miles upstream in the Columbia River. It is found in slow-moving freshwater streams as well as in estuarine habitats. It is generally observed on sand, gravel or rubble substrate, both in or near cover and in open spaces, relying on its drab color as camouflage. It is the largest of the sculpin, with an average size of five inches (the largest recorded at 9.3 inches), and an average lifespan of two to four years (the oldest recorded age of seven years). Prickly sculpin spawn between two and four years of age during April and May, laying between

280 and 7,410 small yellow/orange adhesive eggs, depending on the size of the female. Nests are located under rocks, logs and other debris in flows less than one cubic foot per second. Males guard the nest and fan the eggs with their fins to circulate water around them. Larvae often form schools during their first month and feed on plankton and aquatic insect larvae prior to settling to the bottom. Adults feed on benthic organisms, immature aquatic insects, fish eggs and small fish. The prickly sculpin provide an important prey base for largemouth bass, cutthroat trout, northern pikeminnow and yellow perch (Wydoski and Whitney 2003).

Reticulate Sculpin *(Cottus perplexus)*

Connected dorsal fins, a narrow round caudal peduncle, a lack of palatine teeth and a small mouth distinguish the reticulate sculpin. It is found in pools and riffles in coastal rivers, Puget Sound streams and the lower Columbia River. It prefers habitat with rubble or gravel substrates in quiet water or slow riffles of freshwater streams and wetlands, but it can tolerate brackish water. The reticulate sculpin avoids territories of other sculpin species, minimizing competition. Reticulate sculpin grow slowly, averaging three to four inches in length at four years, with the oldest recorded fish at seven years and about four inches. Spawning first occurs at two years of age when females deposit adhesive eggs on ceilings of nests under rocks or other debris in streams. Males guard the nests, which may contain eggs from more than one female. Food sources include immature aquatic insects, larvae, invertebrates, salmon eggs, fry and other sculpin. Its small size allows the reticulate sculpin to penetrate deep into the gravel substrate (up to 14 inches in the right conditions) to feed on salmon eggs. In turn, it is food for trout and large juvenile salmon (Wydoski and Whitney 2003).

Riffle Sculpin *(Cottus gulosus)*

The mottled, drab-colored riffle sculpin has a large mouth with palatine teeth and a deep and compressed caudal peduncle. They are found in cooler coastal streams, Puget Sound drainages and in the Columbia River upstream to the confluence of the Cowlitz River. They are typically found in slow riffles of small streams and backwaters of larger rivers, except during spawning when they are found in faster riffles (Wydoski and Whitney 2003). They are found over gravel, sand and mud substrates (M. Hallock, pers. comm., 2003) and have a tolerance for brackish waters. Most riffle sculpin reach an average age of four years and an average length of three inches (maximum length of five inches). Spawning occurs in March and April, with small, pale yellow to deep orange adhesive eggs deposited on the ceiling of their nests located in small pockets of rotting logs. Adult males actively guard the nests, which may contain eggs from more than one female. Riffle sculpin feed on crustaceans, aquatic insect larvae, snails and small fish and may, themselves, provide food for trout (Wydoski and Whitney 2003).

Shorthead Sculpin *(Cottus confuses)*

The small head, large lips and slender body distinguish the mottled, drab-colored shorthead sculpin. They are found in the Columbia River system and in Puget Sound and Hood Canal drainages. They prefer cold, fast riffles in streams, sometimes at higher altitudes than other sculpin, on a rubble or gravel bottom. They do not appear to hide as other sculpins do, and are often found in open water. They live at least four to six years and reach a length of about four inches, with the largest recorded at five inches

(Wydoski and Whitney 2003). Spawning occurs in spring when females deposit adhesive eggs, often on ceilings of nests located under rocks or other debris. Males guard the nests, which may contain eggs from more than one female (M. Hallock, pers. comm., 2003). Food sources are bottom organisms, immature aquatic insects, fish eggs and fry. Shorthead sculpin probably serve as food for game fish species (Wydoski and Whitney 2003).

Torrent Sculpin *(Cottus rhotheus)*

The torrent sculpin has a stout body, and is distinguished by a large head and mouth and two broad vertical dark bars that slant obliquely forward from under the soft dorsal fin. The species is widely distributed throughout the state. Torrent sculpin prefer gravel, cobble and boulder substrate within faster water (1.4 to 4.0 feet per second) of larger rivers (>eight feet in width), but they are also found along shorelines of lakes. They may live as long as six years and reach a length of six inches. They reach maturity at two years of age, spawning in late spring under stones in swift water (Wydoski and Whitney 2003). Females deposit adhesive eggs, often on ceilings of nests located under rocks or other debris. Males guard the nests, which may contain eggs from more than one female (M. Hallock, pers. comm., 2003). Torrent sculpin feed on a variety of organisms, such as copepods and ostracods, nymphs and larvae of insects, other sculpin eggs, mollusks and fish. They can also provide forage for game fish (Wydoski and Whitney 2003).

Slimy Sculpin *(Cottus cognatus)*

The small, drab-colored slimy sculpin is found in the upper Columbia River system, including Lake Chelan, in riffles among rocks of cold, clear streams or gravel beaches of lakes—particularly near inlet streams. They average three inches in length, with the largest slimy sculpin recorded at 4.6 inches; and they average four to six years in age. Slimy sculpin spawn in spring, with females depositing eggs often on ceilings of nests under rocks that are guarded by males (M. Hallock, pers. comm., 2003). They are opportunistic feeders, eating the most abundant food available, such as aquatic insects, mollusks, crustaceans, salmon eggs, small fish and vegetation. They are known to provide food for trout, northern pike and burbot (Wydoski and Whitney 2003).

Paiute Sculpin *(Cottus beldingi)*

Paiute sculpin have large heads, weak or no palatine teeth, large bulging eyes somewhat on the top of their heads, dorsal fins separated at the base and a long slender spine at the angle of the preopercle. Like many other sculpin, they have a dark, mottled pattern over a light tan body with a whitish ventral side. They are found east of the Cascade mountains in Washington in the Columbia, Yakima, Walla Walla and Snake Rivers and their tributaries. Paiute sculpin prefer slow to moderate current among rubble or large gravel in wide, warm-water streams with a slight to moderate gradient. In lakes they are found at various depths, from shallow to 700 feet. Growing at a slower rate than other sculpin, they may live to be five years old and reach a length of five inches. They mature at about three years of age and spawn in late spring. Following a courtship ritual, the female deposits adhesive eggs, often on the ceiling of nests located under logs and rootwads that are guarded by males. Their food source is filamentous green algae, ostracods, midge larvae, stoneflies, amphipods and snails. Due to their abundance and role as a food source for game fish, they are considered important in the food chain (Wydoski and Whitney 2003).

Margined Sculpin *(Cottus marginatus)*

Margined sculpin closely resemble slimy sculpin, with a large head, small tapered body and bulging eyes. They have a dark mottled pattern over a tan background with a white belly. They probably have a similar life history to the reticulate sculpin, and are found in the Walla Walla, Touchet and Tucannon Rivers in Washington. They are predominantly found in pools and glides, but are also observed in riffles. They prefer small gravels and silts, avoiding larger gravels and cobble. They reach an average length of about 2.5 inches and probably live to be four years old. Spawning occurs in spring under rocks, rootwads or logs. After courtship, the female deposits a mass of adhesive eggs, often on the ceiling of the nest, which is guarded by the male. They are opportunistic feeders, primarily eating immature aquatic insects, invertebrates, small fish and eggs (M. Hallock, pers. comm., 2003). They occur in streams with rainbow trout and likely provide food for them (Wydoski and Whitney 2003).

Margined sculpin are listed as a Federal species of concern and a state sensitive species in Washington. They are confined to streams in an extremely small area in southeastern Washington, and their habitat has been degraded through agriculture, grazing, logging, and channelization. This species has also been listed as “sensitive” in Oregon for similar reasons (Wydoski and Whitney 2003).

Mottled Sculpin *(Cottus bairdi)*

The mottled sculpin have a large head, an incomplete lateral line and three straight, vertical, dark bands on the body under the soft dorsal fin. Identification is difficult, as their distinguishing features vary in different parts of the state (M. Hallock, pers. comm., 2003). They are found east of the Cascade mountains in the Columbia, Snake and Yakima River systems and west of the mountains in the White River system of Puget Sound. They prefer cool, clear streams with rubble, gravel or rocky bottoms, moderate to fast current and summer water temperatures of about 55–65 °F. The largest recorded specimen was 5.7 inches and at least five years old, but the average is three inches. They mature at two years of age, spawn in spring under rocks, logs and discarded metal debris following a courtship ritual (Wydoski and Whitney, 2003). Adhesive eggs are deposited in clusters of 20 to 150, often on the ceiling of the nest, and are guarded by the males for 20 to 30 days (M. Hallock, pers. comm., 2003). Mottled sculpin eat a variety of organisms, including aquatic insects and most invertebrates. They are an important food source for trout (Wydoski and Whitney 2003).

Longfin Smelt *(Spirincus thaleichthys)*

Smelt are characterized by having cycloid scales and an adipose fin. Longfin smelt are distinguished from eulachon by their long pectoral fins. They are anadromous with landlocked populations in Lake Washington, where they inhabit open water. They have a well-defined migration pattern, dropping to deep water during the day and moving upward in the water column at night. Juveniles in Lake Washington are in water 36 to 72 feet deep from July to December, but feed in deeper water (>60 feet) from January to June. Adults are known to move to depths of 60 to 120 feet during the day. They have not been found in temperatures above 65 °F. Longfin smelt in Lake Washington rarely live to be three years old; most die after spawning.

Anadromous populations spawn in coastal streams from October to December. The Lake Washington population spawns in at least five tributaries, the Cedar River being most important. They migrate upstream to spawn between January and April at night in water temperatures between 40 and 45 °F. In general, females spawn completely on their first migration upstream, but males can return to spawn many times. Females deposit an average of 1,550 small eggs that develop into larvae in approximately 40 days. Landlocked longfin smelt feed on zooplankton and are most likely an important food source for other fish, although their tendency to go into deep waters may restrict their availability (Wydoski and Whitney 2003).

Eulachon ***(Thaleichthys pacificus)***

Eulachon—also known as candlefish—are distinguished from the longfin smelt by shorter pectoral fins. Eulachon are a Washington State Candidate species. They are anadromous, with large spawning runs in the Columbia, Cowlitz, Kalama, Lewis, Sandy and Nooksack Rivers during late winter. They spend most of their lives in the nearshore waters of the Pacific Ocean, migrating only a short distance upstream to spawn. They spawn at night in gravel, with males preceding the females in the migration. Each female produces between 17,300 and 60,000 eggs that are attached to the gravel by a short peduncle. Larvae emerge in about one month and generally move immediately out to sea. At sea, eulachon feed on euphausiid shrimp and typically live for three years. They provide a sport and commercial fishery (Wydoski and Whitney 2003).

Shiner Perch ***(Cymatogaster aggregata)***

The shiner perch is a member of the sunfish family, and is distinguished by yellow and black vertical bars along its sides. In Washington, shiner perch occur in various coastal streams throughout Puget Sound. They are found in abundance in large schools in the shallow water of bays and estuaries of coastal rivers, as well as in Puget Sound during the summer months. There they feed, mate and give birth to their live young. During the summer, they are commonly found at the head of tidewater in the brackish water of estuaries, and in fresh water at the mouths of coastal streams. During the winter, shiner perch are commonly taken by shrimp trawls from waters 60 to 240 feet deep in the Pacific. They live as long as eight years and reach a length of eight inches, with females living longer than males (Wydoski and Whitney 2003). Males are sexually mature at birth. Eggs are fertilized internally, and females bear between six and 20 living young near the end of their first year. The newborns spend the summer in estuaries, doubling their size prior to moving to deeper water in fall. They are opportunistic feeders, preferring bottom organisms and encrusted organisms such as barnacles. They provide forage for marine fish and are considered a delicacy among humans (Wydoski and Whitney 2003).

Pacific Staghorn Sculpin ***(Leptocottus armatus)***

The Pacific staghorn sculpin is distinguished by having a spine with three to four large barbs pointing upward from the preopercle in a manner resembling an antler. They are found in estuaries and bays along the coast and throughout Puget Sound. They may exceed 13 inches in length, with females living longer and growing larger than males. Spawning occurs in marine waters from October to March; adults have less tolerance for low salinities than juveniles. Juveniles feed largely on bottom organisms such as crustaceans, polychaete worms and gammarids. Adults feed on shrimp and fish. The Pacific staghorn sculpin provides food for larger fish and ducks (Wydoski and Whitney 2003).

Starry Flounder *(Platichthys stellatus)*

The starry flounder is a marine flatfish with both eyes on the same side of its head. Starry flounder are white on the ventral side and have conspicuous ventral black bands on their dorsal and anal fins. They have a tolerance for a variety of salinities and are found along the coast and in estuaries and lower rivers, with one sighting as far as 75 miles up the Columbia River. Starry flounder have been recorded at a depth of 900 feet. They avoid rock bottoms, but are found everywhere else. Some move a considerable distance (440 nautical miles). They may reach a length of 3 feet and a weight of 20 pounds. Females grow faster than males and are heavier at a given length. Males mature at two years and females at three years. They spawn in winter with water temperatures averaging 51.8°F. Females deposit large numbers (up to 11 million in a 22.2 inch female) of small, pale yellow-orange buoyant eggs that develop into pelagic larvae. They feed on copepods, amphipods and annelid worms and, as adults, include crabs, mollusks and echinoderms. Feeding slows in winter as temperatures drop. Starry flounder provide both a recreational and commercial fishery (Wydoski and Whitney 2003).

Surf Smelt *(Hypomesus pretiosus)*

Surf smelt occur throughout the marine waters of Washington, from the Columbia River to the Canadian border and southernmost Puget Sound. They are an abundant schooling forage fish living in the nearshore community of Puget Sound. Surf smelt spawning beaches are often located at the heads of bays or inlets associated with freshwater seepage and shaded by trees and bluffs. Shade moderates beach surface temperatures and helps summer-spawned eggs survive to hatching. Surf smelt deposit adhesive, semitransparent eggs on beaches that have a specific mixture of coarse sand and pea gravel and where surf action or drying of the adhesive eggs is avoided. Eggs are deposited near the water's edge at a depth of a few inches around high tide. Many stocks have been documented to spawn year-round, and multiple spawnings within and between tide cycles are common. Juvenile surf smelt rear in the nearshore waters throughout Puget Sound. Adult surf smelt feed primarily on planktonic organisms, and in turn are food for many marine animals such as seabirds, marine mammals and other fish. The movements of juveniles and adults between spawning seasons is virtually unknown. The specific nature of surf smelt spawning grounds and the limited extent of available spawning habitat in Puget Sound has made the species quite vulnerable to shoreline development and construction activities. (Hart 1973; WDFW Forage Fish website http://www.wa.gov/wdfw/fish/forage/smelt.htm; Ecology Puget Sound Shorelines website http://www.ecy.wa.gov/programs/sea/pugetsound/species/smelt.html).

Pacific Sand Lance *(Ammodytes hexapterus)*

The Pacific Sand Lance occurs throughout the coastal northern Pacific Ocean from the Sea of Japan to southern California and across Arctic Canada. Within Washington, sand lance populations are widespread within Puget Sound, the Strait of Juan de Fuca and the coastal estuaries. The abundance and broad distribution of planktonic sand lance larvae throughout the bays and inlets of Puget Sound in late winter suggest that their spawning habitats and spawning activity are widespread in the region. Although most spawning occurs on the finer-grained substrates, sand lance also deposit their eggs on beaches that are armored with gravels up to one inch in diameter. Spawning occurs at tidal elevations ranging from +5 feet to the mean high water line. The deposited eggs are then dispersed along the beach with each tide exchange. When about one inch in length, sand lance "school up" and can be found in bays and inlets throughout Puget Sound. Adults feed in open water during the day and burrow into the sand at night to avoid predation. Because sand lance spawning occurs in the upper intertidal zone of sand gravel beaches, habitats are increasingly vulnerable to the cumulative effects of various types of shoreline development. Trees along bluffs are important for moderating erosion rates and for providing shade, which moderates water temperatures. Fallen trees provide cover and stability of spawning substrates along transport beaches. (WDFW Forage Fish website http://www.wa.gov/wdfw/fish/forage/; NOSC Forage Fish Pages website http://www.nosc.org/sandlance.htm.)

Pacific Herring *(Clupea pallasii)*

Pacific herring inhabit the inshore waters of the Pacific Ocean from Alaska to California. The herring travel in large schools, which can contain several million fish. Adult herring spawn in late winter and early spring in relatively shallow inshore waters. Herring eggs are sticky and can be found stuck on seaweed, rocks, wood and even garbage. The eggs hatch after about ten days, and the tiny larvae feed on invertebrate eggs, small crustaceans and microscopic algae. Throughout the summer months, the young herring continue to grow and begin to display schooling behavior. On the west coast of Vancouver Island, the limiting factor for the survival of young herring during the first half-year of life is the incidence of offshore, wind-induced drifts that remove the young fish from a secure environment. In the fall, the young fish move out to deeper waters, where they remain until they are sexually mature. Adult fish feed on younger fish, small crustaceans, and barnacle and shellfish larvae. (Hart 1973; Pacific herring website http://www.oceanlink.island.net/oinfo/Pacificherring.html.)

3-1.2 Status and Distribution of Fish Species/Populations

This section describes the distribution and status of FPHCP-covered fish species in Washington (see Table 3.2 and Figures 3.1-3.6). Additional information on the distribution and status of these species is included within Section 3-1.1 (Life History of Covered Fish Species), and within the regional summaries by Water Resource Inventory Area (WRIA) (Appendix A of the EIS (NOAA Fisheries and USFWS 2004)). The federally endangered and threatened anadromous fish species (managed under NOAA Fisheries) are administratively designated into aggregations of populations or "Evolutionarily Significant Units" (ESUs). These ESUs are the level at which these anadromous species are broken out for listing. The administrative designation for listing resident or freshwater fish species (managed under USFWS) is the distinct population segment (DPS). Although bull trout officially have two separate DPSs for listing, they are listed as threatened throughout their range. Therefore, for purposes of the FPHCP, bull trout are not broken out into two DPSs. Many of these fish species are also listed as State Sensitive, Candidate or Monitor species. Tables 3.1 and 3.2 show both Federal and state listing status for all FPHCP-covered fish species.

Table 3.2 includes distribution by planning region of the FPHCP-covered fish species in Washington (WDFW 2003; Wydoski and Whitney 2003). The distribution data primarily describe spawning and rearing life stages of covered fish species—migratory pathway distributions may not always be indicated. This distribution data should not be regarded as an exhaustive list of the species present, as the data only represent known information at the time of collection. Data for non-native, introduced fish species (e.g., bass, catfish, bluegill, etc.) are not included in Table 3.2, but may be found in the regional summaries (Appendix A of the EIS (NOAA Fisheries and USFWS 2004)).

The National Research Council (1996) has provided some generalized observations of salmonid population status over broad areas within the Pacific Northwest, which can help us to better understand the logic behind the current status of species with different life cycle characteristics and different geographical distributions:

- Pacific salmon have disappeared from about 40 percent of their historical breeding ranges in Washington, Oregon, Idaho and California over the last century, and many remaining populations are severely depressed in areas where they were formerly abundant.
- Coastal populations tend to be somewhat better off than populations inhabiting interior drainages. Species such as spring/summer chinook, summer steelhead and sockeye are extinct over a greater percentage of their range than species limited primarily to coastal rivers. Anadromous salmonid species most stable over the greatest percentage of their range (fall chinook, chum, pink and winter steelhead) chiefly inhabit rivers and streams in coastal areas.
- Populations near the southern boundary of the species' ranges tend to be at greater risk than northern populations.
- Species with extended freshwater rearing (such as spring/summer chinook, coho, sockeye, sea-run cutthroat and steelhead) are generally extinct, endangered or threatened over a greater percentage of their ranges than species with abbreviated freshwater residence (such as fall chinook, chum and pink salmon).
- In many cases, populations that are not smaller than they used to be are now composed largely or entirely of fish that originated in a hatchery.

Table 3.1 Proposed FPHCP-Covered Fish Species Status and Spawning and Rearing Distribution by Region (WDFW 2003; Wydoski and Whitney 2003; WDFW Forage Fish Website; Ecology Puget Sound Shorelines Website).

Species/Population Name and Status	FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region											
	North Puget Sound (WRIAs 1,3,4,5,7)	Islands (WRIAs 2,6)	South Puget Sound (WRIAs 8,9,10,11,12,13)	West Puget Sound (WRIAs 14,15,16,17,18)	Olympic Coast (WRIAs 19,20,21)	Southwest Washington (WRIAs 22,23,24)	Lwr Columbia (WRIAs 25,26,27,28)	Mid Columbia (WRIAs 29,30,31,37,38,39)	Columbia Basin (WRIA 43)	Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)	Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)	Snake River (WRIAs 32,33,34,35)
Endangered Species												
Upr Col. Spring Chinook *(Oncorhynchus tshawytscha)*										X		
Snake R. Sockeye *(O. nerka)*												X
Upr Columbia Steelhead *(O. mykiss)*										X		
Threatened Species												
Puget Sound Chinook *(O. tshawytscha)*	X		X	X								
Lwr Columbia Chinook *(O. tshawytscha)*							X	X				
Upr Willamette R. Chinook *(O. tshawytscha)*							X					
Snake R. Spring/Summer Chinook *(O. tshawytscha)*												X
Snake R. Fall Chinook *(O. tshawytscha)*												X
Columbia R. Chum *(O. keta)*							X					
Hood Canal Summer Chum *(O. keta)*				X								

Table 3.1 Cont.	**FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region**											
Species/Population Name and Status	**North Puget Sound (WRIAs 1,3,4,5,7)**	**Islands (WRIAs 2,6)**	**South Puget Sound (WRIAs 8,9,10,11,12,13)**	**West Puget Sound (WRIAs 14,15,16,17,18)**	**Olympic Coast (WRIAs 19,20,21)**	**Southwest Washington (WRIAs 22,23,24)**	**Lwr Columbia (WRIAs 25,26,27,28)**	**Mid Columbia (WRIAs 29,30,31,37,38,39)**	**Columbia Basin (WRIA 43)**	**Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)**	**Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)**	**Snake River (WRIAs 32,33,34,35)**
Ozette Lake Sockeye *(O. nerka)*					X							
Lwr Columbia Steelhead *(O. mykiss)*							X	X				
Upr Willamette R. Steelhead *(O. mykiss)*							X					
Mid Columbia Steelhead *(O. mykiss)*								X				
Snake R. Steelhead *(O. mykiss)*												X
Bull Trout Columbia R. DPS *(Salvelinus confluentus)*							X	X		X	X	X
Bull Trout Coastal-Puget Sound DPS *(Salvelinus confluentus)*	X		X	X	X	X						
Unlisted Fish Species												
Pink Salmon (all ESUs***) *(O. gorbuscha)*	X		X	X	X							
Coho all ESUs) *(O. kisutch)*	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X		X		X
Chinook (all unlisted ESUs) *(O. tshawytscha)*	X		X	X	X	X	X			X		
Chum (all unlisted ESUs) *(O. keta)*	X		X	X	X	X						
Sockeye/Kokanee (all unlisted ESUs) *(O. nerka)*	X		X	X	X	X	X	X		X	X[6]	X
Steelhead/Rainbow(all unlisted ESUs) *(O. mykiss)*	X	X	X	X	X	X	X	X	X	X	X[7]	X

Table 3.1 Cont.	**FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region**											
Species/Population Name and Status	**North Puget Sound (WRIAs 1,3,4,5,7)**	**Islands (WRIAs 2,6)**	**South Puget Sound (WRIAs 8,9,10,11,12,13)**	**West Puget Sound (WRIAs 14,15,16,17,18)**	**Olympic Coast (WRIAs 19,20,21)**	**Southwest Washington (WRIAs 22,23,24)**	**Lwr Columbia (WRIAs 25,26,27,28)**	**Mid Columbia (WRIAs 29,30,31,37,38,39)**	**Columbia Basin (WRIA 43)**	**Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)**	**Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)**	**Snake River (WRIAs 32,33,34,35)**
Interior Redband Trout[1] *(O. mykiss)*								X		X	X	
Cutthroat Trout [1] *(O. clarki)*	X	X	X	X	X	X	X	X		X	X	X
Pacific Lamprey [1] *(Lampetra tridentata)*	X		X	X	X	X	X	X		X		X
River Lamprey[1,4] *(L. ayresi)*	X		X	X			X	X				X
Western Brook Lamprey *(L. richardsoni)*	X		X	X	X	X	X	X				X
Pygmy Whitefish[3] *(Prosopium coulteri)*			X		X			X		X	X	
Mountain Whitefish *(P. williamsoni)*	X		X	X	X	X	X	X		X	X	X
Olympic Mudminnow [3] *(Novumbra hubbsi)*			X	X	X	X						
Chiselmouth *(Acrocheilus alutaceus)*								X		X		X
Redside Shiner *(Richardsonius balteatus)*	X		X		X	X	X	X	X	X	X	X
Longnose Dace *(Rhinichthys cataractae)*	X		X		X	X	X	X		X	X	X
Speckled Dace *(R. osculus)*			X	X	X	X	X	X	X	X	X	X
Leopard Dace[4] *(R. falcatus)*							X	X		X		
Umatilla Dace[4] *(R. Umatilla)*								X		X	X	

Table 3.1 Cont.	**FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region**											
Species/Population Name and Status	**North Puget Sound (WRIAs 1,3,4,5,7)**	**Islands (WRIAs 2,6)**	**South Puget Sound (WRIAs 8,9,10,11,12,13)**	**West Puget Sound (WRIAs 14,15,16,17,18)**	**Olympic Coast (WRIAs 19,20,21)**	**Southwest Washington (WRIAs 22,23,24)**	**Lwr Columbia (WRIAs 25,26,27,28)**	**Mid Columbia (WRIAs 29,30,31,37,38,39)**	**Columbia Basin (WRIA 43)**	**Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)**	**Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)**	**Snake River (WRIAs 32,33,34,35)**
Northern Pikeminnow *(Ptychocheilus oregonensis)*			X		X	X	X	X		X	X	X
Tui Chub *(Gila bicolor)*								X		X		
Lake Chub[4] *(Couesius plumbeus)*											X	
Peamouth *(Mylocheilus caurinus)*	X		X	X	X		X	X		X	X	X
Largescale Sucker *(Catostomus macrocheilus)*	X		X		X	X	X	X	X	X	X	X
Bridgelip Sucker *(C. columbianus)*							X	X	X	X	X	X
Longnose Sucker *(C. catostomus)*								X		X		
Mountain Sucker [4] *(C. platyrhynchus)*							X	X		X		X
Salish Sucker [5] *(C. carli* – species pending*)*	X		X	X								
Three-Spine Stickleback *(Gasteroseius aculeatus)*	X		X	X	X	X	X	X		X		X
Sandroller[5] *(Percopsis transmontana)*							X	X		X	X	X
Coastrange Sculpin *(Cottus aleuticus)*	X		X	X	X	X	X					
Prickly Sculpin *(C. asper)*	X		X	X	X		X	X	X	X		
Reticulate Sculpin *(C. perplexus)*			X	X	X	X	X					
Riffle Sculpin *(C. gulosus)*			X	X	X	X	X					

Table 3.1 Cont. **Species/Population Name and Status**	**FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region**											
	North Puget Sound (WRIAs 1,3,4,5,7)	**Islands (WRIAs 2,6)**	**South Puget Sound (WRIAs 8,9,10,11,12,13)**	**West Puget Sound (WRIAs 14,15,16,17,18)**	**Olympic Coast (WRIAs 19,20,21)**	**Southwest Washington (WRIAs 22,23,24)**	**Lwr Columbia (WRIAs 25,26,27,28)**	**Mid Columbia (WRIAs 29,30,31,37,38,39)**	**Columbia Basin (WRIA 43)**	**Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)**	**Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)**	**Snake River (WRIAs 32,33,34,35)**
Shorthead Sculpin *(C. confuses)*	X		X	X	X		X			X	X	
Torrent Sculpin *(C. rhotheus)*	X		X	X	X	X	X	X		X	X	X
Slimy Sculpin *(C. cognatus)*										X	X	
Paiute Sculpin *(C. beldingi)*								X				X
Margined Sculpin[1,3] *(C. marginatus)*												X
Mottled Sculpin *(C. bairdi)*								X		X	X	X
Longfin Smelt *(Spirinchus thaleichthys)*	X		X				X	X				
White Sturgeon *(Acipenser transmontanus)*			X			X	X	X				X
Green Sturgeon[2] (marine fish) *(A. medirostris)*	X		X	X		X	X					
Burbot *(Lota lota)*								X		X	X	X
Eulachon (marine fish)[4] *(Thaleichthys pacificus)*	X	X	X	X	X	X	X					
Shiner Perch (marine fish) *(Cymotagaster aggreagata)*	X	X	X	X	X	X						
Pacific Staghorn Sculpin (marine fish) *(Leptocottus armatus)*		X	X	X	X	X						
Starry Flounder (marine fish) *(Platichthys stellatus)*	X	X	X	X	X	X	X					

Table 3.1 Cont.	**FPHCP-Covered Fish Species Spawning and Rearing Distribution By Planning Region**											
Species/Population Name and Status	**North Puget Sound (WRIAs 1,3,4,5,7)**	**Islands (WRIAs 2,6)**	**South Puget Sound (WRIAs 8,9,10,11,12,13)**	**West Puget Sound (WRIAs 14,15,16,17,18)**	**Olympic Coast (WRIAs 19,20,21)**	**Southwest Washington (WRIAs 22,23,24)**	**Lwr Columbia (WRIAs 25,26,27,28)**	**Mid Columbia (WRIAs 29,30,31,37,38,39)**	**Columbia Basin (WRIA 43)**	**Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)**	**Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)**	**Snake River (WRIAs 32,33,34,35)**
Surf Smelt (marine fish) *(Hypomesus pretiosus)*	X	X	X	X	X	X						
Pacific Sand Lance (marine fish) *(Ammodytes hexapterus)*	X	X	X	X	X	X						
Pacific Herring (marine fish) *(Clupea pallasii)*	X	X	X	X	X	X						

[1]Federal Species of Concern

[2]Federal Candidate Species

[3] State Sensitive Species: "Any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats."
(WAC 232-12-297, Section 2.6)

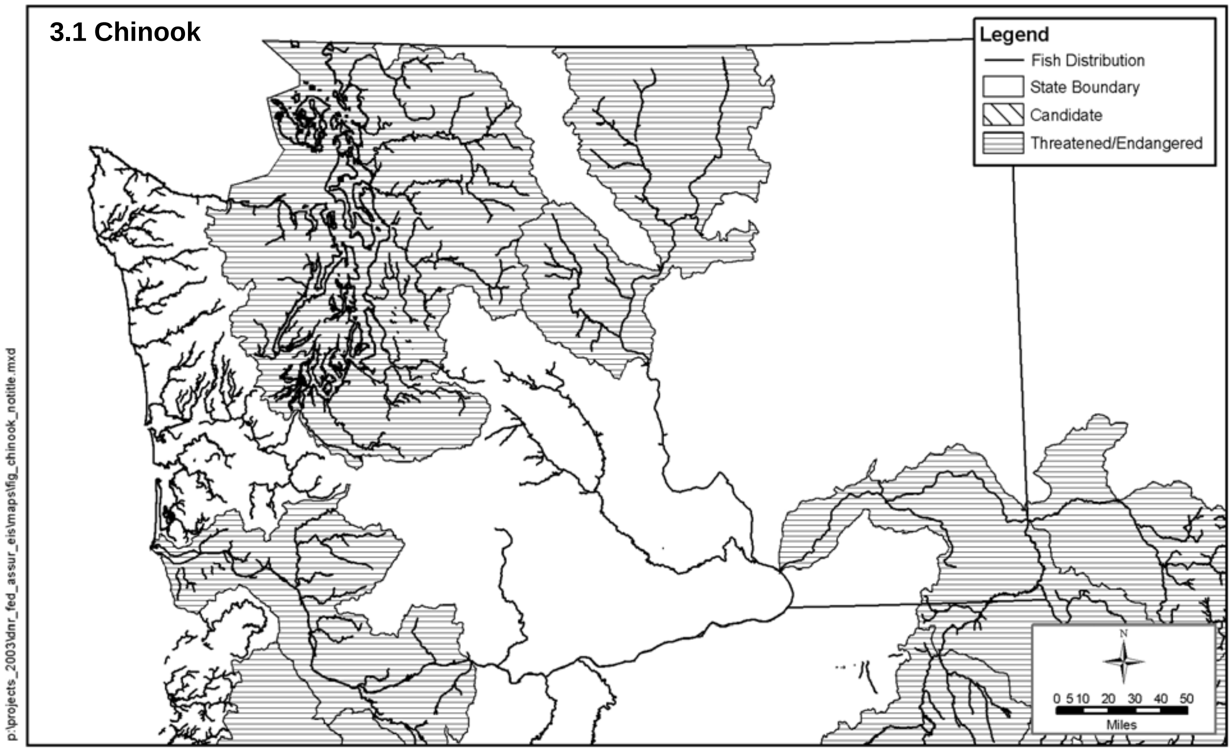
[4] State Candidate Species: "Include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive." *(WDFW Policy M-6001)*

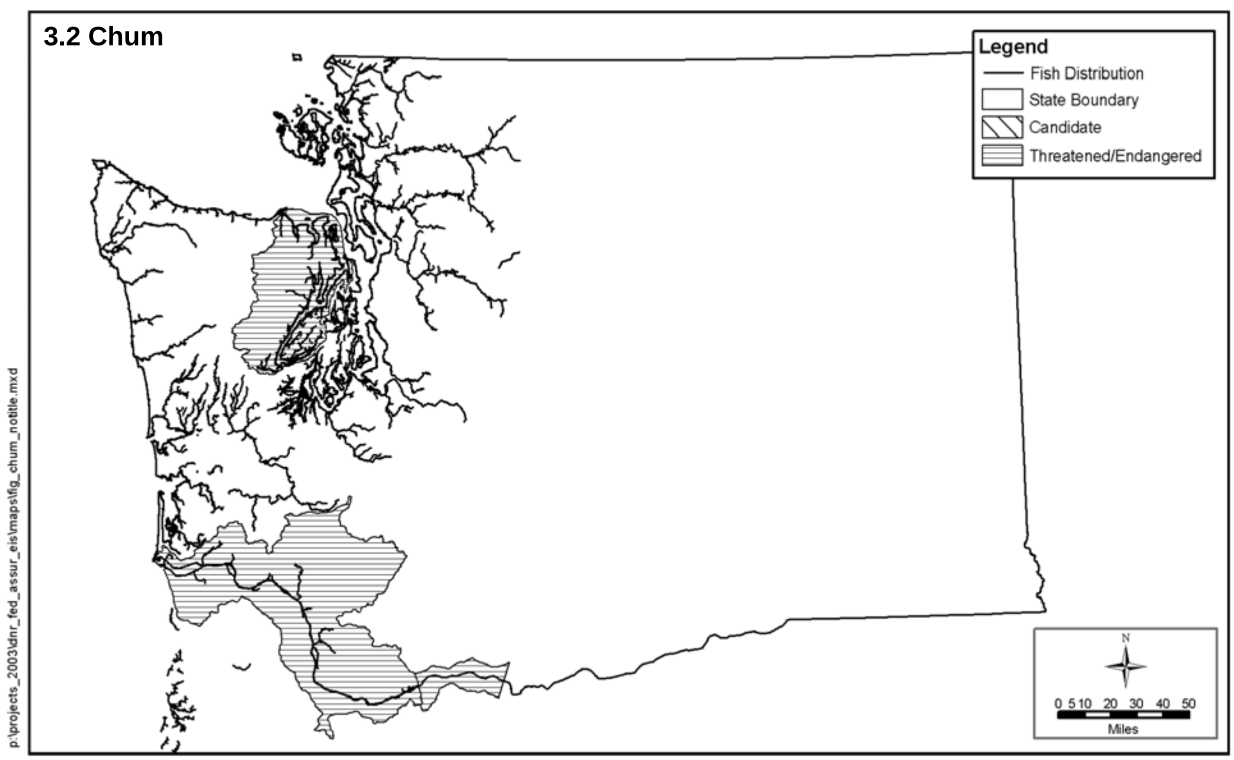
[5] State Monitor Species: State Monitor species are not considered Species of Concern, but are monitored for status and distribution. These species are managed by the Department, as needed, to prevent them from becoming endangered, threatened, or sensitive.

[6]Resident Kokanee

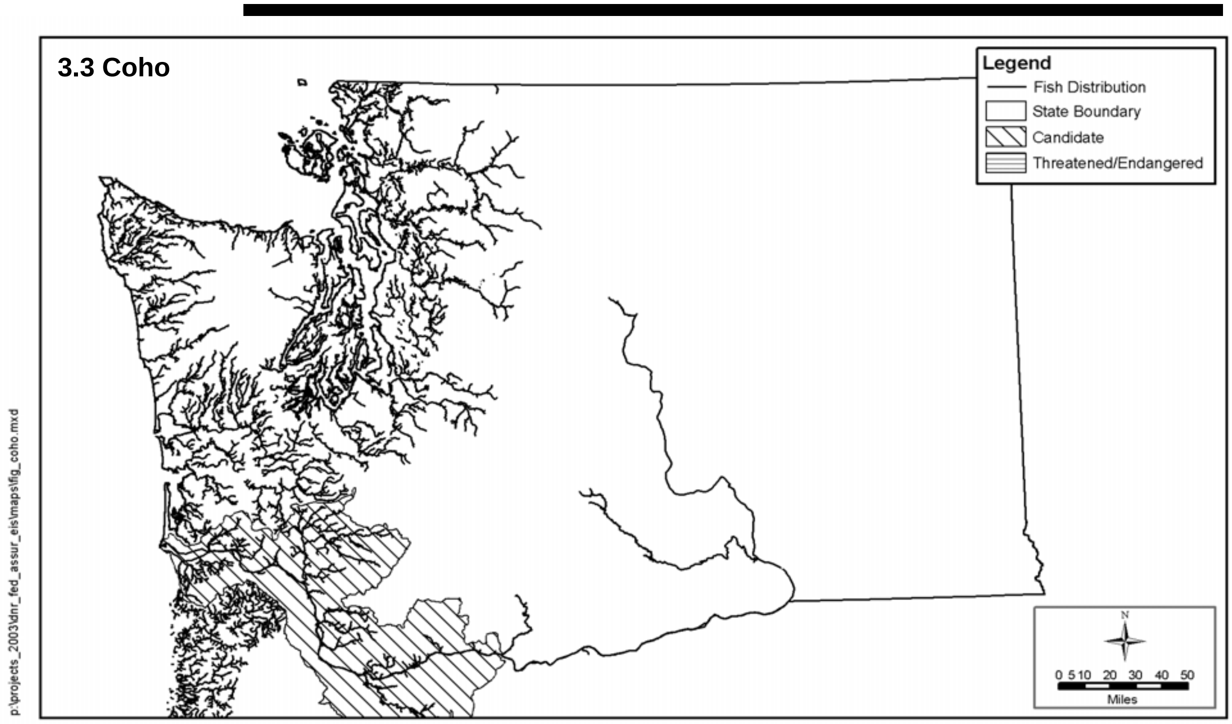
[7]Resident Rainbow Trout

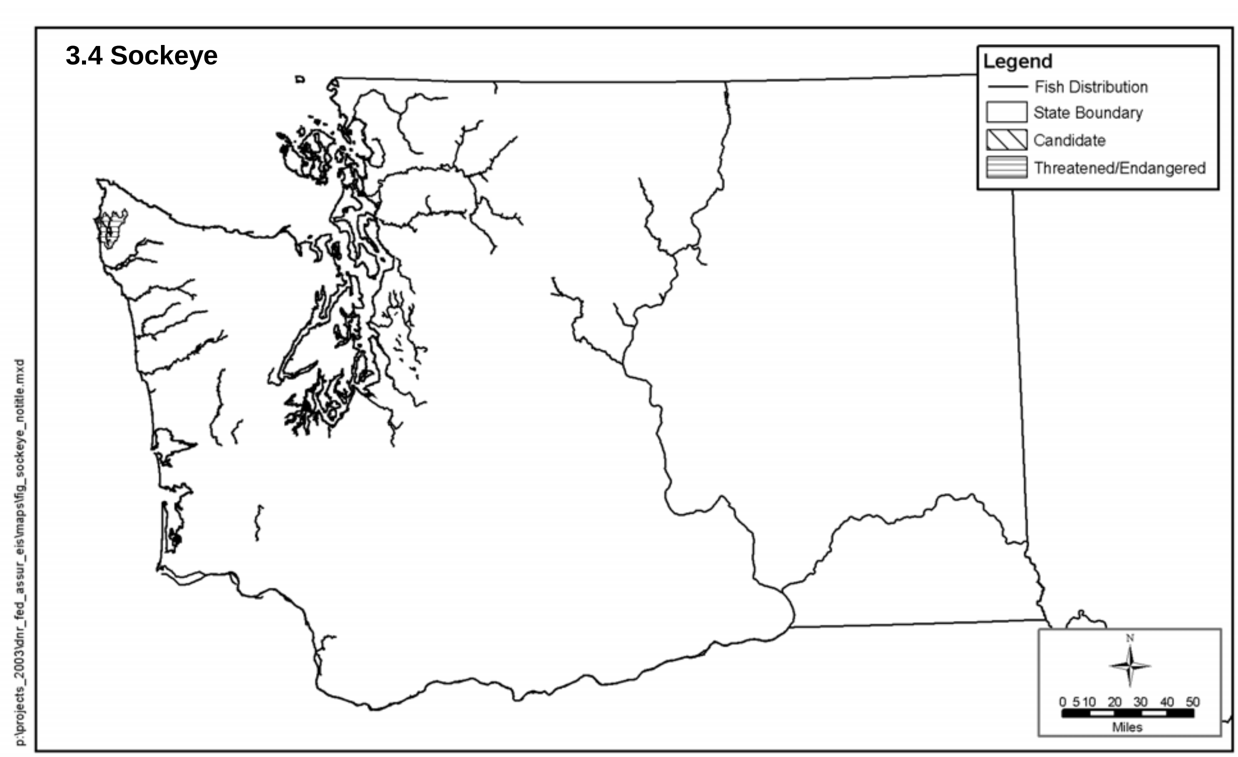
Figures 3.1 & 3.2 Distribution and Endangered Species Act (ESA) Status of Chinook and Chum Salmon within Washington State. (Source: Streamnet Version 99.1; NMFS - www.nwr.noaa.gov/1salmon/Salmesa).



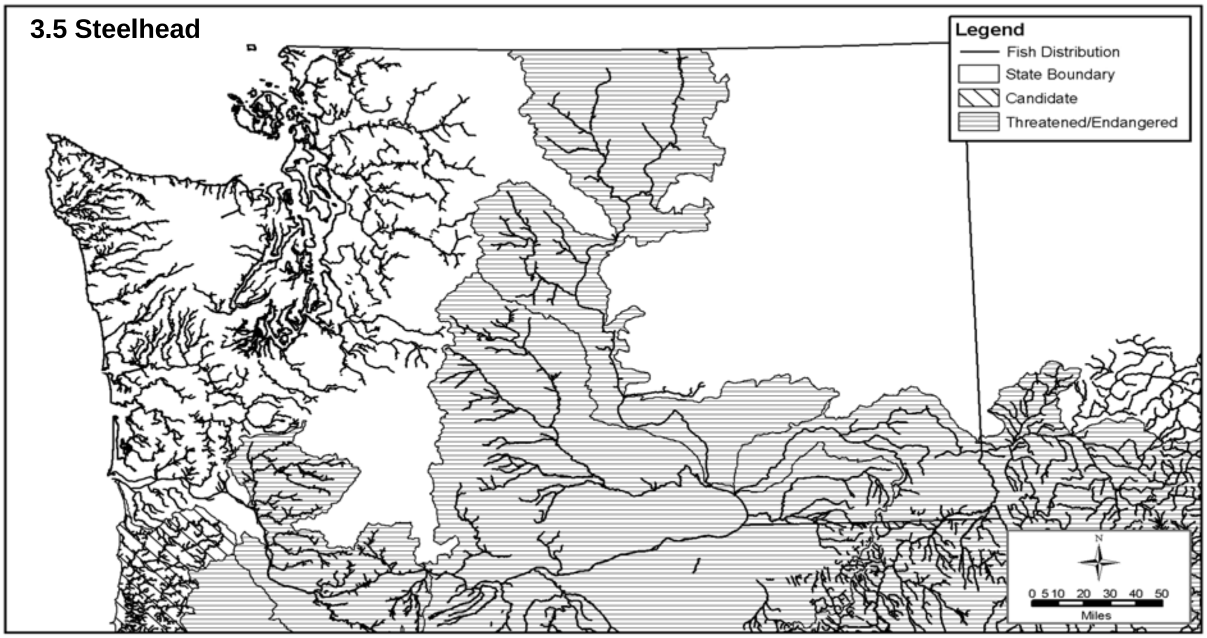


Figures 3.3 & 3.4 Distribution and ESA Status of Coho and Sockeye Salmon within Washington State. (Source: Streamnet Version 99.1; NMFS - www.nwr.noaa.gov/1salmon/Salmesa).

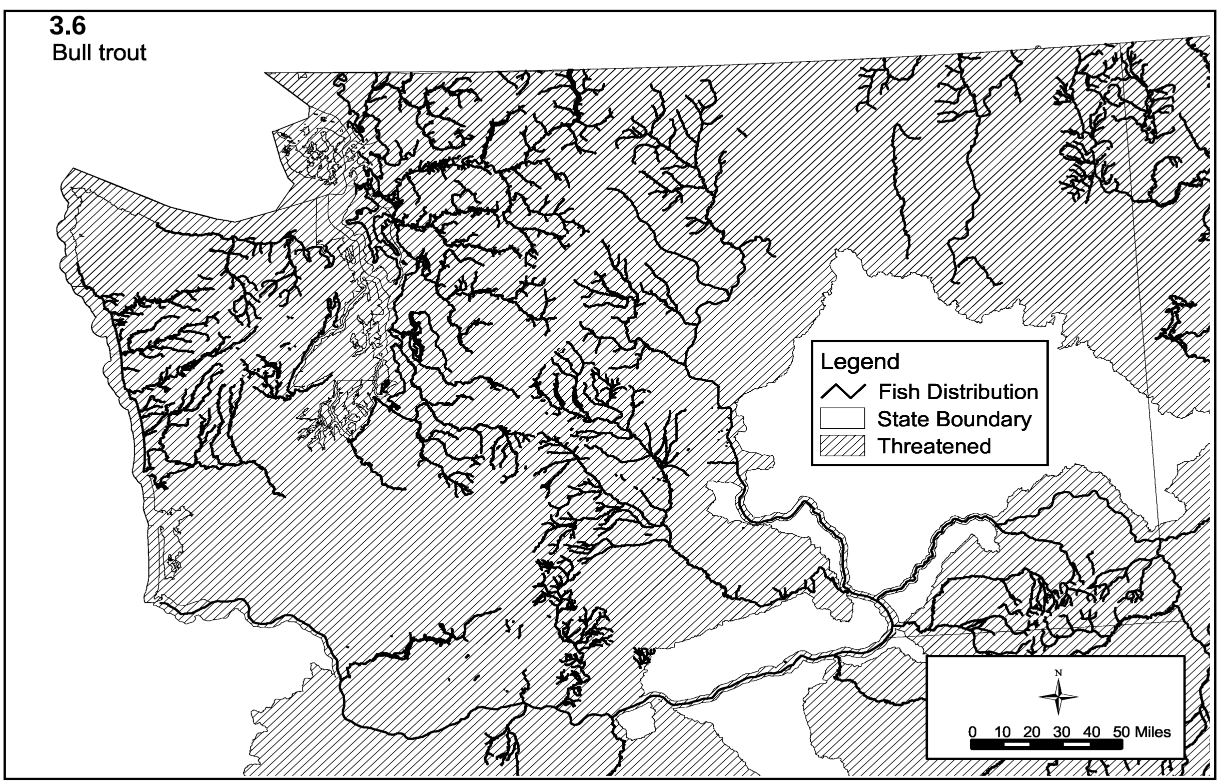




Figures 3.5 & 3.6. Distribution and ESA Status of Steelhead and Bull Trout within Washington State. (Source: Streamnet Version 99.1; NMFS - www.nwr.noaa.gov/1salmon/Salmesa).



p:\projects_2003\dnr_fed_assur_eis\maps\fig_steelhead_notitle.mxd



3-1.3 Habitat Requirements for Covered Fish Species

Fish habitat includes the physical, chemical and biological components of riverine, lacustrine and estuarine/nearshore environments. Habitat requirements for fish can be looked at from the landscape/watershed scale over time to the specific requirements of individual species at the stream reach and habitat type (i.e., pool, riffle, undercut bank, etc.) scale.

Spence et al. (1996) suggests four general principles for consideration when determining habitat requirements for salmonids, and presumably for other aquatic species as well.

- Watersheds and streams differ in their flow, temperature, sedimentation, nutrients, physical structure and biological components.
- Fish populations adapt and have adapted—biochemically, physiologically, morphologically and behaviorally—to the natural environmental fluctuations that they experience and to the biota with which they share the stream, lake or estuary.
- Specific habitat requirements of salmonids differ among species and life-history types, and these requirements change with season, life stage and the presence of other biota.
- Aquatic ecosystems change over evolutionary time.

Consequently, there are no simple definitions of fish habitat requirements, and the goal of conservation should be to maintain habitat elements within the natural range for the particular system (Spence et al. 1996).

3-1.3.1 FRESHWATER HABITAT REQUIREMENTS

Freshwater fish habitat is the product of many components, including water quality, hydrology/flows, complex channel structure, appropriate sediment supplies, access or connectivity throughout the watershed, functioning floodplains and healthy riparian zones. When properly functioning, these components are closely intertwined to form habitat conditions favorable to healthy populations of fish. Key processes regulating the condition of aquatic habitats are the delivery and routing of water, sediment and wood. These processes operate over the terrestrial and aquatic landscape and at various spatial and temporal scales.

Water Quality

Salmonids and other covered fish need clean, cool, well-oxygenated water. High water temperatures and low dissolved oxygen can affect all freshwater aspects of salmonid life history stages, including egg incubation and survival, fry emergence, juvenile feeding and growth, smolt outmigration, adult upstream migration and holding, and spawning activities. Cold groundwater upwellings and areas of hyporheic (river-influenced groundwater) exchange have been documented to be especially important for bull trout spawning habitat (Frissell 1999; Baxter and Hauer 2000), as well as for chum salmon (Lister et al.1980). Adequate riparian cover to provide shade is essential in maintaining cool stream and groundwater temperatures (National Research Council 1996; Frissell 1999) and buffer zones that minimize fine organic loading (i.e., prevent slash and debris inputs) help to maintain the appropriate dissolved oxygen concentrations. Juvenile salmon and trout are generally susceptible to sublethal adverse effects when the average stream temperature is above 59°F (Hicks 2000). Bull trout may be susceptible when average temperatures are greater than about 50°F. The preferred range for most salmon and trout is 54 to 57°F (Bjornn and Reiser 1991).

Suspended sediment and turbidity are two additional water quality parameters of importance to fish. Turbidity and suspended solids can reduce nutrients for fish by decreasing phytoplankton abundance. The diminished light penetration can also result in reductions in algal productivity. Particulate materials physically abrade fish gills, decreasing the ability of the fish to breathe (Spence et al. 1996). Suspended sediments—usually consisting of clays and/or silts—are the portion of the sediment load suspended in the water column which can be measured by turbidity, although organic matter, plankton and microorganisms are also part of a turbidity measurement. Ecology has determined that turbidity should not exceed 5 NTU over background when the background is 50 NTU or less, or a ten percent increase when the background is more than 50 NTU (Ecology 2003).

Hydrology/Flows

Fish need adequate, appropriate stream flows, particularly for adult migration and spawning. Too much can be as much of a problem as too little. Increases in peak flows beyond natural levels may cause increased channel bedload movement and bank erosion. The resulting scouring of the spawning gravels reduces egg-to-fry survival. In addition, movement of large woody debris (LWD) decreases bed and bank stability, which can, in turn, increase egg-to-fry mortalities. Low summer flows can be a problem for juvenile rearing due to reduced available habitat, increased stranding, decreased dissolved oxygen, increased water temperature, concentrated toxic materials and increased predation. Low summer flows may also affect upstream migration for adult spawners.

Although high- or low-flow events may temporarily reduce salmonid numbers, dynamic flows are also needed to perform essential functions important for the long-term persistence of salmonid populations. High-flow events redistribute sediments in streams, flushing fine sediments from spawning gravels and allowing recruitment of gravels in downstream reaches. In addition, extreme flow events are essential in the development and maintenance of healthy floodplain systems through deposition of sediments, recharge of groundwater aquifers, recruitment and transport of LWD and creation of side channels. Low flows may also be important for establishing riparian vegetation on gravel bars and along stream banks (Spence et al. 1996).

Different hydrologic processes dominate different geographical regions or watersheds (Swanston 1991):

- In the rain-dominated zone along the Pacific coast and at lower elevations in the Cascade and Coast Ranges, snow is rare—fall and winter precipitation is almost exclusively rain. In these areas, the streamflow regime closely follows annual precipitation patterns. Moderate- to high-intensity storms during the fall and winter months produce rapid increases in streamflow and occasional floods that disturb channels. At higher elevations, rapid melting of shallow snowpacks during storms may greatly augment these stream flow increases.

- In the snow-dominated areas of interior western North America, most winter precipitation falls as snow and most snow melts during a short, predictable period in the spring. Heavy rainfall is not common during winter months in this zone, but moderately high rainfall may occur during the late fall. Occasional high-intensity rainfall occurs during the summer associated with thunderstorms. Low streamflows are common in the summer after snowmelt ceases, and some first-order streams may go dry.

The "hydrologic regime" of a drainage basin refers to how water is collected, moved and stored over time. The principal components of hydrologic regimes are baseflows, medium-range high flows and flood flows. Hydrologic regimes can be related to elevation as well as geography, and therefore can be considered on both a site and basin scale. Different regimes are described by the pattern of low and high flows over a water year (Postel and Richter 2003).

In forested areas the vegetative cover plays a key role in rainfall/runoff relationships and snowmelt processes affecting basin yields and flow characteristics. Densely vegetated areas generally lose more water to evapotranspiration than areas with sparse vegetation and, therefore, may generate less surface runoff. Removal of vegetation typically reduces water loss to evapotranspiration, resulting in increased water yield from the watershed. Precipitation is intercepted by vegetation and either evaporated directly or transported to the forest floor through stem flow. As vegetated surfaces become saturated, more precipitation reaches the forest floor through stem flow and through fall. A similar process of interception and evaporation occurs on the forest floor, with saturation ultimately resulting in infiltration to groundwater and overland flow to surface water. Uptake and use of precipitation by vegetation also factors into the amount of water running off and reaching surface water. The amount of precipitation intercepted, evaporated, transpired and infiltrated varies depending upon factors such as antecedent moisture conditions, temperature, the intensity and duration of precipitation, slope of the land, as well as the age and composition of vegetation. Dense vegetation also tends to create a lag effect on the runoff resulting from any given precipitation event—runoff tends to be delayed from reaching surface water bodies by all the mechanisms described above. Some precipitation events in heavily forested areas result in little or no measurable runoff due to these effects (Dunne and Leopold 1978).

In mountainous watersheds, the soil and bedrock are key storage areas for water (Hewlett and Hibbert 1963; Anderson et al. 1997). Where present, lakes, ponds and wetlands may also play a significant role in moderating the extremes in high and low flows. Soil and bedrock storage can sustain summer flows even through droughts of many months.

Complex Channel Structure and Large Woody Debris

Deep pools with vegetative cover and large woody debris are important for juvenile overwintering, particularly when off-channel habitat is not available. Pools are also important for adult migration, holding and resting areas. Streams with more structure (logs, rootwads, undercut banks) support more coho (Scrivener and Andersen 1982), not only because they provide more territories and usable habitat, but they also provide more food and cover. As coarse sediment moves downstream, it is intercepted and stored by large woody debris, which then provides spawning gravels for fish. LWD also traps fish carcasses, leaf litter, etc., and creates an environment for microbial colonization and nutrient cycling to take place (Meyer et al. 1988; Spence et al. 1996; Salo and Cundy 1987).

Sediment Supply

Salmonids require sufficient gravels of the right size (size requirement varies among species) for spawning and rearing. After spawning, eggs need clean, stable gravel and interstitial spaces with low levels of fine sediment. Stream channel stability is vital at this life history stage. Sediment supply and transport also are primary determinants of channel form, a major aspect of rearing habitat. Sediment dynamics play a key role in determining habitat quality, quantity and distribution in fluvial systems. Stream productivity—including algae and aquatic invertebrates—is dependent on relatively sediment-free, stable stream substrates.

Sediment delivery rates are controlled by watershed characteristics such as geology, topography, vegetation and hydrology. As a result, there is equilibrium between sediment input and sediment routing that must be maintained to have a healthy stream system (Everest et al. 1987). In forested mountain basins, sediment enters stream channels from natural mass wasting events (landslides and debris torrents), channel bank erosion, surface erosion and soil creep. Channel bank erosion, surface erosion and soil creep tend to occur regularly, as a part of ongoing erosion processes, whereas landslides and debris torrents are more episodic in nature, and tend to occur during rain-on-snow and extreme rainfall events.

Once sediment enters a stream, it can be stored or transported depending on particle size, stream gradient, availability of storage sites and channel morphology. Finer sediments tend to be transported through the system as suspended load, and although they have little effect on channel morphology, they can impact water quality and, if deposited within spawning gravels, can affect egg incubation success. Coarser sediments tend to travel as bedload and can affect channel morphology as they are transported and deposited throughout the channel network. Storage sites for sediment include various types of channel bars, floodplain areas and channel obstructions. When sediment supply greatly exceeds transport capacity, bed instability and aggradation (filling in of the streambed), development of braided reaches, channel avulsions (sudden shifts in channel location) and increased bank erosion rates can occur. In cases where transport capacity exceeds sediment supply, finer bed materials are depleted from the system, and spawning and rearing habitat quality is degraded. Channel complexity created by obstructions such as large woody debris, boulders, channel meanders and bedrock outcrops slows the rate of bedload movement and plays a key role in the formation of scour pools and clean stable gravel deposits.

Connectivity and Access

Migrating adult salmonids and other fish species need unimpeded access to their natal spawning grounds. Juveniles need to be able to move between rearing habitats and, for some species, downstream to the ocean. Even resident fish need connectivity to the various areas needed to fulfill all of their life history requirements, to escape environmental perturbations (i.e., high water temperatures, fluctuating flows, excess sediment, etc.) and to be able to recolonize areas after stochastic events. Natural features of the landscape such as waterfalls, reaches of steep channel gradient, logjams, excessive water velocities and insufficient flows may permanently or temporarily block fish in their attempt to access spawning and rearing locations (Bjornn and Reiser 1991). The degree to which a natural feature blocks access often varies by species, and may change seasonally with changes in discharge. Stream structures such as dams without fish passage, improperly installed and maintained road crossings, and dikes/levees can also result in barriers to fish passage—in some cases, preventing access to large areas of previously available habitat.

Functioning Floodplains

Floodplains are low-elevation, low-gradient portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. They can contain a variety of aquatic habitats, such as side channels, sloughs, backwaters, oxbows, wetlands and lakes. Some of these features have a permanent hydrologic connection to the main channel. However, many are connected only seasonally or during periods of higher flows. Floodplains and their associated aquatic features play an important role in mediating flood flows by storing water and slowly releasing this storage back to the river during lower flows.

Floodplains provide aquatic habitat that is very important for some species and life stages, such as overwintering coho juveniles seeking refuge from high flows. Floodplains help dissipate water energy during floods by allowing water to leave the channel and inundate the adjacent terrestrial landscape, thereby lessening the impact to incubating salmonid eggs. Floodplains also provide for sediment storage, modulating the pulses of sediment from upstream sources to downstream habitat. Connection to sloughs, spring-fed seeps and side channel habitat is critically important for salmonid rearing and overwintering (Spence et al. 1996).

Rivers and their valleys are linked by exchanges of water between the true groundwater and hyporheic zones, and these linkages influence nearly all aspects of the physical and chemical habitat of aquatic organisms (Ward and Stanford 1989). Floodplains provide hyporheic connectivity through coarse beds of alluvial sediments that filter chemicals and ultimately regulate nutrient availability to primary producers in streams and rivers. These interchanges in groundwater are critical to maintaining productivity in rivers and streams and to maintaining healthy and productive fish habitat (National Research Council 1996).

Riparian Zones

Riparian vegetation mediates key interactions between aquatic and terrestrial ecosystems and, in many respects, controls the productivity of streams by influencing water, sediment and nutrient dynamics; shading; inputs of fine particulate organic matter and woody debris; and the stability of streambanks and floodplain terraces (Beschta 1991; Gregory et al. 1991; National Research Council 1996). The direct influence of the riparian zone on streams declines with increasing distance from the channel, and is strongly related to dominant tree species and height, stream size and drainage basin morphology. A natural riparian zone includes a composite of tree stands of different age, size and species (Spence et al. 1996; National Research Council 1996).

Riparian zones perform a number of vital functions that affect the quality of aquatic habitat (Spence et al. 1996). They provide structural complexity, buffer energy of mass wasting events and erosive forces, provide protected access to water for wildlife, provide shade which moderates both air and stream temperatures and provide a source of nutrients. The roots of riparian vegetation stabilize stream banks and maintain undercut banks that offer prime salmonid habitat (Murphy and Meehan 1991). Riparian zones are especially important as the source of LWD input to streams, a phenomenon that directly influences several habitat attributes important to salmonids such as pool formation/maintenance, food sources (such as capture and retention of adult salmon carcasses) and sediment storage (FEMAT 1993; Spence et al. 1996). In addition to contributing leaf detritus, riparian vegetation produces insects that fall into the stream and supplement the salmonid diet (Murphy and Meehan 1991).

Lakes and Reservoirs

Lakes and reservoirs serve as an important component of the life histories of many fish species. Fish exhibiting the “adfluvial” life history strategy (e.g., populations of bull trout, cutthroat and rainbow) use lakes and reservoirs for much of their juvenile and adult rearing, but will spawn in tributaries. In addition to rearing in these waters, sockeye and kokanee will both spawn within tributary streams, as well as along shorelines of lakes and reservoirs. Because lakes and reservoirs will often have more abundant food availability (i.e., plankton and prey species), fish exhibiting the adfluvial life history strategy will often reach the largest sizes (Goetz 1989). For instance, adfluvial bull trout have been reported to reach 40.5 inches and 32 pounds (Goetz 1989); whereas, the resident life history form may only reach 6 to 12 inches (Wydoski and Whitney 2003). Other fish such as coho will often use lakes or reservoirs for rearing—especially winter rearing. Other fish species, such as pygmy whitefish, mountain whitefish, chiselmouth, minnow species (e.g., chubs, peamouth, redside shiner), suckers, burbot, stickleback and sculpin, use lakes and/or reservoirs for a large part of their life histories (Wydoski and Whitney 2003). It is important for connectivity to be maintained within inlet and outlet streams, so that fish are able to have free access during all seasons.

Wetlands

Wetlands provide a vital role in watershed health as a whole, thereby benefiting fish, amphibians and other wildlife habitat. Water quality benefits include conversion of inorganic nutrients to organic forms, primary productivity, breakdown of pollutants and storage of sediments. Wetlands recharge groundwater by storing precipitation and surface flows, thereby increasing infiltration (Richardson 1994). Based on basin morphology, wetlands have a greater stormwater holding capacity than typical upland environments. Wetlands, therefore, reduce peak flows on streams and rivers by slowing and storing overbank flow and by holding upslope stormwater runoff (Reinelt and Horner 1990). Wetlands are known for their high primary productivity and export of organic matter to adjacent aquatic ecosystems (Mitsch and Gosselink 2000).

Many wetlands provide habitat for resident and anadromous fish (including, but not limited to coho, cutthroat, steelhead and rainbow), depending on surface area, cover, water depth, food sources and other attributes necessary for overwintering (Peterson 1982). Wetlands also provide important habitat for many amphibians (see Amphibian Section 3-2).

3-1.3.2 ESTUARY AND NEARSHORE HABITAT REQUIREMENTS

Estuaries are the zones in which fresh and saltwater mix, extending from the ocean to the uppermost extent of tidal influence. Estuaries support a variety of shallow and deep-water habitats and often include extensive areas of tidal fresh water and brackish and marine habitats (Shreffler and Thom 1993). Nearshore obligates—including salmonid forage fish such as surf smelt, Pacific sand lance and Pacific herring—are dependent upon beaches and intertidal areas for spawning (Hart 1973, NOSC Forage Fish website http://www.nosc.org/sandlance.htm, WDFW Forage Fish website http://www.wa.gov/wdfw/fish/forage/smelt.htm, Ecology Puget Sound Shorelines website http://www.ecy.wa.gov/programs/sea/pugetsound/species/smelt.html). Abundant food supplies, wide salinity gradients and diverse habitats make nearshore/estuarine areas particularly valuable to anadromous fish for rearing, feeding and osmoregulatory acclimatization during the transition between fresh water and marine habitats (MacDonald et al. 1987).

Estuaries provide ideal areas for rapid growth of juvenile salmonids because they contain abundant food sources (Healy 1982; Simenstad 1983). The food supply is supported by abundant detrital sources provided by eelgrass beds, kelp forests, salt marshes and terrestrial vegetation coupled with high levels of primary production in the shallow, nutrient-rich waters (Phillips 1984). Riparian areas bordering estuaries (i.e., bluffs, banks) are important for maintaining slope stability, shading, organic matter delivery and large wood recruitment.

Large woody debris generally accumulates in backshore areas at extreme high tides, and can help stabilize the shoreline (Zelo and Shipman 2000). Although not well documented in marine systems, LWD provides structurally complex roosting, nesting, refuge and foraging opportunities for wildlife; foraging, refuge and spawning substrate for fish; and foraging, refuge, spawning and attachment substrate for aquatic invertebrates. Logs embedded in beaches also provide a source of organic matter, moisture and nutrients that assist in the establishment and maintenance of dune and marsh plants (Williams and Thom 2001).

Chum, coho, sockeye, pink and chinook juveniles are known to utilize estuarine habitat, including salt marsh and tidal channels that are dewatered during normal low tides. Pink and chum rely heavily on estuaries for early growth. Chinook utilize salt marsh habitat, estuarine sloughs and tidal channels. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater and prior to migrating offshore. The spawning of Pacific herring—an important forage fish for salmonids—has been documented in estuarine salt marshes. Eelgrass supports copepods, a favored food for juvenile chum salmon. Estuarine habitats are also important for anadromous Dolly Varden and bull trout, where their movement is believed to follow after the timing and behavior of forage fish (i.e., surf smelt, sand lance and herring) (C. Kraemer, pers comm., 1999). The majority of searun coastal cutthroat migrate to the mouths of rivers and estuaries, where they remain for varying lengths of time (most remain an average of 90 days) and feed along beaches in water usually less than ten feet deep (Wydoski and Whitney 2003).

Historically, it was believed that juvenile salmon utilized nearshore environments between April and September. Recent evidence from nearshore beach seining surveys suggests that juvenile salmon can be found within the matrix of nearshore habitats year-round (Cambalik 2001).

3-1.4 Factors Affecting Status and Distribution

As discussed in Section 3-1.3 (Habitat Requirements for Covered Fish), fish habitat is the product of many components within the freshwater and estuarine/nearshore environments, depending on the particular species and life history strategy. These components include water quality, hydrology/flows, complex channel structure, appropriate sediment supplies, access or connectivity throughout the watershed, functioning floodplains, healthy riparian zones and healthy estuarine/nearshore environments. When properly functioning, these components are closely intertwined to form habitat conditions favorable to healthy populations of fish.

This section describes the factors affecting habitat, status and distribution of the FPHCP-covered fish species. Most of the information cited in the following text is specifically referring to salmonids; however, many of the limiting factors apply to other fish species as well. More information on limiting factors for each species, where known, can be found in Section 3-1.2 (Other Fish Species) and in the regional summaries found in Appendix A of the EIS (NOAA Fisheries and USFWS 2004). Though not specifically addressed within this section, many of the factors affecting fish habitat also affect the quality of riparian/aquatic-dependent amphibian habitat. Section 3-2 (Amphibians) and the regional summaries, found in Appendix A of the EIS (NOAA Fisheries and USFWS 2004), contain more specific information relating to limiting factors for FPHCP-covered amphibian species. Also, factors affecting fish and fish habitat usually affect instream productivity and prey-base species.

Water Quality

The principal water quality variables that may be influenced by forest practices are temperature, suspended sediments, dissolved oxygen and nutrients. When streamside vegetation is removed, summer water temperatures usually increase in direct proportion to the increase in sunlight that reaches the water surface (Chamberlin et al. 1991). Sediment generated by road construction often reaches the stream through surface erosion, mass movements of destabilized soil or improper rerouting of water (Meehan 1991). Increased turbidity from suspended sediments decreases light peneration, and may result in a decrease in primary productivity of algae and periphyton. Decreases in primary productivity can adversely affect the productivity of macroinvertebrates and fish (Gregory et al. 1987). When fine sediments are no longer suspended, they settle out onto the substrate and can clog the interstitial spaces in the gravels, reducing oxygen for incubating salmonids.

On the other hand, nutrients can also become more available to the stream immediately following harvest, resulting in part from addition of slash to the forest floor, accelerated decomposition of litter and increased runoff and erosion (Spence et al. 1996). Increased sunlight immediately following harvest also contributes to higher algal primary productivity and a greater abundance of invertebrates, with an associated increase in abundance of predators (including salmonids and other aquatic species) (Salo and Cundy 1987; Murphy and Meehan 1991). Opening the riparian canopy, however, can cause stream temperature to increase to levels that are lethal to salmonids, nullifying any potential benefit of increased food production (Spence et al. 1996; Murphy and Meehan 1991). Cumulative effects of increased water temperature and sediment from numerous disturbances in a watershed (i.e., stream adjacent roads, unstable slopes, etc.) can also nullify any beneficial effects of increased food production. Therefore, an increase in productivity can enhance aquatic species production only if physical habitat components also remain favorable (Murphy and Meehan 1991).

Hydrology/Flows

Regional differences in runoff patterns, ranging from rain-dominated to snow-melt-dominated systems (Swanston 1991), affect how land management practices can impact basin hydrology and stream habitat (Chamberlin et al. 1991). For example, in rain-dominated coastal systems, frequent high winter floods elevate the importance of maintaining and protecting side channels. In interior snow-dominated watersheds, management practices to augment low late-summer rearing flows are important. These regional streamflow differences also influence management practices related to sedimentation. Spring flows related to snowmelt-dominated systems are responsible for most road and channel sediment movement, but within rain-dominated areas, frequent rains provide sufficient energy to transport sediments during many months of the year.

Land management practices can alter basin hydrology by compacting soil, decreasing the amount of forest cover, increasing impervious surfaces and eliminating riparian and headwater wetlands. Timber harvests can reduce the capacity of soil to store moisture, and can thereby diminish low flows and increase high flow discharges in the channel (Lettenmaier 2003). Low flow discharges may also increase for a short period of time due to reduced water loss from evapotranspiration and more runoff reaching the stream channel (Hicks et al. 1991; Knutson and Naef 1997; United States Department of Agriculture Forest Service et al. 1993). Increases in peak flows can increase the incidence of redd scour, and the developing embryos can be destroyed (Furniss et al. 1991). Forest road ditch lines, if connected to stream channels, can act as an extension of the channel network, thus increasing the amount of runoff reaching the stream channel and causing a more intense peak flow in downstream areas. Soil compaction from heavy machinery can locally trigger overland flows during storm events, increasing peak flows and carrying fine sediments into the stream channel. The effects on hydrologic regime from timber harvest are highly variable and depend on, among other factors, the method and size of harvest and the size of the drainage basin in which the harvest occurs. Logging in large drainages generally results in proportionally smaller effects to the hydrology than in smaller drainages (Duncan 1986).

Soil on agricultural and urban lands have lower percolation rates due to compaction or pavement. Overland flows during peak storm events occur often. Increases in peak flows and more frequent bankfull flows are more common than in managed forestlands with the same topography and precipitation (Knutson and Naef 1997).

Another hydrological effect associated with timber harvest is “rain on snow.” Snow accumulations in harvested areas and other non-forested areas are considerably greater than in forestlands at the same elevation. When heavy, warm rain falls, the runoff is affected by both the precipitation and snowmelt—rain on snow. Although these events are relatively infrequent, they can produce the most severe flooding events in Washington State.

Complex Channel Structure and Large Woody Debris

Aquatic habitats can be degraded and eliminated by altering key natural processes such as the delivery and routing of water, sediment and wood (Washington State Conservation Commission 1998; Salo and Cundy 1987). When habitat conditions are disrupted adversely, a reduction in fish survival is likely to occur.

Of particular importance to developing and maintaining complex habitat structure is the presence of large wood in the channel. When there are fewer "steps" or structural elements (i.e., embedded logs) in the stream's profile, more energy is released to move sediment, resulting in a simpler, higher-gradient channel with poorer salmonid habitat (Chamberlin et al. 1991). Loss of stable instream woody debris by direct removal, debris torrents or gradual attrition as streamside forests are converted to managed stands of smaller trees will contribute to loss of sediment storage sites, fewer and shallower scour pools and less effective cover for rearing fish (Chamberlin et al. 1991). Subsequently, there is also a reduction in deep pools that are important for rearing and overwintering, the quantity of hiding areas from predators, the amount and stability of spawning habitat and subsequent egg to fry survival, and invertebrate production and prey availability. Changes in habitat conditions may affect fish assemblage structure and diversity (e.g., favoring species that prefer riffles rather than pools), alter the age-structure of salmonid populations and disrupt the timing of life-history events (Spence et al. 1996; Salo and Cundy 1987).

Harvest of timber in riparian zones—especially in coastal and western Cascade Range watersheds—has created ideal conditions for early-successional tree species, such as red alder, which replaced late-successional conifers as the dominant form of riparian vegetation over large areas (Kauffman 1988). LWD from these alder stands recruits more quickly to the stream than from conifer-dominated stands; however, the hardwood debris is smaller, more prone to breakage and decomposes faster than conifer debris (Bilby 1988). Rotational harvest ages of forests on many industrial forestlands (40-60 years) have been short enough to preclude reestablishment of dominant conifers in riparian zones (Andrus et al. 1988).

Sediment Supply

Human alteration to the land can result in increases or decreases in the supply of sediment to a stream, as well as alterations to the sediment storage capacity of the watershed. Substantial increases in sediment supply from mass wasting, surface erosion, bank destabilization or instream storage losses can cause aggradation, pool filling and a reduction in gravel quality (Chamberlin et al. 1991). The key to appropriate amounts of sediment in a stream channel includes existence of in-channel control factors—particularly LWD—and floodplain modulation of sediment supply from upstream sources.

Increased fine sediment input can result from increased erosion from adjacent land use practices such as agriculture, irrigation, the elimination of floodplain connectivity, logging, and road construction in unstable slope areas (Knutson and Naef 1997). The above land-use practices can also cause an increase in the frequency and magnitude of flooding that, in turn, further increases sediment input. Increases in coarse sediments can fill pools and aggrade (fill) the channel, resulting in reduced habitat complexity and reduced rearing capacity for some species. Increases in total sediment supply can add to the proportion of fine sediments that can be deposited in spawning gravel, thereby reducing hyporheic groundwater exchange (Brunke and Gonser 1997), reducing salmonid egg to fry survival rate and altering benthic invertebrate production. Bull trout have an extended incubation period and are particularly vulnerable to changes in the sediment regime.

Decreases in coarse sediment inputs from the middle and upper watershed can occur from interrupting natural channel processes through constructed barriers (i.e., culverts, etc.) and disconnecting the channel from the floodplain by placement of flood control structures and stream-adjacent road construction. Reduction in coarse sediment supply can reduce the amount of gravel suitable for spawning. The ability of the channel to store coarse sediments—thereby providing spawning gravels for fish—can be impacted by factors such as loss of LWD recruitment to the stream and channel confinement. Loss of LWD reduces structure and complexity in the channel (Salo and Cundy 1987) and increases stream velocity. Channel confinement, which can be caused by land use practices within the floodplain, can also result in higher energy discharges and reduced channel complexity and structure. Without adequate channel structure and complexity, gravel and other bedload is rapidly routed downstream. Such scouring events not only can remove spawning gravels, but can also be lethal to existing salmonid eggs and alevin, and can damage rearing habitat.

Connectivity and Access

Throughout Washington, stream crossing structures have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. Some of the most productive juvenile rearing habitats in streams are located in backwaters along the edge of the channel and in side-channel areas. Roads built next to streams often disrupt access to these off-channel habitats by physically isolating them from the main channel (National Research Council 1996). Blocking culverts at road crossings can also prevent migrating fish from accessing their spawning grounds. Other blocking culverts—especially at higher gradients—can disconnect resident fish from various habitats needed for different life history needs, cutting off their escape from environmental perturbations (i.e., high water temperatures, fluctuating flows, excess sediment, etc.), and potentially preventing their ability to recolonize areas after stochastic events. Other long-term or temporal factors that can affect connectivity within a stream include channel aggradation with associated low flows, high stream temperatures and excessive turbidity.

Functioning Floodplains

Channels can be disconnected laterally from their floodplains through the construction and placement of roads and flood control structures within the floodplain. Roads parallel to streams isolate the stream system from the uplands, and can constrain the natural development of meanders, side channels and attached wetlands (Everett et al. 1994). Forest harvesting can affect alluvial systems by weakening channel banks, removing the source of LWD, altering the frequency of channel-modifying flows and changing sediment supply. Off-channel fish habitats in the floodplain such as side and flood channels, ponds and swamps also can be strongly influenced by forest harvesting (Chamberlin et al. 1991).

As river channels are simplified and constrained, connectivity of surface waters with the hyporheic zone is lost (Frissell 1999). These groundwater interchanges can also be strongly disrupted by activities that remove groundwater or inhibit the movement of water into or out of rivers and floodplains (National Research Council 1996).

Riparian Zones

Since the arrival of settlers in the early nineteenth century, between 50 and 90 percent of riparian habitat in Washington has been lost or modified (Knutson and Naef 1997). Forest practices within riparian zones can alter species composition and encourage the spread of exotic species, increase water temperatures due to loss of shade, increase streambank erosion and reduce LWD recruitment. Reduction of LWD can result in a significant reduction in the complexity of stream channels, including a decline of pool habitat, which reduces the number of rearing salmonids (Knutson and Naef 1997).

Changes in microclimatic conditions within the riparian zone (i.e., solar radiation, soil temperature, soil moisture, air temperature, wind velocity and humidity), resulting from removal of adjacent vegetation, can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al. 1996), including fish habitat. Microclimate is also known to be important for other stream/riparian species, such as amphibians (See Section 3.5).

Strong winds can uproot trees, disturbing the soil, reducing the stabilizing influence of tree roots on steep slopes and substantially increasing the potential for mass soil movements. Windthrow frequently occurs along streams because winds tend to follow the natural pathways provided by the drainage system. Windthrow may be beneficial if it is moderate and at staggered intervals, because it is a primary source of LWD, which is important to fish productivity. However, in a study pertaining to windthrow in forested buffer strips on small streams in northwest Washington, it was noted that trees within small stream buffers (adjacent to clearcut harvest units) are subject to increased wind exposure (Grizzel and Wolff 1998). Because of this increased wind exposure, windthrow is often the primary mechanism of wood delivery in managed forestlands (Grizzel et al. 2000). If too much of the riparian vegetation blows down at once over a long distance, some of the targeted buffer functions can be impaired (Grizzel and Wolff 1998). The short-term benefits to the stream can be followed by a long-term shortage of instream wood once the current debris washes away or decays. Loss of canopy can also result in higher summer stream temperatures and lower winter stream temperatures (Murphy and Meehan 1991; National Research Council 1996).

Lakes and Reservoirs

Literature is limited relating to impacts of forest practices on lake and reservoir habitats. Watershed analyses, however, have been conducted on a number of watersheds including larger reservoirs and lakes (e.g., Lake Whatcom, Keechelus Lake and Thompson Creek). Causal Mechanism Reports have documented that coarse and fine sediment from mass wasting and road maintenance problems can directly deliver into lakes/reservoirs and/or into inlet channels, which then could be rapidly transported to the lake/reservoir. Very large, persistent increases of coarse and fine sediment could have negative effects on the stream habitat immediately upstream of the lake/reservoir margin, as aggradation may lead to channel dewatering, channel avulsion and reduction of pool habitat. This aggradation and channel dewatering can cut off access for adfluvial fish from the lake/reservoir to their spawning tributaries (Draft Keechelus Lake Watershed Analysis, DNR; Lake Whatcom, DNR 1998). The Thompson Creek Watershed Analysis (DNR 1997) notes that shallow eutrophic lakes, such as Newman Lake, could be vulnerable to filling with sediment. Lake filling is a natural geological process that may take thousands of years, but may be accelerated by human activity. The Lake Whatcom Watershed Analysis noted that fine sediment deposition can result in loss of lacustrine habitat, yet gaining wetland characteristics. In extreme cases, such as Mirrow Lake in the Anderson Creek drainage, unnatural prolonged periods of suspended sediments can cause unsuitable living conditions for salmonids.

Wetlands

Impacts from forest practices on wetlands may include removal of nutrients, reduction of soil productivity resulting from extraction methods (road construction, skid trails and staging areas), increased sedimentation, increased soil temperature, alteration in water yield and stream flow patterns and reductions in available habitat (Trettin et al. 1997). Results from studies outside the Pacific Northwest suggest that proper harvesting techniques can minimize impacts to forested wetlands (Shepard 1994).

Estuary and Nearshore Habitat

Various stressors on the nearshore environment, such as loss of shoreline forests, shoreline armoring, overwater structures, landfill and stormwater/wastewater discharge, lead to altered physical processes. These altered processes affect habitat conditions and juvenile salmonid survival, as well as the survival of other nearshore obligates (i.e., fish species that are dependent upon nearshore habitats such as surf smelt, sand lance, herring, etc.). Trees along the shoreline provide shade, which moderates temperatures in littoral spawning habitats used by nearshore obligates. Trees and downed beach wood help to moderate the rate of beach erosion. Downed wood functions to hold substrate (i.e., pea gravel and sand) needed for spawning habitat, to provide organic matter and nutrients and to provide habitat complexity and cover for fish and wildlife. Shoreline armoring, landfill and overwater structures reduce sediment supplies and transport from backshore and alongshore sources. Juvenile access to shallow nearshore corridors is then altered, and tidal exchange is modified, which then reduces prey availability and increases predation. Stormwater and wastewater discharges increase nutrient inputs, which lower dissolved oxygen during periods of thermal stratification. This has become a critical problem in the Hood Canal during the late summer in recent years. Contaminants from wastewater and stormwater discharges accumulate in tissues of marine organisms, causing lesions and tumors and reducing prey and habitat. (Zelo and Shipman 2000; Williams and Thom 2001; NOSC Forage Fish website).

3-2 Amphibians

The FPHCP covers seven amphibian species—five salamanders and two frogs. The following text describes their life histories, habitat requirements, status and known distribution in the state. It should be noted that information is limited on complete distribution of these species, as well as on the factors affecting their status and distribution.

Table 3.2 includes known distribution of FPHCP-covered amphibian species in Washington by planning region. The regional summaries, found in Appendix A of the EIS (NOAA Fisheries and USFWS 2004), also contain more species-specific information by WRIA.

3-2.1 Salamanders

Cascade Torrent Salamander *(Rhyacotriton cascadae)*

The Cascade torrent salamander occurs on the western slopes of the Cascade Range from the Middle Fork of the Willamette River in Oregon north to the south side of the

Skookumchuck River in Washington (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). Although some of the range of the Cascade torrent salamander falls on Federal (i.e., Gifford Pinchot National Forest and Mount Saint Helens National Monument) and state (mostly DNR) lands, a significant portion (at least 70 percent; compare maps in Dvornich et al. 1997 with Atterbury Consultants, Inc. 2003) of its distribution is within privately managed landscapes—the largest segment being under Weyerhaeuser ownership in Washington.

In Oregon, Cascade torrent salamanders require five to six years to reach reproductive maturity (Nussbaum and Tait 1977). Reproduction occurs in low-flow aquatic habitats. The description of the one observed Cascade torrent salamander nest was that it was under a cobble within a glide of a second order headwater stream, 1,500 feet below the stream origin (MacCracken 2004). Variation in nest location is presumed to be similar to those of the Columbia torrent salamander that place their unattached eggs among the substrate spaces of low-velocity headwater streams and seeps. Female Cascade torrent salamanders have a small clutch size (average eight eggs) and are not known to tend their eggs during pre-hatching development. Larval life is thought to be three to four years, with metamorphosis typically occurring in late summer to early fall (Nussbaum and Tait 1977). Longevity is unknown, but they are thought to live at least ten years after metamorphosing (Nussbaum and Tait 1977).

In Oregon, the Cascade torrent salamanders are known to range in elevations to above 4,000 feet, with probability of occurrence peaking at around 2,850 feet. Downstream—where gradients are lower—their occurrence is less frequent (M. Hayes, pers. comm.2004). In Washington, the upper limit of elevation is poorly understood, but anchor ice (i.e., ice that develops from the substrate rather than capping flowing waters) may limit their distribution in smaller, higher-elevation streams. Larvae have been observed more abundantly under sheltering rocks along the lower flow margins of stream channels and in the network of fissures within the streambed and banks (Nussbaum and Tait 1977), and can be common in the headwater landscape (Steele et al. 2003). Adult Cascade torrent salamanders are often found in an underground matrix of small water courses in the rock rubble and stream banks, and in cracks and fissures in stream banks and cliffs (Nussbaum and Tait 1977). General habitat information on *Rhyacotriton* describes them to be in riffles of cold, permanent streams with small water-washed or moss-covered rocks (Bury et al. 1991) with substantial canopy and abundant understory vegetation (Stebbins and Lowe 1951). Constantly in contact with water, *Rhyacotriton* is among the most desiccation-intolerant salamander genera known (Ray 1958), probably due to a dependence on the skin surface for oxygen exchange because of reduced lung capacity (Whitford and Hutchinson 1966).

Table 3.2. Distribution of FPHCP-Covered Amphibian Species by Planning Region.

Species Name and Status	FPHCP-Covered Amphibian Species Known Distribution By Planning Region											
	North Puget Sound (WRIAs 1,3,4,5,7)	Islands (WRIAs 2,6)	South Puget Sound (WRIAs 8,9,10,11,12,13)	West Puget Sound (WRIAs 14,15,16,17,18)	Olympic Coast (WRIAs 19,20,21)	Southwest Washington (WRIAs 22,23,24)	Lwr Columbia (WRIAs 25,26,27,28)	Mid Columbia (WRIAs 29,30,31,37,38,39)	Columbia Basin (WRIA 43)	Upr Columbia (Dnstrm GC Dam) (WRIAs 40, 44-50)	Upr Columbia (Upstrm GC Dam) (WRIAs 51-62)	Snake River (WRIAs 32,33,34,35)
Columbia torrent salamander[1,4] *(Rhyacotriton kezeri)*						X	X					
Cascade torrent salamander[4] *(R. cascadae)*			X			X	X	X				
Olympic torrent salamander[1,5] *(R. olympicus)*				X	X	X						
Dunn's salamander[4] *(Plethodon dunni)*						X	X					
Van Dyke's salamander[1,4] *(P. vandykei)*			X	X	X	X	X					
Coastal tailed frog[1,5] *(Ascaphus truei)*	X		X	X	X	X	X	X		X		
Rocky Mountain tailed frog *(A. montanus)* [1,4]												X

[1]Federal Species of Concern

[2]Federal Candidate Species

[3] State Sensitive Species: "Any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats."
(WAC 232-12-297, Section 2.6)

[4] State Candidate Species: "Include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive." *(WDFW Policy M-6001)*

[5] State Monitor Species: State Monitor species are not considered Species of Concern, but are monitored for status and distribution. These species are managed by the Department, as needed, to prevent them from becoming endangered, threatened, or sensitive.

Cascade torrent salamanders are thought to be sedentary, with typical movements on the scale of a few meters (Nussbaum and Tait 1977; Nijhius and Kaplan 1998), but movement studies were limited to very small spatial scales, so the true extent of movements is unknown. Metamorphosed juveniles and adults probably feed on invertebrates in moist, forested habitats along stream margins—notably amphipods, fly larvae, springtails and stonefly nymphs (Bury and Martin 1967; Bury 1970). Larvae diet is unknown.

The Cascade torrent salamander is a Washington State Candidate species. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions and the associated risk of local extirpation following clearcut timber harvest and the subsequent increase in microhabitat temperatures and sedimentation (Blaustein et al. 1995; Bury and Corn 1988; Hallock and McAllister 2002). Another historical concern has been the lack of protection for headwater streams, seeps and springs (Wilkins and Peterson 2000). A recent study also found Cascade torrent salamanders to have the highest densities mid-rotation in the managed landscape (Steele et al. 2003), but the site selection constraint of minimal sedimentation makes the study ambiguous as to how representative it may be of the managed landscape.

Columbia Torrent Salamander *(Rhyacotriton kezeri)*

The Columbia torrent salamander is distributed in the Coast Range of southwest Washington and northwest Oregon from the Little Nestucca River in the south to the Chehalis River in the north (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). The range of the Columbia torrent salamander occurs primarily in privately owned commercial timberlands from sea level to the highest elevations in their known territory. Based on work in southwest Washington, likelihood of occupancy increases from low to high elevations (Wilkins and Peterson 2000); work in Oregon has shown that likelihood of occupancy increases on basalt formations as opposed to marine sediments and on northerly exposures as opposed to southerly aspects (Russell et al. 2004).

Age at maturity in Columbia torrent salamanders is unknown, but if similar to the southern torrent salamander (their most proximate congener), they may require five to six years to reach maturity, with a total life span that probably exceeds ten years (Nussbaum and Tait 1977). Nests have been found in sandstone substrates, headwater springs and side-slope seeps, with cold (47-49 °F), slow-moving water trickling over loose, unattached eggs (Russell et al. 2002). Unattached eggs are at risk from scour at higher flows. Columbia torrent salamanders probably remain larvae for more than two years, preferably in stable, slow-moving stream microhabitats with loose gravel and cobble, open interstitial spaces and reduced levels of fine sediments. Metamorphosis typically occurs in late summer to early fall, but it can occur throughout the year (Nussbaum and Tait 1977). Juvenile and adult habitat preferences are assumed to be similar, although definitive studies have not been undertaken. Adults prefer cold, permanent streams with small, water-washed or moss-covered rocks/rubble, seeps and small trickling tributary streams with substantial canopy and abundant understory vegetation. It is rarely found out of contact with water as, *Rhyacotriton* is among the most desiccation intolerant salamander genera known (Ray 1958), possibly due to the dependence of oxygenation through the skin rather than through its small lung capacity (Whitford and Hutchinson 1966). Individuals are thought to be highly sedentary, similar to *R. cascadae* (Nussbaum and Tait 1977; Nijius and Kaplan 1998), but definitive movement studies of this torrent salamander have not been conducted. Similar to the southern torrent salamander, post-metamorphic juveniles and adults are thought to feed on invertebrates such as amphipods, fly larvae, springtails and stonefly nymphs (Bury and Martin 1967; Bury 1970).

The Columbia torrent salamander is a Federal Species of Concern and a Washington State Candidate species. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions and the associated risk of local extirpation following clearcut timber harvest (Blaustein et al. 1995; Bury and Corn 1988; Hallock and McAllister 2002). The presence of fine sediments is thought to reduce instream habitat quality for torrent salamanders by filling interstitial spaces critical for movement, egg deposition and larval development (Corn and Bury 1989; Diller and Wallace 1996). However, a recent study has shown Columbia torrent salamanders to be widespread and abundant in the managed landscape of northwestern Oregon (Russell et al. 2004) and parallel data exist for southwestern Washington (M. Hayes, pers. comm. 2003), which has reduced the level of concern for this species. Nonetheless, focused study will be needed to understand how sedimentation may affect this species, a condition that may vary with geology.

Olympic Torrent Salamander *(Rhyacotriton olympicus)*

Olympic torrent salamanders are known to occur only on the Olympic Peninsula south to the Chehalis River (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). They have been observed in 41 percent of 168 streams, and in 47 percent of 235 seeps surveyed within the Olympic National Park (Bury and Adams 2000). They are less abundant along the eastern slope of the Olympics, perhaps due to the warmer, drier climate of the “rainshadow, ” and are more abundant in streams with northerly aspects, steep gradients, reduced fine sediments and fewer undercut banks (Bury and Adams 2000). Recent glaciation wiping habitat clean on the eastern slope of the Olympics is an important, but often unrecognized, alternative explanation for low Olympic torrent salamander abundance and occupancy in that region (M. Hayes, pers. comm.)

Age at maturity in Olympic torrent salamanders is unknown, but if similar to the southern torrent salamander, they may require five to six years to reach maturity, with a total life span that undoubtedly exceeds ten years (Nussbaum and Tait 1977). Reproduction is presumed to be aquatic, but nests of Olympic torrent salamander have not yet been found. Nest sites are suspected to be similar to those known for their congeners, i.e., low flow sites such as seeps, springs or headwater streams with mixed substrates, sometimes under a layer of moss (Nussbaum 1969; Russell et al. 2002). Clutch size is unknown, but fecundity is likely low as gravid females carry relatively few eggs, (average –eight, Good and Wake 1992). Little is known of the larval stage but, based on data from other *Rhyacotriton*, duration is probably greater than two years, and cover requirements include stable, low-flowing microhabitats with loose gravel and cobble and open interstitial spaces with limited fine sediments. Juveniles and adults probably share the same habitat requirements of cold, clear streams, seeps or waterfalls, and splash zones where a thin film of water runs between or under rocks (Leonard et al 1993). As with other torrent salamanders, Olympic torrent salamanders are desiccation intolerant (Whitford and Hutchinson 1996), requiring a moist to wet microenvironment with substantial shading canopy and abundant understory vegetation (Stebbins and Lowe 1951). Due to the wet microhabitat, Olympic torrent salamanders have been observed as surface-active in winter, so overwintering in these areas may not occur (Jones and Raphael 2000).

The Olympic torrent salamander is a Federal Species of Concern and a Washington State Monitor species. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions and the associated risk of local extirpation following clearcut timber harvest (Blaustein et al. 1995; Bury and Corn 1988; Hallock and McAllister 2002). The presence of fine sediments is thought to reduce instream habitat quality for torrent salamanders by filling interstitial spaces critical for movement, egg deposition and larval development (Corn and Bury 1989; Diller and Wallace 1996). Focused study will be needed to understand how sedimentation may affect this species, a condition that may vary with geology.

Dunn's Salamander *(Plethodon dunni)*

The Dunn's salamander is medium-sized, secretive and lungless (plethodontid) (Stebbins 1985), and it can attain a maximum size of up to six inches in total length (Leonard et al. 1993; Nussbaum et al. 1983). It is a strong riparian associate and, within the state, occurs exclusively in the Willapa Hills in southwestern Washington (Leonard et al. 1993; Nussbaum et al. 1983; Petranka 1998). Washington encompasses the northern end of this species' range, and the Chehalis River appears to represent the northernmost limit of this species' range in Washington (Leonard et al. 1993). Dunn's salamanders are relatively common in the Oregon Coast Range, but are less common in Washington headwater streams (Jackson et al. 2003). Most of this species' range in southwestern Washington is currently dominated by private commercial timberlands.

Dunn's salamanders occur in relatively shaded, wet, rocky substrates such as seeps, moist talus slopes and stream edges in forested areas (Leonard et al. 1993; Nordstrom and Milner 1997). Life history data on Dunn's salamanders are sparse—only two nesting records exist (Dumas 1955; Nauman et al. 1999). Eggs are probably laid underground in rocky areas or within suitably decayed woody debris during spring, and hatch in late summer or fall. Juveniles, which may take two to four years to reach sexual maturity, have been found in the same habitats as adults (Petranka 1998). Availability of rocky cover, as with talus or steeper sideslopes, appears to be a common denominator of Dunn's salamander habitat (Corn and Bury 1991, Wilkins and Peterson 2000), but down logs and woody debris may also represent important refuge and foraging habitat (Corkran and Thoms 1996; Leonard et al. 1993).

Dunn's salamanders use aquatic habitats only rarely (Dumas 1955), for example, to escape thermal stress (Eaton Mordas et al. 2004); rather, they are regarded as riparian associates (Corkran and Thoms 1996; Gomez and Anthony 1996). Most Dunn's salamanders have been found in stream bank habitats within a few meters of stream channels, as opposed to riffle or pool habitat (Bury et al. 1991b) or more remote uplands (Wilkins and Peterson 2000).

The Dunn's salamander is a Washington State Candidate species. Concern for this species in the State is prompted by its distribution in presumably small fragmented populations, and by Washington's position at the northernmost tip of the salamander's range (Nordstrom and Milner 1997). Nordstrom and Milner (1997) noted that Dunn's salamanders depend on moist, well-shaded substrates with stable microclimates. Timber harvest can remove canopy cover that maintains microclimatic conditions favored by this species, including cool substrate temperatures and high relative humidity (Chen et al. 1993, 1995; Ledwith 1996; Nordstrom and Milner 1997). Populations can persist in logged areas, but are more likely to do so when mature timber is present upstream than when stands upstream have been cut (Corn and Bury 1989). Vesely and McComb (2002) found that Dunn's salamanders were sensitive to forest practices in riparian areas, and concluded that riparian buffer strips may reduce local declines in abundance. Similarly, West and O'Connell (1998) observed that riparian buffers can promote persistence of amphibians following timber harvest. Several studies have demonstrated a direct relationship between buffer width and the maintenance of cool microclimate and high humidity (Brown and Krygier 1970; Ledwith 1996); but how such alterations may affect Dunn's salamander in its habitat in Washington State remains unaddressed.

Van Dyke's Salamander *(Plethodon vandykei)*

Van Dyke's salamander, another secretive species, is stockier than other plethodontid (lungless) salamanders. They are commonly associated with wet microsites in riparian habitats, both along streams and in seeps, but also occur in isolated seeps; they also occur over a wide elevation range (Jones 1999; Nordstrom and Milner 1997; Petranka 1998; McIntyre 2004). Endemic to Washington, the Van Dyke's salamander is known from three geographically disjunct areas: the Olympic Peninsula, the southern Cascade Range and the Willapa Hills (Leonard et al. 1993). Van Dyke's salamanders have been found at elevations ranging from sea level to 5,000 feet, in areas with an average annual precipitation of at least 60 inches (Jones 1999; Wilson et al. 1995). Most recorded locations come from the wetter, western slopes of these areas (Dvornich et al. 1997). Populations appear to be patchily distributed and of low density, and much potential habitat appears to be unoccupied (Blaustein et al. 1995; Jones 1999). Two out of three geographical areas where this species occurs are dominated by Federal ownership (Olympic National Park and Wilderness Area in the Olympic Peninsula, and Mount Saint Helens National Volcanic Monument in the Gifford Pinchot National Forest in the southern Cascade Range). Private commercial forestlands dominate the third region, the Willapa Hills in southwest Washington).

Van Dykes's salamander juveniles and adults have been found in the splash zones of streams, upland forests, moist talus, cave entrances, seeps and along lakeshores (Blaustein et al. 1995; Jones 1999). Of seven Van Dyke's salamander nests that have been found to date, six were near small headwater streams (Blessing et al. 1999; Jones 1989). No information is available on the location of the seventh (Noble 1925). Three of the four nests described by Blessing et al. (1999) were in old-growth forest, and one was in a riparian buffer of old-growth trees adjacent to a ten-year-old logged stand. Clutches of eggs—apparently laid during spring—have been found under rocks or inside large, moss-covered logs. Eggs may require more than four months to hatch, nearly twice as long as the incubation period of other similar salamander species in this area (Blessing et al. 1999).

Jones (1999) indicates that Van Dyke's salamanders may be found near streams and seeps that are perennial, or spatially or temporally intermittent (i.e., surface water may be absent during some periods or in some stretches). Some studies have suggested that the distribution of Van Dyke's salamander has been limited by clearcutting (Wilson et al. 1995; Corn and Bury 1989). On the other hand, the presence of this species in 30- to 60-year-old forests indicates that individuals may persist within or recolonize disturbed habitats (Nordstrom and Milner 1997). Currently, retaining riparian buffers on headwater streams may protect existing populations if buffers maintain suitable habitat conditions (cool, moist microclimate; and woody debris of the appropriate sizes and decay classes; Nordstrom and Milner 1997; Petranka 1998).

The Van Dyke's salamander is a Federal Species of Concern and a Washington State Candidate species. Limited distribution and isolation of Van Dyke's salamander populations have prompted concern for this species' persistence (Holthausen et al. 1994; Nordstrom and Milner 1997). Lehmkuhl and Ruggiero (1991) assigned this species a high risk of local extinction based on its habitat associations, frequency of occurrence, abundance and dispersal ability. Similarly, Thomas et al. (1993) identified the Van Dyke's salamander as a high-risk species, closely associated with old-growth forest conditions.

3-2.2 Frogs

Coastal (Pacific) Tailed Frog *(Ascaphus truei)*
Rocky Mountain (Inland) Tailed Frog *(Ascaphus montanus)*

Endemic to the Pacific Northwest, tailed frogs are the only species of the family Ascaphidae, and are among the most primitive living frogs. Males are distinguished by a tail-like appendage that is used for internal fertilization, an adaptation to their life in cold, swift streams. Based on an examination of genetic differences, Nielson et al. (2001) recommended that coastal and inland populations of tailed frogs be recognized as distinct species, *Ascaphus truei* (coastal) and *A. montanus* (inland or Rocky Mountain).

Tailed frogs occur throughout the Pacific Northwest, with a range that extends from southwestern British Columbia south to northwestern California (Leonard et al. 1993). In Washington, Coastal tailed frogs have been found in the Willapa Hills and at elevations up to 5,250 feet in the Cascade and Olympic Mountains. Rocky Mountain tailed frogs have been found in the Blue Mountains in the extreme southeastern portion of the state (Dvornich et al. 1997; Leonard et al. 1993; United States Geological Survey 2003). Research to date has not documented significant differences in the life histories and habitat associations of these two species, so they are treated collectively in this discussion.

Tailed frogs are found almost exclusively in cold, rocky streams. The tadpole's sucker-like mouth, used for clinging to rocks and scraping away food, reflects this species' adaptation to life in fast-flowing water (Nussbaum et al. 1983; Leonard et al. 1993). Breeding and rearing habitat for the tailed frog generally consists of permanent, cool (usually less than 59°F) streams with cobble/boulder substrate and woody debris (de Vlaming and Bury 1970; Welsh et al. 1993). In California, these conditions are typically associated with cold, clear, headwaters to mid-order streams in older forest ecosystems (Welsh et al. 1993); to what degree these conditions apply to the higher latitude forests of Washington State is unclear. Adults forage mainly on land along streambanks, but also underwater, seeking cover under rocks and woody debris in streams. At night, adult tailed frogs emerge and may forage up to 1,300 feet into adjacent forested areas (McComb et al. 1993). Older (greater than 200 years), multi-layer forests, downed woody material, ground-level vegetation, ground cover and canopy closure have been shown to be important in northwestern California (Welsh et al. 1993) and may be important in interior southern Washington, as young stands do not seem to provide suitable habitat for this species (Aubry and Hall 1991). Tailed frog presence in younger-age stands suggests that suitable microhabitat conditions occur in forests less than 200 years old (Corn and Bury 1989), but this interpretation, which may change with geography (see Aubry and Hall 1991) and geology (Dupuis and Steventon 1999), needs study.

Tailed frogs typically mate during late August and September, females lay eggs during the summer of the year after mating, and larvae (tadpoles) remain in the water for one to five years (two to four years has been documented in Washington) after hatching (Leonard et al. 1993, Nussbaum et al. 1983, Welsh et al. 1993). The tailed frog's exceptionally long period of larval and pre-reproductive adult development (estimated seven to nine years) increases the vulnerability of local populations to habitat disturbance (Brown 1975; Daugherty and Sheldon 1982; Jennings and Hayes 1994). These factors may also increase the amount of time required for recovery following disturbance (Blaustein et al. 1995). Tailed frog larvae are likely particularly sensitive to sedimentation following clearcutting along headwater streams. They cannot adhere to rocks that are coated with fine sediment, and may have difficulty moving to find suitable substrate (Jackson et al. 2003).

In a study of 40 perennial non-fishbearing streams in southwestern Washington, Wilkins and Peterson (2000) found tailed frogs only in streams with basaltic (i.e., bedrock) lithology, but this pattern may result from marine sedimentary streams being more vulnerable to harvest effects (Adams and Bury 2002, but it does not exclude the alternative that some sedimentary geologies may simply exclude tailed frog presence because of lack of suitable habitat (M. Hayes, pers. comm. 2005). Similarly, Jackson et al. (2003) found tailed frogs only at steep basalt sites, and concluded that local geologic and topographic conditions play a large role in determining the presence and abundance of this species. In both studies, all surveyed streams occurred in second-growth forest stands. In contrast, Adams and Bury (2002) studied streams within unmanaged forests in Olympic National Park, and found that stream amphibians were common in waters with unconsolidated surface geology. Welsh and Lind (2002) also found tailed frogs to be common in streams with unconsolidated geologies in the Klamath-Siskiyou region, noting instead that stream temperature and forest age were the strongest predictors of tailed frog presence and abundance. Collectively, these findings tend to support Dupuis and Steventon's (1999) report that the competency of the parent geology had significant effects on tailed frogs, but that these effects were greatly exacerbated by timber harvest.

Nussbaum et al. (1983) reported that tailed frogs disappeared from streams when areas were logged, speculating that increased water temperature and siltation were the cause. Jackson et al. (2003) compared pre- and post-logging populations of tailed frogs at five streams in southwestern Washington. In the three streams that were clearcut harvested, no tailed frogs were detected immediately following harvest. Two years later, tailed frogs were still absent from two of the three streams. Corn and Bury (1989) and

Dupuis and Steventon (1999) also found that logging had significant negative effects on densities of tailed frogs. In the redwood forests of northern California, Ashton (2002) documented significantly greater numbers of tailed frogs in late-seral forests compared to 40- to 60-year-old second growth. Findings from recent studies have suggested that increased sediment input may be the most important factor behind tailed frog population declines following logging (Dupuis and Steventon 1999; Ashton 2002). Dupuis and Steventon (1999) also found that buffered creeks had, on average, higher densities of tailed frogs than logged creeks. Several studies have also suggested that riparian buffer strips may be able to protect the streamside microhabitat variables required by tailed frogs, even if the surrounding habitat is not maintained as old growth (Bull and Carter 1996; Corn and Bury 1989). In somewhat of a contrast to the above information, tailed frog tadpoles and adults were found in abundance in several high gradient streams surrounded by young (less than 20 years old) riparian and upland stands southeast of Mount St. Helens in the Gifford-Pinchot National Forest (S. Butts, pers. comm., 2004).

The Coastal tailed frog is a Federal Species of Concern and a Washington State Monitor species. The Rocky Mountain tailed frog is a Federal Species of Concern and a Washington State Candidate species. Compared to other stream-breeding amphibians, tailed frogs appear to be the most narrowly distributed and the most sensitive to short- and intermediate-term effects from timber harvest (Jackson et al. 2003). Tailed frogs have demonstrated sensitivity to increased levels of fine sediment, which may reduce the availability of algae and other foods important to tadpoles (Welsh and Ollivier 1998). Local populations are susceptible to extirpation for several reasons, including narrow niche requirements combined with isolated population distribution, long generation time and loss of mature forest along headwater stream habitats (Welsh 1990). Of seven Pacific Northwest anurans (frogs and toads) associated with old-growth forests, the tailed frog is probably the species most likely to be affected by old-growth habitat loss and degradation (Blaustein et al. 1995).