2.0 ESSENTIAL FISH HABITAT DESCRIPTIONS

The following essential habitat and life history descriptions were developed for the three Pacific salmon species actively managed under the *Pacific Coast Salmon Plan*. This includes chinook and coho salmon stocks from Washington, Oregon, Idaho, and California as well as pink salmon stocks originating from watersheds within Puget Sound (PFMC 1997b). Descriptions for pink or sockeye salmon originating from outside of Puget Sound, and for chum salmon (*Oncorhynchus keta*), steelhead (*Oncorhynchus mykiss*), and cutthroat trout (*Oncorhynchus mykiss*) are not included, because incidental catches of these species in Council-managed ocean fisheries are rare.

2.1 ESSENTIAL HABITAT DESCRIPTION FOR CHINOOK SALMON (*Oncorhynchus tshawytscha*)

2.1.1 General Distribution and Life History

The following is an overview of chinook salmon (*Oncorhynchus tshawytscha*) life history and habitat use as a basis for identifying EFH for chinook salmon. More comprehensive reviews of chinook salmon life history can be found in Allen and Hassler (1986), Nicholas and Hankin (1988), Healey (1991), Myers *et al.* (1998), and others. This description serves as a general description of chinook salmon life history for Washington, Oregon, Idaho, and California and is not specific to any region, stock, or population.

Chinook salmon, also called king, spring, or tyee salmon, is the least abundant and largest of the Pacific salmon (Netboy 1958). They are distinguished from other species of Pacific salmon by their large size, the small black spots on both lobes of the caudal fin, black pigment at the base of the teeth, and a large number of pyloric caeca (McPhail and Lindsey 1970). Chinook salmon follow a generalized life history, which includes the incubation and hatching of embryos; emergence and initial rearing of juveniles in freshwater; migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Within this general life-history strategy, however, chinook salmon display diverse and complex life history patterns and tactics. Their spawning environments range from just above tidewater to over 3,200 km from the ocean, from coastal rainforest streams to arid mountain tributaries at elevations over 1,500 m (Major *et al.* 1978). At least 16 age categories of mature chinook salmon have been documented, involving 3 possible freshwater ages and total ages of 2-8 years, reflecting the high variability within and among populations in freshwater, estuarine, and oceanic residency (Healey 1986). Chinook salmon also demonstrate variable ocean migration patterns and timing of spawning migrations (Ricker 1972, Healey 1991).

This variation in life history has been partially explained by separating chinook salmon into two distinct races: stream-type and ocean-type fish (Gilbert 1912, Healey 1983). Stream-type fish have long freshwater residence as juveniles (1-2 years), migrate rapidly to oceanic habitats, and adults often enter freshwater in spring and summer, spawning far upriver in late summer or early fall. Ocean-type fish have short, highly variable freshwater residency (from a few days to several months), extensive estuarine residency, and adults show considerable geographic variation in month of freshwater entry. Within these two types, there is also substantial variability most likely due to a combination of phenotypic plasticity and genetic selection to local conditions (Myers *et al.* 1998).

The natural freshwater range of the species includes large portions of the Pacific rim of North America and Asia. In North America, chinook salmon historically ranged from the Ventura River in California (~34° N latitude) to Kotzebue Sound in Alaska (~66° N latitude); in addition, the species has been identified in North America in the Mackenzie River, which drains into the Arctic Ocean (McPhail and Lindsey 1970, Major *et al.* 1978). At present, the southern-most populations occur in the San Joaquin River, although chinook salmon are occasionally observed in Rivers south of San Francisco Bay, such as the San Luis Obispo and Carmel rivers. In Asia, natural populations of chinook salmon have been documented from Hokkaido Island, Japan (~42° N latitude), to the Andyr River in Russia (~64° N latitude). In marine environments, chinook salmon from Washington, Oregon, and California range widely throughout the north Pacific Ocean and the Bering Sea, as far south as the U.S./Mexico border.

The largest rivers tend to support the largest aggregate runs of chinook salmon and have the largest individual spawning populations (Healey 1991). Major rivers near the southern and northern extremes of the range support populations of chinook salmon comparable to those near the middle of the range. For example, in North America, the Yukon River near the north edge of the range and the Sacramento-San Joaquin River system near the south edge of the range have historically supported chinook salmon runs comparable to those of the Columbia and Fraser rivers, which are near the center of the species range in North America (Healey 1991).

Declines in the abundance of chinook salmon have been well documented throughout the southern portion of the range. Concern over coast-wide declines from southeastern Alaska to California was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Wild chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia (Nehlsen *et al.* 1991), and a number of Evolutionarily Significant Units (ESUs) have been listed or proposed for listing by NMFS as at risk of extinction under the ESA (NMFS 1998, 1999). For example, the Columbia River formerly supported the world's largest chinook salmon run, but currently five Columbia Basin ESUs are listed as "threatened" under the ESA - Snake River spring/summer, Snake River fall, upper Columbia River spring, lower Columbia River and upper Willamette River chinook salmons (NMFS 1992, 1999).

Habitat degradation is the major cause for extinction of populations; many extinctions are related to dam construction and operation (NMFS 1996, Myers *et al.* 1998). Urbanization, agricultural land use, water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon (Nehlson *et al.* 1991, Spence *et al.* 1996). The development of large-scale hatchery programs have, to some degree, mitigated the decline in abundance of chinook in some areas. However, genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations (Reisenbichler 1997, Mundy 1997). Recent increases in pinniped populations also raise concerns over the impacts of pinniped predation on the recovery of salmonids in certain situations (NMFS 1997c).

2.1.2 Fisheries

Chinook salmon are highly prized by commercial, sport, and subsistence fishers, because of their large size and excellent palatability. Because of their migrations through coastal waters, however, chinook salmon returning to Washington, Oregon, and California waters are harvested in fisheries over a wide geographic area. Considerable management and regulatory efforts focus on chinook salmon fisheries primarily due to the value of the fish, the numerous states and agencies involved in regulating these fisheries, and concerns about declining abundance.

Ocean fisheries targeting chinook salmon use hook-and-line gear, but gill nets are used in commercial and tribal freshwater fisheries in the Columbia and Klamath Rivers, and other rivers. Chinook salmon fisheries have some bycatch associated with them, most often other salmonids and undersized chinook salmon. While the majority of these fish survive the hooking encounter, substantial (> 25%) mortality may occur (Wertheimer 1988, Wertheimer *et al.* 1989, Gjernes *et al.* 1993). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC documents *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.1.3 Relevant Trophic Information

Chinook salmon eggs, alevins, and juveniles in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds, and small mammals. The carcasses of chinook adults can also be an important nutrient input in their natal watersheds, as well as providing food sources for terrestrial mammals such as bears, otters, minks, and birds such as gulls, eagles, and ravens (Cederholm *et al.* 1989, Bilby *et al.* 1996, Ben-David *et al.* 1997). Because of their relatively low abundance in coastal and oceanic waters, chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal sea birds (Botkin *et al.* 1995). However, pinniped predation on migrating salmonids, both adult spawners and downstream migrating smolts, can be substantial especially at sites of restricted passage and small salmonid populations (NMFS 1997c).

2.1.4 Habitat and Biological Associations

Table A-3 summarizes chinook salmon habitat use by life history stage.

2.1.4.1 Eggs and Spawning

Chinook salmon spawning generally occurs from July to March depending primarily upon the geographic location and the specific race or population. In general, northern populations tend to spawn from July to October and southern populations from October to February. The Sacramento River supports a unique winter run chinook that spawn from March through July with peak spawning occurring in June (Myers *et al.* 1998). There is a general tendency for stream-type fish to spawn earlier than ocean-type fish in the central and southern parts of the species range, but the difference is generally less than one to two months in most streams. However, spawn timing may vary several months among some chinook salmon populations in larger river systems such as the Columbia or the Sacramento (Healey 1991).

Chinook salmon fecundity and size of eggs, like that of other salmon species, is related to female size, and exhibits considerable small-scale geographic and temporal variability. Fecundity in chinook salmon increases with latitude and ranges from 2,000-17,000 eggs per female, with females in most populations having 4,000-7,000 eggs (Healey and Heard 1984, Beacham and Murray 1993). Stream-type fish also tend to have higher fecundity than ocean-type fish, and northern populations are dominated by stream-type fish (Healey and Heard 1984).

Chinook salmon spawn in a broad range of habitats. They have been known to spawn in water depths ranging from a few centimeters to several meters deep, and in small tributaries 2-3 m wide to large rivers such as the Columbia and the Sacramento (Chapman 1943, Burner 1951, Vronskiy 1972, Healey 1991). Chinook salmon redds (nests) range in size from 2 to 40 m^2, occur at depths of 10-700 cm and at water velocities of 10-150 cm/s (Healey 1991). Typically, chinook salmon redds are 5-15 m^2 and located in areas with water velocities of 40-60 cm/s. The depth of the redd is inversely related to water velocity, and the female buries her eggs in clean gravel or cobble 10-80 cm in depth (Healey 1991). Because of their large size, chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. Female chinook salmon select areas of the spawning stream with high subgravel flow such as pool tailouts, runs, and riffles (Vronskiy 1972, Burger *et al.* 1985, Healey 1991). Because their eggs are the largest of the Pacific salmon, ranging from 6 to 9 mm in diameter (Rounsefell 1957, Nicholas and Hankin 1988), with a correspondingly small surface-to-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation than other salmonids. Fertilization of the eggs occurs simultaneous with deposition. Males compete for the right to breed with spawning females. Chinook salmon females have been reported to remain on their redds from six to 25 days after spawning (Neilson and Geen 1981, Neilson and Banford 1983), defending the area from superimposition of eggs from another female. This period of redd protection roughly coincides with the period the eggs are most sensitive to physical shock.

2.1.4.2 Larvae/Alevins

Fertilized eggs begin their two to eight month (typically three to four month) period of embryonic development and growth in intragravel interstices. The length of the incubation period is primarily determined by water temperature, dissolved oxygen concentrations, and egg size. To survive successfully, the eggs, alevins, and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, and predators. Water surrounding them must be non-toxic, and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Under natural conditions, 30% or less of the eggs survive to emerge from the gravel as fry (Healey 1991).

TABLE A-3. Chinook salmon habitat use by life history stage. (See key to abbreviations and EFH data levels on the next page.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	50-130 d	Non-feeding stage; eggs consumed by birds, fish, and mammals.	Late summer, fall, and winter	Intragravel in stream beds	20-80 cm gravel depth; 15-700 cm water depth	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 5-14°C; **Water velocity** 15-190 cm/s
Larvae (alevins) EFH Data Level 0-4; not all habitats have been sampled	50-125 d until fry emerge from gravel	Non-feeding stage; Alevins consumed by birds, fish and mammals	Fall, winter, and early spring	Intragravel until fry emergence	20-80 cm gravel depth; 15-700 cm water depth	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 5-14°C; **Water velocity** 15-190 cm/s
Juveniles (freshwater) EFH Data level 0-4; not all habitats have been sampled	days-yrs	Insect larvae, adults, plankton	Year-round, depending on race	Streams, lakes, sloughs, rivers	0-120 cm	Varied	NA	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** < 29 ppt
Juveniles (Estuary and oceanic) EFH Data Level 0-3; not all habitats have been sampled	6-months to 2 yrs	Estuary: copepods, euphausiids, amphipods. Ocean: fish, squid, euphausiids	Estuary: spring, summer, fall. Ocean: year-round	BCH BAY, IP, ICS, OCS	P, N, SD/SP 30-80 m preferred depth	All bottom types	Estuarine, littoral then more open water, UP, F, CL, G	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** sea water
Adults EFH Data Level 0-2; not all habitats have been sampled	2-8 yrs of age from egg to mature adult	Fish, squid, euphausiids, amphipods, and copepods	Spawning: July-Feb. Non-spawning: Year round	Oceanic to nearshore migrations, spawn in freshwater	P, N, SD/SP	NA	Different stock groups have specific oceanic migratory patterns	**DO** Preferred >5 mg/l, optimum at saturation; **Temperature** 0-26°C; optimum <14°C

Major sources: Healey 1991, Bjorrn and Reiser 1991, Myers *et al.* 1998, NOAA 1990, Fisher and Pearcy 1995, Spence *et al.* 1996.

KEY FOR TABLES A-3, A-4, AND A-5.

EFH Data Level

0 No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys.

1 Presence/absence distribution data are available for some or all portions of the geographic range.

2 Habitat-related densities are available. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value.

3 Habitat-related growth, reproduction, or survival rates are available. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).

4 Habitat-related production rates are available. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and a healthy ecosystem.

Location where found (in waters of these depths)

BAY - nearshore bays, give depth if appropriate (e.g., fjords)
BCH - beach (intertidal)
BSN - basin (>3,000 m)
IP - island passes (areas of high current), give depth if appropriate
ICS - inner continental shelf (1-50 m)
LSP - lower slope (1,000-3,000 m)
MCS - middle continental shelf (50-100 m)
OCS - outer continental shelf (100-200 m)
USP - upper slope (200-1,000 m)

Where found in water column

D - demersal (found on bottom)
N - neustonic (found near surface)
P - pelagic (found off bottom, not necessarily associated with a particular bottom type)
SD/SP - semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom

Bottom Types

M - mud	S - sand	R - rock
SM - sandy mud	CB - cobble	C - coral
MS - muddy sand	G - gravel	K - kelp

SAV - subaquatic vegetation other than kelp (e.g., eelgrass).

Oceanographic Features

UP - upwelling	G - gyres	F - fronts
CL - thermo-or pycnocline	E - edges	

Other

U=Unknown
NA=not applicable

2.1.4.3 Juveniles (Freshwater)

Chinook salmon fry are typically 33-36 mm in length when they emerge, though there is considerable variation among populations and size at emergence is determined in part by egg size. Juvenile residence in freshwater and size and timing of seawater migration are highly variable. Ocean-type fish can migrate seaward immediately after yolk absorption, but most migrate 30-90 days after emergence. However, some move seaward as fingerlings in the late summer of their first year, while others, particularly in less-productive or cold water systems, overwinter and migrate as yearling fish (Taylor 1990a, 1990b). The proportion of fingerling and yearling migrants within a population may vary significantly among years (Roni 1992, Myers *et al.* 1998).

In contrast, stream-type fish generally spend at least one year in freshwater before emigrating to sea. Alaskan fish are predominantly stream-type, while chinook salmon from northern British Columbia are approximately half stream-type and half ocean-type (Taylor 1990a, Healey 1991). Ocean-type life histories are most common in central and southern British Columbia, Washington, Oregon, and California, with the exception of populations inhabiting the upper reaches of large river basins such as the Fraser, Columbia, Snake, and to a lesser extent the Klamath and Sacramento.

Water and habitat quality and quantity determine the productivity of a watershed for chinook salmon. Both stream and ocean-type fish utilize a wide variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to the estuary. Juvenile chinook inhabit primarily pools and stream margins, particularly undercut banks, behind woody debris accumulations, and other areas cover and reduced water velocity (Lister and Genoe 1970, Bjornn and Reiser 1991). While chinook salmon habitat preferences are similar to coho salmon, chinook salmon inhabit slightly deeper (15-120 cm) and higher velocity (0-38 cm/s) areas than coho salmon (Bjornn and Reiser 1991, Healey 1991). The stream or river must provide adequate summer and winter rearing habitat, and migration corridors from spawning and rearing areas to the sea. Stream-type juveniles are more dependent on freshwater ecosystems, because of their extended residence in these areas. The length of freshwater residence and growth is determined partially by water temperature and food resources. The principal foods in freshwater are larval and adult insects, while those in estuarine areas include epibenthic organisms, insects, and zooplankton.

Growth rates during the period of initial freshwater residency depend on the quality of habitats occupied by the fish. Growth rates between 0.21 mm/d and 0.62 mm/d have been reported for ocean-type fish and between 0.09 mm/d and 0.33 mm/d for stream-type fish (Kjelson *et al.* 1982, Healey 1991, Rich 1920, Mains and Smith 1964, Meeh and Siniff 1962, Loftus and Lenon 1977). For ocean-type fish, growth rates in estuarine habitats are generally much higher than they are in riverine or stream habitats, most likely due to a higher abundance of prey.

2.1.4.4 Juvenile (Estuarine)

Although both stream and ocean-type chinook salmon may reside in estuaries, stream-type chinook salmon generally spend a very brief period in the lower estuary before moving into coastal waters and the open ocean (Healey 1980, 1982, 1983; Levy and Northcote 1981). In contrast, ocean-type chinook salmon typically reside in estuaries for several months before entering coastal waters of higher salinity (Healey 1980, 1982; Congleton *et al.* 1981, Levy and Northcote 1981, Kjelson *et al.* 1982).

Ocean-type chinook salmon typically begin their estuarine residence as fry immediately after emergence or as fingerling after spending several months in freshwater. Fry generally enter the upper reaches of estuaries in late winter or early spring, beginning in January at the southern end of their range in the Sacramento-San Joaquin Delta, to April farther north, such as in the Fraser River Delta (Sasaki 1966; Dunford 1975; Levy *et al.* 1979; Healey 1980, 1982; Gordon and Levings 1984). In contrast, chinook salmon fingerling typically enter estuarine habitats in June and July (April through June in the Sacramento), or approximately as the earlier timed fry are emigrating to higher salinity marine waters. Regardless of time of entrance juvenile ocean-type chinook salmon spend from one to three months in estuarine habitats (Rich 1920; Reimers 1973; Myers 1980; Kjelson *et al.* 1982; Levy and Northcote 1981; Healey 1980, 1982; Levings 1982).

Chinook salmon fry prefer protected estuarine habitats with lower salinity, moving from the edges of marshes during high tide to protected tidal channels and creeks during low tide, although they venture into less-protected areas at night (Healey 1980, 1982; Levy and Northcote 1981, 1982; Kjelson *et al.* 1982; Levings 1982). As the fish grow larger, they are increasingly found in higher-salinity waters and increasingly utilize less-protected habitats, including the use of delta fronts or the edge of the estuary before finally dispersing into strictly marine habitats. In contrast to fry, chinook fingerling, with their larger size, immediately take up residence in deeper-water estuarine habitats (Everest and Chapman 1972, Healey 1991).

The chinook salmon diet during estuarine residence is highly variable and is dependent upon the particular estuary, year, season, and prey abundance. In general, chinook are opportunistic feeders, consuming larval and adult insects and amphipods when they first enter estuaries, with increasing dependance on larval and juvenile fish (including other salmonids) as they grow larger. Preferred diet items for chinook salmon include aquatic and terrestrial insects such as chironomid larvae, dipterans, cladoceans such as *Daphnia*, amphipods including *Eogammarus* and *Corophium*, and other crustacea such as *Neomysis*, crab larvae, and cumaceans (Sasaki 1966, Dunford 1975, Birtwell 1978, Levy *et al.* 1979, Northcote *et al.* 1979, Healey 1980, 1982; Kjelson *et al.* 1982, Levy and Northcote 1981, Levings 1982, Gordon and Levings 1984, Myers 1980; Reimers 1973). Larger juvenile chinook consume juvenile fishes such as anchovy *(Engraulidae)*, smelt *(Osmeridae)*, herring *(Clupeidae)*, and stickleback *(Gasterosteidae)*.

Growth in estuaries is quite rapid and chinook may enter the upper reaches of estuarine environments as 35-40 mm fry, and leave as 70-110 mm smolts (Rich 1920, Levy and Northcote 1981, 1982; Reimers 1973, Healey 1980). Growth rates during this period are difficult to estimate because small individuals are continually entering the estuary from upstream, while larger individuals depart for marine waters. Reported growth for populations range from .22 mm/d to .86 mm/d, and is as high as 1.32 mm/d for groups of marked fish (Rich 1920; Levy and Northcote 1981, 1982; Reimers 1973; Healey 1980; Kjelson *et al.* 1982; Healey 1991; Levings *et al.* 1986).

2.1.4.5 Juveniles (Marine)

After leaving the freshwater and estuarine environment, juvenile chinook disperse to marine feeding areas. Ocean-type fish which have a longer estuarine residence, tend to be coastal oriented, preferring protected waters and waters along the continental shelf (Healey 1983). In contrast, stream-type fish pass quickly through estuaries, are highly migratory, and may migrate great distances into the open ocean.

Chinook salmon typically remain at sea for one to six years. They have been found in oceanic waters at temperatures ranging from 1-15°C, although few chinook salmon are found in waters below 5°C (Major *et al.* 1978). They do not concentrate at the surface as do other Pacific salmon, but are most abundant at depths of 30-70 m and often associated with bottom topography (Taylor 1969, Argue 1970). However, during their first several months at sea, juvenile chinook salmon < 130 mm are predominantly found at depths less than 37 m (Fisher and Pearcy 1995). Because of their distribution in the water column, the majority of chinook salmon harvested in commercial troll fisheries are caught at depths of 30 m or greater.

Chinook salmon range widely throughout the north Pacific Ocean and the Bering Sea, as far south as the U.S./Mexico border (Godfrey 1968, Major *et al.* 1978). Chinook salmon from California, Oregon, Washington, and Idaho have been recovered in coastal areas throughout the Strait of Georgia and Inland Passage, along the Alaskan coast into Cook Inlet and waters surrounding Kodiak Island, extending out into the Aleutian/Rat Island chains to 180° W longitude, and northward in the Bering Sea to the Pribilof Islands (Hart and Dell 1986, Myers *et al.* 1996).

Chinook salmon may stay in coastal waters or may migrate into offshore oceanic habitats. Migration from coastal to more oceanic waters may begin off the coast of Vancouver Island, or may be delayed until reaching as far as Kodiak Island (Hartt and Dell 1986). Limited tag release and recovery data have found Washington origin chinook salmon in the Emperor Sea Mounts area, at ~44° N latitude and 175° W longitude (Myers *et al.* 1996). Based on high seas tagging data presented in Myers *et al.* (1996) and Hartt and Dell (1986), the oceanic distribution of Pacific Northwest chinook salmon appears to include the Pacific Ocean and Gulf of Alaska north of ~44° N latitude and east of 180° W longitude, including some areas of the Bering Sea.

The coastal distribution of chinook salmon is similar to coho salmon (Hartt and Dell 1986), with high concentrations in areas of pronounced coastal upwelling. Juvenile chinook are generally found within 55 km of the Washington, Oregon, and California coast, with the vast majority of fish found less than 28 km offshore (Pearcy and Fisher 1990, Fisher and Pearcy 1995). Historically, juvenile chinook salmon have been reported in coastal streams as far south as San Luis Obispo (Jordan 1895) and the Ventura River (Jordan and Gilbert 1881), so it can be presumed that their historical ocean distribution occasionally included coastal upwelling areas off southern California. Point Conception (34°30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes found north and subtropical fishes found south of this point (Allen and Smith 1988). Therefore, the historic southern edge of the marine distribution appears to be near Point Conception, California, and expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

Ocean migration patterns have been shown to be influenced by both genetics and environmental factors (Healey 1991). Migratory patterns in the ocean may have evolved as a balance between the benefits of accessing specific feeding grounds and the energy expenditure and dispersion risks necessary to reach them. Along the eastern Pacific Rim, chinook salmon originating north of Cape Blanco on the Oregon coast tend to migrate north towards and into the Gulf of Alaska, while those originating south of Cape Blanco migrate south and west into waters off Oregon and California (Godfrey 1968, Major *et al.* 1978, Cleaver 1969, Wahle and Vreeland 1977, Wahle *et al.* 1981, Healey and Groot 1987).

While the marine distribution of chinook salmon can be highly variable within and among populations, migration and ocean distribution patterns show similarities among some geographic areas. For example, chinook salmon that spawn in rivers south of the Rogue River in Oregon disperse and rear in marine waters off the Oregon and California coast, while those spawning north of the Rogue River migrate north and west along the Pacific coast (Godfrey 1968, Major *et al.* 1978, Cleaver 1969, Wahle and Vreeland 1977, Wahle *et al.* 1981, Healey and Groot 1987). These migration patterns result in the harvest of fish from Oregon, Washington, and British Columbia within the EEZ off the Alaskan coast.

Chinook salmon are the most piscivorous of the Pacific salmon. Accordingly, fishes make up the largest component of their diet at sea, although squids, pelagic amphipods, copepods, and euphausiids are also important at times (Merkel 1957, Prakash 1962, Ito 1964, Hart 1973, Healey 1991).

2.1.4.6 Adults

Throughout their range, adult chinook salmon enter freshwater during almost any month of the year, although there are generally one to three peaks of migratory activity in most areas. In northern areas, chinook salmon river entry peaks in June, while in rivers such as the Fraser and Columbia, chinook salmon enter freshwater between March and November, with peaks in spring (March through May), summer (May through July), and fall (August through September). The Sacramento River has a winter-run population that enters freshwater between December and July.

Chinook salmon become sexually mature at a wide range of ages from two to eight years, with "jacks" or precocious males maturing after one to two years. Overall, the most common age of ocean- and stream-type maturing adults is three to five years, with males tending to be slightly younger than females. In general, stream-type fish have a longer generation time than do ocean-type fish, presumably owning to their longer freshwater residence, and chinook salmon from Alaska and more northern latitudes typically mature a year or more later than their southern counterparts (Roni and Quinn 1995, Myers *et al.* 1998). This phenomenon may also be an artifact of fishing pressure.

The size and age of adults varies considerably among populations and years and is influenced by genetic and environmental factors as well as by fishing pressure. Adult chinook salmon size is thought to represent adaptation to local spawning environment (Ricker 1980, Healey 1991, Roni and Quinn 1995). Most adult chinook salmon females are 65-85 cm in length, while the slightly younger males are 50-85 cm. However, male and female fish larger than 100 cm in length are not uncommon in many populations.

Prior to sexual maturation and spawning, adult chinook salmon often hold in large, deep, low velocity pools, with abundant large woody debris or other cover features. These areas may serve as a refuge from high river temperatures, predators, or a refuge to reduce metabolic demands and reserve energy until spawning commences (Berman and Quinn 1991). The spawning densities of chinook and coho salmon have been correlated with a number of factors including large woody debris and pool frequency (Montgomery *et al.* In prep.).

The survival of chinook salmon is affected by factors including run type (i.e., spring, summer, fall), freshwater migration length, and year. Hatchery spring and summer chinook salmon have smolt-to-adult survival rates that average 1%, although survival of many upper Columbia and Snake river basin hatchery stocks is typically less than 0.2% (Coronado-Hernandez 1995). Wild stocks from these areas are thought to have ocean survival rates two to ten times greater than hatchery fish (Coronado-Hernandez 1995). Fall chinook hatchery stocks also survive from smolt to adult at approximately 1%, although fish from some areas, such as the Oregon coast, are consistently higher, but typically less than 5% (Coronado-Hernandez 1995).

2.1.4.7 Databases on Chinook Salmon Distribution

To determine the geographic extent of chinook salmon freshwater and estuarine distribution, we examined the available information and selected databases on chinook salmon distribution and habitat use (see tables in Sections 2.4 and 2.5). The databases fell into three general categories, (1) regional, small scale (1:100,000 or 1:250,000) regional Geographic Information System (GIS) databases on salmon distribution (StreamNet, Washington Rivers Information System [WARIS], Oregon River Information System [ORIS], etc.), (2) local, large scale GIS database of limited coverage (county, tribal datasets, etc.), and (3) databases on habitat quality (U.S. Forest Service [USFS] stream survey data, state agency stream survey data, etc.). Unfortunately, databases in category 2 and 3 are of limited utility in specifically determining chinook salmon freshwater distribution, because they are composed of numerous, incompatible, small databases with incomplete geographic coverage. These datasets may, however, be useful during the EFH consultation process.

Small scale, regional databases such as StreamNet (1998) are suitable for portraying the overall distribution of chinook salmon and have utility for determining presence on the majority of specific stream reaches. Various life stages (migration, spawning and rearing, and rearing only) are delimited in the database distribution data as well. The hydrography used by StreamNet to spatially reference fish distribution is predominantly composed of 1:100,000 scale data, but both 1:63,500 and 1:24,000 linework has been added where appropriate to reference all the distribution data available to the project.

The formation and modification of stream channels and habitats is a dynamic process. Habitat available and utilized by chinook salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events (Sullivan *et al.* 1987, Naiman *et al.* 1992, Reeves *et al.* 1995). To expect the distribution of chinook salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Therefore, current information on chinook salmon distribution is useful for determining which watersheds chinook salmon inhabit, but not necessarily for identifying specific stream reaches and habitats utilized by the species.

2.1.4.8 Habitat Areas of Particular Concern

Information exists on the type of stream reaches preferred by chinook salmon for spawning and rearing. It is generally accepted that salmon spawn and rear primarily in stream reaches with a slope less than 4-5% (Lunetta *et al.* 1997), while they migrate through much steeper stream reaches. Furthermore, recent research has indicated that chinook and other fall-spawning anadromous salmonids are found primarily in plane-bed, pool-riffle, and forced-pool riffle stream channels[1/], which are channel types less than 4% slope (Montgomery and Buffington 1997, Montgomery *et al.* In prep.). Stream reaches greater than 4% slope are not frequently utilized by chinook salmon for spawning and rearing, because of their high bed load transport rate, deep scour, and coarse substrate (Montgomery *et al.* In prep.). Stream reaches less than 4-5% slope that potentially display plane-bed, pool-riffle, forced-pool-riffle morphology can be determined using GIS technology. Gradient and channel type as identified by GIS technology can differ from those actually present in the field (Lunetta *et al.* 1997, Montgomery and Buffington 1997). Therefore, it is important that a 1:24,000

1/ See Montgomery and Buffington (1997) for a description of this channel classification system.

or larger (finer) scale maps are used to determine potential channel type and a fine scale (10 m or less) digital elevation model is used to calculate slopes and channel types. Furthermore, slope and channel type should be confirmed in a representative number of reaches by site visits or existing habitat surveys. While the technology exists to develop this information, data at this scale and resolution have only been developed for specific provinces, not for the entire region; and, therefore, could not be used in the current EFH identification process. However, the existing information should be useful in the consultation process.

The delineation of channel types allows identification of potentially important and vulnerable habitats in the absence of accurate salmon distribution or habitat data. Moreover, degraded stream reaches, those lacking key roughness elements (e.g., large woody debris), and stream reaches with a high potential for restoration will still be identified as potential habitat. Therefore, the protection and restoration of chinook salmon habitat should focus on pool-riffle, plane bed, and forced-pool-riffle channels. Furthermore, any activity adjacent to or upstream of activity that could influence the quality of these important reaches or channels should be evaluated. Other vulnerable habitats that are in need of protection and restoration are off-channel rearing areas (e.g., wetlands, oxbows, side channels, sloughs) and estuarine and other near-shore marine areas. Submarine canyons and other regions of pronounced upwelling are also thought to be particularly important during El Niño events (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, CA 95460, pers. comm.) and may need additional consideration for protection.

2.1.4.9 Freshwater Essential Fish Habitat

Freshwater EFH for chinook salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Important features of essential habitat for spawning, rearing, and migration include adequate (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth, and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation, etc.); (7) space; (8) access and passage; and (9) flood plain and habitat connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table 2-1.

Chinook salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, tributaries, and other water bodies currently viable and most of the habitat historically accessible to chinook salmon within Washington, Oregon, Idaho, and California. Figure A-2 illustrates the watersheds currently utilized by chinook salmon from Washington, Oregon, Idaho and California within the hydologic units identified at the end of the chapter for all Council-managed salmon (Table A-6). Current chinook EFH does not include the aquatic habitat in watersheds above Dworshak Dam and the Hells Canyon Dam complex (Table A-2). Figure A-3 depicts the approximate historical freshwater distribution and the currently identified range of common marine occurrence of chinook salmon from Washington, Oregon, Idaho, and California. The geographic extent of the historic freshwater distribution of chinook salmon is based on data from Table A-5. Data on the marine range of chinook salmon are from National Oceanic and Atmospheric Administration (NOAA) (1990).

The diversity of habitats utilized by chinook salmon coupled with the inadequacy of existing species distribution maps makes it extremely difficult to identify all specific stream reaches, wetlands, and water bodies essential for the species at this time. Defining specific river reaches is also complicated, because of the current low abundance of the species and our imperfect understanding of the species' freshwater distribution, both current and historic. Adopting a more inclusive, watershed-based description of EFH is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic areas and adjacent upslope areas. Furthermore, this watershed-based approach is consistent with other Pacific salmon habitat protection and recovery efforts such as the ESA, Northwest Forest Plan, and the Oregon Coastal Salmon Restoration Initiative (OCSRI). Therefore, the geographic extent of chinook salmon essential habitat was delineated using USGS cataloging unit boundaries.

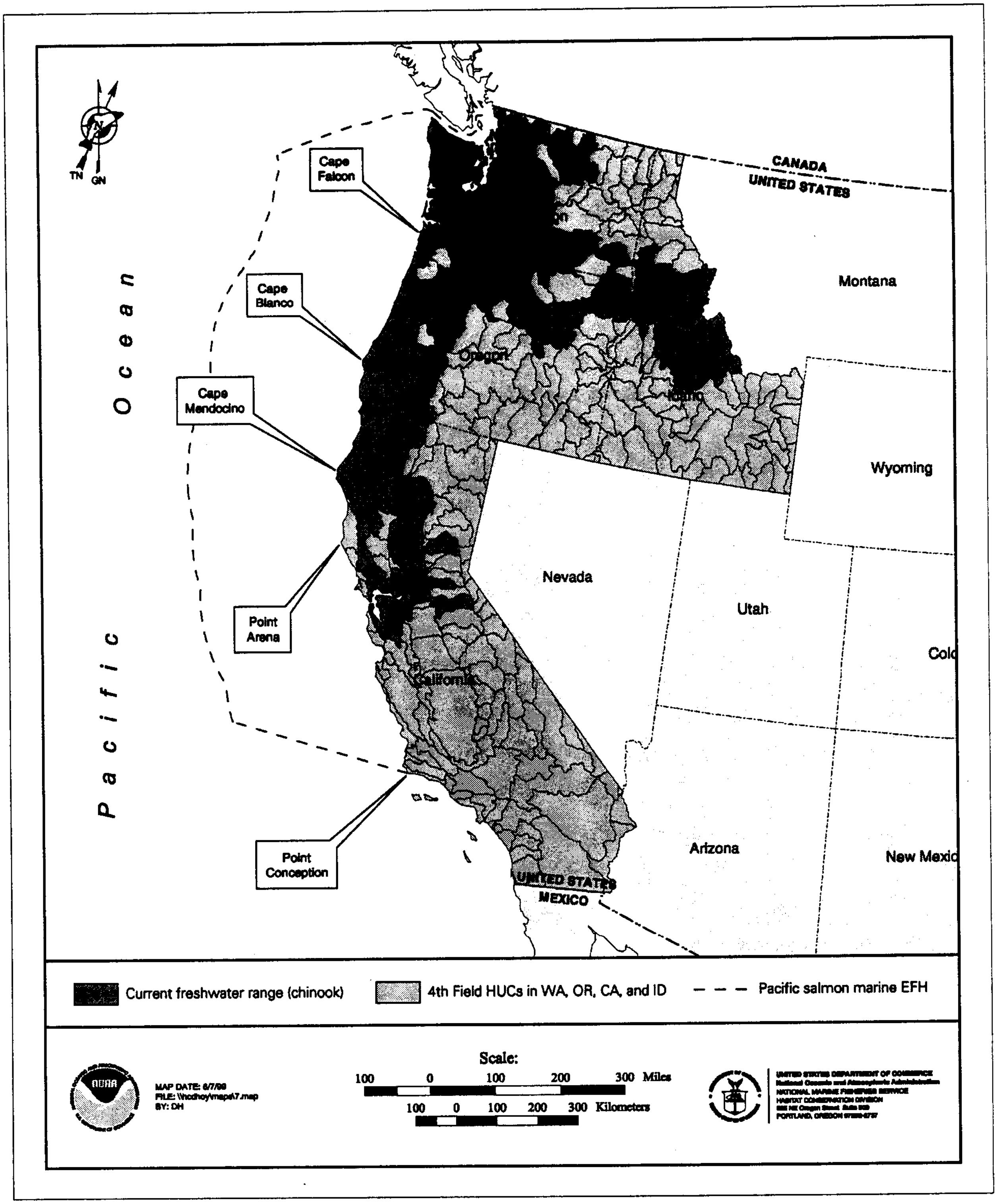

FIGURE A-2. Watersheds currently utilized by chinook salmon from Washington, Oregon, Idaho, and California.

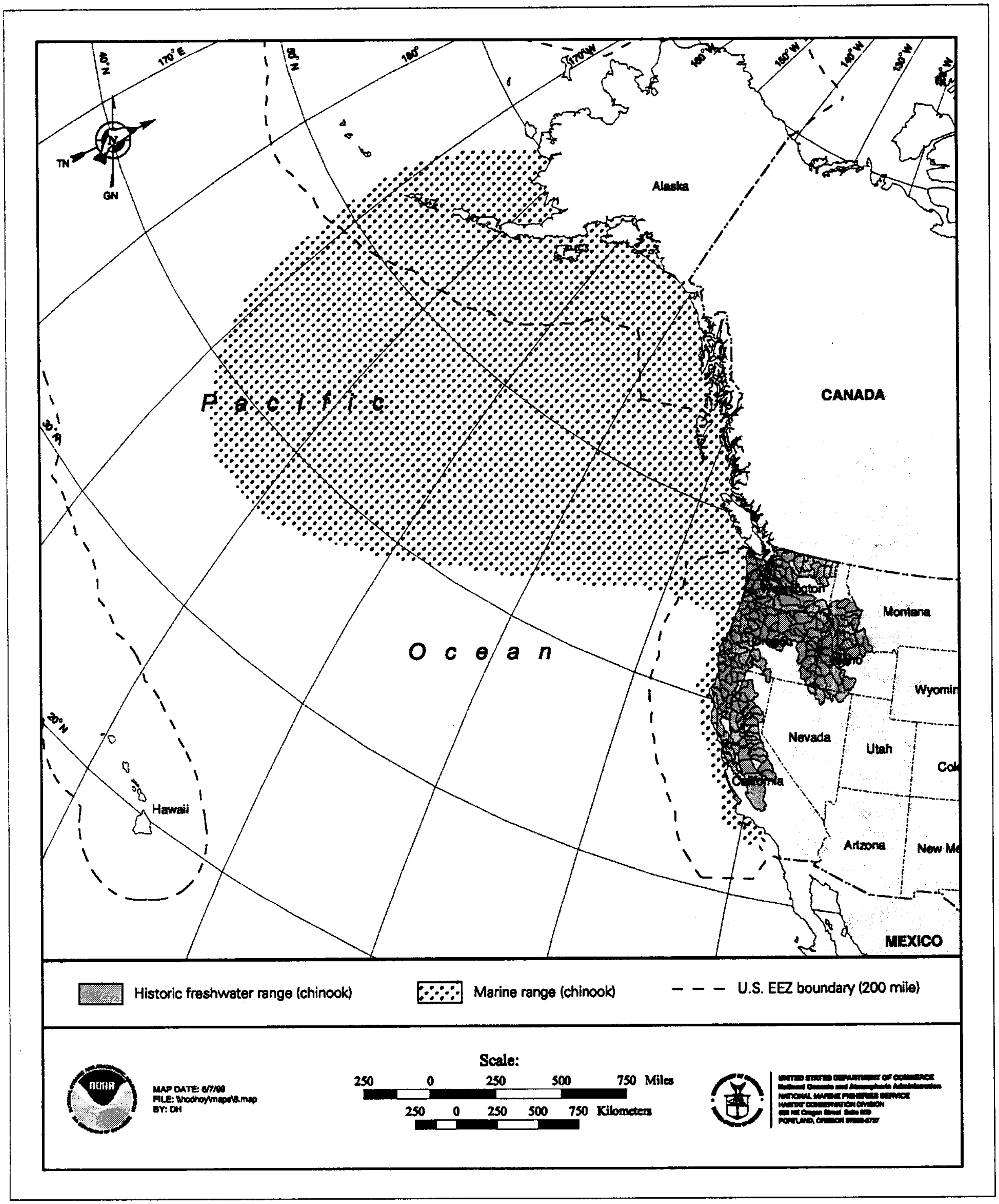

FIGURE A-3. Approximate historically accessible freshwater distribution and currently identified range of common marine occurrence of chinook salmon originating from Washington, Oregon, Idaho, and California.

2.1.4.10 Marine Essential Fish Habitat

The important elements of chinook salmon marine EFH are (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats. The available information for each life-history stage is summarized in Table A-3. Overall chinook salmon marine distribution is extensive, varies seasonally, interannually, and can only be defined generally (Figure A-3).

Limited information exists on chinook salmon habitat use in marine waters. Chinook are found throughout the North Pacific and have been encountered in waters far offshore. Available research (Pearcy and Fisher 1990, Fisher and Pearcy 1995), suggests that ocean-type juvenile chinook salmon are found in highest concentrations over the continental shelf. However, Fisher *et al.* (1983, 1984) found no clear evidence that young chinook were more abundant close to the coast. Ocean-type juvenile chinook appear to utilize different marine areas for rearing than stream-type juvenile chinook that are believed to migrate to ocean waters further offshore early in their ocean residence (Healey 1991). Coded-wire-tag recoveries of chinook salmon from high-seas fisheries and tagging programs (Myers *et al.* 1996; Healey 1991, Fig.18) provide evidence that chinook salmon utilize areas outside the continental shelf. Catch data and interviews with commercial fishermen indicate that maturing chinook salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. Many stream-type chinook populations do not appear to be as heavily exploited as ocean-type chinook, indicating that stream-type fish may be vulnerable to coastal fisheries for only a short time during their spawning migrations (Healey 1991). Determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for chinook salmon includes all marine waters within the EEZ north of Point Conception, California (Figure A-3) and the marine areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council (NPFMC).

2.2 ESSENTIAL HABITAT DESCRIPTION FOR COHO SALMON *(Oncorhynchus kisutch)*

2.2.1 General Distribution and Life History

The following is an overview of coho salmon life history and habitat use as a basis for identifying EFH for coho salmon. Comprehensive reviews of coho salmon life history and habitat requirements can be found in Shapovalov and Taft (1954), Sandercock (1991), Weitkamp *et al.* (1995), and others. This description serves as a general description of coho salmon life history for Washington, Oregon, and California, and is not specific to any region, stock, or population.

Coho or "silver" salmon are a commercially and recreationally important species found in small streams and rivers throughout much of the Pacific Rim, from central California to Korea and northern Hokkaido, Japan (Godfrey 1965, Scott and Crossman 1973). They are distinguished from other Pacific salmon by the presence of irregular black spots confined to the back and the upper lobe of the caudal fin, and bright red sides and a bright green back and head when sexually mature (Godfrey 1965, Scott and Crossman 1973). Coho salmon spawn in freshwater streams, juveniles rear for at least one year in fresh water and spend about 18 months at sea before reaching maturity as adults. Precocious male coho salmon or "jacks" become sexually mature after only 6 months at sea, one year earlier than typical adult fish. Because coho salmon have relatively fixed residence times in both fresh and salt water, the species exhibits fewer age classes than all other Pacific salmon, with the exception of pink salmon. Most coho salmon populations south of central British Columbia consist of two-year-old jacks and three-year-old adults, while populations north of central British Columbia have two or three-year-old jacks and three or four-year-old adults (Gilbert 1912, Pritchard 1940, Shapovalov and Taft 1954, Wright 1970, Godfrey *et al.* 1975, Crone and Bond 1976). The older age at maturity of more northern populations is a product of the juveniles spending two years in freshwater as opposed to one year residence of more southern populations.

Unlike other Pacific salmon species, where the majority of production comes from large spawning populations in a few river basins, coho salmon production results from spawners using numerous small streams (Sandercock 1991). North American coho salmon populations are widely distributed along the

Pacific coast and spawn in tributaries to most major river basins from the San Lorenzo River in Monterey Bay, California, to Point Hope, Alaska, and through the Aleutian Islands (Godfrey 1965, Sandercock 1991). The species is most abundant in coastal areas from central Oregon through southeast Alaska and widely distributed throughout the North Pacific (Manzer *et al.* 1965, French *et al.* 1975, Godfrey *et al.* 1975).

In Alaska, coho salmon catches are at historically high levels, and trends in abundance of most stocks are stable (Baker *et al.* 1996, Slaney *et al.* 1996, Northcote and Atagi 1997, Wertheimer 1997). However, many coho salmon populations in southern British Columbia, Washington, Oregon, and California are depressed from historical levels with stocks at the southern-most end of the range generally at greatest risk of extinction (Nehlsen *et al.* 1991; Nelson 1993, 1994; Brown *et al.* 1994; Bryant 1994). Some stocks, particularly those in the Columbia River Basin above Bonneville Dam (*e.g.*, Idaho coho stocks), are thought to be extinct (Nehlsen *et al.* 1991). Coastal stocks of coho salmon from the Columbia River to the southern extent of their range in Monterey Bay were recently listed as a "threatened" species under the ESA, while coho salmon in the Columbia River Basin, southwest Washington, Puget Sound, and the Strait of Georgia are candidates for listing (NMFS 1995, 1997a, 1997b, 1999a).

Hatchery production of coho salmon is extensive in southern British Columbia, Washington, Oregon, and California, and is used to provide sport and commercial harvest opportunities (Bledsoe *et al.* 1989). The Columbia River is the world's largest producer of hatchery coho salmon, with over 50 million fry and smolts released annually in recent years, followed closely by Puget Sound (Flagg *et al.* 1995, Weitkamp *et al.* 1995). In contrast, most production of coho salmon from northern British Columbia and Alaska is natural, with minimal hatchery influence (Baker *et al.* 1996, Slaney *et al.* 1996). Coho are also used in net-pen cultures in Washington and British Columbia, and attempts to establish coho runs in other areas of the world have met with limited success (Sandercock 1991).

2.2.2 Fisheries

Commercial, tribal, sport, and subsistence fisheries for coho historically and currently occur from the eastern Pacific through the Bering Sea and along the West Coast of North America as far south as central California (Godfrey 1965). Trolling (hook-and-line) is the primary gear type used in ocean fisheries; however, gill nets and purse seines are used in near-shore or in-river commercial fisheries. Sport catches of coho are typically taken by hook-and-line.

Most coho salmon from Washington, Oregon, and California recruit to fisheries after one year in fresh water and about 16 months at sea. These fisheries take place in coastal adult migration corridors, near the mouths of river and in freshwater and marine migration areas (Williams *et al.* 1975) and largely target fish returning to hatcheries.

Bycatch in coho salmon fisheries is usually limited to other salmon species, primarily chinook and chum salmon, and occasionally pink salmon. Species such as steelhead, Dolly Varden, pollock, pacific cod, halibut, salmon sharks, and coastal rockfish make up a small part of the catch. Coho salmon are also taken incidentally in other salmon fisheries. When regulations prohibit the retention of coho, the majority of released fish survive the hooking encounter, however, large numbers can be hooked and substantial mortality incurred. Substantial coho salmon bycatch can lead to restrictions on these fisheries (Pacific Fishery Management Council [PFMC] 1998). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.2.3 Relevant Trophic Information

Coho salmon (both live and carcasses) provide important food for bald eagles and other avian scavengers, numerous terrestrial mammal species (e.g., bear, river otter, racoon, weasels), aquatic invertebrates, marine mammals (e.g., California and Steller sea lion, harbor seal, and orca), and salmon sharks (Scott and Crossman 1973, Cederholm *et al.* 1989). Pinniped predation on migrating salmonids, both adult spawners and downstream migrating smolts, can be substantial especially at sites of restricted passage and small salmonid populations (NMFS 1997c). Carcasses also transfer essential nutrients from marine to freshwater environments (Bilby *et al.* 1996). Eggs, larvae, and alevins are consumed by various fishes, including juvenile steelhead, coho salmon, and cutthroat. Juveniles are eaten by a variety of birds (e.g., gulls, terns, kingfishers, cormorants, mergansers, herons), fish (e.g., Dolly Varden, steelhead, cutthroat trout, sculpins, and arctic char), and mammals (e.g., mink and water shrew) (Shapovalov and Taft 1954, Chapman 1965, Godfrey 1965, Scott and Crossman 1973). Juvenile coho are also predators of pink, sockeye, and chinook salmon fry and may be cannibalistic on the succeeding year's eggs and alevins (Gribanov 1948, Shapovalov and Taft 1954, Scott and Crossman 1973, Beacham 1986, Bilby *et al.* 1996).

2.2.4 Habitat and Biological Associations

Table A-4 summarizes coho salmon habitat use by life history stage.

Coho salmon are highly migratory at each stage of their life and are dependent on high-quality spawning, rearing, and migration habitat. Water depth, water velocity, water quality, cover, and lack of physical obstruction are important elements in all migration habitats. Soon after emergence in spring, fry move from spawning areas to rearing areas. In fall, juveniles may migrate from summer rearing areas to areas with winter habitat (Sumner 1953, Skeesick 1970, Swales *et al.* 1988). Such juvenile migrations may be extensive within the natal stream basin, or, less frequently, fish may migrate between basins through salt water or connecting estuaries (Greg Bryant, NMFS, 1330 Bayshore Way, Eureka, California 98501, pers. comm.). Seaward migration of coho smolts in Washington, Oregon, and California occurs predominantly after one year in fresh water, but may not occur until two or more years in more northern or less productive environments. This migration is primarily triggered by photoperiod and usually coincides with spring freshet (Shapovalov and Taft 1954, Chapman 1962, Crone and Bond 1976). During this transition, coho undergo major physiological changes to enable them to osmoregulate in salt water and are especially sensitive to environmental stress at that time. While migration patterns at sea differ considerably by province and stock, juvenile coho generally migrate north or south in coastal waters and may move north and offshore into the North Pacific Ocean (Loeffel and Forster 1970, Hartt 1980, Miller *et al.* 1983, Pearcy and Fisher 1988). After 12 to 14 months at sea they migrate along the coast to their natal streams.

2.2.4.1 Eggs and spawning

Most coho salmon spawn between November and January, with some populations spawning as late as March (Godfrey *et al.* 1965, Sandercock 1991, Weitkamp *et al.* 1995). Populations spawning in the northern portion of the species range or at higher elevations generally spawn earlier than those at lower elevations or in the southern portion of the range (Godfrey *et al.* 1965, Sandercock 1991, Weitkamp *et al.* 1995). Spawn timing also exhibits considerable small-scale geographical and interannual variability.

In general, coho salmon select sites in coarse gravel where the gradient increases and the currents are moderate, such as pool tailouts and riffles. In these areas, intergravel flow must be sufficient for adequate dissolved oxygen delivery to eggs and alevins. Coho salmon typically spawn in small streams where flows are 0.3.-0.5 m^3/s, although they also spawn in large rivers and lakes (Burner 1951, Bjornn and Reiser 1991). Coho salmon spawning habitat consist primarily of coarse gravel with a few large cobbles, a mixture of sand, and a small amount of silt. High quality spawning grounds of coho salmon can best be summarized as clean, coarse gravel. Typically, redd (nest) size is 1.5 m^2, constructed in relatively silt-free gravels ranging from 0.2 to 10 cm in diameter, with well-oxygenated intragravel flow and nearby cover (Burner 1951, Willis 1954, Bjornn and Reiser 1991, van den Berghe and Gross 1984).

Coho salmon eggs are typically 4.5-6 mm in diameter, smaller than most other Pacific salmon (Beacham and Murray 1987, Fleming and Gross 1990). The fecundity of female coho salmon is dependent on body size, population, and year, and is generally between 2,500 and 3,500 eggs (Shapovalov and Taft 1954, Beacham 1982, Fleming and Gross 1990). Several males may compete for each female, but larger males usually dominate by driving off smaller males (Holtby and Healey 1986, van den Berghe and Gross 1989). After spawning, coho females remain on their redds one to three weeks before dying, defending the area from superimposition of eggs from other females (Briggs 1953, Willis 1954, Crone and Bond 1976, Fleming and Gross 1990).

TABLE A-4. Coho salmon habitat use by life history stage. (See key to abbreviations and EFH data levels on page A-16.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	50 days at optimum temperatures	Non-feeding stage; eggs consumed by birds, fish and mammals	Fall/winter	Streambeds	Intragravel; water depth 4-35 cm	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C; optimum 4.4-13.3°C; **Substrate** 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; **Water velocity** 25-90 cm/s
Larvae (alevins). EFH Data Level 0-4; not all habitats have been sampled	100 days at optimum temperatures	Non-feeding stage; Alevins consumed by birds, fish and mammals	Winter/spring	Streambeds	Intragravel; water depth 4-35 cm	NA	**DO** < 3 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C; optimum 4.4-13.3°C; **Substrate** 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; **Water velocity** 25-90 cm/s
Juveniles (freshwater) EFH Data Level 0-4; not all habitats have been sampled	1-2 yrs, most (>90%) 1 yrs	Aquatic, terrestrial, and estuarine invertebrates, fish; predators include birds, fish, mammals	Rearing - all year Migration - spring and fall	Streams, lakes, BAY (estuaries)	Water depth 0-122 cm in streams	NA	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C; optimum 12-14°C; **Salinity** < 29 ppt; **Water velocity** 5-30 cm/s
Juveniles (marine) EFH Data Level 0-3; not all habitats have been sampled	16 months (except precocious males)	Epipelagic fish (herring, sand lance) and marine invertebrates (copepods, euphausiids, amphipods, crab larvae)	Rearing - all year Migration - all year	BCH, ICS, MCS, OCS, USP, BAY, IP	Pelagic	UP, CL, F; migration influenced by currents, salinity, and temperature	**Temperature** <15°C; **Depth** <10 m
Adults (freshwater) EFH Data Level 1-2; not all habitats have been sampled	up to 2 months	Little or none	Migration - fall Spawning - fall, winter	Rivers, streams, lakes			

Primary Sources: Shapovalov and Taft 1954, Sandercock 1991, Bjorn and Reiser 1991, Weitkamp *et al.* 1995, Spence *et al.* 1996.

2.2.4.2 Larvae/Alevins

Egg incubation time is influenced largely by water temperature and lasts from approximately 38 days at 10.7°C to 137 days at 2.2°C (Shapovalov and Taft 1954, Koski 1965, McPhail and Lindsey 1970, Fraser *et al.* 1983, Murray *et al.* 1990). Eggs, alevins, and pre-emergent fry must be protected from freezing, desiccation, stream bed scouring or shifting, and predators to survive to emergence. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Under natural "average" conditions, 15-27% of the eggs survive to emerge from the gravel as fry, although values of 85% survival have been reported under "optimal" conditions, and survival in degraded habitats or under harsh conditions may be essentially zero (Briggs 1953, Shapovalov and Taft 1954, Koski 1965, Crone and Bond 1976).

As the yolk sac is absorbed, the larvae become photopositive and emerge from the substrate (Shapovalov and Taft 1954, Koski 1965). Fry emerge between March and July, with most emergence occurring between March and May, depending on when the eggs were fertilized and the water temperature during development (Briggs 1953, Shapovalov and Taft 1954, Koski 1965, Crone and Bond 1976). These 30 mm-long newly-emerged fry initially congregate in schools in protected, low-velocity areas such as quiet backwaters, side channels, and small creeks before venturing into protected areas with stronger currents (Shapovalov and Taft 1954, Godfrey 1965, Scrivener and Anderson 1984).

2.2.4.3 Juveniles (Freshwater)

The vast majority of juvenile coho salmon from California to central British Columbia spend one year in fresh water before migrating to sea as 85-115 mm-long smolts (Pritchard 1940; Sumner 1953; Drucker 1972; Blankenship and Tivel 1980; Seiler *et al.* 1981, 1984; Blankenship *et al.* 1983; Lenzi 1983, 1985, 1987; Irvine and Ward 1989; Lestelle and Weller 1994). Because growth rates are lower in colder water, juveniles from northerly areas require two years in fresh water to attain this size, and some populations may need as many as four to five years to reach this size (Gribanov 1948, Drucker 1972, Crone and Bond 1976).

Coho smolt production is most often limited by the availability of summer and winter freshwater rearing habitats (Williams *et al.* 1975, Reeves *et al.* 1989, Nickelson *et al.* 1992). Inadequate winter rearing habitats, such as backwater pools, beaver ponds, wetlands, and other off-channel rearing areas, are considered the primary factor limiting coho salmon production in many coastal streams (Cederholm and Scarlett 1981, Swales *et al.* 1988, Nickelson *et al.* 1992). If spawning escapement is adequate, sufficient fry are usually produced to exceed the carrying capacity of rearing habitat. In such cases, carrying capacity of summer habitats set a density-dependent limit on the juvenile population, which then may suffer density-independent mortality during winter depending on the severity of conditions, fish size, and quality of winter habitat.

Coastal streams, wetlands, lakes, sloughs, tributaries, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats exist in smaller streams less than fourth order having low-gradient alluvial channels with abundant pools formed by large woody debris (Foerster and Ricker 1953, Chapman 1965). Beaver ponds and large slackwater areas can provide some of the best rearing areas for juvenile coho (Bustard and Narver 1975, Nickelson *et al.* 1992). Coho juveniles may also use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter (Crone and Bond 1976).

During summer rearing, the highest juvenile coho densities tend to occur in areas with abundant prey (e.g., drifting aquatic invertebrates and terrestrial insects that fall into the water) and structural habitat elements (e.g., large woody debris and associated pools). Preferred habitats include a mixture of different types of pools, glides, and riffles with large woody debris, undercut banks, and overhanging vegetation which provide advantageous positions for feeding (Foerster and Ricker 1953, Chapman 1965, Reeves *et al.* 1989, Bjornn and Reiser 1991). Coho grow best where water temperature is between 10 and 15°C, and dissolved oxygen (DO) is near saturation. Juvenile coho can tolerate temperatures between 0° and 26°C if changes are not abrupt (Brett 1952, Konecki *et al.* 1995). Their growth and stamina decline significantly when DO levels drop below 4 mg/l, and a sustained concentration less that 2 mg/l is lethal (Reeves *et al.* 1989). Summer populations are usually constrained by density-dependant effects mediated through territorial behavior. In flowing water, juvenile coho usually establish individual feeding territories, whereas in lakes, large pools, and estuaries they are less likely to establish territories and may aggregate where food is abundant (Chapman 1962, McMahon 1983). Because growth in summer is often density-dependent, the size of juveniles in late summer is often inversely related to population density.

In winter, territorial behavior is diminished, and juveniles aggregate in freshwater habitats that provide cover with relatively stable depth, velocity, and water quality. Winter mortality factors include hazardous conditions during winter peak stream flow (e.g., scour, high velocities), stranding of fish during floods or by ice damming, physiological stress from low temperature, and progressive starvation (Hartman *et al.* 1984). In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, beaver ponds, off-channel ponds, sloughs, and secondary channel pools with abundant large woody debris, and undercut banks and debris along riffle margins (Skeesick 1970, Nickelson *et al.* 1992). Survival in winter, in contrast to summer, is generally density-independent, and varies directly with fish size and amount of cover and ponded water, and inversely with the magnitude of the peak stream flow. Survival from eggs to smolts is usually less than 2% (Neave and Wickett 1953).

Habitat requirements during seaward migration are similar to those of rearing juveniles. High streamflow aids their migration by flushing them downstream and reducing their vulnerability to predators. Migrating smolts are particularly vulnerable to predation, because they are concentrated and moving through areas of reduced cover. Mortality during seaward migration can be quite high (Tytler *et al.* 1978, Dawley *et al.* 1986, Seiler 1989). The seaward migration of smolts in native stocks is thought to be timed so that the smolts arrive in the estuary and nearshore ocean when food is plentiful (Foerster and Ricker 1953, Shapovalov and Taft 1954, Drucker 1972). In California the seaward migration is also timed to occur prior to closing of some estuaries and tidal reaches by the formation of impassible sand bars (Bryant 1994). Rapid growth during the early period in the estuary and nearshore ocean is critical to survival, because of mortality from predation which may be size dependent (Myers and Horton 1982, Dawley *et al.* 1986, Pearcy and Fisher 1988, Holtby *et al.* 1990, Pearcy 1992).

2.2.4.4 Juveniles (Estuarine)

The amount of time juvenile coho salmon rear in estuaries appears to be highly variable, with more northern populations generally dwelling longer in estuaries than more southern populations (Pearce *et al.* 1982, Simenstad *et al.* 1982, Tschaplinksi 1982). For example, Oregon coast, Columbia River, and Puget Sound coho salmon are thought to remain in estuarine areas for several days to several weeks, while many British Columbian, and Alaskan populations remain in estuaries for several months (Myers and Horton 1982, Pearce *et al.* 1982, Simenstad *et al.* 1982, Tschaplinksi 1982, Levings *et al.* 1995). Similar to the stream environment, large woody debris is also an important element of juvenile coho salmon habitat in estuaries (McMahon and Holtby 1992). In estuarine environments, coho salmon consume large planktonic or small nektonic animals, such as amphipods (*Corophium* spp., *Eogammarus* spp.), insects, mysids, decapod larvae, and larval and juvenile fishes (Myers and Horton 1982, Simenstad *et al.* 1982, Dawley *et al.* 1986). They are in turn preyed upon by marine fishes, birds, and mammals. In estuaries, smolts occur in intertidal and pelagic habitats, with deep, marine-influenced habitats often preferred (Pearce *et al.* 1982, Dawley *et al.* 1986).

2.2.4.5 Juveniles (Marine)

Two primary dispersal patterns have been observed in coho salmon after emigrating from freshwater. Some juveniles spend several weeks in coastal waters before migrating northwards into offshore waters of the Pacific Ocean (Hartt 1980, Hartt and Dell 1986, Pearcy and Fisher 1988, Pearcy 1992), while others remain in coastal waters near their natal stream for at least the first summer before migrating north. The later dispersal pattern is commonly seen in coho salmon from California, Oregon, and Washington (Shapovalov and Taft 1954, Godfrey 1965, Miller *et al.* 1983). It is not clear whether these less-migratory fish, particularly those from coastal areas, make extensive migrations after the first summer. However, it is known that some Puget Sound/Strait of Georgia-origin coho salmon spend their entire ocean residence in the Sound and Strait, while others migrate to the open ocean in late summer (Healey 1980, Godfrey *et al.* 1975, Hartt and Dell 1986). The spatial distribution of suitable habitat conditions is affected by annual and seasonal changes in oceanographic conditions and may affect the tendency for fish to migrate from, or reside in, coastal areas after ocean entry.

Juvenile coho salmon generally stay in nearshore coastal and inland waters well into October (Hartt and Dell 1986). Juvenile coho from Oregon and presumably other areas will initially be found south of their natal streams, moved by strong southerly currents (Pearcy 1992). When these currents weaken in the winter months, juvenile coho migrate northward. In strong upwelling years, where the band of favorable temperatures and available prey is more extensive, coho salmon appear to be more dispersed off shore. In weak upwelling years, coho salmon concentrate in upwelling zones closer to the shore (Pearcy 1992), and often near submarine canyons and other areas of consistent upwelling (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, California, 95460, pers. comm., February 1998). Generally, juvenile coho are found in highest concentrations within 60 km of the California, Oregon, and Washington coast, with the majority found within 37 km of the coast (Pearcy and Fisher 1990, Pearcy 1992). Puget Sound origin coho salmon are typically found in the Strait of Juan de Fuca and coastal waters of Vancouver Island throughout summer months (Hartt and Dell 1986).

Coho leaving Puget Sound and other inland waters are found to migrate north along the east or West Coast of Vancouver Island and out into the Pacific Ocean (Williams *et al.* 1975, Hartt and Dell 1986). Tag, release, and recovery studies suggest that immature coho salmon from Washington and Oregon are found as far north as 60° N latitude along the Pacific Coast, and California-origin coho salmon as far north as 58° N latitude in Southeast Alaska (Myers *et al.* 1996). Coho salmon from Oregon streams have been taken in offshore waters near Kodiak Island in the northern Gulf of Alaska (Hart and Dell 1986, Myers *et al.* 1996). Westward migration of coho salmon into offshore oceanic waters appears to extend beyond the EEZ beginning around 45° N latitude off the Oregon coast (Myers *et al.* 1996). Coded-wire and high-seas tag data for Washington and Oregon suggest that oceanic migration for these coho stocks can extend as far south and west as 43° N latitude and 175° E longitude around the Emperor Sea Mounts (Myers *et al.* 1996), believed to be an area of high prey abundance. Thus it appears that coho salmon stocks from Washington, Oregon, and California are found at least occasionally in the Pacific Ocean and Gulf of Alaska north of 44° N latitude to 57° N latitude, extending westward and southward along the Aleutian chain to the Emperor Sea Mounts area near 43° N latitude and 175° E longitude.

While juvenile and maturing coho are found in the open north Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf within 60 km of the coast. Coho salmon have been occasionally reported off the coast of southern California near the Mexican border (Bryant 1994). However, Point Conception (34°30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes primarily found north and subtropical fishes to the south (Allen and Smith 1988), although the southern limit expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

Coho salmon in coastal and oceanic waters are comprised of stocks from a wide variety of streams from Washington, Oregon, and California (Godfrey *et al.* 1975, French *et al.* 1975, Burgner 1980, Hartt 1980, Hartt and Dell 1986, Weitkamp *et al.* 1995). Analysis of coded-wire tag (CWT) data indicates distinct migration patterns for various basins, provinces, and states. For example, coho salmon from the Columbia River make up a high proportion of fish captured in Oregon waters, whereas coho from the Washington coast are rarely recovered in Oregon waters, but frequently recovered in British Columbia (Weitkamp *et al.* 1995). The vast majority of CWT coho salmon are recovered in coastal waters where coho salmon fisheries occur.

Marine invertebrates, such as copepods, euphausiids, amphipods, and crab larvae, are the primary food when coho first enter salt water. Fish represent an increasing proportion of the diet as coho salmon grow and mature (Shapovalov and Taft 1954, Healey 1978, Myers and Horton 1982, Pearcy 1992). Growth is controlled mainly by food quantity, food quality, and temperature. Growth is best in pelagic habitats where forage is abundant and sea surface temperature is between 12 and 15°C (Godfrey *et al.* 1975, Hartt 1980, Healey 1980). Coho salmon rarely use areas where sea surface temperature exceeds 15°C and are generally found in the uppermost 10 m of the water column. Coho salmon do not aggregate in offshore oceanic waters and prefer slightly warmer ocean temperatures than do other Pacific salmon (Godfrey 1965, Manzer *et al.* 1965, Welch 1995). Before entering fresh water, most coho slow their feeding and begin to lose weight as they develop secondary sexual characteristics and large gonads. Precocious males return to spawn after approximately six months at sea, but most coho remain at sea for about 16 months before returning to coastal areas and entering fresh water to spawn (Godfrey 1965; Wright 1968, 1970; Sandercock 1991).

2.2.4.6 Adults

Adult coho enter fresh water from early July through December, often after the onset of fall freshets, with peak river entry occurring as early as September in Alaska, in October and November in British Columbia, Washington, and Oregon, and in December and even January in California (Briggs 1953, Godfrey 1965, Ricker 1972, Fraser *et al.* 1983, Bryant 1994). Some populations, often referred to as the "summer-run" coho salmon, are exceptionally early, entering rivers in late spring and early summer (Aro and Shepard 1967, Houston 1983, Washington Department of Fisheries [WDF] *et al.* 1993). In general, larger river basins have a wider range of river entry times than do smaller systems, and river entry occurs later the farther south a river is situated (Godfrey 1965, Sandercock 1991). The fish feed little and migrate upstream to their natal stream using olfactory cues imprinted in early development (Harden Jones 1968, Quinn and Tolson 1986, Sandercock 1991). Fidelity of mature fish to natal streams is high, and straying rates are generally less than 5% (Shapovalov and Taft 1954, Lister *et al.* 1981, Labelle 1992). Adult coho may travel for a short time and distance upstream to spawn in small streams or may enter large river systems and travel for weeks to reach spawning areas more than 2,000 km upstream (Godfrey 1965, Aro and Shepard 1967, McPhail and Lindsay 1970, Sandercock 1991, WDF *et al.* 1993).

Most coho salmon spawn at approximately the same time regardless of when they entered fresh water (Foerster and Ricker 1953, Shapovalov and Taft 1954, Sandercock 1991). Consequently, populations that enter fresh water in late summer and early fall may reside in fresh water three to four months before spawning, while fish entering fresh water in late fall may spawn within weeks of fresh water entry. At the extreme southern end of their range in central California, most coho salmon enter fresh water in late December or January and spawn shortly thereafter (Briggs 1953, Shapovalov and Taft 1954, Bryant 1994).

The survival of coho salmon is generally affected by numerous factors in both salt and fresh water, including ocean conditions, location of natal stream, freshwater migration length, stream flow, and other environmental factors. Hatchery coho salmon have smolt-to-adult survival rates that average between 3-5%, but can be much higher in areas such as Puget Sound, or lower during unfavorable years (Coronado-Hernandez 1995). Wild stocks typically show marine survival rates two to three times greater than hatchery fish (Seiler 1989, Pearcy 1992, Coronado-Hernandez 1995).

2.2.4.7 Databases on Distribution

To determine the geographic extent of coho salmon freshwater and estuarine distribution, we examined the available information and databases on coho salmon distribution and habitat use (see tables in Sections 2.4 and 2.5). The databases fell into three general categories, (1) regional, small-scale (e.g., 1:100,000 or 1:250,000) regional GIS databases on coho salmon distribution (e.g., StreamNet, WARIS, ORIS, etc.); (2) local, large scale GIS database of limited scope (e.g., county, tribal datasets, etc.); and (3) databases on habitat surveys and habitat quality (e.g., USFS stream survey data, state, and tribal stream survey data, etc.). Unfortunately, databases in categories 2 and 3 are of limited utility in determining coho salmon freshwater distribution, because they are comprised of many small, disparate, incompatible databases with incomplete geographic coverage. These datasets may, however, be useful during EFH consultations.

Small-scale, regional databases such as StreamNet (1998) are suitable for portraying the overall distribution of chinook salmon and have utility for determining presence on the majority of specific stream reaches. Various life stages (migration, spawning and rearing, and rearing only) are delimited in the database distribution data as well. The hydrography used by StreamNet to spatially reference fish distribution is predominantly composed of 1:100,000 scale data, but both 1:63,500 and 1:24,000 linework has been added where appropriate to reference all the distribution data available to the project.

The formation and modification of stream channels and habitats is a dynamic process. Habitat available and utilized by coho and other salmonids also changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events (Sullivan *et al.* 1987, Naiman *et al.*1992, Reeves *et al.* 1995). It is unrealistic to expect coho salmon distribution within a stream, watershed, province, or region to remain static over time. Therefore, coarse scale regional GIS databases are useful only for determining which watersheds coho salmon inhabit, but not for identifying specific stream reaches and habitats utilized by the species.

2.2.4.8 Habitat Areas of Particular Concern

Information exists on the type of stream reaches preferred by coho salmon for spawning and rearing. It is generally accepted that they spawn and rear in stream reaches and channels less than 4-5% gradient (Lunetta *et al.* 1997). Furthermore, coho and other fall spawning anadromous salmonids are found primarily in plane-bed, pool-riffle, and forced-pool-riffle stream channels[2/], which are channel types less than 4% (Montgomery and Buffington 1997, Montgomery *et al.* In press). Stream reaches greater than 4% slope (gradient) are generally not utilized by coho salmon for spawning, because of their high bed load transport rate, deep scour, and coarse substrate (Montgomery *et al.* In press). Stream reaches less than 4% that potentially display plane-bed, pool-riffle, and forced-pool-riffle morphology can be identified using GIS technology. However, channel types identified with GIS technology can differ from those actually present in the field (Lunetta *et al.* 1997, Montgomery and Buffington 1997). Therefore, it is important that 1:24,000 or larger scale maps be used to determine potential channel type and a fine scale (10 m or less) digital elevation model to calculate slopes. Furthermore, slope and channel type should be confirmed in a representative number of reaches by site visits or existing habitat surveys. While the technology exists to develop this information, data at this scale and resolution have only been developed for provinces, not the entire region; and, therefore, could not be used in the current EFH identification process. However, the existing information will be useful in the consultation process.

The delineation of channel types allows identification of potentially important and vulnerable habitats in the absence of accurate salmon distribution or habitat data. Moreover, degraded stream reaches, those lacking key roughness elements (e.g., large woody debris), and stream reaches with a high potential for restoration will still be identified as potential habitat. Therefore, the protection and restoration of coho salmon habitat should focus on pool-riffle, plane bed, and forced-pool-riffle channels. Furthermore, any activity adjacent to or upstream of activity that could influence the quality of these important habitats should be evaluated. Other vulnerable habitats that are in need of protection and restoration are off-channel rearing areas (e.g., wetlands, oxbows, side channels, sloughs), estuaries, and other near-shore marine areas. Submarine canyons and other regions of pronounced upwelling are also thought to be particularly important during El Niño events (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, California 95460, pers. comm.) and may need additional consideration for protection. Finally, off-channel areas are particularly important winter habitats for juvenile coho salmon (Cederholm and Scarlett 1981), and one of the primary factors limiting coho salmon smolt production in many areas (Nicholson *et al.* 1992).

2.2.4.9 Freshwater Essential Fish Habitat

Freshwater EFH for coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. Important features of essential habitat for spawning, rearing, and migration include adequate (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, channel complexity, aquatic vegetation, etc.); (7) space; (8) access and passage; and (9) habitat and flood plain connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table A-4.

Coho salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, and other water bodies currently viable and most of the habitat historically accessible to coho within Washington, Oregon, and California. Figure A-4 illustrates the watersheds currently utilized by coho from Washington, Oregon, and California within the USGS hydrologic units identified at the end of the chapter for all Council-managed salmon (Table A-6). Figure A-5 depicts the approximate historical freshwater distribution and the currently identified range of common marine occurrence of coho salmon. The geographic extent of the historic freshwater distribution of coho salmon is based on data from Table A-6. Data on the marine range of coho salmon are from NOAA (1990).

2/ See Montgomery and Buffington (1997) for a description of this channel classification system.

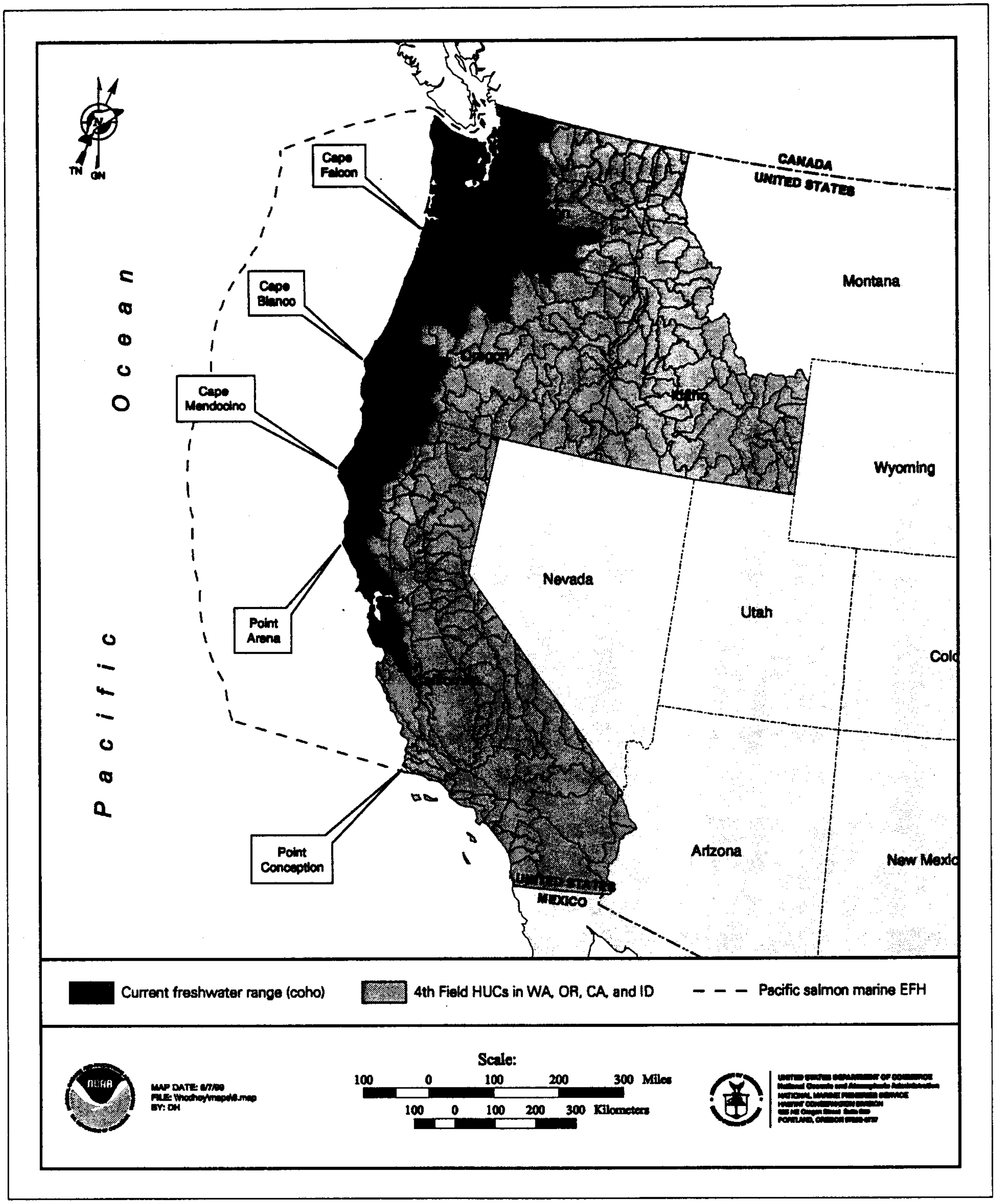

FIGURE A-4. Watersheds currently utilized by coho salmon from Washington, Oregon, and California.

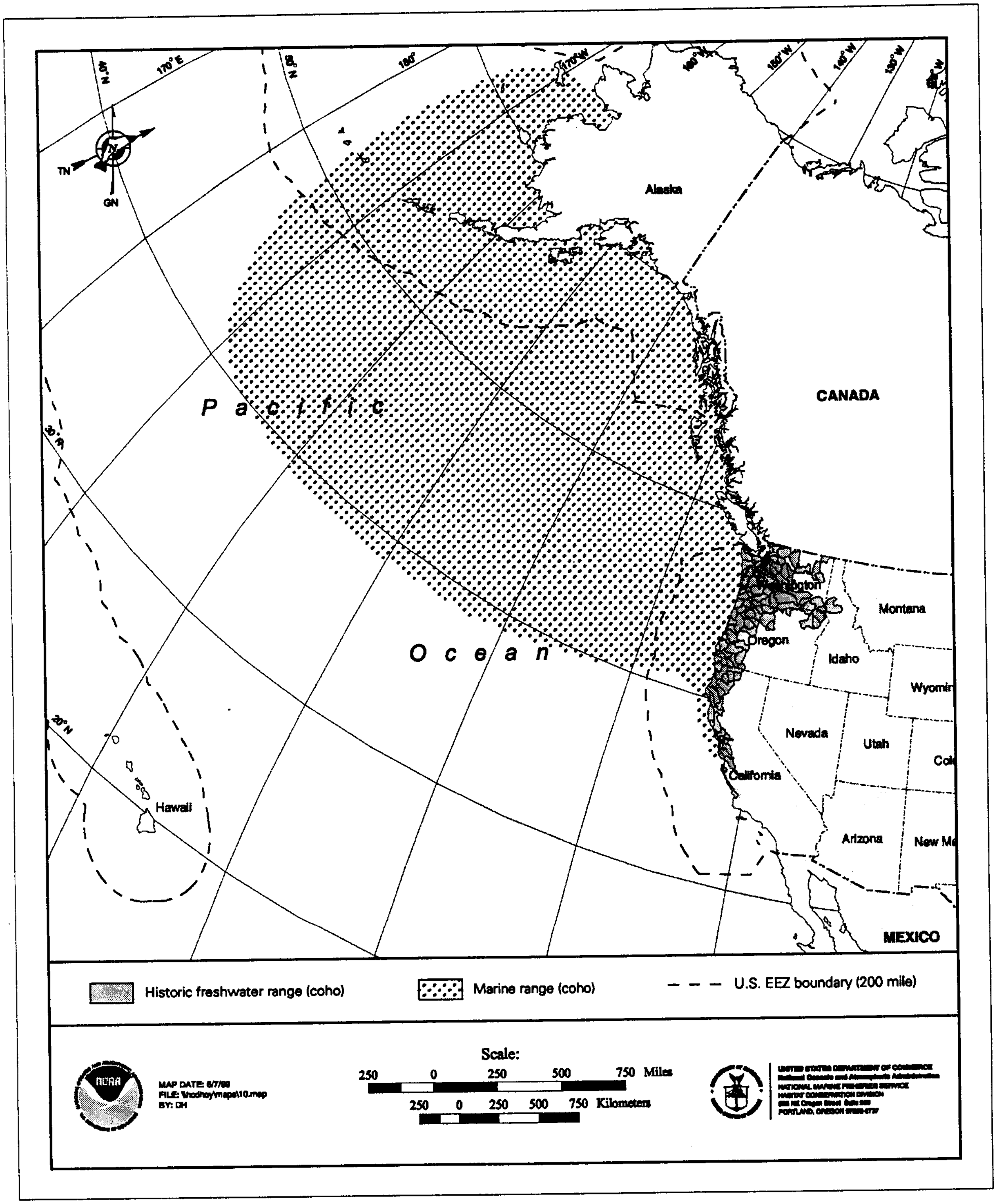

FIGURE A-5. Approximate historically accessible freshwater distribution and currently identified range of common marine occurrence of coho salmon from Washington, Oregon, and California.

The diversity of habitats utilized by coho salmon coupled with the inadequacy of existing species distribution maps makes it extremely difficult to identify all specific stream reaches, wetlands, and water bodies essential for the species at this time. Designating each specific river reach would invariably exclude small important tributaries from designation as EFH. Defining specific river reaches is also complicated, because of the current low abundance of the species and of our imperfect understanding of the species' freshwater distribution, both current and historical. Adopting a more inclusive, watershed-based description of EFH is appropriate because, it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic areas and adjacent upslope areas. Moreover, this watershed-based approach is consistent with other Pacific salmon habitat protection and recovery efforts such as the ESA, Northwest Forest Plan, and the OCSRI. Therefore, the geographic extent of coho salmon essential habitat was delineated using USGS cataloging units.

2.2.4.10 Marine Essential Fish Habitat

The important elements of coho salmon marine EFH are (1) estuarine rearing; (2) ocean-rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Overall, coho salmon marine distribution is extensive, varies seasonally, interannually, and can only be defined generally (Figure A-5).

Limited information exists on coho salmon habitat use in marine waters. While juvenile and maturing coho are found in the open north Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf, coho have also been encountered in an extensive offshore area as far west as 44° N latitude, 175° W longitude (Sandercock 1991). CWT recoveries of coho salmon from high seas fisheries and tagging programs (Myers *et al.*, 1996; Healey 1991, fig.18) provide evidence that coho salmon utilize offshore areas. Shapalov and Taft (1954) reported coho within 150 km offshore in their study of Waddell Creek coho. Catch data and interviews with commercial fishermen indicate that maturing coho salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. However, determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for coho salmon includes all marine waters within the EEZ north of Point Conception, California (Figure A-5) and the marine areas off Alaska designated as salmon EFH by the NPFMC.

2.3 ESSENTIAL HABITAT DESCRIPTION FOR PUGET SOUND PINK SALMON (*Oncorhynchus gorbuscha*)

2.3.1 General Distribution and Life History

The following is an overview of pink salmon life history and habitat use as a basis for identifying EFH for pink salmon. Comprehensive reviews of pink salmon life history and habitat requirements can be found in Aro and Shepard (1967), Neave (1966), Heard (1991), Hard *et al.* (1996), and others. This description serves as a general description of pink salmon life history with an emphasis on populations from Puget Sound and the Fraser River.

Pink (or "humpback") salmon are the smallest of the Pacific salmon, averaging just 1.0-2.5 kg at maturity (Scott and Crossman 1973). Adult pink salmon are distinguished from other Pacific salmon by the presence of large dark oval spots on the back and entire caudal fin, and their general coloration and morphology (Scott and Crossman 1973). Maturing males develop a marked hump on their back, which is responsible for their vernacular name "humpback" salmon. Pink salmon are unique among Pacific salmon by exhibiting a nearly invariant two-year life span within their natural range (Gilbert 1912, Davidson 1934, Pritchard 1939, Bilton and Ricker 1965, Turner and Bilton 1968). Upon emergence, pink salmon fry migrate quickly to sea and grow rapidly as they make extensive feeding migrations. After 18 months in the ocean the maturing fish return to freshwater to spawn and die. Pink salmon spawn closer to tidewater than most other Pacific salmon species, generally within 50 km of a river mouth, although some populations may migrate up to 500 km upstream to spawn, and a substantial fraction of other populations may spawn intertidally (Hanavan and Skud 1954, Hunter 1959, Atkinson *et al.* 1967, Aro and Shepard 1967, Helle 1970, WDF *et al.* 1993). Pink salmon often have extremely large spawning populations throughout much of their range, exceeding hundreds of thousands of adult fish in many populations (Takagi *et al.* 1981, Heard 1991, WDF *et al.* 1993).

The natural range of pink salmon includes the Pacific rim of Asia and North America north of approximately 40° N latitude. However, the spawning distribution is more restricted, ranging from 48°N latitude (Puget Sound) to 64°N latitude (Norton Sound, Alaska) in North America and 44° N latitude (North Korea) to 65° N latitude (Anadyr Gulf, Russia) in Asia (Neave *et al.* 1967, Takagi *et al.* 1981). Within this vast area, spawning pink salmon are widely distributed in streams of both continents as far north as the Bering Strait. North, east, and west of the Bering Strait, spawning populations become more irregular and occasional. In marine environments along both the Asian and North American coastlines, pink salmon occupy waters south of the limits of spawning streams. In North America, pink salmon regularly spawn as far south as Puget Sound and the Olympic Peninsula. However, most Washington state spawning occurs in northern Puget Sound (Williams *et al.* 1975, WDF *et al.* 1993). On rare occasions, pink salmon are observed in rivers along the Washington, Oregon, and California coasts, but it is unlikely spawning populations regularly occur south of northwestern Washington (Hubbs 1946, Ayers 1955, Herrmann 1959, Hallock and Fry 1967, Williams *et al.* 1975, Moyle *et al.* 1995, Hard *et al.* 1996).

Because of its fixed two-year life cycle, pink salmon spawning in a particular river system in odd- and even-numbered years are reproductively isolated from each other and exist as genetically distinct lines (Neave 1952; Beacham *et al.* 1988; Gharret *et al.* 1988; Shaklee *et al.* 1991, 1995; Hard *et al.* 1996). In some river systems, such as the Fraser River in British Columbia, the odd-year line dominates; returns to the same systems in even-numbered years are negligible (Vernon 1962, Aro and Shepard 1967). In Bristol Bay, Alaska, the major runs occur in even-numbered years, whereas the coastal area between these two river systems is characterized by runs in both even- and odd-numbered years. In Washington state and southern British Columbia, odd-numbered-year pink salmon are the most abundant (Ellis and Noble 1959, Aro and Shepard 1967, Ricker and Manzer 1974, WDF *et al.* 1993). However, small even-numbered-year populations exist in the Snohomish River in Puget Sound and in several Vancouver Island rivers (Aro and Shepard 1967, Ricker and Manzer 1974, WDF *et al.* 1993).

Pink salmon populations in Alaska are abundant, with historic record catches over the past decade, exceeding 100 million fish statewide in several years (Wertheimer 1997). Farther south, pink salmon populations may not be at record levels, but are generally healthy. For example, recent reviews of the status of pink salmon from Washington and southern British Columbia indicated that, with a few exceptions, odd-year populations in those areas were generally healthy and near historic levels, while even-year populations were small, but stable or increasing (Ricker 1989, Nehlsen *et al.* 1991, Lichatowich 1993, Hard *et al.* 1996). For example, the 1995 run-size estimate of Fraser River odd-year pink salmon was approximately 12 million fish, and that of Puget Sound was 3.4 million fish (PFMC 1998).

2.3.2 Fisheries

Pink salmon are the most abundant Pacific salmon, contributing about 40% by weight and 60% in numbers of all salmon caught commercially in the north Pacific Ocean and adjacent waters (Neave *et al.* 1967). Coastal fisheries for pink salmon presently occur in Asia (Japan and Russia) and North America (Canada and the United States), with major fisheries in Russia, Canada, and the U.S. Historically, some pink salmon were caught in high seas fisheries by Japan and Russia. Most pink salmon in the U.S. are caught in Alaska where major fisheries occur in the Southeast, Prince William Sound, and Kodiak regions; with lesser fisheries in the Cook Inlet, Alaska Peninsula, and Bristol Bay regions (Heard 1991). Catches of pink salmon decrease south of Alaska, with about 10 million fish caught annually in British Columbia, 2-3 million in Washington, and a negligible number in Oregon and California (Heard 1991, PFMC 1999a). Most pink salmon are harvested in the marine environment by purse seines with smaller commercial catches made by set and drift gill net and troll fisheries. Marine recreational fisheries primarily use troll gear. Washington marine pink salmon harvests are predominantly composed of Fraser River-origin fish (Hard *et al.*1996, PFMC 1984). The Pacific Salmon Commission (PSC) manages fisheries for pink salmon in U.S. Convention waters north of 48° N latitude to meet Fraser River natural spawning escapement and U.S./Canada allocation requirements. Fisheries for pink salmon have some bycatch associated with them, primarily other

Pacific salmon species. A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.3.3 Relevant Trophic Information

Pink salmon eggs, alevins, and fry in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, especially sculpins, birds, and small mammals (Pritchard 1934, Hoar 1958, Hunter 1959, Tagmazyan 1971, Khorevin *et al.* 1981). In the marine environment, pink salmon fry and juveniles are food for a host of other fishes, including other Pacific salmon, and coastal sea birds (Thorsteinson 1962, Parker 1971, Bakshtansky 1980, Karpenko 1982).

Subadult and adult pink salmon are known to be eaten by 15 different marine mammal species, sharks, other fishes such as Pacific halibut, and humpback whales (Fiscus 1980). Because pink salmon are the most abundant salmon in the North Pacific, it is likely they comprise a significant portion of the salmonids eaten by marine mammals.

Pink salmon spawning populations often number in the hundreds of thousands of fish, consequently, their carcasses provide significant nutrient input into many coastal watersheds. Adult pink salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals, fishes, and aquatic invertebrates (Cederholm *et al.* 1989, Michael 1995, Bilby *et al.* 1996).

2.3.4 Habitat and Biological Associations

Table A-5 summarizes pink salmon habitat use by life history stage.

2.3.4.1 Eggs and Spawning

Pink salmon choose a fairly uniform spawning bed in both small and large streams in Asia and North America. Generally, these spawning beds are situated on riffles with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents (Semko 1954, Heard 1991, Mathisen 1994). In large rivers, they may spawn in discrete sections of main channels or in tributary channels. Pink salmon avoid spawning in deep, quiet water, in pools, in areas with slow current, or over heavily silted or mud-covered streambeds. Places selected for egg deposition is determined primarily by the optimal combination of water depth and velocity. Although intertidal spawning is extensive in some areas of the north Pacific such as Prince William Sound (Hanavan and Skud 1954, Helle 1970), it is not in Washington, Oregon, and California (Williams *et al.* 1975, WDF *et al.* 1993, Hard *et al.* 1996).

On both the Asian and North American sides of the Pacific Ocean, pink salmon generally spawn at depths of 30-100 cm (Dvinin 1952, Hourston and MacKinnon 1956, Graybill 1979, Goloranov 1982). High densities of spawning pink salmon are usually found at depths of 20-25 cm, but occasionally to depths of 100-150 cm. In dry years, on crowded spawning grounds, nests can be found at shallower depths of 10-15 cm. Water velocities in pink salmon spawning grounds vary from 30-100 cm/s, sometimes reaching 140 cm/s (Hourston and MacKinnon 1956, Smirnov 1975, Graybill 1979, Golovanov 1982), but usually average 60-80 cm/s.

In general, pink salmon select sites in gravel where the gradient increases and the currents are relatively fast. In these areas, surface stream water must have permeated sufficiently to provide intragravel flow for dissolved oxygen delivery to eggs and alevins. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles, a mixture of sand, and a small amount of silt. Pink salmon are often found spawning in the same river reaches and habitats as chinook salmon. High quality spawning grounds of pink salmon can best be summarized as clean, coarse gravel (Hunter 1959).

Pink salmon have the lowest fecundity of Pacific salmon, averaging 1,200-1,900 eggs per female, and also some of the smallest eggs (Pritchard 1937, Neave 1948, Beacham *et al.* 1988, Beacham and Murray 1993). In Washington and southern British Columbia spawning areas, eggs are deposited from August to October—slightly earlier in northern Puget Sound and the upper Dungeness River than elsewhere in northwestern Washington (WDF *et al.* 1993, Hard *et al.* 1996).

TABLE A-5. Pink salmon habitat use by life stage. (See key to abbreviations and EFH data levels on page A-16.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	90-100 d	Non-feeding stage; eggs consumed by birds, fish and mammals	Late summer, fall, and winter	Intragravel in stream beds	15-50 cm depth in gravel; water depth 10-15 cm	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 4.4-13.3°C; **Water velocity** 20-140 cm/s
Larvae (alevins) EFH Data Level 0-4; not all habitats have been sampled	100-125 d, fry emerge and migrate quickly from stream	Non-feeding stage; alevins consumed by birds, fish, and mammals	Fall, winter, and early spring	Intragravel until fry emergence	15-50 cm depth in gravel; water depth 10-15 cm	Medium to course gravel	NA	**DO** < 3 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 4.4-13.3°C; **Water velocity** 20-140 cm/s
Juveniles EFH Data Level 0-3; not all habitats have been sampled	2 yrs	Copepods, euphausiids, decapod larvae, amphipods, fish squid	Estuary: spring Ocean: year-round	BCH BAY, IP	P, N; migration influenced by currents, salinity, and temperature	All bottom types	Estuarine, littoral then open water; UP, F, CL, E; migration may be influenced by surface currents, salinities and temperatures	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** sea water; School with other salmon and Pacific sandfish
Adults EFH Data Level 0-2; not all habitats have been sampled	2 yrs of age from egg to mature adult	Fish, squid, euphausiids, amphipods, and copepods	Spawning: Aug-Dec	Oceanic to nearshore migrations	P, N	NA	Different regional stock groups have specific oceanic migratory patterns	**DO** lethal at <3 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum <14°C; Migration timing for different regional stock groups varies; earlier in the north, later in the south

Primary sources: NOAA 1990, Bjornn and Rieser 1991, Heard 1991, Spence *et al.* 1996.

2.3.4.2 Larvae/Alevins

Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices (Heard 1991). To survive successfully, the eggs, alevins, and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury, and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. These requirements are only met partially even under the most favorable natural conditions. Overall, freshwater survival of pink salmon from egg to advanced alevin and emerged fry is frequently 10-20%, but can be as low as 1% (Neave 1953, Hunter 1959, Wickett 1962, Taylor 1983). Some British Columbia artificial spawning channels have achieved egg-to-fry survival as high as 57% (Cooper 1977, MacKinnon 1963).

2.3.4.3 Juveniles (Freshwater)

Newly emerged pink salmon fry are fully capable of osmoregulation in sea water. Schools of pink salmon fry may move quickly from the natal stream area or remain to feed along shorelines up to several weeks. The timing and pattern of seaward dispersal is influenced by many factors, including general size and location of the spawning stream, characteristics of adjacent shoreline and marine basin topography, extent of tidal fluctuations and associated current patterns, physiological and behavioral changes with growth, and possibly different genetic characteristics of individual stocks (Heard 1991).

Pink salmon fry emerge from gravels at a size of 28-35 mm, and begin migrating downstream shortly thereafter. This downstream migration timing varies widely by region and from year to year within regions and individual streams. In Puget Sound and southern British Columbia, fry migrate downstream in March and April, occasionally extending into May.

2.3.4.4 Juveniles (Estuarine and Marine)

The use of estuarine areas by pink salmon varies widely, ranging from passing directly through the estuary en route to nearshore areas to residing in estuaries for one to two months before moving to the ocean (Hoar 1956, McDonald 1960, Vernon 1966, Heard 1991). In general, most pink salmon populations use this former pattern; and, therefore, depend on nearshore, rather than estuarine environments, for their initial rapid growth.

Pink salmon populations that reside in estuaries for extended periods utilize shallow, protected habitats such as tidal channels and consume a variety of prey items, such as larvae and pupae of various insects (especially chironomids), cladocerans, and copepods (Bailey *et al.* 1975, Hiss 1995). Even more estuarine-dependant pink salmon populations have relatively short residence period when compared to fall chinook and chum salmon that use estuaries extensively. For example, while these other species reside in estuaries throughout the summer and early fall, pink salmon are rarely encountered in estuaries beyond June (Hiss 1995).

Immediately after entering marine waters, pink salmon fry form schools, often in tens or hundreds of thousands of fish (McDonald 1960, Vernon 1966, Heard 1991). During this time, they tend to follow shorelines and, at least for the first few weeks at sea, spend much of their time in shallow water of only a few centimeters deep (LeBrasseur and Parker 1964, Healey 1967, Bailey *et al.* 1975, Simenstad *et al.* 1982). It has been suggested that this inshore period involves a distinct ecological life-history stage in pink salmon (Kaczynski *et al.* 1973). In many areas throughout their ranges, pink salmon and chum salmon fry of similar age and size co-mingle in both large and small schools during early sea life (Heard 1991).

Pink salmon juveniles routinely obtain large quantities of food sufficient to sustain rapid growth from a broad range of habitats providing pelagic and epibenthic foods (Parker 1965, Martin 1966, Neave 1966, Healey 1967, Bailey *et al.* 1975). Collectively, diet studies show that pink salmon are both opportunistic and generalized feeders and, on occasion, they specialize in specific prey items. Diel stomachs sampling suggests that juvenile pink salmon are diurnal feeders, foraging primarily at night (Parker and LeBrasseur 1974, Bailey *et al.* 1975, Simenstad *et al.* 1982, Godin 1981). Common prey items include copepods (especially harpacticoids), barnacle nauplii, mysids, amphipods, euphausiids, decapod larvae, insects, larvaceans, eggs of invertebrates and fishes, and fish larvae (Gerke and Kaczynski 1972, Bailey *et al.* 1975, Healey 1980, Simenstad *et al.* 1982, Godin 1981, Takagi *et al.* 1981, Landingham 1982). Growth rates during this period of early marine residence range from 3.5-7% of body weight per day, equivalent to an approximately 1 mm increase in length per day (LeBrasseur and Parker 1964, Phillips and Barraclough 1978, Healey 1980, Karpenko 1987).

At approximately 45-70 mm in length, pink salmon move out of the nearshore environment into deeper, colder waters to begin their ocean migration (Manzer and Shepard 1962, LeBrasseur and Parker 1964, Phillips and Barraclough 1978, Healey 1980). For populations originating from Puget Sound and southern British Columbia rivers, this movement begins in July and lasts through October as fish migrate out of protected, inland waters and northward along the coast towards Alaska (Pritchard and DeLacy 1944, Barraclough and Phillips 1978, Hartt 1980, Healey 1980). After reaching approximately Yakutat in central Alaska, Washington-origin pink salmon move out into the Gulf of Alaska and follow the main current in the gyre, subsequently migrating southward during their first fall and winter in the ocean, then northward the following spring and summer. They then begin their homewards migration, again entering coastal waters as they move south toward their natal streams (Manzer *et al.* 1965, Neave *et al.* 1967, Takagi *et al.* 1981, Ogura 1994). Tagging studies indicate that juvenile and maturing Puget Sound pink salmon are most concentrated in nearshore areas of Vancouver Island and the Hecate Strait extending as far north as approximately 58° N latitude (Yukatat Bay, Alaska), and seaward to approximately 140° W longitude (Myers *et al.* 1996). The southernmost distribution of Puget Sound pink salmon is not clear, but in general the largest concentrations of pink salmon of British Columbia and Washington-origin are found north of 48° N latitude (Hartt and Dell 1986, Myers *et al.* 1996).

Pink salmon from Washington State and British Columbia and those originating in southeastern, central, and southwestern Alaska, occur in marine waters where they might interact in some way with the salmon fisheries off the coast of southeast Alaska. Pink salmon from these regions also co-mingle in the Gulf of Alaska during their second summer at sea while migrating toward natal areas (Manzer *et al.* 1965, Neave *et al.* 1967, Takagi *et al.* 1981).

In contrast to this extended ocean migration, it is believed that some Stillaguamish River and possibly other Puget Sound pink salmon remain within Puget Sound for their entire ocean residence period (Jensen 1956, Hartt and Dell 1986). This tendency to reside in Puget Sound and the Strait of Georgia is commonly exhibited by both coho and chinook salmon, but is unusual for pink salmon. These "resident" fish are much smaller than individuals that migrated to the ocean, reaching only 35-45 cm as adults, some 10 cm shorter than migratory fish from the same area (Hartt and Dell 1986).

In the ocean, pink salmon primarily consume fish, squid, euphausiids, and amphipods, with lesser numbers of pteropods, decapod larvae, and copepods (Allen and Aron 1958, Ito 1964, LeBrasseur 1966, Manzer 1968, Takagi *et al.* 1981). During this phase, most pink salmon are found in the upper-most 12 m of the water column, the actual depth varying with seasonal and diurnal patterns (Manzer and LeBrasseur 1959, Manzer 1964).

2.3.4.5 Adults

Ocean growth of pink salmon is a matter of considerable interest; because, although this species has the shortest life span among Pacific salmon, it also is among the fastest growing (Heard 1991). Entering the estuary as fry at around 30 mm in length, maturing adults return to the same area 14-16 months later ranging in length from 450 to 550 mm. Adults display a latitudinal trend in size, with the largest fish occurring in the southern portion of the range (Heard 1991). Most odd-year Fraser River and Washington fish weigh approximately 2.5 kg, while Washington even-year fish may be slightly smaller at 2.1 kg. By comparison, pink salmon from central and southeast Alaska typically weigh 1.3-1.8 kg (Takagi *et al.* 1981, Heard 1991).

Adult pink salmon enter freshwater between June and September, with northern populations generally entering earlier than southern populations (Neave *et al.* 1967, Takagi *et al.* 1981). Odd-year pink salmon from Puget Sound typically enter freshwater between mid-July and late September, with considerable local variation—the earliest run (Dungeness River) begin entering freshwater in mid-July, while the median return date of the latest-returning runs is October 15 (WDF *et al.* 1993, Hiss 1995). Snohomish River even-year fish enter freshwater three to four weeks earlier than the odd-year run in the same system, even though the two populations use the same habitat (WDF *et al.* 1993).

As with other Pacific salmon, fertilization of pink salmon eggs occurs upon deposition (Heard 1991). Males compete with each other to breed with spawning females. Pink salmon females remain on their redds one to two weeks after spawning, defending the area from superimposition of eggs from another female (McNeil 1962, Ellis 1969, Smirnov 1975).

Measured marine survivals of pink salmon, from entry of fry into stream mouth estuaries to returning adults, have ranged from 0.2% to over 20%. For North America, estimated fry-to-adult survival averages between 1.7% and 4.7% (Pritchard 1948, Parker 1962, Ricker 1964, Ellis 1969, McNeil 1980, Taylor 1980, Vallion *et al.* 1981, Blackbourn 1990). Generally, much of the natural mortality of pink salmon in the marine environment occurs within the first few months before advanced juveniles move offshore into more pelagic ocean waters (Parker 1965, 1968). Pink salmon populations can be very resilient, rebounding from weak to strong run strength in regional stock groups within one or two generations. Conversely, strong runs may also become weak within several generations, causing pink salmon populations to exhibit high natural variability (Neave 1962, Ricker 1962).

2.3.4.6 Databases on Distribution/Habitat Areas of Particular Concern

Annual spawner survey data are available for most streams in the Puget Sound basin utilized by pink salmon. Furthermore, WDF *et al.* (1993) and Williams *et al.* (1975) provide information on streams and stream reaches most utilized for pink salmon spawning. Because pink salmon enter freshwater primarily to spawn and juveniles spend little to no time in freshwater, adequate spawning habitat is critical to sustaining productive pink salmon populations. Therefore, it is important that pink salmon spawning areas and estuarine rearing areas receive adequate protection.

2.3.4.7 Freshwater Essential Fish Habitat

Freshwater EFH for Puget Sound pink salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. Important features of essential habitat for spawning, rearing, and migration include adequate, (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth, and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, channel complexity, etc.); (7) space; (8) access and passage; and (9) habitat and flood plain connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table A-5. Pink salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, and other water bodies currently viable and most of the habitat historically accessible to pink salmon within Washington. Figure A-6 illustrates the watersheds currently utilized by Puget Sound pink salmon within the USGS hydrologic units identified in Table A-6. Figure A-7 depicts the approximate historical freshwater distribution and currently identified range of common marine occurrence of Puget Sound pink salmon. The geographic extent of these pink salmon is based on data from Table A-6. Data on the marine range of Puget Sound pink salmon is from NOAA (1990).

The inadequacy of existing species distribution maps makes it extremely difficult to identify all specific stream reaches essential for the species at this time. Designating each specific river reach would invariably exclude small, important tributaries from designation as EFH. Adopting a more inclusive, watershed-based description of EFH is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and habitat use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic and adjacent upslope areas. Moreover, this watershed-based approach is consistent with other Pacific salmon habitat protection and recovery efforts such as the ESA, Northwest Forest Plan, and the OCSRI. Therefore, the geographic extent of Puget Sound pink salmon essential habitat was delineated using USGS cataloging unit boundaries.

2.3.4.8 Marine Essential Habitat

The important elements of pink salmon marine EFH are (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Overall pink salmon marine distribution is extensive, varies seasonally, interannually, and can only be defined generally (Figure A-7). Estuarine and nearshore areas such as Puget Sound and other inland marine waters of Washington State and British Columbia are critical to the early marine survival of pink salmon. Therefore, essential marine habitat for Puget Sound pink salmon includes all nearshore marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca and Strait of Georgia. It is difficult to determine a western limit for pink salmon essential marine habitat, because of limited information on their ocean distribution, but it is clear that the vast majority are found in Canadian, Alaskan, and international waters both within and outside the EEZ north of Cape Flattery, Washington (Figure A-7).

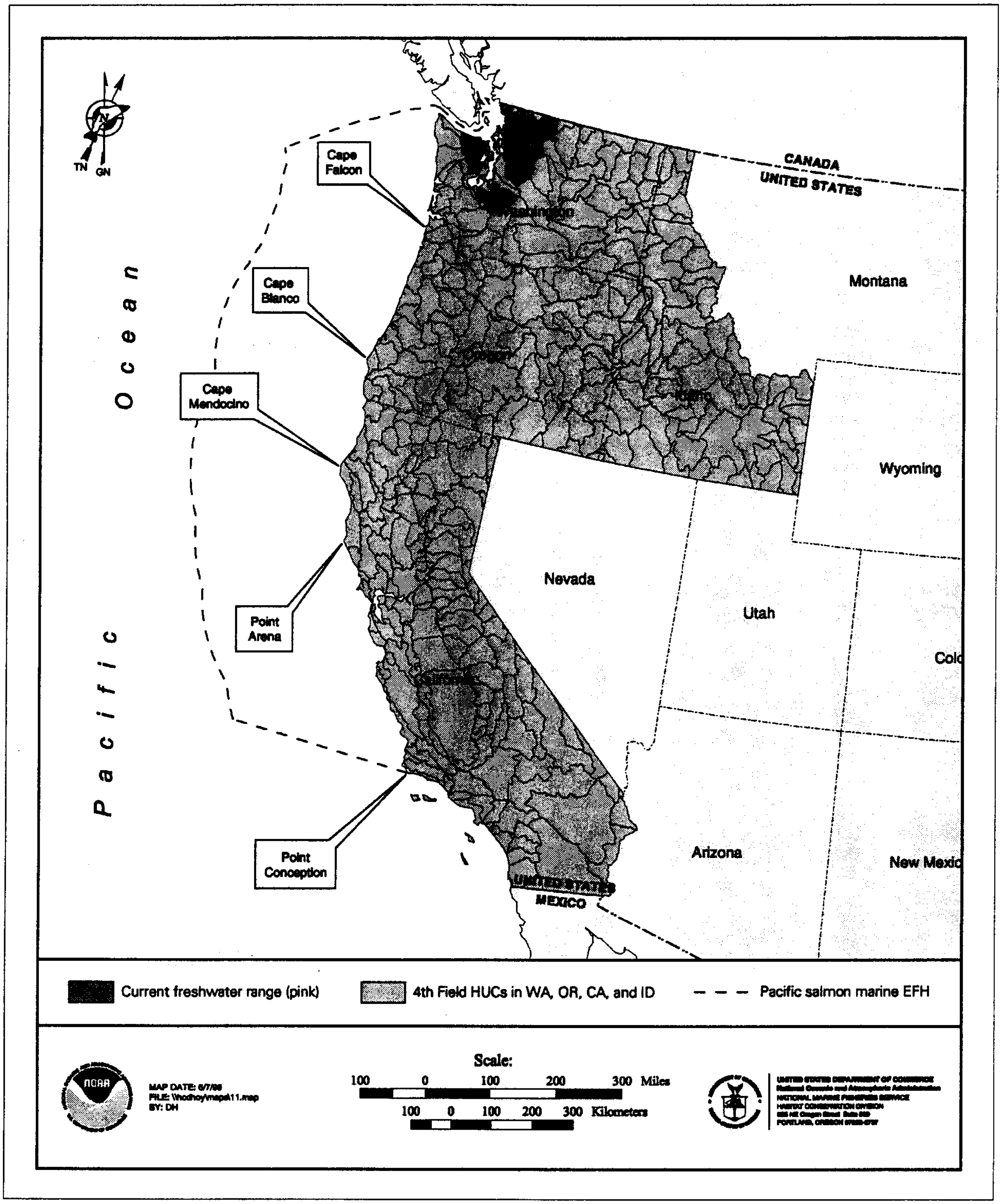

FIGURE A-6. Watersheds currently utilized by pink salmon from Washington.

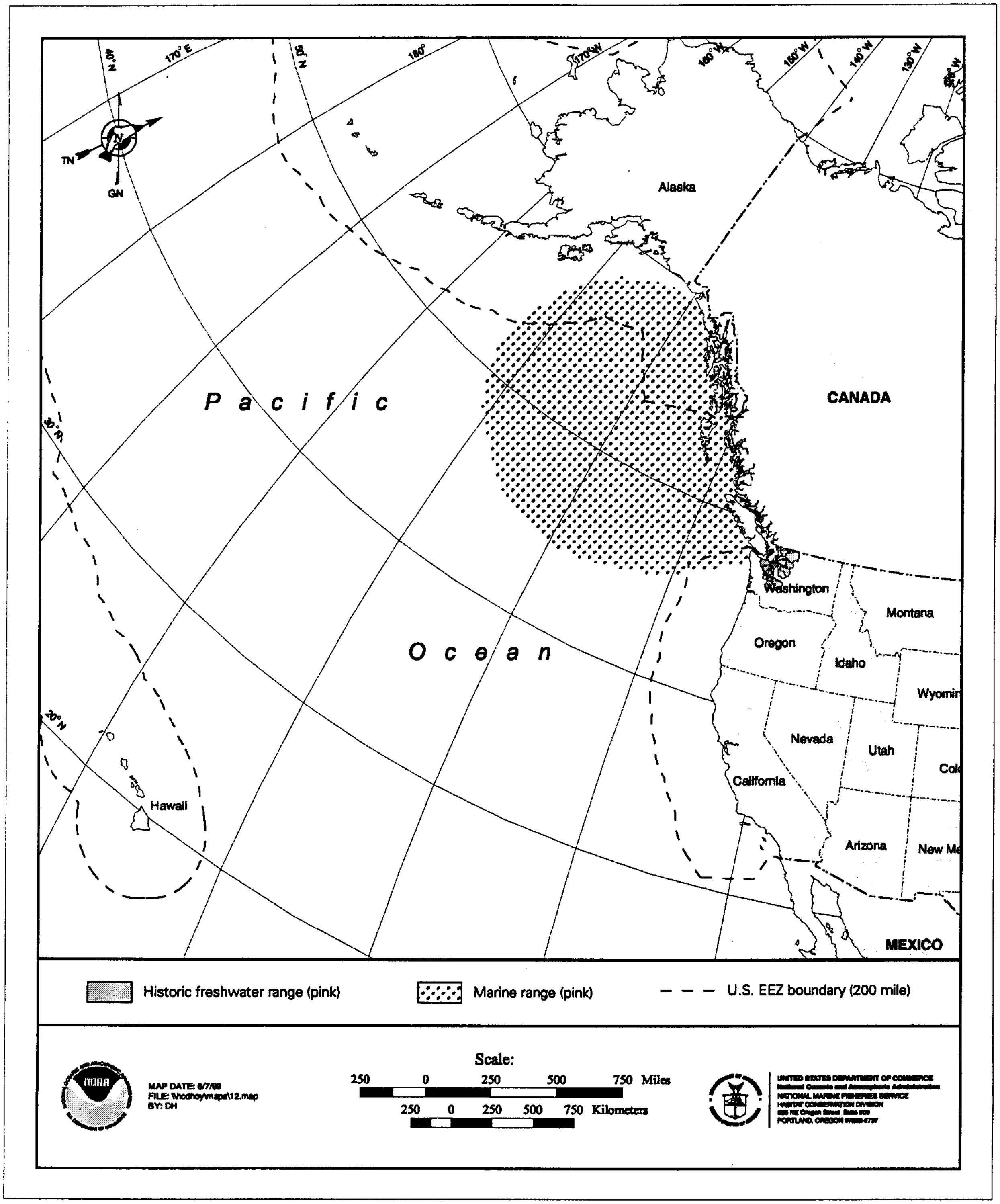

FIGURE A-7. Approximate historically accessible freshwater distribution, and currently identified range of common marine occurrence of Puget Sound pink salmon.

2.4 USGS HYDROLOGIC UNITS UTILIZED BY PACIFIC SALMON AND ADDITIONAL SOURCES OF SALMON DISTRIBUTION INFORMATION

A listing of the USGS hydrologic units utilized by salmon is provided in Table A-6. This information was used as a basis for the current and historic geographic distribution of salmon in freshwater habitat. Table A-7 provides a summary of additional sources of salmon distribution information utilized for this appendix.

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 1 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17110001	WA/BC	Fraser/Whatcom	C[2]	WDF *et al.* 1993
17110002	WA	Strait of Georgia	C[1,2,3]	WDF *et al.* 1993
17110003	WA	San Juan Islands	C[2]	WDF *et al.* 1993
17110004	WA	Nooksack R.	C[1,2,3]	WDF *et al.* 1993
17110005	WA	Upper Skagit	C[1,2,3]	WDF *et al.* 1993
17110006	WA	Sauk R.	C[1,2,3]	WDF *et al.* 1993
17110007	WA	Lower Skagit R.	C[1,2,3]	WDF *et al.* 1993
17110008	WA	Stillaguamish R.	C[1,2,3]	WDF *et al.* 1993
17110009	WA	Skykomish R.	C[1,2,3]	WDF *et al.* 1993
17110010	WA	Snoqualmie R.	C[1,2,3]	WDF *et al.* 1993
17110011	WA	Snohomish R.	C[1,2,3]	WDF *et al.* 1993
17110012	WA	Lake Washington	C[1,2]	WDF *et al.* 1993
17110013	WA	Duwamish R.	C[1,2]	WDF *et al.* 1993
17110014	WA	Puyallup R.	C[1,2,3]	WDF *et al.* 1993
17110015	WA	Nisqually R.	C[1,2,3]	WDF *et al.* 1993
17110016	WA	Deschutes R.	C[1,2]	WDF *et al.* 1993
17110017	WA	Skokomish R.	C[1,2]	WDF *et al.* 1993
17110018	WA	Hood Canal	C[1,2,3]	WDF *et al.* 1993
17110019	WA	Puget Sound	C[1,2]	WDF *et al.* 1993
17110020	WA	Dungeness - Elwha	C[1,2,3]	WDF *et al.* 1993
17110021	WA	Crescent - Hoko	C[1,2]	WDF *et al.* 1993
17100101	WA	Hoh - Quillayute	C[1,2]	WDF *et al.* 1993
17100102	WA	Queets - Quinault	C[1,2]	WDF *et al.* 1993
17100103	WA	U. Chehalis R.	C[1,2]	WDF *et al.* 1993
17100104	WA	L. Chehalis R.	C[1,2]	WDF *et al.* 1993
17100105	WA	Grays Harbor	C[1,2]	WDF *et al.* 1993
17100106	WA	Willapa Bay	C[1,2]	WDF *et al.* 1993
17080001	OR/WA	L. Columbia - Sandy	C[1,2]	Fulton 1968[1], 1970[2]; WDF *et al.* 1993[1,2]; Oregon Department of Fish and Wildlife (ODFW) 1996[2]
17080002	WA	Lewis R.	C[1,2]	Fulton 1968[1], 1970[2]; WDF *et al.* 1993[1,2]
17080003	OR/WA	L. Columbia-Clatskanie	C[1,2]	Fulton 1968[1], 19702; WDF *et al.* 1993[1,2]; ODFW 1996[2]
17080004	WA	Upper Cowlitz R.	C[1,2]	Fulton 1968[1], 1970[2]; WDF *et al.* 1993[1,2]
17080005	WA	Lower Cowlitz R.	C[1,2]	Fulton 1968[1], 1970[2]; WDF *et al.* 1993[1,2]

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 2 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17080006	OR/WA	L. Columbia	$C^{1,2}$	Fulton 1968[1], WDF *et al.* 1993[1,2], ODFW 1996[2]
17090001	OR	M.F. Willamette R.	C^{1}	Fulton 1968
17090002	OR	Coast F. Willamette R.	H^{1}	Fulton 1968, ODFW 1996
17090003	OR	U. Willamette R.	$C^{1,2}$	Fulton 19681, BPA 1994[2], ODFW 1996[1]
17090004	OR	McKenzie R.	$C^{1,2}$	Fulton 1968[1], BPA 1994[2]
17090005	OR	North Santiam R.	$C^{1,2}$	Fulton 1968[1],BPA 1994[2], ODFW 1996[1],
17090006	OR	South Santiam R.	$C^{1,2}$	Fulton 1968[1], BPA 1994[2]
17090007	OR	Mid. Willamette R.	$C^{1,2}$	Fulton 1968[1], BPA 1994[2], ODFW 1996[1]
17090008	OR	Yamhill R.	C^{2}, H^{*1}	Parkhurst *et al.* 1950[1,2], BPA 1994[2]
17090009	OR	Mollala-Pudding	$C^{1,2}$	Fulton 1968[1], Parkhurst *et al.* 1950[2], BPA 1994[2], ODFW 1996[1]
17090010	OR	Tualatin R.	C^{2}, H^{*1}	Parkhurst *et al.* 1950[1], BPA 1994[2]
17090011	OR	Clackamas R.	$C^{1,2}$	Fulton 1968[1], BPA 1994[2], ODFW 1996[1]
17090012	OR	L. Willamette R.	$C^{1,2}$	Fulton 1968[1],BPA 1994[2], ODFW 1996[1]
17070101	OR/WA	M. Columbia-L. Wallula	$C^{1,2}$	Fulton 1968 [1], Fulton 1970[2]
17070102	OR/WA	Walla Walla R.	$H^{*1,2}$	Fulton 1968 [1], Fulton 1970[2]
17070103	OR	Umatilla R.	H^{*1}	Fulton 1968
17070104	OR	Willow	H^{1}	NMFS 1998
17070105	OR/WA	Mid. Columbia-Hood	$C^{1,2}$	Fulton 1968[1], 1970[2]; WDF *et al.* 1993[2], ODFW 1996[2]
17070106	WA	Klickitat R.	$C^{1,2}$	Fulton 1968[1], 1970[2]
17070301	OR	Upper Deschutes R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070303	OR	Beaver - South Fork	H^{1}	Fulton 1968, Nehlson 1995, ODFW 1996
17070304	OR	Upper Crooked R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070305	OR	Lower Crooked R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070306	OR	Lower Deschutes R.	$C^{1,2}$	Nielson 1950[1], Fulton 1968[1], 1970[2]; BPA 1994[2]
17070307	OR	Trout Creek	C^{2}, H^{*1}	Nielson 1950[1], BPA 1994[2]
17070201	OR	Upper John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070202	OR	N.F. John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070203	OR	Middle F. John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070204	OR	Lower John Day R.	C^{1}	Nielson 1950, Fulton 1968
17030001	WA	Upper Yakima R.	$C^{1,2}$	Fulton 1968, WDF *et al.* 19932
17030002	WA	Naches R.	$C^{1,2}$	Fulton 1968, WDF *et al.* 19932
17030003	WA	Lower Yakima R.	$C^{1,2}$	Fulton 1968, WDF *et al.* 19932
17020005	WA	Chief Joseph	C^{1}, H^{*2}	Fulton 1968[1], Bryant and Parkhurst 1950[2], WDF *et al.* 1993[1]
17020006	WA/BC	Okanogan R.	C^{1}	Fulton 1968, WDF *et al.* 1993
17020007	WA/BC	Similkameen	H^{1}	Fulton 1968, WDF *et al.* 1993
17020008	WA	Methow R.	C^{1}, H^{*2}	Fulton 1968[1], Bryant and Parkhurst 1950[2]WDF *et al.* 1993[1]

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Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17020010	WA	Upper Columbia-Entiat	C^{1},H^{2}	Fulton 1968^{1}, Fulton 1970^{2}, WDF *et al.* 1993^{1}, Bryant and Parkhurst 1950^{2}, BPA 1994^{2}
17020011	WA	Wenatchee R.	$C^{1,2}$	Fulton 1968^{1}, Bryant and Parkhurst 1950^{2}, WDF *et al.* 1993^{1}, BPA 1994^{2}
17020016	WA	U. Colum.-Priest Rapids	$C^{1,2}$	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{1}
17020001	WA/BC	F. D. Roosevelt Lake	$H^{1,2}$	Bryant and Parkhusrt 1950^{1,2}, Fulton 1968^{1}
17020002	WA/BC	Kettle R.	H^{1}	Bryant and Parkhusrt 1950, Fulton 1968
17020003	WA	Colville R.	H^{1}	Bryant and Parkhusrt 1950, Fulton 1968
17020004	WA	Sanpoil R.	H^{1}	Bryant and Parkhusrt 1950, Fulton 1968
17010307	WA	Lower Spokane R.	$H^{1,2}$	Bryant and Parkhusrt 1950^{1,2}, Fulton 1968^{1}, Fulton 1970^{2}
17010216	WA/BC	Pend Oreille R.	H^{1}	Bryant and Parkhurst 1950, Fulton 1968
17060101	OR/ID	Hells Canyon	C^{1}	Fulton 1968, Mathews and Waples 1991
17060102	OR	Imnaha R.	C^{1}	Fulton 1968, Mathews and Waples 1991, ODFW 1996
17060103	OR/WA/ID	Lower Snake - Asotin	$H^{*1,2}$	Parkhurst 1950^{2}, Mathews and Waples 1991^{1}
17060104	OR	Upper Grande Ronde	C^{1}, H^{*2}	Parkhurst 1950^{2}, Fulton *et al.* 1969^{1}, Mathews and Waples 1991^{1}
17060105	OR	Wallowa R.	C^{1}, H^{*2}	Parkhurst 1950^{2}, Fulton 1968^{1}, Mathews and Waples 1991^{1}
17060106	OR/WA	Lower Grande Ronde	C^{1}, H^{*2}	Parkhurst 1950^{2}, Mathews and Waples 1991^{1}, ODFW 1996^{1}
17060107	WA	L. Snake/Tucannon R.	C^{1}, H^{*2}	Parkhurst 1950^{2}, WDF *et al.* 1993^{1}
17060110	WA	Lower Snake R.	C^{1}, H^{*2}	Parkhurst 1950^{2}, Mathews and Waples 1991, ODFW 1996^{1}
17060201	ID	U. Salmon R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060202	ID	Pahsimeroi R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060203	ID	M. Salmon - Panther	C^{1}	Fulton 1968, Mathews and Waples 1991
17060204	ID	Lemhi R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060205	ID	Upper M.F. Salmon	C^{1}	Fulton 1968, Mathews and Waples 1991
17060206	ID	Lower M.F. Salmon	C^{1}	Fulton 1968, Mathews and Waples 1991
17060207	ID	M. Salmon-Chamberlain	C^{1}	Fulton 1968, Mathews and Waples 1991
17060208	ID	S.F. Salmon R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060209	ID	Lower Salmon R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060210	ID	Little Salmon R.	C^{1}	Fulton 1968, Waples *et al.* 1991
17060301	ID	Upper Selway R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060302	ID	Lower Selway R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060303	ID	Lochsa R.	C^{1}	Fulton 1968, Mathews and Waples 1991
17060304	ID	M.F. Clearwater R.	C^{1}	Fulton 1968
17060305	ID	S.F. Clearwater R.	C^{1}	Fulton 1968
17060306	WA/ID	Clearwater	C^{1}, H^{*2}	Parkhurst 1950^{2}, Fulton 1968^{1}

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Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17060307	ID	Upper N.F. Clearwater	H[1]	Fulton 1968, Mathews and Waples 1991
17060308	ID	Lower N.F. Clearwater	H[1]	Fulton 1968, Mathews and Waples 1991
17050201	OR/ID	Brownlee Reservoir	H[1]	Fulton 1968, Mathews and Waples 1991
17050202	OR	Burnt R.	H[1]	Fulton 1968
17050203	OR	Powder R.	H[1]	Fulton 1968
17050101	ID	C.J. Strike Resevoir	H[1]	Fulton 1968, Mathews and Waples 1991
17050102	ID/NV	Bruneau R.	H[1]	Fulton 1968
17050103	ID	Middle Snake - Succor	H[1]	Fulton 1968, Mathews and Waples 1991
17050104	ID	Upper Owyhee	H[1]	Fulton 1968
17050105	ID/NV/OR	S.F. Owyhee R.	H[1]	Fulton 1968
17050106	ID/NV/OR	E. Little Owyhee R.	H[1]	Fulton 1968
17050107	ID/OR	Middle Owyhee R.	H[1]	Fulton 1968
17050108	ID/OR	Jordan Cr.	H[1]	Fulton 1968
17050109	OR	Crooked - Rattlesnake	H[1]	Fulton 1968
17050110	OR	Lower Owyhee R.	H[1]	Fulton 1968
17050111	ID	North and M.F Boise R.	H[1]	Fulton 1968
17050112	ID	Boise - Mores	H[1]	Fulton 1968
17050113	ID	S.F. Boise R.	H[1]	Fulton 1968
17050114	ID	Lower Boise R.	H[1]	Fulton 1968
17050115	ID/OR	Middle Snake - Payette	H[1]	Fulton 1968, Mathews and Waples 1991
17050116	OR	Upper Malheur R.	H[1]	Fulton 1968
17050117	OR	Lower Malheur R.	H[1]	Fulton 1968
17050118	OR	Bully Cr.	H[1]	Fulton 1968
17050119	OR	Willow Cr.	H[1]	Fulton 1968
17050120	ID	S.F Payette R.	H[1]	Fulton 1968
17050121	ID	M.F. Payette R.	H[1]	Fulton 1968
17050122	ID	Payette R.	H[1]	Fulton 1968
17050123	ID	N.F. Payette R.	H[1]	Fulton 1968
17050124	ID	Weiser R.	H[1]	Fulton 1968
17040212	ID	U. Snake - Rock	H[1]	Fulton 1968, Mathews and Waples 1991
17040213	ID/NV	Salmon Falls	H[1]	Fulton 1968, Mathews and Waples 1991
17100201	OR	Necanicum R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[2]
17100202	OR	Nehalem R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100203	OR	Wilson-Trask-Nestuccu	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100204	OR	Siletz-Yaquina R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100205	OR	Alsea R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100206	OR	Siuslaw R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100207	OR	Siltcoos R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100301	OR	N. Umpqua R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 5 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17100302	OR	S. Umpqua R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100303	OR	Umpqua R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100304	OR	Coos R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100305	OR	Coquille R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100306	OR	Sixes R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100307	OR	Upper Rogue R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100308	OR	Middle Rogue R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100309	CA/OR	Applegate R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100310	OR	Lower Rogue R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100311	CA/OR	Illinois R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
17100312	CA/OR	Chetco R.	C[1,2]	ORIS 1994[1,2], ODFW 1996[1,2]
18010101	CA/OR	Smith R.	C[1,2]	Nehlsen *et al.*1991[1], Klamath River Basin Fisheries Task Force (KRBFTF) 1991[1], Brown and Moyle 1991[2]
18010201	OR	Williamson R.	H[1]	KRBFT 1991, Nehlson *et al.* 1991
18010202	OR	Sprague R.	H[1]	KRBFT 1991, Nehlson *et al.* 1991
18010203	OR	Upper Klamath Lake	H[1]	KRBFT 1991, Nehlson *et al.* 1991
18010206	CA/OR	Upper Klamath R.	C[1,2]	KRBFT 1991[1], Brown and Moyle 1991[2]
18010207	CA	Shasta R.	C[1,2]	Nehlsen *et al.* 1991[1], KRBFT 1991, Brown and Moyle 1991[2]
18010208	CA	Scott R.	C[1,2]	KRBFT 1991[1], Brown and Moyle 1991[2]
18010209	CA/OR	Lower Klamath R.	C[1,2]	KRBFT 1991[1], Brown and Moyle 1991[2]
18010210	CA	Salmon R.	C[1,2]	KRBFT 1991[1], Brown and Moyle 1991[2]
18010211	CA	Trinity R.	C[1,2]	KRBFT 1991[1], Brown and Moyle 1991[2]
18010212	CA	S.F. Trinity R.	C[1,2]	KRBFT 1991[1], California Department of Fish and Game (CDFG) 1998[2]
18010102	CA	Mad-Redwood	C[1,2]	Higgins *et al.* 1992[1,2]
18010103	CA	Upper Eel R.	C[1,2]	Brown and Moyle 1991[2], Higgins *et al.* 1992[1]
18010104	CA	Middle Fork Eel R.	C[1,2]	Brown and Moyle 1991[2], Higgins *et al.* 1992[1]
18010105	CA	Lower Eel R. R.	C[1,2]	Brown and Moyle 1991[2], Nehlsen *et al.* 1991[1], Higgins *et al.* 1992[1,2]
18010106	CA	South Fork Eel R.	C[1,2]	Brown and Moyle 1991[2], Nehlsen *et al.* 1991[1], Higgins *et al.* 1992[1,2]
18010107	CA	Mattole R.	C[1,2]	Nehlsen *et al.* 1991[1], Brown and Moyle 1991[2], Higgins *et al.* 1992[2]
18010108	CA	Big - Navarro - Garcia	C[2], H*[1]	Brown and Moyle 1991[2], Higgins *et al.* 1992[2], Maahs and Gilleard 1994[1]
18010109	CA	Gualala - Salmon R.	C[2], H*[1]	Brown and Moyle 1991[2], Nehlsen *et al.* 1991[1], Higgins *et al.* 1992[2]
18010110	CA	Russian R.	C[1,2]	Nehlsen *et al.* 1991[1], Brown and Moyle 1991[2]
18010111	CA	Bodega Bay	C[2], H*[1]	Nehlsen *et al.* 1991[1], Brown and Moyle 1991[2]
18050001	CA	Suisun Bay	C[1,2]	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2]

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 6 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
18050002	CA	San Pablo Bay	C[1,2]	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2]
18050003	CA	Coyote	C[1,2]	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2], NMFS 1998[1]
18050004	CA	San Francisco Bay	C[1,2]	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2], NMFS 1998[1]
18020001	CA, OR	Goose Lake	H[1]	Clark 1929, Evermann and Clark 1931
18020003	CA	Lower Pit R.	H[1]	Clark 1929, Yoshiyama *et al.* 1996
18020004	CA	McCloud R.	H[1]	Clark 1929, Yoshiyama *et al.* 1996
1802005	CA	Sacramento Headwaters	H[1]	Clark 1929, Yoshiyama *et al.* 1996
18020101	CA	Sac. L. - Cow L. Clear	C[1]	Clark 1929, Evermann and Clark 1931
18020102	CA	Lower Cottonwood Cr.	C[1]	Clark 1929, Hanson *et al.* 1940
18020103	CA	Sac.-Lower Thomes	C[1]	Clark 1929, Evermann and Clark 1931
18020104	CA	Sac.-Stone Corral	C[1]	Clark 1929, Evermann and Clark 1931
18020105	CA	Lower Butte	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020106	CA	Lower Feather R.	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020107	CA	Lower Yuba R.	C[1]	Clark 1929, Nehlsen *et al.* 1991
18020108	CA	Lower Bear R.	C[1]	Clark 1929, Hanson *et al.* 1940
18020109	CA	Lower Sacramento R.	C[1]	Clark 1929
18020110	CA	L. Cache Creek	H[1]	Yoshiyama *et al.* 1996
18020111	CA	Lower American R.	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020112	CA	Sac.-Upper Clear	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020113	CA	Cottonwood Headwaters	C[1]	Clark 1929, Hanson *et al.* 1940, Yoshiyama *et al.* 1996
18020114	CA	U. Elder- U. Thomes	H[1]	Yoshiyama *et al.* 1996
18020115	CA	Upper Stony Creek	H[1]	Yoshiyama *et al.* 1996
18020118	CA	Upper Cow-Battle	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020119	CA	Mill-Big Chico	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020120	CA	Upper Butte Cr.	C[1]	Clark 1929, Yoshiyama *et al.* 1996
18020121	CA	N.F. Feather R.	H[1]	Clark 1929, Hanson *et al.* 1940
18020122	CA	E. Branch N.F. Feather	H[1]	Clark 1929, Hanson *et al.* 1940
18020123	CA	M.F. Feather R.	H[1]	Clark 1929, Hanson *et al.* 1940
18020125	CA	Upper Yuba R.	C[1]H[1]	Clark 1929, Yoshiyama *et al.* 1996
18020128	CA	N.F. American R.	H[1]	Clark 1929, Yoshiyama *et al.* 1996
18020129	CA	S.F. American R.	H[1]	Clark 1929, Yoshiyama *et al.* 1996
18030010	CA	Upper King	H[1]	Yoshiyama *et al.* 1996
18030012	CA	Tulare-Buena Vista Lakes	H[1]	Yoshiyama *et al.* 1996
18040001	CA	U. Mid. San Joaquin - Lower Chowchilla	H*[1]	Clark 1929, Yoshiyama *et al.* 1996

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 7 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
18040002	CA	Mid. San Joaquin - L. Merced - L. Stanislaus	H^{*1}	Clark 1929, Yoshiyama *et al.* 1996
18040003	CA	San Joaquin Delta	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18040004	CA	L. Calaveras-Mormon Slough	H^{*1}	Clark 1929, Yoshiyama *et al.* 1996
18040005	CA	L. Consumnes-L. Mokelumne	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18040006	CA	Upper San Joaquin	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18040008	CA	Upper Merced	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18040009	CA	Upper Tuolumne	$C^{1}H^{1}$	Clark 1929, Campbell and Moyle 1990
18040010	CA	Upper Stanislaus	H^{1}	Clark 1929, Campbell and Moyle 1990
18040011	CA	Upper Calaveras	C^{1}	Clark 1929
18040012	CA	Upper Mokelumne	H^{1}	Clark 1929
18040013	CA	Upper Cosumnes	$C^{1}H^{1}$	Clark 1929
18060001	CA	San Lorenzo - Soquel	C^{2}, H^{*1}	Snyder 1914^{1}, Brown and Moyle 1991^{2}, Bryant 1994^{2}
18060002	CA	Pajaro R.	C^{2}, H^{*1}	Snyder 1914^{1}, Bryant 1994^{2}
18060006	CA	Central Coastal	$H^{*1,2}$	Jordan 1895^{1}, Brown and Moyle 1991^{2}, Bryant 1994^{2}
18050005	CA	Tomales-Drake Bays	C^{2}	Brown and Moyle 1991
18050006	CA	San Fran.-Coastal South	C^{2}	Brown and Moyle 1991
18060012	CA	Carmel R.	H^{*2}	Brown and Moyle 1991

Note: Juvenile chinook salmon were also reported in the Ventura River (USGS No. 18010101) by Jordan and Gilbert (1881), but no other reports of adults or a self sustaining population were located.

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 1 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE:								
StreamNet/ Northwest Environmental Database (NED)- Pacific States Marine Fisheries Commission (PSMFC)	River Reach Number (RRN) linked dBase files - online database	Dynamically segmented reach file - 1:100,000	CRB, coastal OR, WA, limited CA data	Mapping, consultation	Species distribution information, escapement, hatcheries, (wetlands, wildlife and other data in NED)	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Matt Freid PSMFC Gladstone, OR (503) 650-5400 www.psmfc.org
USFS/Bureau of Land Management (BLM) habitat surveys and distribution data, aquatic inventory and stream identification	Hardcopy and some digital files	Individual habitat units - some data linked to 1:100,000 reaches	Federal forest/range lands, private lands in matrix	Consultation	Species distribution and habitat quality data not collected using consistent criteria, needs evaluation	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Shaun McKinney USFS Siuslaw, NF (541) 750-7188
National Wetlands Inventory (NWI) - U.S. Fish and Wildlife Service (USFWS)	ArcInfo digital line graph (DLG) coverages - online dBase.	DLG files - 1:24,000 scale	Nationwide	Mapping, consultation	Wetland and estuarine habitats nationwide	General	Egg to smolt Juvenile marine	www.nwi.fws.gov
Estuarine Living Marine Resources (ELMR) – NOAA National Ocean Service (NOS)	Hardcopy, digital development proposed	Relative estuarine abundance/ 1:500,000	All major West Coast estuaries	Mapping	Relative species abundance in West Coast estuaries, validates species presence, digital data of limited utility for EFH mapping	Chinook, Coho, Sockeye, Pink	Juvenile marine Adult marine	Steve Brown NOAA - Ocean Resources Conservation and Assessment Division (ORCA) Sephen.K.Brown@noaa.gov (301) 713-3000
Pacific Salmon Tagging database - Fisheries Research Institute (FRI), University of Washington	Hardcopy and digital database	Tag release/ recovery data - scale N/A	CA, OR, WA, ID	Mapping	Tag release recovery data showing ocean distribution of West Coast stocks	Chinook, Coho, Sockeye, Pink	Adult Marine	Katherine Myers Box 35790 University of Washington Seattle, WA 98195
Minerals Management Service, National Marine Sanctuaries databases	Hardcopy reports/ maps, digital availability unknown.	Substrates, key habitat areas - Variable data formats, completeness	Various sites on CA, OR, WA coasts	Needs further evaluation	Data sources being reviewed by PFMC Groundfish Management Team for nearshore distribution, possible relevance to anadromous EFH effort	General	Adult marine	National Marine Sanctuary Program
Pacific Fisheries Information Network (PACFIN) - PSMFC	Online database	Commercial catch data - scale variable	Coastal CA, OR, WA	Needs further evaluation	Some salmonid presence information inferred from catch data	Chinook, Coho, Sockeye, Pink	Adult marine	PSMFC Gladstone, OR www.psmfc.org

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 2 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
California Rivers Assessment (CARA) – Public Service Research Program, UC Davis	PC database, some online data	Presence data by reach/ 1:250,000	CA	Mapping	Presence/absence for a subsample of rivers, some historic use data	Chinook, Coho	Adult spawning Egg-smolt rearing	David Hudson (916)752-0532 http://endeavor.des.ucdavis.edu
Environmental Protection Agency (EPA)/USGS Hydrography – USGS Water Information Clearinghouse	GIS polylines	1:100,000 scale reach file	CA, OR, WA, ID	Template for general EFH mapping	Hydrography template for mapping species distribution data	General	Adult spawning Egg-smolt rearing	Tom Haltom USGS (916)278-3061 tchaltom@usgs. gov
Brown and Moyle Report - NMFS Southwest Regional Office (SWR)	Hardcopy	Current and historical coho freshwater distribution	Northern/ central CA coast	Mapping, integrated with SW region coho data	Historic extent of coho salmon habitat in CA from available documentation by stream name	Coho	Adult spawning Egg-smolt rearing	NMFS Northwest Regional Office (NWR) 525 NE Oregon St. Portland, OR 97323
CA Dept. of Forestry and Fire Protection (CDFFP)/Private timberland surveys	Hardcopy reports, various GIS, and other databases	Land use, cover, own., hab. surveys, etc. variable scales	Private forest lands, CA	EFH consultation	Variable scale/structure data collected on private forest lands, much of these data are proprietary	Coho, Chinook, General	Adult spawning Egg-smolt rearing	Robin Marose CDFFP (916)227-2656 Various sources for private data
CDFG - Eel River surveys	PC database	Presence data attached to reach file - 1:100,000	Eel River, CA	EFH mapping	Coho distribution limited to the Eel River basin in CA, integrated with NMFS SW region coho data	Coho	Adult spawning Egg-smolt rearing	Paul Veisze (916)323-1667 pveisze@dfg.ca. gov
CDFG Hazardous Materials Spill Response database	Various hardcopy reports, GIS, and other databases	Shoreline and substrates data - various scales and formats	Local to state level	EFH consultation	Habitat type, substrate, and other data useful to long term EFH management	General	Juvenile marine Adult marine	Kim McKlegneghan (916)322-9210
NMFS San Francisco Bay and Gulf of Farralones surveys	Hardcopy reports, digital not available	Beach seine/trawl data for pathology studies	San Francisco Bay Delta and Gulf of Farallones chinook dist.	EFH consultation	Chinook salmon parr, smolts, and juveniles collected for pathology studies, useful for presence/absence.	Chinook, General	Juvenile marine Adult marine	Bruce Macfarlane (415)435-3149 Bruce.Macfarlane@noaa.gov
San Francisoco Bay National Estuary Program	Hardcopy reports, digital data availability unknown	Habitat and pollutant sites - variable scales	San Francisco Bay and Delta	EFH consultation	Possible source for data on key habitat areas (e.g., submerged aquatic vegetation)	General	Juvenile marine Adult marine	www.abag. ca.gov/bayarea/sfep/sfep.html

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 3 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
CDFG San Francisco Bay Delta surveys	Hardcopy reports, digital data availability unknown	Trawl/seine data for relative abundance	All species, San Francisco Bay/Delta CA	EFH consultation	CDFG surveys of fish community composition at several stations throughout S.F. Bay Estuary	Chinook, General	Juvenile marine Adult marine	Judd Muscat CDFG (916)324-3411
Oregon River Information Coverages - ODFW	GIS polyline coverages and attribute data	Dynamically segmented reach file - 1:100,000	OR	EFH mapping, consultation and manage-ment	ORIS data updated to larger scale, preferred scale for province maps, species distribution segregated by use type, useful for general mapping	Chinook, Coho	Adult spawning Egg-smolt rearing	http://rainbow.dfw.state.or.us/ ftp
Oregon Rivers Information System - ODFW	GIS and reach linked attribute database	Dynamically segmented reach file - 1:250,000	OR	EFH mapping	Useful for coarse maps of large areas, under-represents spawning habitat. Migration corridor and spawning areas not clearly distinguished	Chinook, Coho	Adult spawning Egg-smolt rearing	Brent Forsberg ODFW P.O. Box 59 Portland, OR 97297
ODFW Core Area Maps	GIS and attribute database	Dynamically segmented 1:100,000 reach files	OR	Mapping, consultation	Preferred spawning and rearing habitats in key river basins information is good for coastal streams, less detailed in Columbia River Basin	Chinook, Coho	Adult spawning Egg-smolt rearing	http://rainbow.dfw.state.or.us/ ftp
ODFW Habitat Surveys	Hardcopy data, linkage to GIS in progress	Habitat units, will be linked to 1:24,000 scale reaches	OR coast state and private lands	Consultatio n	Habitat suitability surveys for salmonids at management relevant scales, identifies current and potential anadromous habitats	General	Adult spawning Egg-smolt rearing	Kim Jones ODFW (541)737-7619 jonesk@fsl.orst. edu
OR Dept. of Land Conservation & Development estuarine inventories	Various hardcopy reports and digital databases	Estuarine extent, habitat types	OR Coast	Consultatio n	Statewide criteria for estuarine inventories implemented at the county level	General	Adult spawning Juvenile marine	Various county level data sources

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 4 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
Coastal Change Analysis Program (CCAP) - NOAA Coastal Services Center (CSC)/ Columbia R. National Estuary Prog. - EPA	GIS and attribute database - CD format	Habitat/land cover data - variable scales	Columbia River Estuary, OR coast to Tillamook Bay	Consultation	Time series remote sensing images of uplands habitat change, useful for identifying long term EFH trends	General	Adult spawning Egg-smolt rearing Juvenile marine	NOAA - CSC www.csc.noaa.gov
Tillamook Bay National Estuary Project - Oregon State University	Hardcopy reports, GIS coverages	Reach/land cover data/ 1:24,000 - 1:100,000 scale	Tillamook Bay basin, OR HUC# 17100203	Mapping, consultation	Species distribution data for coho, chinook and chum, segregated by use type for Tillamook Bay tributaries	Chinook, Coho, General	Adult spawning Egg-smolt rearing Juvenile marine	www.orst.edu/ dept/tbaynep/ active.html
State/Private watershed analysis data, watershed organization databases	Various hardcopy and digital databases	Numerous data categories, variable scales	State and private lands OR/WA/CA/ ID	Consultation	Locally specific data useful for EFH consultation	Chinook, Coho, Sockeye, Pink, General	Adult spawning Egg-smolt rearing	Various sources
WARIS - Washington Department of Fish and Wildlife (WDFW)	GIS and attribute database	Dynamically segmented reach file - 1:100,000	WA	Mapping, consultation	Species distribution segregated by use type, useful for general mapping.	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Martin Hudson WDFW (360) 902-2487 hudsomgh@dfw.wa.gov
Western Washington Watershed Screening Database (WWWSD) - WDFW	GIS ArcInfo coverages, database	Reach, land cover data, road density - 1:24,000	Western WA	Mapping, consultation	Habitat screening tool potentially useful for identifying key stream reaches, demonstrates extent of river miles at 1:24,000	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Brad Johnson EPA Region 10 (206)553-4150 bjohnson@r0dj05.r10.epa.gov
Washington State Department Natural Resources Stream Typing Database	Digital	1:24,000	WA	EFH consultation and mapping	Fish presence and absence, template for Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP)	general (salmonid presence and absence)	Adult spawning Egg-smolt rearing	Wash. DNR 1111Wash. St. SE Olympia, WA 98504 (360) 902-1000
Salmon and Steelhead Stock Inventory (SASSI) - WDFW	Hardcopy (integrated with WARIS)	Dynamically segmented 1:100,000 reach files	WA	Mapping, consultation	Preferred spawning and rearing habitats by species for river basins with critical spawning habitat	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	WDFW P.O. Box 43138 Olympia, WA 98504-3150 (360)902-2700

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 5 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
SSHIAP - WDFW and Northwest Indian Fisheries Commission (NWIFC)	Hardcopy, GIS database in development	Channel morphology, stream flows, seral stage - 1:24,000	Western WA (partially complete)	Mapping, consultation	Habitat suitability surveys at management relevant scales useful for identifying currently and potentially suitable anadromous habitats	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Randy McIntosh NWIFC (360)438-1180
Willapa Watershed Information System - Interrain Pacific	GIS and attribute database - CD format	GIS reach and land cover - variable scales	Willapa Bay basin, WA	Consultation	Time series remote sensing images of uplands habitat change, useful for identifying long term trends	Chinook, Coho	Adult spawning Egg-smolt rearing Juvenile marine Adult marine	Interrain Pacific (503)226-8108 www.interrain.org
Idaho Rivers Information System - Idaho Department of Fish and Game (IDFG)	GIS and attribute database	Dyna. seg. reach file - 1:250,000 (in conversion to 1:100,000)	ID	Mapping	Data scale limits utility to general mapping for information purposes only	Chinook	Adult spawning Egg-smolt rearing	Jerome Hansen IDFG 600 S. Walnut Boise, ID 83707 (208)334-3098
Puget Sound Intertidal Habitat Inventory - Washington Department of Natural Resources	GIS and attribute database - CD format	Substrates and vegetation - 1:24,000 scale	Puget Sound, WA	Consultation	Puget Sound shoreline habitat inventories, partially complete coverage of Bellingham Bay to Canadian border	General	Juvenile marine Adult marine	WA Nat. Heritage Program Mail Stop 47027 Olympia, WA 98504
Puget Sound National Estuary Program (NEP) - EPA	Hardcopy, digital avail. unknown	unknown	Puget Sound, WA	Consultation	Sediment contamination, point source pollution location data, etc.	General	Juvenile marine Adult marine	Nancy McKay Puget Sound NEP (360)407-7300
Tribal/local government habitat, land cover, zoning maps, etc.	Various hardcopy and digital formats	Various data types and scales	Local: CA, OR, WA, ID	Consultation	Numerous tribal/local government data sources may have consultation and management utility	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Various sources
Commercial fishing logbooks	Hardcopy	Location of key marine habitat areas - scale N/A	Coastal CA, OR, WA	Needs further evaluation	Experience based knowledge of key salmonid marine habitat areas and characteristics	Chinook, Coho, Sockeye, Pink	Adult marine	Various sources

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 6 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 2 - HABITAT-RELATED DENSITIES:								
NMFS Salmonid Escapement Database (prepared by Big Eagle Associates and LGL), Incorporated into StreamNet	Restricted database	Salmonid escapement in selected West Coast rivers - 1:100,000 reaches	Selected river basins CA, OR, WA, ID	See StreamNet (incorporated into StreamNet)	Escapement data acquired from state, federal, tribal and intergovernmental agencies for Washington, Oregon, and California	Chinook, Coho, Sockeye, Pink	Adult spawning	NMFS - Northwest Fisheries Science Center (NWFSC) 2725 Montlake Blvd. E Seattle, WA 98112
Klamath Resources Information System – USFWS	GIS and interactive database - CD format	Multiple data coverages, bibliographic data - variable scales	Klamath River basin below Iron Gate dam	consultation	Escapement data for all species in selected area sub-basins, model system for consultation and management	Chinook, Coho	Adult spawning Egg-smolt rearing	USFWS Klamath River Fishery Resource Office, P.O. Box 1006, Yreka, CA 96097
Desktop GIS System for Salmonid Resources in the Columbia River	GIS database	1:250,000	Columbia River Basin (WA, OR, ID)	mapping and consultation	Spawning escapement and hatchery release data, similar to StreamNet	Coho, Chinook, Sockeye	Adult spawning, juvenile (hatchery smolts)	Bob Emmett NMFS 2030 S. Marine Sciences Dr. Newport, OR 87365
EFH DATA LEVEL 3 - REPRODUCTION, GROWTH, SURVIVAL RATES BY HABITAT:								
NA								
EFH DATA LEVEL 4 - PRODUCTION RATES BY HABITAT:								
NA								